Manual

Transport Noise Management Code of Practice: Volume 2 – Construction Noise and Vibration

May 2023

Gazetted 11 August 2023

Effective until 10 August 2030 unless repealed earlier

Important Note:

This document is developed solely and specifically for use on Government Supported Transport Infrastructure where design and construction are administered by the Department of Transport and Main Roads. It is not suitable for any other purpose.

This code of practice states the ways of achieving compliance with the general environmental duty for an activity that causes, or is likely to cause, environmental harm, in accordance with section 551 of the *Environmental Protection Act* 1994 (EP Act).

If this document forms part of a contract with Department of Transport and Main Roads, use of the document is subject to the terms of the contract.

Copyright

Licence

CC BY licence summary statement

Translating and interpreting assistance

The Queensland Government is committed to providing accessible services to Queenslanders from all cultural and linguistic backgrounds. If you have difficulty understanding this publication and need a translator, please call the Translating and Interpreting Service (TIS National) on 13 14 50 and ask them to telephone the Queensland Department of Transport and Main Roads on 13 74 68.

Disclaimer

While every care has been taken in preparing this publication, the State of Queensland accepts no responsibility for decisions or actions taken as a result of any data, information, statement or advice, expressed or implied, contained within. To the best of our knowledge, the content was correct at the time of publishing.

Feedback

Please send your feedback regarding this document to: tmr.techdocs@tmr.qld.gov.au

Amendment Register

Issue / Rev. no.	Reference section	Description of revision	Authorised by	Date
1	–	First Edition	CE (E&T)	September 2014
2	–	Second Edition	CE (E&T)	March 2016
3	–	Third Edition	CE (E&T)	May 2023

Contents

Tables

Figures

1 Overview

1.1 Framework of the Code of Practice

The *Transport Noise Management Code of Practice* is structured into volumes. At the date of publication there are two volumes:

- Volume 1: Road Traffic Noise
- Volume 2: Construction Noise and Vibration.

Transport Noise Management Code of Practice Volume 1 is primarily used to address operational road traffic noise, while Volume 2 (this Code) is primarily used to address transport infrastructure construction noise and vibration.

This document has been developed by the Queensland Department of Transport and Main Roads and endorsed by the Queensland Department of Environment and Science. Unless otherwise noted, all references to 'the department', 'departmental' and so on refer to the Queensland Department of Transport and Main Roads.

The following refers to Volume 2 unless noted otherwise.

1.2 Purpose of the Code

This Code is a practical guide for government supported transport infrastructure to achieve compliance with general environmental duty defined in the *Environmental Protection Act* 1994 (EP Act) with respect to environmental harm and nuisance. Overall, the department's obligation to meet its general environmental duty associated with construction activities requires all reasonable and practicable measures to be implemented to prevent or minimise environmental harm (which includes environmental nuisance) from construction noise and vibration.

This Code is a published standard under the *Transport Infrastructure Act* 1994 (TI Act) that provides a framework for assessment and management of the potential impact of construction noise and vibration on public wellbeing, amenity and safety.

This Code is gazetted under s551 of the EP Act. This Code states the ways of achieving compliance with the general environmental duty (s319 of the EP Act) for an activity that causes, or is likely to cause, environmental harm. The general environmental duty requires that a person must not carry out any activity that causes, or is likely to cause, environmental harm unless all reasonable and practicable measures are taken to prevent or minimise the harm.

This Code is not mandatory; however, this Code can only be relied on to demonstrate general environmental duty if it is followed in its entirety. The department requires compliance with the Code where it is a requirement of a condition of contract. Where a transport infrastructure project does not comply with this Code, the project will need to be able to demonstrate compliance with its general environmental duty defined in the EP Act with respect to environmental harm and nuisance by other means.

This Code is applicable to noise and vibration impacts from the following permanent and temporary works:

- construction or demolition associated with transport infrastructure (including earthworks and vegetation clearance)
- construction or demolition associated with public utilities related to transport infrastructure (including earthworks and vegetation clearing)
- mobile or temporary fixed facilities associated with a construction project (transport infrastructure/utilities) and established on a short-term or semi-permanent basis to meet the specific requirements of the construction project – this does not include facilities which are located outside the project boundary
- traffic generated by construction projects including haul routes within the project boundary
- blasting associated with construction projects (transport infrastructure/utilities) within the project boundary.

The following are out of scope for this Code:

- Noise and vibration resulting from maintaining transport infrastructure or from works conducted in relation to emergency repairs to infrastructure or to public utilities located in the reserve performed as a function under the *Disaster Management Act* 2003. Environmental management for maintaining transport infrastructure is generally considered within a separate contractual arrangement by the department.
- Impacts to native fauna (including terrestrial and aquatic species) or cultural heritage, as environmental harm for these matters is considered separately by the department within MRTS51 (excluding vibration damage to Heritage Sites which is considered on a case-by-case basis within this Code).
- Noise and vibration impacts from supply chain haul routes (external to the project boundary), as noise and vibration impacts and risk mitigation measures for supply chain haul routes shall be specified by the construction contractor within a Supply Chain Haul Route management strategy as per MRTS02.
- Impacts to Public Utility Plant (PUP), as they are governed by the service provider codes of practice/permitting (including exclusion zones and vibration limits) and any other requirements specified within the detailed design drawings, relevant specifications and contract documentation. The designer is responsible for liaising with the relevant utility provider during the design phases in accordance with the department's functional specifications for PUP. The construction contractor is responsible for liaising with the relevant utility authority based on their work methods to seek approval during construction to manage potential impacts in accordance with MRTS170, MRTS171 and utility provider requirements.
- Vibration impacts to the department's structures. The department's Structures Section shall be contacted by the designer and construction contractor to determine requirements in relation to the management of potential vibration damage to the department's structures.
- Environmentally Relevant Activities.

1.3 Objectives of the Code

The Code objectives are the following:

- Provide a framework for the identification and assessment of noise and vibration impacts from transport infrastructure construction. Community amenity and potential building/structural damage impacts are considered.
- Provide guidance regarding reasonable and practicable noise and vibration control measures to be considered for transport infrastructure construction.
- Provide guidance on how a construction contractor meets its general environmental duty by mitigating noise and vibration impacts with a noise and vibration management plan.

1.4 Principles of the Code

Construction noise and vibration, like other environmental impacts, must be managed to prevent and/or minimise potential adverse impacts (that is, prevent or minimise environmental harm). Construction of infrastructure is predominantly temporary and provides a benefit to the community; therefore, it should be recognised as an essential part of urban and rural development. Whilst predominantly temporary, some construction activities have the potential to continue for prolonged periods. Where this is the case, the risk of impact due to the duration of exposure is increased and shall be considered when determining the level of required management and mitigation.

This Code has been developed to focus on balancing the management of noise and vibration impacts of construction projects with community expectations and requires all ‘Practicable’ and ‘Reasonable’ mitigation and management measures to be implemented to prevent and/or minimise environmental harm in accordance with general environmental duty.

The terms ‘Practicable’ and ‘Reasonable’ are the guiding principle for the application of this Code and they frame the intent of the Code when considering the management of noise and vibration impacts, particularly mitigation measures.

A noise and vibration mitigation measure, being of administrative or engineering nature, is considered practicable if it is capable of being implemented or engineered. The practicality of the mitigation measure should consider the bounds of the project, technical feasibility, environmental impacts, maintenance aspects and implications in relation to safety.

To determine whether a mitigation measure is reasonable relies upon common sense and good judgement to arrive at a decision. Overall, the reasonableness of the noise and vibration measures should be weighed with community expectations, cost effectiveness and other environmental implications. The following (and other relevant issues) shall be considered when determining reasonableness:

- the effectiveness of noise and vibration measures (for example, reduction in absolute level, duration of exposure, post construction benefits of mitigation, potential for damage to buildings and structures)
- community/stakeholder expectations (for example, community support and input from local and public agencies)
- cost effectiveness (for example, attenuation benefits, costs and life cycle of attenuation treatments, disruption to infrastructure and assets, potential cost of repairs/rehabilitation without mitigation)

- environmental impacts (for example, impacts of mitigation on drainage/overland flow paths, disturbance of contaminated land, light spillage, impacts on air quality, streetscape and scenic/visual amenity)
- risk to safety (for example, safety clearance zones for traffic which restrict available periods of construction to evening and night, such as rail possessions or road corridor closure restrictions).

1.5 Legislative framework

Legislation that is relevant to the environmental assessment process for the department from a maintenance and construction perspective include:

- *Environmental Protection Act* 1994 (EP Act)
- *Transport Infrastructure Act* 1994 (TI Act)

The EP Act is the legislative instrument which seeks to protect environmental values. Environmental harm, which includes environmental nuisance, is the adverse or potential adverse impact on an environmental value. The environmental values covered by this Code are qualities of the acoustic (that is, noise and vibration) environment that are conducive to human health and wellbeing, protecting the amenity of the community and protecting property from damage.

The EP Act defines the general environmental duty as follows, '*A person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm*'. This gazetted Code of Practice under s551 of the EP Act provides a framework for a transport infrastructure construction project to comply with its general environmental duty requirements.

The *Environmental Protection (Noise) Policy* 2019 is subordinate legislation to the EP Act and is used to provide nuisance criteria for environmental noise emissions with a long-term focus. It is noted that nuisance from maintaining and ordinary use of transport infrastructure is excluded from offences relating to nuisance and contravening a noise standard (see Schedule 1, Part 1 item 1 and 2, EP Act).

The TI Act (s9) requires the construction, maintenance and operation of all government supported infrastructure to be carried out with the following objectives:

- to take into account best practice and national benchmarks
- to reduce adverse environmental impacts.

Under the TI Act, the Chief Executive is authorised to publish standards if necessary. Standards published by the Chief Executive should be designed to consider the transport objectives, namely efficiency, affordable quality and cost effectiveness. In addition to being a gazetted Code of Practice under the EP Act, this Code is also a published standard and is authorised by the Chief Executive.

1.6 Departmental policies

1.6.1 Environmental management process

The *Environmental Processes Manual* outlines the environmental assessment and management processes for transport infrastructure projects undertaken by the department. Projects are required to follow the specified process and address relevant departmental technical standards and implement appropriate mitigation measures. This Code is one of a series of technical standards published by the department.

1.6.2 Technical specifications

Transport and Main Roads Technical Specifications (MRTS) are used to manage construction activities conducted by or on behalf of the department.

The following specifications include specific requirements and conditions relating to noise and vibration associated with transport construction works:

General environment

MRTS51	*Environmental Management*

Ground vibration and airblast technical note

TN03	*Measurement of Ground Vibration and Airblast*

Blasting

MRTS55	*Use of Explosives in Roadworks*

Piling works

MRTS63	*Cast-In-Place Piles*
MRTS63A	*Piles for Ancillary Structures*
MRTS64	*Driven Tubular Steel Piles (with reinforced concrete pile shaft)*
MRTS65	*Precast Prestressed Concrete Piles*
MRTS66	*Driven Steel Piles*

Noise fences

MRTS15	*Noise Fences*

In some cases, noise fences would be considered a practical and reasonable mitigation measure. In construction, noise fences may be temporary or permanent structures. Permanent noise fences, whether or not they would be required to meet operational traffic noise mitigation requirements, must be designed and constructed in accordance with the requirements of MRTS15.

PUP

MRTS170	*Public Utilities in Road Projects Site Works*
MRTS171	*Public Utilities in Road Projects Principal Contractor Responsibilities*

Other specifications

MRTS02	*Provision for Traffic*
MRTS03	*Drainage Structures, Retaining Structures and Embankment Slope Protections*
MRTS04	*General Earthworks*
MRTS06	*Reinforced Soil Walls*
MRTS16	*Landscape and Revegetation Works*
MRTS28	*Contractor's Site Facilities and Camp*
MRTS84	*Deck Wearing Surface*
MRTS84A	*Removal of Bridge Deck Wearing Surface*
MRTS100	*High Strength Geosynthetic Reinforcement in Road Embankments*
MRTS104	*Asphalt Geosynthetics for Delaying Pavement Reflective Cracking*
MRTS305	*Dredging*

These specifications may include particular construction methods and work practices which should be considered when determining noise and vibration mitigation and management measures.

1.7 Other related matters

The following matters are not the focus of this Code, but are generally addressed by other legislation, policies or standards:

- Operational noise emissions from different transport modes, which are covered by various government policies including:
  - Road traffic – *Transport Noise Management Code of Practice* Volume 1: *Road Traffic Noise*, 2013 (Transport and Main Roads).
  - Road traffic – *Development Affected by Environmental Emissions from Transport Policy* Version 4, 9 October 2017 (Transport and Main Roads).
  - Rail traffic – *Interim Guideline – Operational Railway Noise and Vibration* (2019) (Transport and Main Roads).
  - Airports – *Airports Act* 1996 (Commonwealth).
  - Airports – Airport (Environmental Protection) Regulation 1997 (Commonwealth).
- Operational vibration emissions from different transport modes, which are technically not the subject of this Code. However, it is expected that the vibration limits for human comfort should generally be met. The following standards can be referenced:
  - Rail traffic – *Interim Guideline – Operational Railway Noise and Vibration* (2019) (Transport and Main Roads).
  - Australian Standard AS ISO 2631.2:2014 [ISO 2631-2: 2003]: *Mechanical vibration and shock - Evaluation of human exposure to wholebody vibration* – Part 2: *Vibration in buildings (1 Hz to 80 Hz)*. Standards Australia, Sydney.

  - British Standard BS 6472-1:2008 *Guide to evaluation of human exposure to vibration in buildings – Vibration sources other than blasting*. British Standards Institution, London.
  - *Development Affected by Environmental Emissions from Transport Policy* Version 4, 9 October 2017 (Transport and Main Roads).
- Occupational noise and vibration requirements associated with construction and maintenance, which are covered by:
  - *Work Health and Safety Act* 2011 (Qld).
  - *Work Health and Safety Regulation* 2011 (Qld).
  - Associated codes of practice.
- Industry noise and vibration requirements (including Environmentally Relevant Activities (ERA) within the construction area), which are addressed in the following Queensland Department of Environment and Science (DES) documents:
  - DES Guideline – *Noise and vibration from blasting* (2022).
  - DES Manual – *Noise measurement manual* (2020).
- Local government planning schemes, which address the noise and vibration impact management from a council perspective.
- Operator environmental guidelines, which address the noise and vibration impact management from an operator perspective.

1.8 Structure of the Code

The management of transport construction noise and vibration is outlined in this Code within the following chapters.

Chapters 3, 4, and 7 are written primarily for:

- departmental staff
- project managers
- acoustical consultants.

Chapters 5 and 6 are written primarily for:

- departmental staff
- acoustical consultants.

Chapters 5 and 6 requirements should also be generally understood by project managers.

Chapter 2 ***Description of construction noise and vibration*** defines construction noise and vibration including:

- factors contributing to the generation and propagation of noise and vibration
- a set of noise and vibration descriptors relevant to this Code.

Chapter 3 ***Criteria*** provides guidance on construction noise and vibration criteria for human comfort and structural damage.

Chapter 4 ***Assessment*** outlines the type and specific requirements of a construction noise and vibration assessment. It specifies:

- the assessment process to ensure compliance with this Code
- construction noise and vibration assessment requirements.

Chapter 5 ***Measurements*** outlines the requirements for noise and vibration measurement. This chapter provides advice of the following:

- location and mounting of sensors
- minimum specification for monitoring equipment
- relevant standards to consider.

Chapter 6 ***Prediction*** provides guidance on recommended prediction methods for noise and vibration. It provides various levels of prediction and recommends available methods and algorithms.

Chapter 7 ***Management plan*** provides the requirements for a Noise and Vibration Management Plan (NVMP).

Chapter 8 ***Glossary of terms*** provides definitions of important technical terms and abbreviations.

Chapter 9 ***References*** provides a list of documentation considered in the formulation of this Code.

Appendix A ***Reporting requirements*** provides construction noise and vibration assessment reporting requirements.

Appendix B ***Mitigation and management options*** provides examples of control options to be considered in assessments.

2 Description of construction noise and vibration

Environmental noise (or community noise) is unwanted or harmful sound, usually generated by human activities including road traffic, railways, air transport, industry, recreation and construction, that is perceived in areas frequented by the general community. Environmental noise typically excludes noise exposure within the workplace.

Construction noise is a component of environmental noise associated with construction activities. While most construction machinery and equipment can generate airborne noise, heavy construction equipment and trains can also generate groundborne noise (noise radiated from building structures as a result of groundborne vibration).

Construction activities involving blasting, piling, compaction, tunnelling equipment and large compressors, as well as heavy transportation such as trucks and trains, can create significant levels of vibration.

Construction can occur in close proximity to sensitive receptors including residential properties, educational facilities, hospitals and community facilities. The effects from exposure to excessive levels of noise and vibration may include:

- sleep disturbance
- annoyance (impacts on recreation, including relaxation/conversation)
- inhibited concentration, leading to difficulties in studying or learning
- building/structural damage (including impacts on sensitive building contents).

2.1 Construction noise

2.1.1 What is noise

2.1.1.1 Definition of noise

The EP Act defines noise as '*vibration of any frequency, whether emitted through air or another medium*'. For the purpose of this Code, noise is defined as 'unwanted sound' (that is, vibration of the air).

Noise may be described as sound power (unit of Watts) at the source or as sound pressure (unit of Pascal) at a specified distance from a source. It is more commonly presented as sound power level (L_w, unit of dB referenced to 10^{-12} W) or sound pressure level (L_p, unit of dB referenced to 20 µPa). Sound power level is an absolute that does not vary with distance or acoustic environment. The following formula gives the sound pressure level in relation to the root mean square (RMS) of a given sound pressure to the reference sound pressure (ρ_{ref}) of 20 µPa.

$$L_\rho = 20log_{10}\left(\frac{\rho_{rms}}{\rho_{ref}}\right)dB$$

The conversion between sound pressure level and sound power level should consider geometrical spreading (K), directivity (Directivity Index, DI_M) of the source as well as other propagation effects (excess attenuation, A_E) (see Section 2.1.1.2 of this Code). The formula is as follows:

$$L_p = L_w - K + DI_M - A_E$$

If directivity and excess attenuation are set to zero, the relationship between sound pressure level and sound power level may be described as:

$L_p = L_w - 10log_{10}(4\pi r^2)$ *(spherical spreading)*

$L_p = L_w - 10log_{10}(2\pi r^2)$ *(hemispherical spreading for example, location on the ground)*

where r is the radius from a noise source.

Noise is generally measured by a sound level meter. The measured noise data is generally time-weighted as exponential averaging in RMS measurements. By convention, these time-weightings include:

- 0.125 s for time-weighting F (Fast)
- 1 s for time-weighting S (Slow).

This temporally time-weighted data is then analysed to produce values for various noise descriptors required for a given time period (for example, 15 minutes). Noise levels in this Code are assumed to be 'Fast' response unless otherwise stated.

Shorter term descriptors may also be used; for example, the peak sound pressure levels (< 30 µsec) measured or calculated from the greatest absolute instantaneous sound pressure level during a specified time interval for airblast.

The frequency contribution of noise to the overall noise level can also be analysed. This is typically conducted by the use of constant percentage bandwidth filters (1/1, 1/3 octave or Fast Fourier Transform (FFT)) in which the noise signal is converted to a discrete frequency spectrum. For environmental acoustics, the audible frequency for humans with unimpaired hearing perception is typically within the range of 20 to 20 000 Hz. The octave bands are generally in accordance with IEC 61260 (for example, 1/1 octave bands within the audible spectrum include 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000, 16 000 Hz).

It should be noted that human ears do not perceive all frequencies equally. To compensate for this, the frequency content of noise is weighted to account for human perception. A-weighting is commonly used to approximate the frequency response of the human hearing system. It weights the lower frequencies as less perceptible than the middle and higher frequencies. Noise levels in this Code are assumed to be A-weighted unless stated otherwise.

2.1.1.2 Noise propagation

Construction noise emanates from the source and propagates through the atmosphere. There are numerous factors influencing the noise level received at a sensitive receptor, including:

- directivity of the source, DI_M (source may be noisier in a particular direction for example, exhaust outlet)
- separation distance from the source, K (attenuation associated with geometrical spreading)
- excess attenuation, A_E:
  - atmospheric absorption (attenuation is a function of temperature, humidity and frequency within the atmosphere)
  - meteorological influences (attenuation or enhancement due to surface temperature and humidity, vertical temperature profile, wind speed and direction)

- ground absorption (influence of hard or soft ground types on propagation)
- topography and structures (attenuation due to intervening buildings and terrain features. It should be noted that under certain meteorological conditions, such as temperature inversions, attenuation provided by obstacles can be degraded).

2.1.2 Noise categories

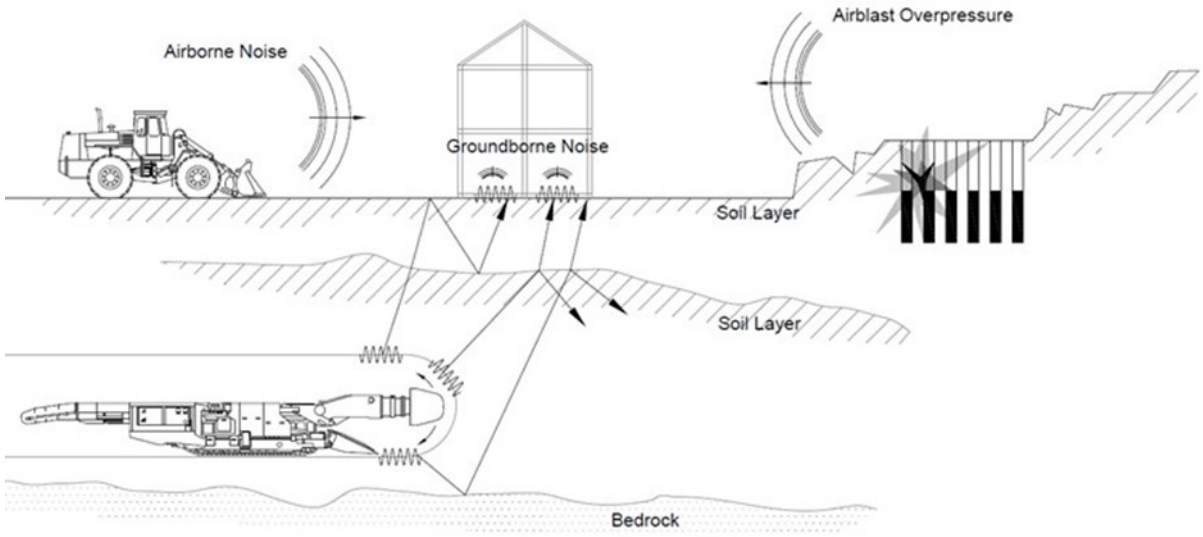
Noise emissions for the purpose of this Code are categorised as:

- airborne noise (general construction which includes construction traffic within the project boundary)
- groundborne noise (construction)
- airblast (blasting).

Blasting (explosions) can cause groundborne vibration and airblast (also known as blast overpressure) which is the pressure wave (or pulse) transmitted through the air as the result of an explosion. Airblast may have both acoustic effects in terms of overpressure and vibration effects in terms of airborne and groundborne vibration. The acoustic and vibration effects of airblast are discussed separately in this chapter.

The types of noise emissions and transmission paths are illustrated in Figure 2.1.2.

Figure 2.1.2: Noise emissions and transmission paths



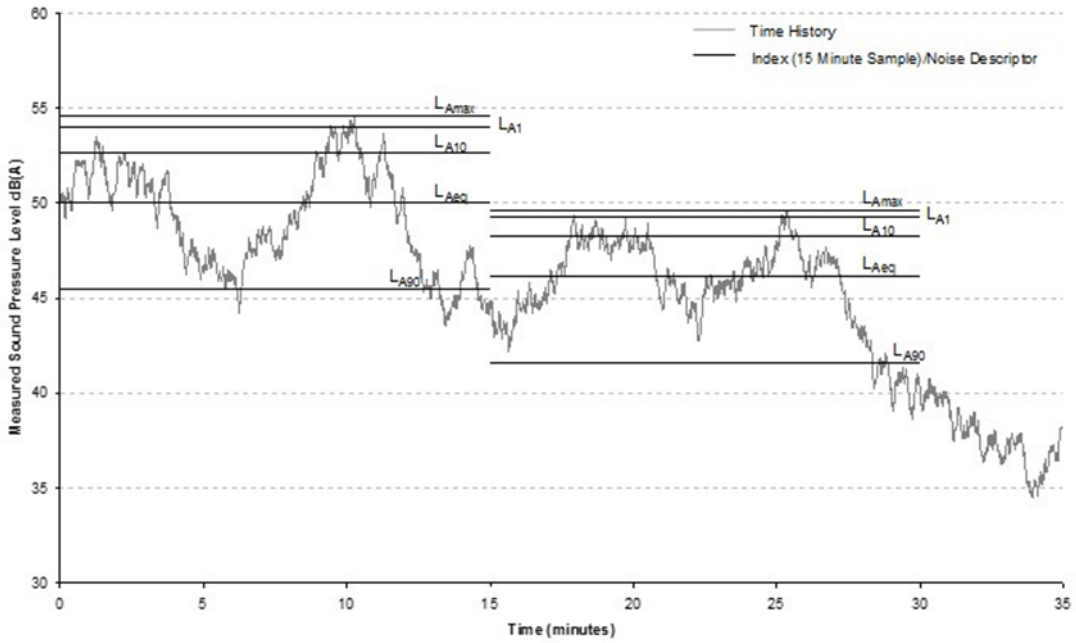
2.1.2.1 Airborne noise

When considering construction airborne noise the following noise descriptors may be used:

- $L_{Amax,T}$ – the maximum A-weighted noise level in a given time period T.
- $L_{A\%,T}$ – the A-weighted noise level which is exceeded for a percentage (for example, 1, 10, 90%) of a given time period T.
- $L_{Aeq,T}$ – the continuous steady A-weighted noise level that has the same mean square sound energy as a noise under consideration whose level varies within that time period T.

These descriptors are generally considered for discrete 15 minute (or hourly) periods as presented in Figure 2.1.2.1 and then further evaluated for different time periods of a day. The time periods may form part of the descriptors.

Figure 2.1.2.1: Example of sound pressure level time history and descriptors



Airborne construction noise typically fluctuates. This fluctuation is due to discrete activities of work being conducted for discrete durations at different points within the construction area, utilising various processes and machinery. Noise from certain items (for example, generators, pumps, idling machinery) of fixed mechanical plant may be considered as steady state or quasi-steady state in nature. Noise from some machinery/activities may be considered as non-steady state and its characteristics may cause greater annoyance. The types of construction noise and their characteristics are described in Table 2.1.2.1(a) with examples of construction activities.

Table 2.1.2.1(a): Construction noise type

Type	Description	Typical Construction Activity
Continuous	Noise that gives fluctuations over a range of not more than 3 dB	Generators, pumps, idling machinery, tunnel boring
Intermittent	Noise that gives fluctuations greater than 5 dB	Vehicle manoeuvring, hammering
Tonal	A sound producing a definite pitch sensation in a listener	Air compressor, grinding
Impulsive	Sound characterised by brief excursions of sound pressure level (acoustic impulses) that significantly exceed the background sound pressure level. The duration of a single impulsive sound is usually less than one second.	Air release, piling, hammering, metal falling on metal
Dominant low frequency	Where the noise is dominated by sound in the frequency range 10 Hz to 200 Hz	Vibrating roller, burners

Adjustments may be required to account for distinct noise characteristics when assessing potential annoyance. The requirement for the use of adjustment factors is denoted by 'adj'; for example, $L_{Aeq,adj,T}$. Adjustment factors for different noise characteristics are presented in Table 2.1.2.1(b).

Table 2.1.2.1(b): Adjustment factors

Factor	Assessment/ measurement	When to apply	Correction	Comments
Tonal Noise	1/3 octave or narrow band analysis	Level of 1/3 octave band exceeds the level of the adjacent bands on both sides by: • 5 dB or more if the centre frequency of the band containing the tone is above 400 Hz. • 8 dB or more if the centre frequency of the band containing the tone is 160 to 400 Hz inclusive. • 15 dB or more if the centre frequency of the band containing the tone is below 160 Hz.	5 dB	Narrow-band frequency analysis may be required to precisely detect presence of tonality.
Low frequency Noise	Measurement of C-weighted and A-weighted level	Measure/assess C and A frequency weighted levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more.	5 dB	C-weighting is designed to be more responsive to low-frequency noise. All noise energy down to 10 Hz should be considered.
Impulsive Noise	A-weighted fast response and impulse (I) response	If difference in A-weighted maximum noise levels between fast response and impulse response is greater than 2 dB.	Apply difference in measured levels as the correction, up to a maximum of 5 dB	Impulse response is defined by a short rise time of 35 milliseconds (ms) and decay time of 1.5 s.
Intermittent / Modulating Noise	Measurement of difference between L_{A10} and L_{A90}, average difference between short term samples, or subjectively assessed	• Difference between L_{A10} and L_{A90} exceeds 5 dB repeatedly for a characteristic averaging period (for example, 10 seconds) for intermittent sources. • Average difference between measured L_{Aeq} levels exceeds 5 dB for a characteristic sampling frequency (for example, 10 Hz) for rapidly varying source. • Subjectively annoying for a combination not easily characterised.	5 dB	Adjustment to be applied for nighttime only.
Maximum Adjustment	Refer to individual modifying factors	Where two or more adjustment factors are indicated.	Maximum correction of 10 dB(A)	

While sources may have characteristics that require adjustments to be applied, the magnitude of the factors will depend on the age/type of technology/machinery, whether sources are enclosed/shielded, and the distance from the source to the receptor. For example, older equipment designs may be less silenced or exhibit more tonal characteristics; poor maintenance and general deterioration may introduce whines or rattles; enclosure may selectively reduce particular frequencies; distance will attenuate some frequencies more than others and their level in relation to background level. These factors will affect the final adjustment applied.

2.1.2.2 Groundborne noise

Groundborne noise (also known as structureborne noise or regenerated noise) is a separate issue to airborne noise. Groundborne noise is generated by vibration transmitted through the ground into a structure. The vibration of structures causes noise to be radiated into a room.

Groundborne noise may be caused by underground works such as road headers and tunnel boring machines (TBM), as well as construction traffic, conveyors and ventilation fans within tunnels. Works located above ground are typically dominated by airborne noise which masks the groundborne component. However, this may not always be the case if the sensitive receptor is well shielded from the airborne noise component and groundborne noise becomes dominant.

Groundborne noise from construction is typically measured using A-weighting and slow response (L_{ASMax} or L_{ASeq}), generally within the frequency range of 16 Hz to 250 Hz as described in ISO 14837 *Mechanical vibration – ground-borne noise and vibration arising from rail systems*.

Groundborne noise tends to be more noticeable than airborne noise at the same A-weighted level due to the large portion of energy at low frequencies. If groundborne noise is dominated by very low frequencies then the use of A-weighted sound pressure levels may underestimate the subjective response.

2.1.2.3 Airblast

Airblasts (overpressure due to blasting) contain significant airborne energy at frequencies at or below the audible range of the human ear.

Airblasts are typically measured as L_{peak} dB(L), which is the flat (Z-weighting) peak noise level (derived from the peak pressure level and measured with a meter equipped with a peak detector). It should not be confused with the maximum level, such as L_{max} and L_{Amax} which refers to the maximum RMS sound pressure level.

2.2 Construction vibration

2.2.1 What is vibration

2.2.1.1 Definition of vibration

Vibration is an oscillatory motion of particles that propagates in the form of characteristic waves (for example, compression, shear and surface waves). Vibration may be described by:

- displacement – the distance that an element moves away from its static position
- velocity – the instantaneous speed of an element
- acceleration – the rate of change of the speed of an element.

Velocity and acceleration are often used to characterise the expected response of humans, structures and equipment to vibration levels. They are normally described in units of metre per second (m/s) and

metre per second squared (m/s^2) respectively. Decibel notation, while not common, is sometimes utilised to express vibration levels (for example, VdB). It is important that if vibration is expressed in decibels, the reference value needs to be included as a notation (usually $5x10^{-8}$ m/s international, $1x10^{-6}$ in/s United States of America).

The frequency range of interest for construction vibration is typically from 0.5 to 500 Hz. However, most building damage from man-made sources occurs in the frequency range of 1 Hz to 150 Hz (ISO 14837-1:2005).

2.2.1.2 Frequency and weightings

Human perception of vibration depends on various factors, including the vibration frequency and direction. Human perception of building vibration is mainly related to the frequency range of 0.5 Hz to 80 Hz for the three translational axes: x, y and z. Generally, different frequency ratings are required for different axes of motion. Once weighted, the overall vibration level may be used to assess the potential for impacts relating to perception, comfort or adverse comment for whole-body vibration.

British Standard BS 6472-1:2008 *Guide to evaluation of human exposure to vibration in buildings – Vibration sources other than blasting* revises the weighting values for RMS acceleration from previous versions and fixes the axes (z axis is always vertical to the ground, geocentric earth based coordinate system) so that they no longer relate to human orientation (head to foot). This standard utilises the weighting W_b in the z axis and W_d in the x and y axes. W_b and W_d are defined in British Standard BS 6841:1987 '*Guide to measurement and evaluation of human exposure to whole-body mechanical vibration and repeated shock'*. The weightings demonstrate maximum sensitivity to vertical acceleration in the frequency range 4 Hz to 12.5 Hz and to horizontal acceleration in the range 1 Hz to 2 Hz.

British Standard BS 6472-1:2008 has sought to simplify the assessment methodology and descriptors from the previous 1992 version and the methodologies contained within ISO 2631-1:1997 '*Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration* – Part 1: *General requirements'*. It utilises vibration dose value (VDV) for all vibration types. VDV is a cumulative measurement of the vibration level received over an 8-hour or 16-hour period. It is calculated by the fourth root of the integral with respect to time of the fourth power of the acceleration after it is weighted. Previous methods relied on a combination of approaches including acceleration and VDV for evaluation of human perception.

2.2.1.3 Vibration propagation

Construction activities transfer energy to the ground from the machinery, which results in elastic and inelastic deformation of the surrounding materials. Part of this energy travels in the form of elastic waves and results in ground and structure vibration.

The most common waves due to vibration are compression, shear and Rayleigh (or surface) waves. These waves travel at different speeds and attenuate at different rates as a function of the physical properties of the ground.

Compression and shear waves travel in the body of the material and attenuate as they travel from the source. Rayleigh waves and other boundary waves are constrained to propagate in the plane of a surface and attenuate less rapidly. The effect of such differences in propagation speed is sometimes observed with blast monitoring where the ground motion changes as each wave type passes the receptor position.

For surface construction activities, Rayleigh waves which occur at the surface of the ground are very common and are dominant at some distance from the site due to their lower rate of attenuation. The situation will be more complicated closer to the source, where constructive and/or destructive interference of wave forms can occur as a result of wave-type interactions.

For underground construction activities and operations, vibration propagation is mainly via compression and shear waves. However, surface waves may become dominant, and this depends on the depth of the underground operations and the separation distance to the point of interest.

The magnitude of the vibration transferred from ground to a structure is directly linked to its effects such as structure damage or disturbance to people. Generally, adverse comment from occupants of buildings may be expected when vibration levels are only slightly above thresholds of perception.

For groundborne vibration, the magnitude of the vibratory disturbance at a receptor structure is determined by factors such as:

- the energy input to the ground
- the distance between source and receptor
- the ground conditions at the site (soil or rock, height of water table and so on)
- the efficiency of the coupling between the ground and the receptor structures
- the manner in which the receptor structure responds to the vibration input. The resulting amplification or attenuation of the input would vary based on the foundation and type of construction.

Due to complicated ground conditions and other variables associated with construction vibration, an exact vibration assessment result is generally not to be expected by use of available prediction methods. Rather, regular monitoring of vibration levels at adjacent sensitive receptors is often required to help understand the vibration effect. This is particularly the case with activities such as piling and operation of heavy vibratory compaction plant, where avoidance of damage or other disruption is critical.

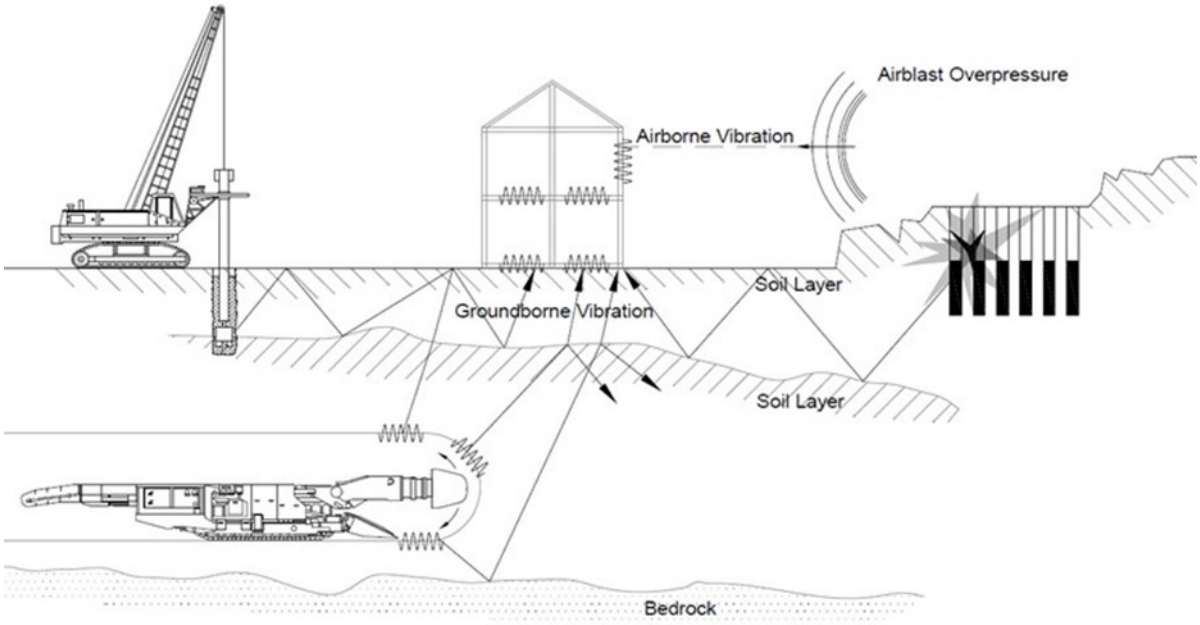
2.2.2 Vibration categories

Vibration emissions for the purpose of this Code are categorised as:

- groundborne vibration (construction)
- airborne vibration (construction).

The types of vibration emissions and transmission paths are illustrated in Figure 2.2.2.

Figure 2.2.2: Vibration emissions and transmission paths



2.2.2.1 Groundborne vibration

Groundborne vibration may be caused by various sources including construction activities, infrastructure and industry operations. Groundborne construction vibration typically fluctuates with the type of equipment utilised and it can be classified as different vibration types as shown in Table 2.2.2.1.

Table 2.2.2.1: Construction vibration type

Vibration types	Description	Typical Construction Activity
Continuous	Vibration that continues uninterrupted during a defined period (may be constant or variable). This may include quasi-continuous vibration sources which may be continuous for a portion of the assessment period.	Tunnel boring, vibratory rollers, excavators, piling.
Transient	Vibration in which the oscillatory displacement of the ground or structure reaches a peak and then decays rapidly towards zero.	Isolated dropping of heavy item.
Intermittent	Intermittent vibrations include a number of transient vibrations.	Heavy vehicle movements, piling, jack hammering, hydraulic hammering, rock breaking.

Note: Continuous and intermittent vibration may give rise to dynamic magnification at the resonance frequency of building/structural components and/or vibration-sensitive equipment.

Several vibration descriptors are used to assess the likelihood of vibration impacts based on the velocity and acceleration.

Peak particle velocity (PPV or v_p) is a commonly used vibration descriptor for building/structural damage. It can also be used for human perception. It is defined as the maximum peak of the instantaneous fluctuating vibration velocity signal. The overall maximum instantaneous velocity of particle motion is defined as the resultant PPV, which is the vector sum of the three orthogonal component particle velocities (component PV) as follows:

$$v_p = \sqrt{v_T^2 + v_L^2 + v_V^2}$$

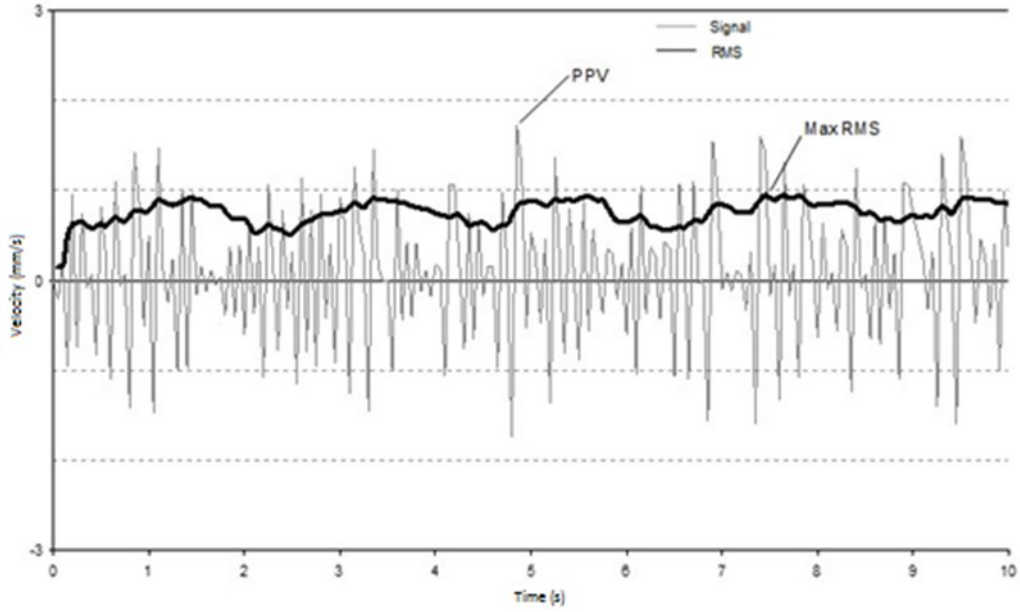
Where:

v_p is the resultant PPV of the particle velocity at a particular time

v_T, v_L and v_V are the respective transverse, longitudinal and vertical component PV of the particle velocity at a particular time.

Vibration may also be described as an average value and used to gauge human perception. The RMS is utilised to average the vibration signal as the net arithmetic average would result in zero. The RMS of the raw signal is the square root of the average of the squared amplitude of the signal. The RMS average is typically defined over a one-second period. Figure 2.2.2.1 presents an example of the relationship between the signal, PPV and RMS vibration velocity.

Figure 2.2.2.1: Vibration signal and descriptors



While weighted RMS acceleration was historically used in evaluating vibration impacts on human comfort and perception, vibration dose value (VDV) has become a focus in more recent years with the exception of blasting. The VDV (in $m/s^{1.75}$) is given by the fourth root of the integral with respect to time of the fourth power of the acceleration after it is weighted (see British Standard BS 6472-1:2008).

VDV is a cumulative measure which increases as the exposure duration increases. It is much more strongly influenced by vibration magnitude than by duration. A doubling or halving in the vibration magnitude is equivalent to an increase or decrease of exposure duration by a factor of sixteen.

British Standard BS 5228-2:2009 *Code of practice for noise and vibration control on construction and open sites* – Part 2: *Vibration* recommends an alternative approach to VDV when considering human

response to vibration from construction activities. This alternative approach utilises PPV which is more commonly used to gauge potential building damage as well as impacts from blasting. The PPV descriptor is also commonly used in vibration prediction methods. Therefore, it may be beneficial that both human perception and building damage are evaluated against PPV in the context of construction vibration assessment.

2.2.2.2 Airborne vibration

Airborne vibration is structural vibration induced by low frequency sound. Sources of airborne vibration may include airblast (overpressure from blasting), piling and vibratory compaction plant. Large vibratory screens used with crushing and screening operations are sometimes also the source of airborne vibration. Mechanically driven plant with poor quality, defective or missing mufflers can also cause airborne vibration.

Depending on the frequency and level of airborne vibration, persons exposed may hear the disturbance as sound or experience it via other sensations such as a feeling of vibration or pulsation in the chest or abdomen. Alternatively, the sound and accompanying vibration may not be noticed as a direct sensation but may be noticed in terms of 'rattles' or other similar high frequency noise associated with the induced vibration of a lightweight building element such as a window or door.

While nuisance effects may occur, it is rarely necessary to specify particular limits (with the exception of blasting) for airborne vibration for plant or equipment used in construction activities. When investigating vibration related complaints, airborne vibration should be considered on a case-by-case basis.

2.3 Construction noise and vibration descriptors

2.3.1 Noise descriptors

The following noise descriptors are used in this Code as the basis to determine airborne construction noise criteria:

- background noise level
- rating background level (RBL).

Definition of these descriptors can be found in the Glossary.

The preferred noise descriptors in this Code for construction noise measurement and assessment are as follows:

- Airborne noise – $L_{Aeq,adj,15\ minute}$, the adjusted A-weighted equivalent continuous sound pressure level considering adjustment factors (see Table 2.1.2.1(b)), measured over a 15-minute time period. This descriptor is used to gauge the impact of general construction noise levels and can be measured inside or outside of a building. It is used along with RBL when measured externally.
- Groundborne noise – L_{ASMax}, the A-weighted maximum sound pressure level using slow response.
- Airblast – L_{peak} dB(L), the peak noise level (derived from the peak pressure) using the linear frequency weighting and Peak Hold time weighting.

2.3.2 Vibration descriptors

In this Code, the preferred vibration descriptors for construction vibration measurement and assessment to determine human perception and structure damage are as follows:

- Component Particle Velocity (component PV) – the instantaneous particle velocity of a particle at each orthogonal component axis.
- Peak Component Particle Velocity (PCPV) – the maximum instantaneous velocity of a particle in any one of the three orthogonal component axis directions during a given time interval. Also represented by the notation $v_{i, max}$ in DIN 4150-3.
- Peak Particle Velocity (Resultant PPV) – the maximum instantaneous velocity of a particle at a point during a given time interval determined as the vector sum of component velocities in three orthogonal directions.

3 Criteria

This chapter defines working hours, sensitive receptors and criteria/limits that shall be used when assessing noise and vibration impacts from construction of transport infrastructure.

3.1 Sensitive receptors, work periods and activities

3.1.1 Sensitive receptors

Sensitive receptors have the potential to be impacted by construction noise and vibration. In this Code, sensitive receptors for noise and human comfort impacts from vibration include the following:

- accommodation activity (including caretaker's accommodation, community residence, dual occupancy, dwelling house, dwelling unit, home-based business, multiple dwelling, nature-based tourism, non-resident workforce accommodation, relocatable home park, residential care facility, resort complex, retirement facility, rooming accommodation, rural workers' accommodation, short term accommodation and tourist park)
- hotel or other premises which provides accommodation for the public
- educational establishment (including primary and secondary schools, colleges, technical institutes, universities or other educational institutions)
- childcare centre (including crèches, early childhood centres, kindergartens and preschools)
- health care service (including medical centres, health clinics, surgeries and other medical institutions)
- hospital
- community uses (including art galleries, community halls, libraries and museums)
- place of worship
- court of law
- commercial office or retail facility
- outdoor recreational area (such as public park or gardens open to the public, whether or not on payment of a fee, for passive recreation other than for sport or organised entertainment) or a private open space.

While outdoor recreational areas are considered to be noise and vibration sensitive sites, for the durations involved in construction activities, it is not considered necessary or justified for mitigation measures to be required, but they may be included on a case-by-case or project-specific basis.

Where the sensitive receptor is a tenancy within a larger building then the tenancy shall be assessed.

3.1.2 Sensitive buildings, structures and building contents

In this Code, sensitive receptors which can be susceptible to damage/disruption from construction vibration include the following:

- buildings
- structures:
  - infrastructure, for example dams, bridges, railway tracks/sleepers, railway signalling systems, railway switches and so on

  - ancillary structures, for example cemetery/memorial structures, monuments, tennis courts, pools, fences, sheds, retaining walls, underground fuel storage tanks, etc.
  - heritage sites. Heritage sites shall be reviewed for condition and sensitivity on a project-specific basis. For advice on heritage sites (including heritage listed and Aboriginal or Torres Strait Islander cultural heritage sites) within or near the project area, please contact the relevant District Cultural Heritage Officer. Sensitive sites are not always readily known and may require further investigation
- building contents (such as, but not limited to, sensitive equipment including some laboratory (microscopes, balances), surgical, precision manufacturing equipment, and so on).

3.1.3 Construction activities and work periods

For this Code, construction activities are those occurring within the project boundary, which include the following:

- general construction – permanent and temporary works associated with construction (for example, piling and compaction, work sites, earthworks), demolition, temporary/fixed facilities, temporary plant and construction traffic/haul routes
- blasting.

Table 3.1.3 defines different work periods of the day used in this Code for construction activities.

Table 3.1.3: Work periods for construction activities

Work Period	General Construction	Blasting
Standard hours	Monday – Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm	Monday – Friday 9:00 am to 3:00 pm Saturday 9:00 am to 1:00 pm
Non-Standard hours – day/evening	Monday – Friday 6:00 pm to 10:00 pm Saturday 7:00 am to 8:00 am, 1:00 pm to 10:00 pm Sunday 7:00 am to 10:00 pm	Generally, blasting is not to be conducted outside Standard hours. Any blasting outside of Standard hours must be approved by the department's project manager prior to blasting. It is noted that reduced limits may be required to be achieved outside of Standard hours.
Non-Standard hours – night	Monday – Sunday 10:00 pm to 7:00 am	

Note: Public holiday periods are taken to be the same periods as defined for Sunday.

3.2 Construction noise criteria

Noise criteria in this Code are considered primarily to be aimed at dealing with nuisance. Where criteria are exceeded, all reasonable and practicable control measures are required to be implemented. If all administrative and construction activity related control measures are applied and noise levels are still greater than the nominated criterion values, the Registered Professional Engineer of Queensland (RPEQ) (that is, Assessing RPEQ) shall determine any reasonable and practicable respite, temporary relocation and architectural treatment requirements (refer to Appendix B Section B.6 & B.7). The construction contractor will need to consult with the affected person or community with regards to these measures where determined by the Assessing RPEQ.

Noise criteria are defined for the following noise emissions categories:

- airborne noise (general construction)
- groundborne noise
- airblast.

The determination of noise criteria for this Code is based on the review of Queensland state legislation as well as Australian and international standards and guidelines.

3.2.1 Airborne noise

3.2.1.1 General construction criteria

For accommodation activities (including hotels or other premises which provides accommodation for the public), noise emissions associated with general construction activities, such as piling and compaction, shall be assessed using the criteria in Table 3.2.1.1(a). It should be noted that these limits are for the noise contribution from construction only (component limit).

The noise criteria for general construction activities are defined as lower and upper limits which are assessed adjacent to external facades. The noise criteria are defined for the following work periods:

- Standard hours – work within Standard hours shall be encouraged where possible
- Non-Standard hours.

All reasonable and practicable measures shall be implemented to achieve the lower limit for Standard and Non-Standard hours. Exceedance of the upper limit requires the Assessing RPEQ to determine any reasonable and practical respite, temporary relocation and architectural treatment requirements.

Table 3.2.1.1(a): External construction noise criteria

Work Period		External Noise level $L_{Aeq,adj,15\ minute}$[4, 5], dB(A)	
		Lower Limit	**Upper Limit**
Standard hours	Monday – Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm	RBL + 10 [1][2][3]	75 Where: RBL > 55
			70 Where: 40 < RBL ≤ 55
			65 Where: RBL ≤ 40
Non-Standard hours - Day/Evening	Monday – Friday 6:00 pm to 10:00 pm Saturday 7:00 am to 8:00 am Saturday 1:00 pm to 10:00 pm Sunday 7:00 am to 10:00 pm	RBL + 5 [3]	RBL + 5 [3]
Non-Standard hours - Night	Monday – Sunday 10:00 pm to 7:00 am	RBL + 5 [3]	RBL + 5 [3]

Notes:

[1] RBL + 5 dB(A) should be considered where a facility, equipment and long-term earthworks are required in an area for greater than six months. Where this occurs, the minimum lower limit is 45 dB(A) for Standard hours.

[2] Where the lower limit value exceeds the upper limit value, the lower limit is taken to equal the upper limit value.

[3] Minimum lower limit is 50 dB(A) for Standard hours and 45 dB(A) for Non-Standard hours. A maximum lower/upper limit of 75 dB(A) applies to Non-Standard hours.

[4] Noise contribution from construction activity determined as the component level (that is, noise from construction activity only).

[5] The noise level from construction includes adjustment factors from Table 2.1.2.1(b) (for example, low frequency noise, impulsivity, tonality, intermittency and modulation).

For commercial and retail facilities when required to be assessed in the construction project, the upper limit values may be utilised. Where these premises include external uses such as outdoor dining/sports venue, it may be reasonable to minimise construction activity during the time that the majority of trade is conducted (for example, lunchtime, sporting games).

In addition, sensitive receptors require the internal criteria as presented in Table 3.2.1.1(b) to be met where reasonable and practicable. The criteria shall be considered for the operational hours of the sensitive receptors.

Table 3.2.1.1(b): Internal construction noise criteria for sensitive receptors

Location	Internal Noise Limit $L_{Aeq,adj,15\ minute}$, dB(A)
Hospital & health care service (wards, surgeries, operating theatres, consulting rooms)	40
Educational establishment (rooms designated for teaching/research purposes) & childcare centre	45
Court of law (court rooms)	35
Court of law (court reporting and transcript areas, Judges' chambers)	40
Community use & place of worship	45

Some institutions/facilities, such as concert halls, TV studios, recording studios, auditoriums and theatres, may require specific acoustic performance in order to operate successfully. If these facilities are potentially affected by airborne noise, then consultation with the affected parties shall be conducted to determine a reasonable and practicable approach to mitigation.

3.2.2 Groundborne noise

Groundborne noise (structureborne noise or regenerated noise) is the noise radiated into a room caused by structural vibration, due to, for example, underground works using road headers and tunnel boring machines. Groundborne noise has significant low frequency components and tends to be more noticeable compared with airborne noise at the same A-weighted level. Where this is observed, the internal noise criteria presented in Table 3.2.2 shall be met, where reasonable and practicable.

Table 3.2.2: Construction groundborne noise criteria

Location	Groundborne Noise Limit	
	Work Period	**L_{ASMax}, dB(A)**
Accommodation activity (including hotels or other premises which provides accommodation for the public)	Standard hours	40
	Non-Standard hours – day/evening	35
	Non-Standard hours – night	
Hospital & health care service (wards, surgeries, operating theatres, consulting rooms)	All	35
Educational establishment (rooms designated for teaching/research purposes) & childcare centre	While in use	35
Court of law (court rooms)		30
Court of law (court reporting and transcript areas, Judges' chambers)		35
Community use & place of worship		40
Commercial (offices)		40
Retail facility		45

Some institutions/facilities, such as concert halls, TV studios, recording studios, auditoriums and theatres, may require specific acoustic performance in order to operate successfully. If these facilities are potentially affected by groundborne noise then consultation with the affected parties shall be conducted to determine a reasonable and practicable approach to mitigation.

3.2.3 Blasting – Airblast

The following documents contain criteria for human comfort and building/structural damage for airblast (blast overpressure):

- Australian Standard AS 2187.2:2006
- ANZEC '*Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration'*, 1990
- EP Act Section 440ZB
- DES Guideline - *Noise and Vibration from Blasting* (DES, 2022).

Table 3.2.3 presents the human comfort criteria taken from DES Guideline - '*Noise and Vibration from Blasting* to minimise annoyance from airblast. The criteria in Table 3.2.3 shall be used to assess annoyance from airblast.

Table 3.2.3: Human comfort criteria to minimise annoyance from airblast

Location	Airblast Limit L_{peak}
Sensitive receptors	Not more than 115 dB(L) for 9 out of any 10 consecutive blasts, and not more than 120 dB(L) for any blast
Occupied non-sensitive sites, such as factories and commercial premises	See Australian Standard AS 2187.2:2006, Table J5.4(A)

The Assessing RPEQ will need to review the limits in Table 3.2.3 to determine if they need to be lowered in the proximity of some receptors, such as institutions/facilities, such as concert halls, TV studios, recording studios, auditoriums and theatres, may require specific acoustic performance in order to operate successfully. If these facilities are potentially affected by airblast then consultation with the affected parties shall be conducted to determine a reasonable and practicable approach to mitigation.

Structural/building damage airblast limits are to be taken from Table J5.4(B) within Australian Standard AS 2187.2:2006. It should be noted that the structural/building damage airblast limits within AS 2187.2:2006 may need to be lowered where facades contain large sections of glazing.

For groundborne vibration due to blasting, the criteria in Section 3.3.1.1, 3.3.1.2, and 3.3.1.3 of this Code are to be used. These sections contain criteria concerning human comfort, building damage, and structure and building contents damage/disruption.

3.3 Construction vibration criteria

Vibration criteria in this Code relate to human comfort, structural/building damage and damage/disruption to building contents. Where criteria are exceeded, all reasonable and practicable control measures are required to be implemented. If all administrative and construction activity related control measures are applied and vibration levels exceed the nominated human comfort criterion values, the Assessing RPEQ shall determine any reasonable and practicable respite and temporary relocation requirements (refer to Appendix B Section B.6 & B.7). The construction contractor will need to consult with the affected person or community with regards to the measures determined by the Assessing RPEQ. Consultation with sensitive receivers regarding respite and temporary relocation requirements shall not be used as a means to operate within the safe working distances for vibration damage to buildings/structures and damage/disruption to building contents.

Vibration criteria are defined for the following vibration emissions categories:

- groundborne vibration (general construction and blasting)
- airborne vibration (including airblast).

The determination of vibration criteria for this Code is based on the review of Queensland state legislation as well as Australian and international standards and guidelines.

3.3.1 Groundborne vibration

Vibration criteria for both human comfort and damage/disruption due to groundborne vibration caused by construction activities (for example, piling, compaction and blasting) are provided in this section. It

should be noted that in most cases compliance with the human comfort criteria would also achieve the building damage criteria.

3.3.1.1 Human comfort

General construction

British Standard BS 5228-2:2009 provides an alternative approach to that historically used to assess human comfort presented in British Standard BS 6472-1:2008. While BS 6472-1 provides guidance on human response to vibration in buildings in terms of VDV, BS 5228-2 Table B.1 provides guidance on the use of PPV which is typically measured to determine potential building damage.

For human comfort, to minimise annoyance due to groundborne construction vibration, this Code adopts Resultant PPV vibration levels with lower and upper limits as presented in Table 3.3.1.1(a). The lower limits are generally considered to be just perceptible and/or tolerable with prior warning. The upper limits are considered to cause significant annoyance if exceeded.

All reasonable and practicable measures shall be implemented to achieve the lower limit. Exceedance of the upper limit requires the Assessing RPEQ to determine any reasonable and practical respite and temporary relocation requirements.

Table 3.3.1.1(a): Human comfort vibration criteria to minimise annoyance

<table>
<tr><th rowspan="2">Location</th><th rowspan="2">Work Period</th><th colspan="2">Resultant PPV, mm/s</th></tr>
<tr><th>Lower limit</th><th>Upper limit</th></tr>
<tr><td rowspan="3">Accommodation activity (including hotels or other premises which provides accommodation for the public)</td><td>Standard hours</td><td>1.0</td><td>2.0</td></tr>
<tr><td>Non-Standard hours – day/evening</td><td rowspan="2">0.3</td><td rowspan="2">1.0</td></tr>
<tr><td>Non-Standard hours – night</td></tr>
<tr><td>Hospital and health care service (wards, surgeries, operating theatres, consulting rooms)</td><td>All</td><td rowspan="4">0.3</td><td rowspan="4">1.0</td></tr>
<tr><td>Educational establishment (rooms designated for teaching/research purposes) & childcare centre</td><td rowspan="3">While in use</td></tr>
<tr><td>Court of Law (Court rooms)</td></tr>
<tr><td>Court of Law (Court reporting and transcript areas, Judges’ chambers)</td></tr>
<tr><td>Community use & place of worship</td><td rowspan="2">While in use</td><td rowspan="2">1.0</td><td rowspan="2">2.0</td></tr>
<tr><td>Commercial (offices) and retail facility</td></tr>
</table>

Blasting

Blasting causes groundborne vibration, and it may also cause the secondary effect of airborne vibration due to airblast.

The following documents contain blasting vibration criteria for human comfort:

- Australian Standard AS 2187.2:2006
- ANZEC '*Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration*', 1990
- EP Act Section 440ZB
- DES Guideline *'Noise and Vibration from Blasting'* (DES, 2022).

The Code sets human comfort criteria for vibration from blasting as presented in Table 3.3.1.1(b).

Table 3.3.1.1(b): Human comfort vibration criteria to minimise annoyance from blasting

Location	Blasting Limit Resultant PPV
Buildings of special value or significance (may include historical buildings, monuments)	2 mm/s
Sensitive receptor	Not more than 5 mm/s for 9 out of any 10 consecutive blasts and not more than 10 mm/s for any blast
Occupied non-sensitive sites, such as factories and commercial premises	See Australian Standard AS 2187.2:2006, Table J4.5(A)

All reasonable and practicable measures shall be implemented to meet the criteria contained in Table 3.3.1.1(b). Refer to Section 3.3.1.2 and 3.3.1.3 for damage criteria applicable to vibration from blasting.

3.3.1.2 Building damage

The vibration criteria for building damage due to blasting is considered the same as that induced by transient groundborne vibration due to general construction activities.

Vibration levels for potential building damage are contained in British Standard BS 7385-2:1993 *Evaluation and measurement for vibration in buildings* – Part 2: *Guide to damage levels from groundborne vibration*, and they are referenced in British Standard BS 5228-2:2009 and Australian Standard AS 2187.2:2006. The vibration levels in BS 7385-2:1993 are adopted as building damage criteria from construction activities in this Code. It should be noted that the vibration values are related predominantly to transient vibration, which does not give rise to resonant responses in structures and to low-rise buildings. Dynamic loading caused by continuous/intermittent vibration (for example, vibratory rolling, piling, tunnel boring, rock breaking and rock hammering) may give rise to dynamic magnification due to resonance; in this case, BS 7385-2:1993 recommends a reduction of the transient vibration levels. Where details of the natural frequencies of buildings and structures (or portions thereof), ground characteristics and source characteristics (including frequencies) are not available, the assessment shall assume that resonance impacts are possible for all continuous/intermittent sources.

German Standard DIN 4150-3:2016-12 *Vibration in Buildings – Part 3: Effects on Structures* provides building damage criteria for short-term or long-term vibration. DIN 4150-3:2016-12 provides guidance on an additional type of structure that is of intrinsic value, which is a category not specifically covered within British Standard BS 7385-2:1993.

The department recommends both British Standard BS 7385-2:1993 and German Standard DIN 4150-3:2016-12 be used for construction projects to determine the likely building/structural damage impacts. The results of the assessment shall be used to inform the need for condition surveys as presented in Section 4.4 and restrict the locations of construction equipment/activity with the use of safe working distances/exclusion zones to ensure vibration damage limits are met.

3.3.1.3 Structures and building contents damage/disruption

Impacts to PUP and the department's structures are managed by other requirements, refer to Section 1.2.

Where structures (excluding PUP and the department's structures) are at risk of vibration damage from the project, it is the responsibility of the Assessing RPEQ to contact the owners to determine their specific requirements in relation to vibration exposure. In the absence of owner advice/requirements, the Assessing RPEQ is responsible for nominating a vibration damage limit. Where relevant, guidance for structures may be taken from British Standard BS 5228-2:2009 or German Standard DIN 4150-3:2016-12 and consideration given to the age, condition and material/construction of the sensitive receptor.

It is the responsibility of the Assessing RPEQ to contact the relevant District Cultural Heritage Officer to determine presence of heritage sites. Where heritage sites are at risk of vibration damage from the project (and considered sensitive to vibration damage) it is the responsibility of the Assessing RPEQ to contact the owners to determine their specific requirements in relation to vibration exposure. In the absence of owner advice/requirements, the Assessing RPEQ is responsible for nominating a vibration damage limit. Where the heritage site is a building or structure, the Assessing RPEQ will need to determine the appropriate vibration damage limit. The Assessing RPEQ shall consider the condition of the heritage site, its construction, its intrinsic value and any requirements set by the District Cultural Heritage Officer when determining an appropriate limit.

It is the responsibility of the Assessing RPEQ to conduct a building contents investigation and contact the surrounding sensitive receptors which are likely to contain building contents at risk of vibration damage/disruption from the project (for example, sensitive equipment located at hospitals/health care services, laboratories, and so on). For disruption/damage of building contents including sensitive instruments and electronics, vibration criteria shall be established by the Assessing RPEQ through discussion with the manufacturer, supplier and/or owner/operator. Reference may also be made to previous experience or, if appropriate, other published sources such as '*Vibration control design of high technology facilities*' (Ungar et al, 1990). Note that sensitive equipment shall not be limited to that equipment identified by Ungar.

It should be noted that British Standard BS 5228-2:2009 and German Standard DIN 4150-3:2016-12 do not consider effects of vibration on soil settlement. Vibration-induced soil settlement may still occur at vibration levels below structural damage limits. Settlement may affect structural foundations and services as well as slopes and temporary excavations. Expert advice is to be sought if soil settlement is a potential issue.

Where an asset owner requires a displacement/settlement criterion to be met, the Assessing RPEQ is required to obtain agreement in writing from the owner with regards to adequate mitigation and management measures (for example, exclusion zones, monitoring requirements, and so on). This

agreement shall be appended to the assessment report and form part of the overall mitigation and management strategy.

3.3.2 Airborne vibration

Airborne vibration is structural vibration induced by low frequency sound. Sources of airborne vibration may include airblast (overpressure due to blasting), piling and vibratory compaction plant.

This Code does not provide specific criteria for impacts associated with airborne vibration due to construction activities other than blasting as they are typically rare and should be considered on a case-by-case basis.

For blasting, the airborne vibration effects shall be assessed by using airblast (blast overpressure) criteria as per Section 3.2.3.

4 Assessment

During the planning and design (or preconstruction) stage, noise and/or vibration risks from construction activities may be identified. This may be in the form of a design stage construction noise and/or vibration assessment report.

During the construction stage the construction contractor shall identify noise and vibration risks for construction activities and prepare a noise and vibration assessment report prior to construction works commencing.

The department is responsible for the review and acceptance of all noise and/or vibration assessment reports. The department's project manager will consider the scale of works and likely impacts and be responsible for acceptance of assessment reports, based on advice from the department's environmental staff and/or Engineering and Technology Branch where appropriate.

Once accepted, the contents of the construction stage noise and vibration assessment report shall be used to develop and maintain a Noise and Vibration Management Plan (NVMP). Refer to Chapter 7 for NVMP requirements.

The department requires that all noise and vibration assessments under this Code are conducted/supervised by a Registered Professional Engineer of Queensland (RPEQ) with relevant experience in assessing construction noise and vibration from infrastructure projects (that is, Assessing RPEQ).

4.1 Type of assessments

Construction noise and vibration assessments can be conducted at two stages of a project:

- design stage (may include other planning stages)
- construction stage.

Assessment types based on the project stage are presented in Table 4.1.

Table 4.1: Noise and vibration assessment types

Stage	Assessment Type	Description
Design	Design Stage Assessment	Assessment and reporting completed during the design stage provides project specific mitigation and management measures based on the expected details of construction obtained via consultation with the designer. The assessment shall propose solutions to any construction noise and vibration issues and revise the assessment in consultation with the designer.
Construction	Construction Stage Assessment	Assessment and reporting completed after the design stage has been finalised but prior to construction works commencing provides project specific mitigation and management measures. The assessment shall be based on the details of construction (that is, fleet, schedule, and so on) and determine solutions to any construction noise and vibration issues. Once accepted by the department, mitigation and management measures shall be incorporated into the NVMP.
	Complaint Assessment	Assessment and reporting typically in conjunction with monitoring in response to a complaint and/or damage. If the complaint is determined to be justified, then additional mitigation and management measures shall be determined and incorporated into the NVMP.
	Trial Assessment	Assessment and reporting documenting the details and results from a trial of a particular work activity and/or selected plant/equipment. Trial Assessments may be required where there is insufficient knowledge available to predict the resulting impacts with a reasonable level of confidence. If the Trial Assessment is accepted by the department, then the description of works, impacts and mitigation and management measures shall be incorporated into a revised construction stage assessment and NVMP.

All assessments shall include the following:

- identify all relevant work practices and equipment. Review all stages of the construction project to identify all relevant noise and vibration generating construction works and activities including (but not limited to):
  - work sites for each activity
  - likely hours of construction for activities
  - duration of activities
  - construction traffic (within the project boundary)
  - piling
  - excavation and blasting
  - underground works.
- identify sensitive receptors, buildings, structures and building contents
- identify the relevant noise and vibration issues
  - airborne noise
  - groundborne noise
  - groundborne vibration (including blasting)
  - airborne vibration (including airblast (blast overpressure)).

Assessment reporting requirements are included in Appendix A. Measurement, prediction and reporting requirements are dependent on the assessment type, refer to Section 4.2, Section 4.3 and Appendix A.

Construction activities (including blasting) should be generally undertaken within the Standard hours. Construction activities which have the potential for significant impacts should be discouraged where possible in the nighttime. The use of high impact machinery such as piling, vibratory rollers and impact devices (rock breakers and jack hammers) should be avoided where possible for night work construction in residential or other areas sensitive to nighttime impacts. Where night work is required in the vicinity of residential or other sensitive areas, careful planning and a higher level of mitigation and management is required.

Mitigation and management options are provided in Appendix B. The Assessing RPEQ shall determine and document in an assessment report all reasonable and practical project specific mitigation and management options based on (but not limited to) those presented in Appendix B.

Project specific mitigation requires the Assessing RPEQ to set definitive mitigation requirements (for example, 8 t vibratory roller (noting brand & model number) shall not operate (including startup and rundown) within 10 m of any building or structure). The use of passively worded mitigation is not accepted (for example, a smaller roller class should be considered when within 10 m of a building or structure).

4.2 Assessment during design stage

A design stage assessment shall be conducted for a project during the development of the design and shall determine project specific noise and vibration mitigation/management requirements.

The Assessing RPEQ shall consult with the designer to obtain expected details of construction, including type of activities (for example, clearing and grubbing, earthworks, piling, bridge construction, relocation works, pavement works, and so on), plant/equipment and scheduling/timing (that is, duration and work periods, and so on). The assessment shall assess a range of different equipment sizes and methods (for example, different piling methods, multiple roller sizes, multiple hydraulic hammer sizes, and so on) to determine if there are any restrictions/limitations to equipment selection/construction activity (for example, in order to maintain safe working distances). The equipment/plant assessed should allow for a conservative set of assumptions if methods are unknown (for example, when assessing pier piling methods consider impact piling, vibratory piling of casings and bored piling/screw in casings).

The assessment shall identify noise and vibration issues. Where noise and vibration issues are identified, the Assessing RPEQ propose solutions to these issues in consultation with the designer and revise the assessment report to include all options assessed and the recommended solution. Documentation of the design iteration/alterations should be made in a clear section of the report which details the methods which were unsuitable, and those proposed in their place.

It is the responsibility of the Assessing RPEQ to contact relevant owners of structures, heritage sites and building contents and obtain their vibration criteria and other requirements. The Assessing RPEQ is responsible for requesting in writing the vibration limits and requirements and appending all correspondence to and from the owner to the report.

A design stage assessment shall include requirements as presented in Table 4.2.

Table 4.2: Design stage assessment requirements

Item	Requirements
Measurement requirements	Measurements are a requirement for a design stage assessment and shall be as follows: • Ambient noise monitoring shall be conducted. Sensitive receptors should be grouped by location and a representative location selected for each group. This data is used to determine the general construction noise criteria. Noise monitoring locations shall be accepted by the department prior to conducting the monitoring. • Ambient vibration monitoring shall not be conducted unless approved by the department. If approved, sensitive receptors should be grouped by location and a representative location selected for each group. This data can be used to provide an existing benchmark for comparison to construction vibration exposure. Chapter 5 provides methods for noise and vibration measurements. While requirements for geo-technical investigations are not within the scope of this Code, it is noted that the results of such investigations are highly relevant to the choice of construction method and also to the understanding of ground propagation conditions and ground-related vibration susceptibilities at the site.
Prediction requirements	Predictions for a design stage assessment require the use of specific algorithms or detailed computer models. The assessment shall consider relevant details (for example, structural foundations, ground characteristics, water table, topography, meteorology, external facade construction/orientation of buildings/structures). Predictions shall consider 'worst case' operations for each of the identified construction activities/work methods during the various phases of a given construction project. Chapter 6 provides requirements for conducting noise and vibration predictions. Predictions shall be made for construction, construction traffic and blasting.
Reporting requirements	Reporting shall include reporting requirements as presented in Appendix A.

4.3 Assessment during construction stage

A construction stage assessment shall be completed after the design stage has been finalised but prior to construction works commencing and shall provide project specific mitigation and management measures.

The Assessing RPEQ shall consult with the construction contractor to obtain details of construction plant/equipment, activities and work methods, construction scheduling/timing (that is, Standard vs Non-Standard hours per activity) and activity durations (that is, number of days/weeks/months per activity/stage).

The assessment shall assess the construction contractor's fleet and determine if there are any restrictions/limitations to equipment/activity selection (for example, exclusion zones in order to maintain safe working distances). Where issues arise, it is expected that the Assessing RPEQ shall determine a solution to any noise and vibration issues in consultation with the construction contractor and revise the assessment to resolve these issues (for example, additional roller class with a lower centrifugal force is required to maintain safe working distances to structures, piling method is not suitable due to potential for damage to structures, and an alternative piling method is required).

It is the responsibility of the Assessing RPEQ to contact relevant owners of structures, heritage sites and building contents and obtain their vibration criteria and other requirements. The Assessing RPEQ is responsible for requesting in writing the vibration limits and requirements and appending all correspondence to and from the owner to the report.

A construction stage assessment shall include requirements as presented in Table 4.2.

During construction, the project's construction stage assessment must be reassessed where:

- structural/building damage is, or is suspected to be, caused by the project’s activities, or
- changes in the equipment/work method, intensity, location, duration or timing of impacts can be reasonably foreseen to increase noise and vibration impacts.

In addition to the construction stage assessment, complaint assessments and trial assessments are used during construction to determine if additional/revised mitigation and management measures are required for a project.

Complaint assessments are typically conducted in response to complaints (noise, vibration and/or suspected damage) received during construction or in the event of damage. Trial assessments may be conducted where the impacts from a work activity are unknown or difficult to predict. The results of complaint and/or trial assessments, if accepted by the department's project manager, shall be used to update NVMP mitigation and management measures.

4.3.1 Complaint assessment

A complaint assessment typically involves measurement of particular work activities which are perceived by sensitive receptors to cause unreasonable interference and/or may be responsible for damage/disruption to buildings, structures and building contents. A complaint assessment requires the impact of the activity to be measured, predicted or a combination of both, to determine likely impacts during 'worst case' construction and environmental conditions.

A complaint assessment should be conducted for a justifiable complaint only when preliminary investigations and communication cannot quickly resolve the issue. A complaint assessment shall be conducted for damage/disruption to buildings, structures and building contents.

Where the complaint is in regard to construction noise and the RBL at the complainant's premises is measured to be below 30 dB(A), the assessment shall investigate practicable and reasonable noise mitigation in addition to those required based on the thresholds nominated in Table 3.2.1.1(a).

The complaint assessment should include the following as presented in Table 4.3.1.

Table 4.3.1: Complaint assessment requirements

Item	Requirements
Measurement requirements	Justify the selection of monitoring locations. Locations should be selected to adequately represent all identified sensitive receptors, buildings, structures and building contents. Chapter 5 provides methods for noise and vibration measurements. The duration of the measurements during construction will be specified within the NVMP and shall be accepted by the department's project manager prior to monitoring. Any deviation from duration specified within the NVMP due to consultation with potentially affected parties and/or project specific circumstances shall be agreed with the department prior to conducting measurements. As a minimum, monitoring shall cover noise and/or vibration 'worst case' operations.
Prediction requirements	Prediction may be required to support the determination of 'worst case' construction impacts. The use of predictions to support measurements will require acceptance from the department prior to use. Chapter 6 provides requirements for conducting noise and vibration predictions.
Reporting requirements	Reporting shall include reporting requirements as presented in Appendix A and justification of the duration of measurements and how 'worst case' construction impacts were included within the assessment.

4.3.2 Trial assessment

A trial assessment may be required for a particular work activity where there is insufficient knowledge available to predict the resulting noise and vibration impacts with a reasonable level of confidence. A trial assessment may be required during the construction of a project.

Trial assessments shall be negotiated with the department and consulted with the surrounding affected community prior to any trial works being conducted. A methodology for the trial assessment shall be submitted to the department. No trial assessment shall be conducted until the methodology has been accepted by the department. Trial works shall only cover a discrete period of work to allow measurement. The trial assessment (if accepted by the department's project manager) can be used to update the NVMP requirements for the equipment/activity which was the focus of the trial.

The assessment requirements are the same as those required for complaints response, with the exception that monitoring shall be conducted for the duration of the trial works. In addition, the trial assessment report shall provide sufficient detail which confirms that the trial is representative of project activities and project site conditions.

4.4 Condition surveys

Condition surveys are required for all buildings and structures (including heritage sites susceptible to damage from vibration) in the vicinity of the construction activity which could potentially be subject to airblast and vibration impacts at levels that could cause damage. Building contents investigations are required to identify and assess any sensitive building contents.

Building condition surveys may result in the identification of particularly vibration sensitive building structures or contents. The condition survey information obtained shall be used to develop appropriate vibration mitigation measures and revise/set vibration damage limits for inclusion in the assessment report and in the project NVMP.

4.4.1 Building condition and other ancillary structures

The building condition survey program provides the mechanism by which the condition of buildings and other ancillary structures is determined prior to and following completion of construction. The program shall be based on the area likely to be affected by damage due to construction vibration.

This is essential to ensure that:

- building condition is known prior to the onset of any construction vibration impacts, and
- adequate vibration mitigation and management is exercised during the period of construction.

Properly conducted, the building condition survey process also provides an effective means of establishing necessary contacts with the affected community well before commencement of any vibration-related disruption.

All condition surveys and subsequent reporting shall be conducted/supervised by a RPEQ with relevant experience (that is, Structural Engineer RPEQ), unless accepted otherwise (prior to survey) by the department's project manager.

Where an allotment which has been nominated for a condition survey contains large and/or numerous structures, the RPEQ conducting/supervising the condition survey shall obtain acceptance from the department's project manager with regards to the extent of the survey.

Requirements for condition surveys shall be determined on the basis of the results and recommendations of a vibration assessment.

Building condition survey reports shall be submitted to the department prior to commencement of construction. After completion of the works, post-construction building condition surveys shall be conducted. Post-construction building condition survey reports detailing the results of the inspections shall be submitted to the department following completion of the relevant activity.

Timeframes for provision of building condition surveys will be set by the department.

4.4.2 Building contents

Where vibration sensitive building contents are identified as present in buildings or other structures, a building contents investigation shall be conducted by the Assessing RPEQ to ensure that the relevant items and their particular location, vibration susceptibilities (including details of mounting to surfaces) and condition are properly described and considered.

4.4.3 Structures

Similar detailed site investigations may be needed where other structures (including heritage sites) susceptible to damage from vibration are present.

With infrastructure structures (for example, bridges), it is important to establish the actual condition of the asset prior to construction vibration specifications, mitigation and management being finalised.

Where a recent condition survey is not available, a condition survey of the structure (for example, bridge) shall be conducted, and the type of condition survey is at the discretion of the department. It is the responsibility of the RPEQ conducting/supervising the condition survey to gain acceptance from the department's project manager and asset owner with regards to the type and extent of the condition survey.

5 Measurement

This chapter describes the methods and standards required by the Code when conducting noise and vibration measurements of construction activities. The measurements are assessed using the required descriptors for the corresponding noise and vibration modes. If alternative measurement methods are proposed, they will require acceptance by the department prior to use.

It is important to note that for any measurement, the instrumentation must be properly protected from unintended vibration or electromagnetic interference. As a general rule when conducting noise measurements in the vicinity of vibratory plant or other sources of vibration, it is essential to ensure that the equipment is located in a stable position and properly isolated from obvious sources of vibration. Non-shielded cabling should not be used for the purpose of noise measurement.

The measurement results need to be analysed against the work periods (for example, Standard hours, Non-Standard hours for day/evening/night) as defined in Chapter 3.

Typically, measurements are conducted for selected locations which are representative of the identified relevant receptors (including buildings and structures). This limits measurements to a smaller group of representative receptors.

5.1 Noise measurement

5.1.1 Instrumentation

Sound level meters used for the purposes of noise assessment or noise compliance must be Class 1 or Class 2, complying with the requirements of Australian Standard AS/NZS IEC 61672.1-2019. Measurement conducted using octave and third octave band filters should comply with the requirements of AS IEC 61260.

Other measurement equipment, such as data recorders, analogue tape recorders, chart recorders or statistical analysers, may be used in conjunction with the sound level meter, provided that the overall accuracy of the measurement system is not less than that which would be acceptable for a Class 2 sound level meter.

5.1.2 Calibration

Calibration of sound level meters, or sound level meters in conjunction with other measurement equipment, should be conducted by a NATA certified calibration laboratory at intervals of preferably 12 months, but in any event not exceeding two years.

Calibrated reference sound sources used to check calibration in the field (‘sound level calibrators’) should be recalibrated at least once a year.

A field check of instrument calibration (including any attached measurement equipment) should be made before and after each set of measurements, using a Class 1 sound level calibrator.

Notwithstanding this, where instrumentation will be unattended and used for an extended period at the same site (for example, ’noise logging’), care should be taken to ensure that field checks of calibration are made at appropriate intervals by considering the reliability and stability of the measurement instrument or system.

If during a field check of instrument calibration, the sound level meter reading differs from the calibrated reference level, the difference must be noted.

In all cases, where a difference in field calibration of more than 1 dB is noted between consecutive checks, measurement data affected shall be discarded.

5.1.3 Airborne noise measurement

Noise measurement and reporting (including determination of adverse weather and atypical/extraneous noise impacts) should be conducted generally in accordance with Australian Standard AS 1055:2018 for construction and ambient noise.

Noise measurements should be conducted generally with the sound level meter set to A-weighting and fast response and with an approved windscreen fitted to the sound level meter microphone. Unless specified otherwise, noise level measurements should be presented to a single decimal place with the appropriate units specified (for example, 61.2 dB(A)).

A portable weather station should be collocated with noise measurements where meteorological influences may affect the measured noise levels. The portable weather station should be well placed to limit the effects of obstructions and capable of measuring the following:

- temperature
- humidity
- barometric pressure
- rainfall
- wind speed and direction (anemometer should be located 2.0 m ± 0.2 m above ground).

5.1.3.1 Rating background level

Rating background level (RBL) is the overall single-figure background level representing each work period as defined in Chapter 3. It is derived from the measured ambient background levels at noise sensitive receptors. Specifically, RBL is derived from the following:

- Determining the background noise level for each work period using the tenth percentile method of measured $L_{A90,1\ hour}$. Noise levels measured in each work period of each day are ranked from the lowest to highest with the lowest tenth percentile position taken by multiplying the number of samples within each work period by 0.1. The tenth percentile position is rounded up if not a whole number with the value at that position taken to be the background level for that day's work period.
- Taking the median of background levels over all days for each work period as RBL. The RBL values should be rounded to the nearest whole number.

A plot shall also be provided in reporting showing the L_{A1}, L_{A10}, L_{A90} and L_{Aeq} values for the measurements period.

The measurement of ambient background levels used to determine RBL should be conducted prior to construction and any disruption in traffic that may accompany the commencement of the project (including disruptions due to activities in other parts of the project area). It shall meet the following requirements:

- The microphone should be placed in free-field and be at least 3.5 m from any building or other vertical reflecting surface. Measurements may also be conducted at a distance of 1 m from a facade. While the selection of locations is site specific, any influences from surrounding facades should be noted.

- The microphone height shall be at least 1.5 m above ground finished floor level but may be at a higher level if the noise sensitive building is multistorey.
- Measured using 1 hour measurement interval periods.
- Measurements shall be conducted over a seven day period (shorter periods may be approved by the department) with results provided for consecutive 1 hour measurement intervals throughout the measurement period.
- Measurements are analysed for each work period.
- Representative of the localised noise environment.

If the measurement location is affected by noise from the construction activities or other extraneous sources, then:

- the background level may be measured at an equivalent position not subject to the effects of the construction and/or extraneous noise, or
- if possible, the background ambient noise is measured during a scheduled break in the construction activity.

5.1.3.2 Construction noise

Measurement for gauging the impact of construction noise levels should be conducted at a time which is relevant to the particular noise source of interest. Where practicable, measurements shall coincide with the time at which disruption due to noise from an activity would be considered 'worst case'.

Measurement reporting shall document any influence from background or extraneous noise levels. Any corrections for background or extraneous noise contribution should be clearly stated.

The $L_{Aeq,adj,15\ minute}$ is normally used to measure general construction noise. The measurement can be conducted externally or internally of noise sensitive buildings. Adjustment factors as defined in Chapter 2 may need to be applied. To determine the suitable adjustment factors, measurements shall provide results for the following:

- non-frequency weighted one-third octave band levels
- L_{eq} measured using A- and C-weighting
- impulse response and fast response maximum noise levels for specific construction activities, both conducted using A-weighting.

External

The $L_{Aeq,adj,15\ minute}$ measured externally can be used for comparison with external criteria or in conjunction with the calculated facade noise attenuation to determine internal noise impacts. The external measurement shall meet the following requirements:

- The microphone should be placed in free-field and at least 3.5 m from any building or other vertical reflecting surface or 1 m from the most exposed facade. If measurement is made in front of a window, the window should be closed.
- The microphone height shall be at least 1.5 m above ground finished floor level but may be at a higher level if the noise sensitive building is multistorey. The position may be selected to be the centre of the most exposed window to construction noise.

- Measurements shall be made for 15 minute intervals. Duration would be dependent on the activity with a minimum of 15 minutes of activity measured.
- The measurement results shall be analysed for the work periods defined in Chapter 3.

Internal

The $L_{Aeq,adj,15\ minute}$ may also be measured inside a building to determine pre-construction internal noise environments for sensitive receptors as well as the impact of general construction noise exposure. The measurement shall meet the following requirements:

- The microphone should be placed at least 1 m from walls or other major reflecting surfaces and 1.5 m from windows. The presence of furnishings or other reflective surfaces, which may result in shielding or scattering of the noise, should also be considered.
- The microphone shall be 1.2 m to 1.5 m above the floor.
- Measurements shall be made for 15 minute intervals.
  - During construction – overall duration would be dependent on the activity with a minimum of one interval (15 minutes of activity) measured. Construction measurements shall document any influence from background or extraneous noise levels. Any corrections for background contribution shall be clearly stated.
  - Pre-construction – unattended measurements shall include two days of representative weekday traffic (and two days of representative weekend traffic if weekend activities are planned) (shorter periods may be approved by the department)
- The measurement results shall be analysed for the work periods defined in Chapter 3.

Pre-construction noise measurement inside buildings may be warranted as part of detailed assessments where:

- non accommodation activity receivers are involved
- external measurement is not possible due to site constraints
- external criteria cannot be met and more detailed internal investigation is required.

5.1.4 Groundborne noise measurement

Groundborne noise measurement and reporting should be conducted using methodologies in general accordance with the provisions of ISO 14837-1.

The L_{ASMax} is the groundborne noise assessment descriptor. It shall be measured inside a building to determine the internal noise impacts.

A Class 1 sound level meter set to A-weighting and slow response shall be used. Measurement shall be conducted at a time which corresponds to the particular noise source of interest. Where practicable, measurements shall coincide with the time at which disruption due to noise from an activity would be considered ‘worst case’.

The measurement for this purpose shall meet the following requirements:

- The microphone should be placed at least 1 m from walls or other major reflecting surfaces and 1.5 m from windows. The presence of furnishings or other reflective surfaces, which may result in shielding or scattering of the noise, should also be considered.

- The microphone shall be 1.2 m to 1.5 m above the floor.
- All windows, doors and other openings to the room shall be closed.
- Measurements shall be made for 15 minute intervals. Duration should be dependent on the activity with a minimum of one interval (15 minutes of activity) measured.
- Measurements shall document any influence from background or extraneous noise levels. Any corrections for background noise contribution shall be clearly stated.
- The measurement results shall be analysed for the work periods defined in Chapter 3.

5.1.5 Airblast measurement

Airblast measurement and reporting should be conducted using methodologies in accordance with the provisions of Australian Standard AS 2187.2-2006 Appendix J.

Airblast measurements should be conducted with an appropriate sound level meter capable of measuring L_{peak} dB(L). Measurement should be conducted during blasting activity and located away from structures that may produce reflections and cause spurious readings. The measurement should meet the following requirements:

- The microphone should be placed at least 1 m above ground level unless a specific investigation shows that measurements taken at a lower height are valid.
- The microphone should be oriented in a direction of maximum sensitivity to the incident sound and a windshield fitted in accordance with the manufacturer's recommendations.

5.2 Vibration measurement

This section describes vibration measurements for groundborne vibration only. It does not prescribe any methods to measure airborne vibration with the exception of airblast (see Section 5.1.5 of this Code). Any methods to measure airborne vibration except for airblast should be discussed with the department to determine acceptability.

Instrumentation and methodologies required for vibration measurement will depend on the type of vibration and whether human comfort or buildings/structures/contents are being considered. Requirements may also vary based on the types of ground, buildings or structures on which measurement is undertaken.

Instrumentation utilised for vibration monitoring should be of sufficient sensitivity to allow comparison with the criteria specified in Chapter 3. Instrumentation shall also comply with the minimum requirements contained in the following standards:

- for human perception and blasting – Australian Standard AS 2187.2-2006 Appendix J, or
- the relevant standard under which those limits were developed (for example, British Standard BS 7385-2 and German Standard DIN 4150-3).

While standards may state additional requirements, the following three sections provide general requirements for instrumentation performance, calibration and coupling to substrate.

5.2.1 Instrumentation

Vibration measurement may be conducted using either geophones (seismic velocity transducers) or accelerometers, in a triaxial transducer arrangement (that is, for both triaxial geophones or accelerometers) with the transducers arranged orthogonally, so that each of the three component

vibration velocities or accelerations can be measured. In all cases, the particular transducer orientation shall be properly recorded and documented. This shall specifically include the transducer orientation with respect to the source and to the surface on which it is fixed.

The instrumentation selected shall have a frequency range meeting the particular assessment requirements.

5.2.2 Calibration

Testing and recalibration of geophones, accelerometers and other vibration measurement instrumentation shall be conducted by a NATA certified calibration laboratory at intervals of 12 months.

5.2.3 Coupling to substrate

To ensure the vibration measurement accuracy, it is critical to maintain effective and secure coupling of the transducers to the ground, building foundations, other structural elements or substrates on which measurement is undertaken.

The following guidelines should be followed:

- for geophones – the guidance given in the ISEE *Field Practice Guidelines for Blasting Seismographs*
- for accelerometers – the guidance given in International Standard ISO 5348:2021.

The preferred coupling method depends on site conditions. Where there is a rigid surface (for example, concrete or rock), adhesive or mechanical bonding can be used. Where the surface is soil, the transducer can be embedded or fixed to an embedded mount (for example, 200 mm concrete cube or similarly sized cylinder). If measurements are repeated at the same location, an embedded mount is particularly justified for consistency of results.

Coupling with soil spikes in soft conditions may lead to exaggerated measurements and shall not be used, unless accepted otherwise (prior to use) by the department's project manager.

5.2.4 Human perception

Measurements for gauging human perception shall be conducted to determine the Resultant PPV and meet the following requirements:

- Measurements on the ground shall be representative of ground motions at the subject building or structure, but at sufficient distance from the building or structure to avoid undue interference from that structure.
- Measurements within a structure shall be located on the floor of the room where any complaint originates or where the greatest adverse impact is predicted. One or two measurement points in a suitable available area, preferably in the central part of the room, will typically be sufficient in most cases.
- Measurement shall be conducted during construction activity for a representative two day period to determine vibration exposures (shorter periods may be approved by the department's project manager).

5.2.5 Structural damage/building contents

Measurement of PCPV (or $v_{i, max}$) and Resultant PPV for assessing structural damage and building contents shall be:

- located at the base/foundation of the structure, or as required by the standard
- also located at the horizontal plane of the highest floor of a structure, if required
- located to be representative of sensitive building contents, if required
- conducted during construction/blasting activity or for a representative two-day period to determine pre-construction exposure (shorter periods may be approved by the department).

6 Prediction

Noise and vibration prediction forms part of the construction noise and vibration assessment.

Predictions may be supported by measurements and involve detailed computer modelling to determine impacts.

This chapter provides guidance on the requirements, reference sources and methodologies for construction noise and vibration prediction.

6.1 Noise prediction

6.1.1 Airborne construction noise

Noise predictions require consideration of:

- locations of all noise receptors that may be affected by construction works
- plant and machinery required during each stage and their activity (that is, running times and location)
- potential noise emissions in the form of sound power levels (L_w) (or sound pressure (L_p) at a reference distance (m)) from construction activities
- noise attenuation due to distance, ground and air absorption, screening effects by topography, buildings, temporary or permanent noise barriers
- enhancements in the noise level due to the effects of sound reflection and situations such as propagation over water
- meteorological effects including wind speed and direction as well as atmospheric stability.

Noise emission data for construction plant and equipment may be measured, obtained from manufacturers or estimated based on available databases. There are numerous databases of plant and equipment noise emission data. Whilst a useful resource, care should be taken when using this data to ensure that it is representative of local equipment selections.

Available databases include:

- British Standard BS 5228-1:2009 including the 2014 Amendment where Annex C and Annex D contain current and historical noise emission data respectively.
- The European Commission issued Directive 2000/14/EC (amended by Directive 2005/88/EC, by Regulation (EC) No 219/2009, and by Regulation (EU) 2019/1243, and corrected by corrigendum) on equipment sound power levels.
- The Department of Planning, Transport and Infrastructure in South Australia document entitled '*Infrastructure Works at Night – Operational Instruction 21.7*'.
- Australian Standard AS 2436-1981 Appendix D which contains sound power levels for construction equipment.
- Australian Standard AS 2436-2010 Appendix A which contains typical sound levels for construction equipment and which is derived from Australian Standard AS 2436-1981, British Standard BS 5228-1 and DEFRA database (noted previously).

The preferred external receptor position, for purposes of prediction, is at 1 m from the most exposed facade of the relevant noise receptor and 1.5 m above floor level. Where internal noise levels are

required, guidance from Australian Standard AS 2436-2010 may be used to estimate the noise reduction from outside to inside. Where estimates indicate that internal noise levels will potentially exceed noise criteria, a detailed assessment should be made and reported.

Predictions require octave band noise level emissions, digitised topography and the inclusion of intervening barriers, air absorption and meteorology. This requires the use of computer noise modelling packages and relies on various algorithms developed to predict environmental noise.

The use of a computer noise model enables the consideration of multiple noise sources, receptors and propagation conditions. The method in ISO 9613 2:1996 '*Acoustics - Attenuation of sound during propagation outdoors* – Part 2: *General method of calculation*' is recommended and supported in many computer noise modelling packages. Meteorological variables should be considered as per the method.

All predictions shall consider the relevant character adjustment ($L_{Aeq,adj,T}$) to predictions and shall be based on the factors described in Chapter 2 (for example, tonality, impulsivity, and so on).

6.1.2 Groundborne noise

Prediction of groundborne noise is typically based on the groundborne vibration levels or empirically derived formulae. In order to predict groundborne noise, the following methods may be used:

- British Standard BS 5228-2:2009 and the 2014 Amendment, including:
  - Annex E – which contains empirical formulae for the prediction of groundborne noise for a range of construction activities. These formulae are based on work conducted by Hiller and Crabb '*Groundborne vibration caused by mechanised construction works TRL report 429*'.
- Prediction of groundborne vibration is as per model development and evaluation presented in Section 6.2 of this Code. These groundborne vibration predictions may be used to estimate groundborne noise using the following methodology.

  In order to estimate groundborne noise, RMS velocities may be derived from predicted Peak Particle Velocity (PPV) using 'crest factor' considerations. Where this approach is used, care should be taken to ensure that the crest factors utilised are appropriate to the particular vibration characteristics of the construction plant and equipment being assessed.

  RMS velocities may then be used to calculate groundborne noise levels as per the procedure set out in the FTA, 2018 document '*Transit noise and vibration impact assessment manual*'. The procedure involves the following:
  - prediction of the unweighted vibration velocity profile referenced to $1x10^{-6}$ in/s.
  - adjustments to vibration propagation (coupling loss, floor-to-floor attenuation and amplification due to resonances of floors, walls and ceilings)
  - application of an adjustment to the unweighted velocity profile referenced to $1x10^{-6}$ in/s.

  This procedure provides an estimate of the levels of radiated noise given the average vibration amplitude of the room surfaces. It assumes that the unweighted sound pressure level is approximately 5 dB less than the vibration velocity level when the velocity level is referenced to $1x10^{-6}$ in/s. The adjustment based on frequency content is applied to the measured/predicted value to estimate the A-weighted noise level within the room.

6.1.3 Airblast

Predictions of airblast and reporting shall be conducted using methodologies in Australian Standard AS 2187.2-2006 Appendix J.

Predictions of airblast L_{peak} dB(L) shall be at the preferred location which is typically 1 m from the most exposed facade of the relevant receptor.

Other methodologies may also be used and shall be confirmed with the department for acceptability.

6.2 Vibration prediction

This section focuses on vibration prediction for groundborne vibration only. It does not prescribe any methods to predict airborne vibration, with the exception of airblast for which the airborne vibration effects are considered by limiting airblast (blast overpressure) (see Section 6.1.3 of this Code).

Any methods to predict airborne vibration except for airblast shall be discussed with the department to determine acceptability.

As a preliminary to all ground vibration predictions, available details relating to the project proposal should be reviewed. This should include, for example, geotechnical reports and ground vibration records from previous works if relevant.

Prediction of groundborne vibration shall consider:

- source (location, depth, soil structure interaction, and so on)
- propagation path (geological profile and properties, water table, obstructions, and so on)
- receptors (soil-structure interaction, foundation type, building/floor type, and so on).

Predictions should be at the preferred location which is typically the most exposed location of the relevant receptor.

Predictions may rely on the following methods for predicting PCPV and Resultant PPV:

- empirical formulae (may include a combination of parametric and empirical methods)
- measured vibration level combined with propagation estimates.

Information to support these methods should be sourced from the following documents:

- Australian Standard AS 2187.2-2006 Appendix J – contains a method for the prediction of Resultant PPV from blasting
- British Standard BS 5228-2:2009 and the 2014 Amendment, including:
  - Annex C and Annex D – they contain current and historical piling vibration emission data respectively
  - Annex E – it contains empirical formulae for the prediction of vibration for a range of construction activities. These formulae are based on work conducted by Hiller and Crabb '*Groundborne vibration caused by mechanised construction works TRL report 429*'
- California Department of Transportation document entitled '*Transportation and Construction Induced Vibration Guidance Manual, 2020*'.

Other methodologies may also be used but shall be confirmed with the department for acceptability prior to use.

Predictions of free field vibration using these methods may be corrected to account for the attenuation/amplification of a building structure. This allows predictions to be made at a point of interest within a structure. The following documents provide guidance on the estimation of coupling losses and amplification of structures that may be applied to free field predictions:

- US Federal Transit Administration (FTA) document entitled '*Transit noise and vibration impact assessment manual, 2018*'
- US Department of Transport – Transportation Systems Center, '*Handbook of Urban Rail Noise and Vibration Control Report UMTAMA-06-0099-82-2, 1982*'.

The conditions which form the basis for parametric/empirical formulae may not represent the particular conditions of the project area. Therefore, it is important to account for these differences by considering predictions over a range of possible values and noting any uncertainty which would be expected. Predictions should be conducted within the ranges against which the model is validated. If extrapolation of the method is required, it shall be clearly noted with the expected uncertainty.

Methodologies and other parameterisations based on measurements at unrelated sites, while sufficient for many purposes, are generally limited in accuracy. Where the consequences of an under-prediction of a result would be critical in terms of structural damage, or where the predictions imply major modification to the proposed work method (particularly where experience would suggest such modification is unlikely to be necessary), further and more detailed investigations may be warranted to remove as far as is practicable the uncertainties involved in the prediction process.

More detailed predictions generally require site specific vibration propagation data or additional information. Appropriate measurements are typically used to support model development and/or determine uncertainty. ISO 14837-1-2005 provides useful information on the development and refinement of model methods. The use of more detailed methods shall be confirmed with the department for acceptability prior to use.

Subject to acceptance (prior to use), predictions may consider the following:

- Prediction supported by additional measurements of vibration levels associated with particular construction equipment/activities in conditions similar to those at the relevant site. This would require sufficient detail provided for the measurement conditions, the plant measured, geological conditions and any other parameters relevant to the activity or vibration emission.
- Measurement of site-specific soil attenuation properties for use in model predictions. The measurement of transfer mobility may be used to characterise the propagation of vibration from the source to the receptors. The results may provide confirmation of vibration prediction assumptions relating to soil attenuation and transfer functions. Guidance relating to measurement of transfer mobility (and force density) for at grade and underground operations is contained in the FTA's document '*Transit noise and vibration impact assessment manual, 2018*'.
- Detailed numerical solutions may be required in complex situations where measurements are impractical. A detailed model may be developed and may include numerical solutions based on:
  - finite element method (FEM)
  - finite difference method (FDM)

- boundary element method (BEM).

In some cases, the uncertainty of predictions may be such that it is necessary to conduct continuous vibration monitoring during works adjacent to the relevant site. Where this is done, the vibration data may be used to adjust work procedures so that appropriate levels are not exceeded. Refer to Chapter 4 for trial assessments and Chapter 5 for measurement methodologies.

7 Management Plan

A NVMP shall be developed based on mitigation and management measures within an accepted construction stage assessment (refer to Chapter 4).

Control of noise and vibration from transport construction projects shall rely on effective mitigation and management measures implemented in accordance with a Noise and Vibration Management Plan (NVMP).

The objective of a NVMP is to ensure that all reasonable and practicable measures are taken to minimise noise and vibration impacts on the community, buildings and structures, and that the affected community and other stakeholders are well informed and consulted throughout the construction process. In order to maintain positive community relations, the public should be kept informed about the construction plans and efforts to minimise noise and vibration. Procedures shall be established as part of a NVMP for prompt response and corrective action with regard to noise and vibration complaints during construction.

It is the responsibility of the construction contractor to develop, implement and maintain a NVMP. A NVMP shall be developed based on mitigation and management measures within an accepted construction stage assessment (refer to Chapter 4). A NVMP shall be prepared as a standalone document (but may incorporate sub-plans where required for a specific activity or project phase), and appended to the Environmental Management Plan for Construction (EMP(C)).

The department is responsible for the review and acceptance of an adequate NVMP. The department's project manager will consider the scale of works and likely impacts and be responsible for acceptance of the NVMP, based on advice from the department's environmental staff and/or Engineering and Technology Branch where appropriate.

It is the responsibility of the construction contractor and its representatives to ensure that a NVMP is accepted by the department's project manager prior to construction works commencing.

During construction it is the responsibility of the construction contractor and its representatives to implement the accepted NVMP and conduct additional construction stage assessments (refer to Chapter 4) where required to maintain its function. Any revision to the NVMP shall be accepted by the department's project manager prior to use. It is at the discretion of the department's project manager whether construction continues prior to the acceptance of a revised NVMP. Reporting to the department during construction is required for compliance monitoring purposes.

7.1 Noise and Vibration Management Plan

A NVMP shall provide accessible and consistent documentation of noise and vibration criteria/limits, and mitigation and management measures which apply to the subject activity or project.

A NVMP shall include (but not be limited to) the following:

- A statement in the introductory section which states the intent of the NVMP

  This NVMP has been prepared in accordance with the Transport Noise Management Code of Practice: Volume 2 – Construction Noise and Vibration (Code). All reasonable and practicable mitigation will be implemented to achieve the noise and vibration criteria nominated in the

Code. This NVMP will be reviewed and additional reasonable and practicable measures implemented as follows:

- *where directed by the department, or*
- *in response to a justifiable complaint or in the event of structural/building damage caused by or suspected to be caused by the project's activities, or*
- *in response to a trial or complaint assessment which identifies additional mitigation and management measures, or*
- *where changes in the equipment/work method, intensity, location, duration or timing of impacts can be reasonably foreseen to increase noise and vibration impacts.*

The wording of the above statement may be altered at the discretion of the department.

- Description of construction works, as follows:
  - all activities/work methods and corresponding equipment (for example, clearing and grubbing, piling, compaction, asphalt works and so on)
  - include details of work periods for each activity/work method (including site access and haul routes within the project boundary)
  - include the duration/hours that each activity/work method operates within a work period
  - include the number of work periods/days required to complete each activity/work method
  - issues which may affect hours of operation; for example, safety clearance zones for traffic which restrict available periods of construction to Non-Standard hours day/evening and/or night e.g. rail possessions or road corridor closure restrictions
  - include the restrictions that mitigation has on work periods/hours of operation, areas of operation and duration of activities (for example, where plant or equipment is not permitted to operate for a given area and work period/hours of operation).
- Figures which clearly present the locations of each activity/work method (including site access and haul routes within the project boundary). The figures and plan shall differentiate areas where activity/work methods are planned to be conducted during Standard vs Non-Standard hours (that is, it should be clear where works are proposed in areas during Non-Standard hours day/evening and night periods versus those conducted during Standard hours). In addition, the figures shall include the following:
  - site access points for construction traffic
  - construction traffic and haul routes within the project boundary
  - facilities associated with the project and the access arrangements to and from such facilities
  - noise and vibration sensitive receptors, buildings, structures and building contents (including heritage sites). Receptor catchment areas shall also be included
  - particular landforms for which specific vibration (or other) protection is required.

- Noise and vibration categories covered by the plan; for example, airborne noise, groundborne noise, groundborne vibration (including blasting), and airborne vibration (including airblast).
- Noise and vibration criteria/limits applicable to the construction including, where relevant, limits applicable to:
  - specific construction activities
  - particular items of plant
  - facilities
  - all buildings, structures and building contents
  - safe working distances (provide a table of safe working distances from specific activities) to prevent damage to buildings, structures and building contents.
- Reasonable and practicable mitigation and management measures for noise and vibration from construction activities. This would include specific noise and vibration mitigation and management measures that apply:
  - during Standard hours
  - during Non-Standard hours
  - during designated stages within the overall project duration (for example, during piling activities)
  - during the operation of specific types of equipment/work method (for example, impact breakers, piling or vibratory rollers)
  - for specific types of construction activities (for example, blasting within defined proximity of a particular building or structure)
  - in the vicinity of a particular noise and vibration sensitive site
  - to any respite, temporary relocation (alternative activity/accommodation) and architectural treatment
  - to exclusion zones for each item of equipment/activity identified as requiring a safe working distance. Figures shall be provided showing exclusion zones within the construction footprint for each activity, types of equipment and work method. Exclusion zones shall be based on safe working distances.
- Dilapidation/building/structural condition survey and reporting requirements (or if these have been conducted separately, reference to the relevant completed pre-construction surveys). Figures shall be included to present the locations of all condition survey requirements.
- Monitoring procedures to determine compliance with noise and vibration criteria/limits including, where relevant, nominated monitoring positions and designated reporting intervals.
- Complaint and trial monitoring and assessment procedures.
- Reference to any associated documents, such as relevant assessment reports used in plan preparation and associated documents and management plans.

- Community liaison requirements and complaint procedures, refer to Section 7.2 (including all contact details). The central point of contact shall have the authority to alter mitigation and construction activities onsite to reduce impacts.
- Consultation/Notification requirements, including:
  - consultation with regards to respite, temporary relocation and architectural treatment requirements - receptors which require consultation shall be tabulated
  - consultation for specific activities (for example, piling, compaction works)
  - general notification to the surrounding community
  - areas of notification/consultation requirements shall be documented in the plan and clearly presented in figures.
- Reporting procedures to provide the department and other relevant authorities with evidence of compliance when requested.
- Reporting procedures to notify the department (i.e. project manager) within 24 hours of any complaints occurring, or within 24 hours of becoming aware of any damage caused by construction activities.
- Reporting procedures to notify the DES within 24 hours of any material environmental harm or serious environmental harm caused by construction activities.

7.2 Community consultation

Good community consultation practices are a key component for the management of disruption from construction activities. Prior to construction works commencing, clear communication channels shall be established between the project team and those persons and organisations in the community potentially affected by project-related activities. The receptors nominated for community consultation shall be guided by the prediction of noise and vibration impacts, particularly sensitive receivers exceeding upper limits for noise and/or vibration. This is particularly important where activities with potential for high levels of disruption, such as blasting, piling or night work will be required. It is important that information is provided in a transparent and consistent manner in relation to exposure, duration, mitigation and management measures.

Community consultation shall maintain a working relationship with the community by implementing the following:

- Disseminating information regarding the project schedule and potential impacts/mitigation to the surrounding sensitive locations. The following may be used:
  - letterbox drops
  - community meetings
  - newsletters
  - website
  - discussions with affected persons
  - a point of contact for information (dedicated phone line).
- Initiating a procedure for complaints response including a dedicated phone line for Standard and Non-Standard hours.

7.2.1 Notification

Notification regarding specific construction activities shall be provided to adjacent residents and property owners likely to be affected by noise and vibration from the activity. Such notification shall be provided prior to the activity commencing (typically one week notice) and shall provide the following details:

- the reason for the activity
- types of equipment required
- mitigation and management measures used
- the expected hours of operation, including any permitted site preparation works which will occur outside Standard hours
- the likely duration and impact of operation at the site and any requirement for subsequent additional works
- contact details for further information and complaints.

Where changes are made to any of these items, particularly changes to hours of operation or likely duration of the operation, affected residents and property owners shall be notified.

These requirements are additional to any general community engagement procedures adopted at project level.

7.2.2 Complaints

The project shall establish an effective documented complaints handling procedure which provides a fair and quick response to complaints. A complaint handling procedure shall include the following:

- A dedicated phone line should be provided to enable the community to contact a central project representative.
- A central point of contact (this contact shall have the authority to alter mitigation, management and construction activities onsite to reduce impacts).
- A register of complaints shall be maintained, including time, date, location, person's contact details and any details regarding construction activities which are the focus of the complaint. In addition, the actions taken and any accepted alterations to the NVMP shall be recorded. The timeframe for response as well as likely actions shall be provided immediately to the complainant by the recipient of the complaint.
- Reporting procedures to notify the department (i.e. project manager) within 24 hours of any complaints occurring, or within 24 hours of becoming aware of any damage caused by construction activities.
- Reporting procedures to notify the DES within 24 hours of any material environmental harm or serious environmental harm caused by construction activities.

Where possible, the complaint shall be resolved quickly using all reasonable and practicable mitigation and management measures.

Reporting procedures contained within this Code do not override the project’s legislative obligations with respect to notification presented in the EP Act.

8 Glossary of terms

8.1 General definitions

Term	Definition
Aboriginal or Torres Strait Islander cultural heritage	Aboriginal or Torres Strait Islander cultural heritage is anything that is: • a significant Aboriginal or Torres Strait Islander area in Queensland, or • a significant Aboriginal or Torres Strait Islander object in Queensland, or • evidence of archaeological or historic significance of Aboriginal or Torres Strait Islander occupation of an area of Queensland under the *Aboriginal Cultural Heritage Act* 2003 and *Torres Strait Islander Cultural Heritage Act* 2003.
Accommodation activity	Refer to Schedule 24 of the Planning Regulation 2017.
Assessing RPEQ	The Registered Professional Engineer of Queensland (RPEQ) with relevant experience in assessing construction noise and vibration from infrastructure projects conducting and/or supervising the noise and vibration assessment and reporting.
Assessment	A procedure designed to identify whether noise and vibration issues are likely to be significant and to ensure all reasonable and practicable mitigation management measures are recommended. Chapter 4 defines the requirements for different assessment types.
Blasting	The practice of the use of explosions for the purpose of loosening or breaking up rock or other material.
Building condition survey	A survey of a building or structure conducted for the purpose of providing documentation and record of the building's 'state of repair' at a particular time. Building condition surveys are sometimes also referred to as 'dilapidation surveys'.
Building contents investigation	A survey or investigation carried out for the purposes of documentation of particular vibration sensitive building contents or equipment located in a specific building or group of such buildings. It also means the subsequent investigations and assessments necessary to establish the particular sensitivities of identified vibration sensitive contents or equipment.
Building envelope	Those building components (comprising the external walls, floors and roofs/ceilings) which separate internal spaces of a building from the external environment and particularly from sources of external noise.
Caretaker's accommodation	Refer to Schedule 24 of the Planning Regulation 2017.
Childcare centre	Refer to Schedule 24 of the Planning Regulation 2017.
Community engagement	The process of ensuring good communication with those members of the community likely to be affected by project related activities and effects (see Chapter 7).
Community residence	Refer to Schedule 24 of the Planning Regulation 2017.
Community use	Refer to Schedule 24 of the Planning Regulation 2017.
Construction	All construction activities including blasting, piling, construction traffic and temporary facilities and plant.

Term	Definition
Construction contractor	Means an external business providing an expert professional service under the conditions of a contract. Construction contractor includes a Local Government, Queensland Department of Transport and Main Roads Service Delivery Unit, or Joint Venture (including only Local Government(s) and/or Queensland Department of Transport and Main Roads Service Delivery Unit(s)).
Construction traffic	All traffic associated with construction.
Descriptor (of sound or vibration)	A measure or index used to describe the fluctuating amplitude or level of a sound or vibration signal (or a subset of those amplitudes or levels), derived from the actual fluctuating signal values by statistical or other methods.
Dual occupancy	Refer to Schedule 24 of the Planning Regulation 2017.
Dwelling house	Refer to Schedule 24 of the Planning Regulation 2017.
Dwelling unit	Refer to Schedule 24 of the Planning Regulation 2017.
Dynamic compaction	The process whereby ground compaction is achieved by repeatedly lifting and dropping a large mass (or tamping weight) onto the substrate. Typically masses of 10 to 20 tonnes and heights of 15 to 20 m are used.
Educational establishment	Refer to Schedule 24 of the Planning Regulation 2017.
Environmental harm	Refer to Schedule 4 of the *Environmental Protection Act* 1994.
Environmentally Relevant Activity	Refer to Schedule 4 of the *Environmental Protection Act* 1994.
Environmental nuisance	Refer to Schedule 4 of the *Environmental Protection Act* 1994.
Environmental value	Refer to Schedule 4 of the *Environmental Protection Act* 1994.
Frequency	For a periodic, oscillatory or vibratory phenomena, the ‘frequency’ means the number of times the phenomena repeats itself in a unit time interval. Frequency is measured in Hertz (Hz); 1 Hz being one cycle per second.
Frequency analysis	The process used to discriminate between the various frequency components (or tones) which together comprise the overall sound or vibration signal. Sound varies in both level and frequency (subjectively, loudness and pitch). For many purposes to assess noise (or vibration) effects and control requirements, it is necessary to have information regarding both the overall level of the sound (or with vibration, the displacement, velocity or acceleration amplitudes) and also the various frequency components comprising the overall signal. Conventionally, the frequency spectrum is divided into standard ‘octave bands’ where the centre frequency of each band is double that of the previous band. Each octave band may be further subdivided into ‘third-octave bands’. Frequency analysis may also be conducted using smaller fractions of an octave band or by a ‘narrow band’ process, where the frequency spectrum is divided into a large number of bands of equal width.
General construction	Construction with the exclusion of blasting.

Term	Definition
Government supported transport infrastructure	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994.
Habitable room	Any room which is used for purposes of work, relaxation or sleeping and which is not a bathroom, laundry, toilet or room used primarily for storage purposes.
Haul route	A road or group of such roads used to transport materials and equipment to and from a construction site. It also means a road or track within a construction site used by heavy vehicles (trucks and scrapers and so on) for purposes of transportation of materials within the site.
Health care service	Refer to Schedule 24 of the Planning Regulation 2017.
Heritage listed	A place, building, tree, natural formation or other structure of cultural heritage significance which is listed on the Queensland Heritage Register under the provisions of the *Queensland Heritage Act* 1992.
Heritage site	Includes heritage listed and Aboriginal or Torres Strait Islander cultural heritage sites.
Hertz (Hz)	Cycles per second.
Home-based business	Refer to Schedule 24 of the Planning Regulation 2017.
Hospital	Refer to Schedule 24 of the Planning Regulation 2017.
Hotel	Refer to Schedule 24 of the Planning Regulation 2017.
Impact pile driving	Pile driving by sinking or driving a pile by direct or indirect hammering or impact. It includes pile driving by the use of a drop hammer, internal drop hammer, diesel hammer, double-acting hammer, single-acting hammer, air, steam or hydraulic hammer or other mechanical impact device excluding hand held devices.
Impact roller	A ‘square roller’ or ‘lobed roller’ which achieves soil compaction as a result of the impacts imparted to the soil as the roller rotates and the mass of each face or lobe of the roller impacts the ground surface.
Justifiable Complaint	A complaint that is not considered to be vexatious or frivolous by the department.
Multiple dwelling	Refer to Schedule 24 of the Planning Regulation 2017.
Nature-based tourism	Refer to Schedule 24 of the Planning Regulation 2017.
Non-Standard hours – day/evening	See Chapter 3.
Non-Standard hours – night	See Chapter 3.
NVMP	Noise and Vibration Management Plan (see Chapter 7).

Term	Definition
Office	Refer to Schedule 24 of the Planning Regulation 2017.
Passive recreation area	An area used for passive recreation, such as a park, playground, or walking track. Does not include drainage reserves/channels, landscape buffer strips or environmental/conservation areas/corridors.
Pile	Any sheet, column, post, tube or caisson driven or formed in the ground pile and includes any pile referred to as a 'bored pile', 'jacked pile', 'screw pile', 'cast-in-place pile', 'caisson pile', 'composite pile', 'sand pile', 'sheet pile' and any other form of pile.
Piling	Works in connection with or for the installation or forming of a pile in the ground by hammering, jacking, screwing, augering, boring, jetting, vibrating, casting; or by any other means. It includes the driving or sinking of any casing or tube into the ground to form a well or caisson for foundation purposes, whether or not the pile casing or tube is later withdrawn.
Piling and related ground improvement methods (short form, piling and related activities)	Piling, dynamic compaction, vibroflotation and impact placement of stone columns or other ground stabilisation by use of equipment normally or typically used for impact pile driving. It also includes insertion of wick drains (band drains) by vibratory or other means.
Piling system for impact and vibratory pile driving	The particular combination of pile driver and the type of pile.
Place of worship	Refer to Schedule 24 of the Planning Regulation 2017.
Pneumatic tyred roller	A roller equipped with pneumatic tyres. The majority of such rollers are static rollers and achieve compaction of the substrate by a combination of the static weight of the roller and the kneading action of the roller tyres on the substrate. Such rollers typically incorporate mechanisms to increase the applied mass by use of ballast. To enhance tyre kneading effects, pneumatic rollers may incorporate systems to automatically vary tyre pressure and to pivot or oscillate individual wheel sets.
Pneumatic tyred vibratory roller	A pneumatic tyred roller with the tyres mounted from a common axle which incorporates a vibratory mechanism (similar to a steel drum vibratory roller).
Pre-construction survey	A survey or investigation conducted in the vicinity of a proposed construction site (or group of such sites), carried out for the purposes of identifying all buildings, structures, building contents, heritage sites, ground and landform elements susceptible to vibration induced disruption or damage for which protection must be provided. The pre-construction survey, by definition, must be conducted prior to commencement of any construction activity at the construction site.
Public road	A road that is open to the public, whether or not on payment of money.
Relocatable home park	Refer to Schedule 24 of the Planning Regulation 2017.
Residential care facility	Refer to Schedule 24 of the Planning Regulation 2017.
Resort complex	Refer to Schedule 24 of the Planning Regulation 2017.
Retirement facility	Refer to Schedule 24 of the Planning Regulation 2017.
RMS	Root mean square.

Term	Definition
Rooming accommodation	Refer to Schedule 24 of the Planning Regulation 2017.
Rural workers' accommodation	Refer to Schedule 24 of the Planning Regulation 2017.
Safe working distance	The minimum distance from vibration sensitive buildings, structures or other items, at which a particular class or type of activity may be carried out under a defined level of operational vibration control.
Sensitive receptor	See Chapter 3.
Short term accommodation	Refer to Schedule 24 of the Planning Regulation 2017.
Standard hours	See Chapter 3.
Static roller	A roller which achieves compaction of the substrate soil primarily as a result of application of the weight of the roller drum to the substrate, as it advances over the area to be compacted. The term static roller includes vibratory rollers when these are operated in non-vibratory mode.
Supply chain haul routes	Refer to MRTS02 *Provision for Traffic*.
Temporary facility	Includes sites such as depots, plant maintenance and layover areas, batch plants, asphalt plants, crushing and screening equipment, stockpile sites and all other materials processing and handling sites established on a short-term or semi-permanent basis, to service the specific requirements of a particular road construction or maintenance project. This does not include activities which are classed as Environmentally Relevant Activities (ERA).
Temporary plant	Particular items of mechanical plant or equipment (such as pumps, stationary generators and compressors and so on) which are not associated with a temporary facility, but which will be required to operate at the one site more or less continuously over an extended period. This does not include plant activities which are associated with an Environmentally Relevant Activity (ERA).
Tourist park	Refer to Schedule 24 of the Planning Regulation 2017.
Transport infrastructure	Refer to Schedule 6 of the *Transport Infrastructure Act* 1994.
Vibroflotation	Ground improvement techniques (vibrocompaction and vibroreplacement) which use a large vibrating probe or 'poker' (in some cases, an H-pile driven at resonance by a vibratory pile driver) to penetrate the ground and use vibration to compact the surrounding materials. Once the probe has reached a predetermined depth, additional material is introduced into the hole and is compacted as the probe is gradually withdrawn to form a dense column of sand or stone ('stone-columns').
Vibratory pile driving	The process of pile driving by application of vibration to the pile shaft, whereby vibration of the pile causes soil fluidisation in the immediate vicinity of the pile during part of each vibratory cycle. The consequent loss of frictional soil support allows the advance of the pile into the substrate due to the combined weight of pile and pile driver.
Vibratory roller (also vibratory roller compactor)	A roller which achieves compaction of the substrate by a combination of static weight and vibration of the roller drum. Typically, the vibration results from the rotation of an eccentric (unbalanced) mass or masses located within the roller drum.

Term	Definition
Wick drains (also band drains)	Vertical drainage conduits installed in soft sediments to provide drainage of excess water. These comprise a central plastic conduit and a porous jacket which filters soil water entering the drain. They are installed using a mandrel or lance, which protects the drain as it is forced into the ground. Once the mandrel reaches the required depth, it is withdrawn, leaving the drain in place. The mandrel and drain are typically inserted using plant which is similar to a small vibratory pile driver. Alternatively hydraulic jacking may be used to push the mandrel into the ground. Other systems use a combination of vibratory and hydraulic means.
Workforce accommodation	Refer to Schedule 24 of the Planning Regulation 2017.

8.2 Noise related definitions

Term	Definition
A-weighting	Frequency weighting 'A' as described in AS/NZS IEC 61672.1:2019 *Electroacoustics—Sound level meters* Part 1: *Specifications*.
A-weighted equivalent continuous sound pressure level (denoted L_{Aeq})	The equivalent continuous sound pressure level measured using an A-weighted network.
Adjusted measured noise level (denoted $L_{Aeq,adj}$)	The measured noise level of a noise source, with adjustments applied to correct for background ambient sound pressure level and particular audible characteristics. The adjusted measured noise level is also referred to as the assessed noise level.
Airblast (overpressure due to blasting)	The pressure wave transmitted through the air, caused by an explosion and which contains significant airborne energy at frequencies in or below the audible range of the human ear.
Ambient noise	The totally encompassing sound in a given situation at a given time, composed of sound from all sources near and far, measured by the totally encompassing time average A-weighted sound pressure level in a given situation at a given time.
Background noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L_{A90} descriptor.
Background noise level	The minimum ambient level, in the absence of the noise source under investigation. It may be defined as the A-weighted sound pressure level that is equalled or exceeded for 90 per cent of that part of the interval in which the investigated noise is absent (L_{A90}).
C-weighting	Frequency weighting 'C' as described in AS/NZS IEC 61672.1:2019 *Electroacoustics—Sound level meters* Part 1: *Specifications.*
C-weighted equivalent continuous sound pressure level (denoted L_{Ceq})	The equivalent continuous sound pressure level measured using a C-weighted network.
Continuous noise (steady state noise)	Noise that gives fluctuations over a range of not more than three dB.

Term	Definition
Dominant low frequency noise	Where the noise is dominated by sound in the frequency range 10 Hz to 200 Hz.
Engineering noise control	Measures which provide a reduction in the noise level at the receiver by physical means (excluding personal hearing protection).
Equivalent continuous sound pressure level (denoted L_{eq})	That level, which, if present as a steady signal, would in any particular time period have the same sound energy as the actual fluctuating sound pressure level in the same period.
Fast response	An instrument time weighting (125 ms) within the sound level meter.
Frequency weighting	The practice of modifying the level of the various components of an incoming signal in a standardised manner which varies with the frequency or spectral composition of the signal. With sound level meters or other sound measurement instrumentation, this is done to provide an instrument response which approximates the (non-linear) response of the human perception of hearing to sounds of different frequency and level. The two frequency weightings in most common use are the A- and C-weightings. Z-weighting is now being used in blast noise assessment and low frequency noise evaluation.
Groundborne noise (also structureborne noise or regenerated noise)	A separate issue to airborne noise, groundborne noise is generated by vibration transmitted through the ground into a structure. The vibration of structures causes noise to be radiated into a room.
Impulsivity	Sound characterised by brief excursions of sound pressure level (acoustic impulses) that significantly exceed the background sound pressure level. The duration of a single impulsive sound is usually less than one second.
Infrasound	Very low frequency sound below the normal range of human hearing (that is, less than around 20 Hz).
Intermittent noise (also transient, variable noise)	Noise that gives fluctuations greater than five dB.
L_{A1}	The A-weighted sound pressure level, which in any particular time period is exceeded one per cent of the time by the actual fluctuating sound pressure level.
L_{A10}	The A-weighted sound pressure level, which in any particular time period is exceeded 10 per cent of the time by the actual fluctuating sound pressure level.
L_{A90}	The A-weighted sound pressure level, which in any particular time period is exceeded 90 per cent of the time by the actual fluctuating sound pressure level. In the absence of the noise source under consideration, the L_{A90} is commonly utilised as a measure of the background or average minimum ambient sound pressure level.
$L_{A\%,T}$	The A-weighted sound pressure level that is exceeded for the percent exceedance under consideration for the time interval (T) considered.
$L_{Aeq,T}$	The A-weighted, equivalent continuous sound pressure level within a time interval (T).
$L_{Aeq,adj,T}$	The A-weighted sound pressure level of a continuous steady sound, adjusted for characteristics (see Chapter 2, Table 2.1.2.1(b) *Adjustment factors*), that within a time interval (T) has the same mean square sound pressure level as a sound pressure level that varies with time.

Term	Definition
$L_{Aeq,adj,15\ minute}$	The adjusted A-weighted equivalent continuous sound pressure level considering adjustment factors (see Table 2.1.2.1(b)), measured over a 15-minute time period.
L_{Amax}	The maximum A-weighted sound pressure level in any particular time period. L_{Amax} is an RMS parameter and should not be confused with the peak level (or non-RMS instantaneous maximum level).
L_{ASMax}	The A-weighted maximum sound pressure level using slow response.
L_{Ceq}	The C-weighted, equivalent continuous sound pressure level.
Noise	Defined by the *Environmental Protection Act* 1994 as 'vibration of any frequency, whether emitted through air or another medium'. For the purposes of this Code, noise is used in the more limited sense of 'unwanted sound' (that is, vibration of the air).
Peak sound pressure level	The peak sound pressure level (L_{peak}) or 'peak level' is 20 times the logarithm to the base 10 of the ratio of the peak sound pressure to the reference sound pressure (20 µPa). For purposes of blast monitoring, peak level is synonymous with 'overpressure level' or 'airblast level'. Peak level is a non-RMS level. It should not be confused with the maximum level (L_{max} or L_{Amax}) which refers to the maximum, RMS, sound pressure level.
Peak noise level	The peak sound pressure level.
Rating background level (RBL)	The overall single-figure background level representing each assessment period (for example, Standard hours, Non-Standard hours). The RBL is the level as derived and presented in Chapter 5.
Slow response	An instrument time weighting (1 second) within the sound level meter.
Sound pressure	The instantaneous difference between the actual pressure and the average or barometric pressure at any particular location. Sound pressure is measured in Pascals (Pa). The 'effective sound pressure' is the RMS sound pressure. The 'maximum sound pressure' is the maximum RMS sound pressure. The 'peak sound pressure' is the instantaneous amplitude (non-RMS or 'peak') of the (positive or negative) fluctuation in pressure during the passage of a sound wave.
Sound pressure level (Lp)	The level of the RMS sound pressure level in decibels given by $L_p = 10\log_{10}(p/p_o)^2$ (where p is the RMS sound pressure in Pascals. The reference sound pressure p_o is 20 µPa).
Sound power level (L_w) for the noise source	An absolute that does not vary with distance or differing acoustic environments. It is 10 times the common logarithm of the ratio of the sound power of the source to a reference sound power (usually 1 pW).
Sound absorption	That property of a material or surface which allows it to absorb and dissipate sound.
Sound absorption coefficient	The ratio of sound energy absorbed (that is, not reflected) by a material (or surface) to the total sound energy incident upon it.
Sound level meter	An instrument which is designed and calibrated for measurement of sound pressure level.
Time response (also time weighting) of a sound level meter	The dynamic response of the instrument (refer AS IEC 61672.1-2004/AS/NZS IEC 61672.1-2019). Time weightings in common use include 'Fast', 'Slow', 'Impulse' and 'Peak' (see also **fast response**, **slow response**).
Tonality	A sound producing a definite pitch sensation in a listener.

Term	Definition
Z-weighting	Frequency weighting 'Z' as described in AS/NZS IEC 61672.1:2019 *Electroacoustics—Sound level meters Part 1: Specifications*.

8.3 Vibration related definitions

Term	Definition
Airborne vibration	Structural vibration induced by low frequency sound.
Amplification factor for ground vibration	The ratio of the vibration amplitude at a particular point on a building or structure to the vibration amplitude measured at the base or on the foundation of the building or structure.
Component particle velocity (component PV)	The instantaneous velocity of a particle at each orthogonal component axis (transverse, longitudinal and vertical).
Continuous vibration	Vibration that continues uninterrupted during a defined period (may be constant or variable). This may include quasi-continuous vibration sources which may be continuous for a portion of the assessment period. Note: Continuous vibration may give rise to dynamic magnification at the resonance frequency of building/structural components and/or vibration-sensitive equipment.
Crest factor	The ratio between the peak amplitude and the maximum RMS amplitude of a signal.
Groundborne vibration	Vibration transmitted from a source to a receiver via the ground (see also **Structureborne vibration**).
Intermittent vibration	Intermittent vibrations include a number of transient vibrations. Note: Intermittent vibration may give rise to dynamic magnification at the resonance frequency of building/structural components and/or vibration-sensitive equipment.
Particle displacement, velocity and acceleration	Can be characterised by measurement of the displacement, velocity or acceleration of a representative point (a 'particle') of the ground or structure affected by the disturbance. For measurements of ground motion (or for other surfaces) the particle displacement is defined as the distance that the ground (or other surface) is displaced from its mean (or static) position during the course of a vibration. The particle velocity is the rate of change of displacement of the ground or floor, and the particle acceleration the rate of change of that velocity.
Peak component particle velocity (PCPV)	The maximum instantaneous velocity of a particle in any one of the three orthogonal component axes during a given time interval. Also represented by the notation $v_{i,\,max}$ in DIN 4150-3.
Peak particle velocity (Resultant PPV, PPV or v_P)	The maximum instantaneous velocity of a particle at a point during a given time interval. The Resultant PPV is the vector sum of the three orthogonal component particle velocities (component PV) as follows: $v_p = \sqrt{v_T^2 + v_L^2 + v_V^2}$ where: v_P is the Resultant PPV of the particle velocity at a particular time v_T, v_L and v_V are the respective transverse, longitudinal and vertical component PV of the particle velocity at a particular time.

Term	Definition
Propagation velocity for vibration	The speed with which the vibratory disturbance (a wave) propagates within the medium in which it travels. For vibrations of the air (sound), the propagation velocity is the 'speed of sound'.
RMS particle acceleration	The root mean square particle acceleration.
RMS particle velocity	The root mean square particle velocity, commonly used (with the RMS particle acceleration) to assess human response to vibration. Unless otherwise specified, RMS particle velocity (denoted v_{RMS}) refers to the overall vector sum RMS particle velocity rather than to any particular component of the RMS particle velocity.
Short-term and long-term vibration	As defined in DIN 4150-3.
Structureborne vibration	Vibration transmitted from a source to a receiver via intervening structure(s) (see also **Groundborne vibration**).
Transient vibration	Vibration in which the oscillatory displacement of the ground or structure reaches a peak and then decays rapidly towards zero.
Vibration	Vibration of the ground or of structures and buildings; that is, the oscillatory displacement of the ground or of structures and buildings.

9 References

The following documents were considered in the compilation of this Code.

Australian and New Zealand Environment Council [ANZEC], (1990). *Technical Basis for Guidelines to Minimise Annoyance Due To Blasting Overpressure and Ground Vibration.*

Australian Standard AS 1055-2018: *Acoustics - Description and measurement of environmental noise*: *General Procedures*. Standards Australia, Sydney, New South Wales.

Australian Standard AS/NZS 2107: 2016: *Acoustics – Recommended design sound levels and reverberation times for building interiors*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS 2187.2-2006: *Explosives – Storage and Use* – Part 2: *Use of explosives*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS 2436-1981: *Guide to Noise Control on Construction, Maintenance and Demolition Sites*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS 2436-2010: *Guide to noise and vibration control on construction, demolition and maintenance sites*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS 2670.1-2001 [ISO 2631-1:1997]: *Evaluation of Human Exposure to Whole-Body Vibration* – Part 1: *General Requirements*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS 2670.2-1990 [ISO 2631-2:1989]: *Evaluation of Human Exposure to Whole-Body Vibration* – Part 2: *Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS ISO 2631.2: 2014 [ISO 2631-2:2003]: Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration Part 2: Vibration in buildings (1 Hz to 80 Hz). Standards Australia, Sydney, New South Wales.

Australian Standard: AS 2868-1986: *Classification of Machinery for Earthmoving Construction, Surface Mining and Agricultural Purposes*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS 3671-1989 *Acoustics – Road traffic noise intrusion – Building siting and construction*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS 4742-2003 [ISO 9533:1989]: *Earth-moving Machinery – Machine-mounted forward and reverse audible alarm – Sound test method*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS IEC 61260.1:2019 [IEC 61260-1:2014]: *Electroacoustics – Octave-band and fractional-octave-band filters Part 1: Specifications*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS IEC 61260.2:2019 [IEC 61260-2:2016+AMD1:2017]: *Electroacoustics – Octave-band and fractional-octave-band filters Part 2: Pattern evaluation tests*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS IEC 61260.3:2019 [IEC 61260-3:2016]: *Electroacoustics – Octave-band and fractional-octave-band filters Part 3: Periodic tests*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS IEC 61672.1-2004 [IEC 61672-1:2002]: *Electro-acoustics – Sound level meters – Specifications*. Standards Australia, Sydney, New South Wales.

Australian Standard: AS/NZS IEC 61672.1:2019 [IEC 61672-1:2003]: *Electro-acoustics – Sound level meters – Part 1: Specifications*. Standards Australia, Sydney, New South Wales.

British Standard: BS 5228-2:2009: *Code of practice for noise and vibration control on construction and open sites* – Part 1: *Noise*. British Standards Institution, London, England.

British Standard: BS 5228-2:2009: *Code of practice for noise and vibration control on construction and open sites* – Part 2: *Vibration*. British Standards Institution, London, England.

British Standard: BS 6472:1992: *Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)*. British Standards Institution, London, England.

British Standard: BS 6472-1:2008: *Guide to evaluation of human exposure to vibration in buildings – Vibration sources other than blasting*. British Standards Institution, London, England.

British Standard: BS 6841:1987: *Measurement and evaluation of human exposure to whole-body mechanical vibration and repeated shock*. British Standards Institution, London, England.

British Standard: BS 7385-2: 1993: *Evaluation and Measurement for Vibration in Buildings* – Part 2: *Guide to Damage Levels from Ground-borne Vibration*. British Standards Institution, London, England.

California Department of Transportation (2020). Transportation and Construction Vibration Guidance Manual April 2020 Report: CT-HWANP-RT-20-365.01.01, California Department of Transportation, Sacramento, United States of America.

Department of Environment and Conservation (1989). *Environmental Guideline E1, Noise from construction, renovation and demolition sites*. Department of Environment and Conservation, Brisbane, Queensland.

Department of Environment and Science (DES) (2020). *Noise Measurement Manual, ESR/2016/2195 Version 4.01 dated 10 March 2020*. Department of Environment and Science, Queensland.

Department of Environment and Science (DES) (2022). *Guideline: Noise and Vibration from Blasting, ESR/2016/2169 Version 3.02 dated 9 February 2022.* Permits and Licensing, Department of Environment and Science, Queensland.

Department of Transport and Main Roads (2013), *Road Traffic Noise Management: Code of Practice* Volume 1, Department of Transport and Main Roads, Brisbane, Queensland.

Department of Transport and Main Roads (2013), *Environmental Processes Manual 2023*, Department of Transport and Main Roads, Brisbane, Queensland.

Department of Transport and Main Roads (2019), Interim Guideline Operational Railway Noise and Vibration, Department of Transport and Main Roads, Brisbane, Queensland.

Directive 2000/14/EC of the European Parliament and the Council of 8 May 2000 on the approximation of the laws of the Member States to noise emission in the environment by equipment for use outdoors. 3.7.2000 L162 Official Journal of the European Communities, Brussels.

Directive 2005/88/EC of the European Parliament and the Council of 14 December 2005 amending Directive 2000/14/EC on the approximation of the laws of the Member States to noise emission in the environment by equipment for use outdoors. 27.12.2005 L344/44 Official Journal of the European Communities, Strasbourg.

Regulation (EC) No 219/2009 of the European Parliament and the Council of 11 March 2009 adapting a number of instruments subject to the procedure referred to in Article 251 of the Treaty to Council

Decision 1999/468/EC with regard to the regulatory procedure with scrutiny — Adaptation to the regulatory procedure with scrutiny — Part Two. 31.3.2009 L 87/109 Official Journal of the European Communities, Strasbourg.

Regulation (EU) 2019/1243 of the European Parliament and of the Council of 20 June 2019 adapting a number of legal acts providing for the use of the regulatory procedure with scrutiny to Articles 290 and 291 of the Treaty on the Functioning of the European Union (Text with EEA relevance). 25.7.2019 L 198/241 Official Journal of the European Communities, Brussels.

Federal Transit Administration (2018). Transit Noise and Vibration Impact Assessment Manual FTA Report No. 0123, US Federal Transit Administration, Washington, United States of America.

German Standard: DIN 4150-3:2016-12 Vibration in Buildings – Part 3: Effects on Structures. Deutsches Institut fur Normung e.V., Berlin, Germany

Hiller DM, Crabb GI (2000). *Ground-borne vibration caused by mechanised construction works: TRL Report 429*. Transport Research Laboratory, Crowthorne, Berkshire, United Kingdom.

ISEE (2020). *ISEE Field Practice Guidelines for Blasting Seismographs* 2020. International Society of Explosives Engineers, Blast Vibration and Seismograph Section, Cleveland, Ohio.

International Standard: ISO 2631-1:1997. *Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration* – Part 1: *General requirements*. International Organization for Standardization, Switzerland.

International Standard: ISO 5348:2021(E). *Mechanical vibration and shock – Mechanical mounting of accelerometers*. International Organization for Standardization, Switzerland.

International Standard: ISO 9613-2:1996. *Acoustics – Attenuation of sound during propagation outdoors* – Part 2: *General method of calculation*. International Organization for Standardization, Switzerland.

International Standard: ISO 14837-1:2005. *Mechanical vibration – ground-borne noise and vibration arising from rail systems*. International Organization for Standardization, Switzerland.

New Zealand Standard: NZS 6803:1999. *Acoustics – Construction Noise*. Standards New Zealand, Wellington, New Zealand.

Nichols HR, Johnson CF, Duvall WI (1971). *Blasting Vibrations and their effects on Structures*: Bureau of Mines Bulletin 656. US Department of the Interior, Washington DC, United States of America.

NSW Department of Planning (2008). *Development Near Rail Corridors and Busy Roads – Interim Guideline*. Department of Planning, New South Wales.

NSW Environment Protection Authority (2000). *NSW Industrial Noise Policy*. Environment Protection Authority, Sydney, New South Wales.

NSW Environment Protection Authority (2017). *Noise Policy for Industry*. Environment Protection Authority, Sydney, New South Wales.

NSW Environment Protection Authority (2013). *Rail Infrastructure Noise Guideline*. Environment Protection Authority, Sydney, New South Wales.

NSW Department of Environment and Climate Change (2009) *Interim Construction Noise Guideline*. State of NSW, Sydney, New South Wales.

NSW Department of Environment and Conservation (2006). *Assessing vibration: a technical guideline*. Department of Environment and Conservation NSW, Sydney, New South Wales.

Office of the Parliamentary Counsel (2018). Airports (Environment Protection) Regulations 1997, Compilation No. 9 Registered 16 April 2018, Office of the Parliamentary Counsel, Canberra, Australian Capital Territory.

Office of the Parliamentary Counsel (2021). *Airports Act* 1996, *Compilation No. 34 Registered 15 January 2021*, Office of Parliamentary Counsel, Canberra, Australian Capital Territory.

Office of the Queensland Parliamentary Counsel (2018). *Aboriginal Cultural Heritage Act* 2003, Current as at 9 November 2018. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Office of the Queensland Parliamentary Counsel (2019). *Environmental Protection (Noise) Policy 2019*, Current as at 1 September 2019. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Office of the Queensland Parliamentary Counsel (2022). *Nature Conservation Act* 1992, Current as at 21 October 2022. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Office of the Queensland Parliamentary Counsel (2022). *Planning Act* 2016, Current as at 10 June 2022. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Office of the Queensland Parliamentary Counsel (2023). *Disaster Management Act* 2003, Current as at 1 March 2023. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Office of the Queensland Parliamentary Counsel (2023). *Environmental Protection Act* 1994, Current as at 5 April 2023. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Office of the Queensland Parliamentary Counsel (2023). *Planning Regulation* 2017, Current as at 14 March 2023. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Office of the Queensland Parliamentary Counsel (2023). *Professional Engineers Act* 2002, Current as at 1 March 2023. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Office of the Queensland Parliamentary Counsel (2023). *Queensland Heritage Act* 1992, Current as at 1 March 2023. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Office of the Queensland Parliamentary Counsel (2023). *Transport Infrastructure Act* 1994, Current as at 1 March 2023. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Office of the Queensland Parliamentary Counsel (2023). *Work Health and Safety Act* 2011, Current as at 1 March 2023. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Office of the Queensland Parliamentary Counsel (2023). Work Health and Safety Regulation 2011, Current as at 1 April 2023. Office of the Queensland Parliamentary Counsel, Brisbane, Queensland.

Saurenmann HJ, Nelson JT, Wilson GP (1982). *Handbook of Urban Rail Noise and Vibration Control: UMTA-MA-06-0099-82-1*. US Department of Transportation, Washington DC, United States of America.

South Australia Department of Planning, Transport and Infrastructure (2017). *Management of Noise and Vibration: Construction and Maintenance Activities OPERATIONAL INSTRUCTION 21.7*. Department of Planning, Transport and Infrastructure.

Ungar E, Sturz D, Amick C (1990). *Vibration control design of high technology facilities. Sound and vibration*. Sound and Vibration, July 1990, p. 22.

VicRoads (2007). *Technical Guidelines: Noise Guidelines – Construction and Maintenance Works*, Publication No. 01922 – Version 2 (October 2007), VicRoads.

Appendix A Assessment reporting requirements

Assessment reporting shall include the following as a minimum:

- Details of the Assessing RPEQ. This includes the Assessing RPEQ's number, signature and date of report signing.
- Description of construction works, as follows:
  - all activities/work methods and corresponding equipment (for example, clearing and grubbing, piling, compaction, asphalt works and so on)
  - include details of work periods for each activity/work method (including site access and haul routes within the project boundary)
  - include the duration/hours that each activity/work method operates within a work period
  - include the number of work periods/days required to complete each activity/work method
  - issues which may affect hours of operation; for example, safety clearance zones for traffic which restrict available periods of construction to Non-Standard hours day/evening and/or night e.g. rail possessions or road corridor closure restrictions
  - provide figures which clearly present the locations of each activity/work method (including site access and haul routes within the project boundary). The figures and report shall differentiate areas where activity/work methods are planned to be conducted during Standard vs Non-Standard hours (that is, it should be clear where works are proposed in areas during Non-Standard hours day/evening and night periods versus those conducted during Standard hours).
- List and clearly present in figures all sensitive receptors, buildings, structures and building contents. All sensitive receptors shall be field checked (including tenancies). A pre-construction survey shall be conducted to ensure that all buildings (including tenancies), structures, building contents, heritage sites and ground and landform elements susceptible to noise and vibration induced disruption or damage are identified. Each receptor shall be given a unique identification number and receptors grouped into catchment areas. The report shall document the receptor identification numbers in each catchment area and define the extent of each catchment area graphically in figures.
- Identify all relevant noise and vibration categories to be considered in the assessment – airborne noise, groundborne noise, groundborne vibration (including blasting), and airborne vibration (including airblast) from all construction activities including, but not limited to, work sites, construction traffic, excavation and blasting and underground works. Where a noise or vibration category is not considered within the assessment, clearly document and adequately justify why the category has not been assessed in the report.
- Description of measurements conducted shall include:
  - relevant standards
  - equipment brand/model (that is, noise, vibration and weather measurement equipment)
  - noise/vibration measurement settings used during the measurement period (for example, time weighting, frequency weighting, measurement interval, measurements duration, and so on.)

  - details of measurement location (for example, facade/free field, height of ground/floor level, accelerometer mounting method)
  - NATA calibration certificates (appended to the report)
  - details of field calibration
  - details of weather measurement location(s), height above ground, and so on
  - summary of periods affected by inclement weather and extraneous sources. Details of periods excluded due to weather and extraneous sources. A clear statement shall be provided as to whether sufficient data remains (after exclusion) to provide a reasonable representation of measured construction noise source or the background noise environment
  - a statement regarding the suitability of the RBLs determined by noise measurement shall be included in the assessment report. This statement shall note whether the RBLs are representative of the localised noise environment for the relevant sensitive receivers
  - any other reporting requirements as required by Chapter 5 and the relevant standards
  - where measurement data is used to quantify the emission from activities/work methods and corresponding equipment, the report shall provide all operational and environmental information which relates to the measured data. Uncertainty in operational and environmental variables and available information shall be reported and considered when estimating representative 'worst case' emissions.

- Determination of noise and vibration criteria/limits, clearly presenting all relevant criteria/limits, including the following:
  - The Assessing RPEQ is responsible for providing written correspondence (for example, emails) with all owners/manufacturers/operators/District Cultural Heritage Officer (outgoing and incoming). This information shall be appended to the report and discussions provided in the report with regards to their application in the assessment.
  - Selection of vibration damage criteria for buildings and structures should be carefully considered. Where details of the natural frequencies of buildings and structures (or portions thereof) are not available, the assessment shall assume that resonance impacts are possible for continuous/intermittent sources.

    In addition, the application of the vibration damage criteria should consider the overall structure as well as all elements (e.g. lightweight fit outs/curtain walls within a reinforced structure).
  - A summary of all relevant noise and vibration criteria used in the assessment shall be provided. This includes a summary section of vibration criteria/limits for which the assessment and mitigation and management of buildings, structures and building contents is based on.
- Details of noise and vibration prediction and other requirements as per Appendix A Section A.1 and A.2 and any other reporting requirements as required by Chapter 6 and the relevant standards and source documents.

- Assessment of construction noise and vibration predictions and/or measurements against construction noise and vibration criteria/limits, including the following:
  - Assessment shall be based on individual receptor predictions and reported separately for each catchment area.
  - Assessment shall be presented separately by catchment area for each activity/work method for Standard hours, Non-Standard hours day/evening and Non-Standard hours night (for example, clearing and grubbing, demolition, earthworks, compaction, pavement works, piling works, and so on.).
  - The assessment shall include a summary by catchment area of exceedances for each activity/work method for Standard hours, Non-Standard hours day/evening and Non-Standard hours night.
  - Discussion of each activity/work method including a summary by catchment area of impacts/exceedances and a statement as to the mitigation and management measures required. These sections shall provide a clear linkage to the mitigation and management methods proposed for the project.
- Determine reasonable and practicable mitigation and management measures:
  - All reasonable and practicable mitigation and management measures shall be identified and reported. Project specific noise and vibration mitigation and management measures shall be determined.
  - Mitigation and management measures shall be determined and reported based on each:
    - catchment area/defined group of receptors
    - activity/work method
    - work periods.
  - Appendix B contains examples of mitigation and management measures which may be considered. The assessment shall not be limited to the mitigation and management examples provided in Appendix B.
  - Mitigation and management measures shall be site specific and based on the assessment of predictions and/or measurements. Mitigation and management measures in an assessment report are required to be qualified with terms such as 'shall', 'restricted to' and so on. The use of 'should', 'consider', 'may' and other similar terms shall not be used when specifying mitigation and management measures.
  - Where all administrative and construction activity related control measures are determined and noise/vibration levels are predicted/measured to exceed the upper limits (that is, noise or human comfort vibration criteria/limits) or internal noise criteria/limits, then reasonable and practicable respite, alternative accommodation/activity and architectural treatment (refer to Appendix B Section B.6 & B.7) shall be determined and documented in the report.
    Note: This shall not be used to exceed vibration damage/disruption criteria/limits.
  - Any construction equipment/activity that has not been assessed in this report and has the potential to cause noise and vibration impacts shall not operate on site until assessed in a revised report and accepted by the department's project manager.

- Identify where building/structure condition surveys are required. The extents of condition surveys required shall be presented in tables and graphically in figures. These condition surveys shall be conducted based on guidance presented in Section 4.4 of this Code.
- Identify vibration monitoring, reporting requirements and procedures for specific activities/plant/equipment for sensitive receptors, where required. This item shall not be a replacement for maintaining safe working distances. The duration and extent of vibration monitoring is at the discretion of the department's project manager.
- Identify what trial assessment(s) are required.
- Identify noise and vibration monitoring requirements, reporting and procedures for complaint assessment.
- Identify consultation/notification requirements, including:
  - Consultation for affected persons and the community with regards to respite, temporary relocation and architectural treatment requirements (refer to Appendix B Section B.6 & B.7). Receptors which require consultation shall be tabulated.
  - Consultation for specific activities (for example, piling, compaction works).
  - General notification to the surrounding community where predictions are above the lower limits.
  - Areas of notification/consultation requirements shall be documented in the report and clearly presented in figures.
- A conclusion section which includes a summary of requirements to be incorporated into a NVMP. Details of the requirements of NVMPs are contained in Chapter 7. Sufficient detail shall be contained within the assessment report to enable the preparation of an adequate NVMP.

  Note: A design stage assessment shall provide a summary of mitigation and management measures required based on the expected details of construction. The design stage assessment shall not be used to develop a NVMP as an accepted construction stage assessment is required to determine the final requirements for inclusion in an NVMP.

A.1 Noise Reporting

Reporting of construction noise prediction shall also include the following as a minimum:

- Adopted prediction methods and their general assumptions. Include references for the prediction method.
- All noise predictions shall be rounded to the nearest whole number (for example, 65.5 dB(A) shall be rounded to 66 dB(A)).
- Details of noise sources included in the predictions.
  - The source of estimated noise emission shall be documented including all assumptions in relation to position, adjustment (for example, tonality, impulsivity, and so on), activity, control measures (including estimated mitigation efficiency) and adjustments when based on a similar source. Predictions of $L_{Aeq,adj,15\ minute}$ shall be conducted with and without all reasonable and practicable controls, with residual exceedances noted.

  - The estimated sound power level for all items of plant and equipment shall be included in the report including any octave band level data utilised and the relevant operating conditions, location and height to which the sound power level data applies.
- Details of all noise sensitive receptors, including specifically each receptor's height in relation to local ground level. Assumptions made regarding facade reflections and reflections from other surfaces in the immediate vicinity of the receptors shall also be stated.
- Details of all terrain and design surface data used in the modelling. Include the source, resolution and accuracy of any data used in the assessment.
- Details of any buildings, structures, walls, bunds or noise barriers considered to be significant and included in the modelling process. This shall include relative height to local ground level, capture method (for example, survey) and accuracy.
- Assumptions made in relation to ground cover (hard ground, soft ground, and so on). This shall include any areas where propagation over water would occur for significant distances.
- Meteorological assumptions of the modelling algorithm.
- Noise prediction results for each activity/work method shall be tabulated and presented graphically as contours for all sensitive receptors and compared against the noise criteria/limits. The contour intervals in figures shall be selected so that the extent of predicted exceedances can be readily identified.

A.2 Vibration Reporting

Reporting of construction vibration prediction shall also include the following as a minimum:

- Information relied on for predictions including:
  - topographical and geotechnical data used in the assessment
  - measured data and modification methods for that data including justification as to its relevancy for the project.
- Construction activity/work method (including plant and equipment) details included in the project assessment including:
  - description of the activity/work method requirements
  - size of the plant/equipment including brand, model number and technical specifications
  - specific requirements relating to the size/specifications of the plant, where relevant (for example, MRTS66, Annexure MRTS66.1 Clause 1 and 2 which specify the hammer type and minimum energy input per blow)
  - location of the activities/work methods (including plant/equipment). This information shall also be presented in figures
  - duration/timing of activities/work methods (including plant/equipment).

- Prediction methodologies and inputs to the predictions. The following details shall be provided:
  - details of vibration prediction methods including formulas/algorithms and all input parameters used to determine the propagation of vibration and exposure at sensitive receptors, buildings, structures and building contents. Formulas and all input parameters for each activity, plant/equipment and work method shall be documented in the report
  - the reference standard or other document for formulas and algorithms shall be documented for each activity, plant/equipment and work method
  - source vibration levels, reference distance, input energy and any assumptions made in relation to ground conditions
  - the range of applicability of the prediction method
  - the expected accuracy of the prediction method
  - assumptions made to adapt the methodology to the requirements of the project assessment
  - details of the measurements used in source determination, including a description of plant (including parameters relevant to their vibratory source strength; for example, vibratory rollers, the drum width and nominal drum amplitude, centrifugal force), measured levels, ground/geological conditions and any other parameters relevant to the activity or vibration emission. The report shall include sufficient information to justify why the measured data is relevant to the project.
- Relevant sensitive receivers, buildings, structures and building contents. The following actions shall be undertaken:
  - identify relevant receptors (including buildings and structures)
  - document assumptions relating to the relevant structural details and vibration transmission between the ground and the building, contents or structure
  - predict safe working distances for purposes of operational control of particular plant, equipment and work methods.
- Assumptions made regarding vibration control techniques with the following information included:
  - A description of the control techniques to be used and their location (for example, pre-boring/drilling with driven piles, jetting with dynamic compaction or other high energy ground improvement techniques). A detailed description shall be provided.
  - Required performance of the control technique. Where the use of a vibration control technique is critical to the predicted result but site specific assessment is needed for detailed prediction, the report shall provide indicative calculations for an example situation to demonstrate the potential of the control technique. Details of results achieved with previous applications of the technique may also be relevant. Recommendations for further assessments necessary for the operational implementation of the technique shall be provided where necessary.

- Results of the assessment with the following included:
  - All predictions for human comfort, building/structural damage, building content damage/disruption shall be tabulated for each receptor, building, structure and building contents. Predictions shall also be presented in tables and figures for each activity/work method for the various offset distances for each vibration limit (including predicted vibration contours presented in figures for each plant/equipment item/activity/work method). The contour intervals in figures should be selected so that the extent of predicted exceedances can be readily identified.
  - A table of safe working distances shall be provided for each activity, type of equipment and work method to prevent potential damage to buildings/structures and damage/disruption to buildings contents.
  - The reported mitigation and management measures shall ensure that activities, equipment, and work methods shall never operate within the safe working distances.
  - Figures shall be provided showing exclusion zones within the construction footprint for each activity, type of plant/equipment and work method. Exclusion zones shall be based on safe working distances; for example, safe working distances for an ## t roller and # t roller are 15 m and 10 m respectively for a building and presented as follows:

Note: Sketch to present exclusion zone concept only.

Note: Activities, equipment and work methods shall never operate within the safe working distances. Any relaxation to this requirement will need to be requested in writing (separately to the assessment report) to the department's project manager. Where a relaxation is accepted by the department's project manager it shall be appended to the NVMP.

Appendix B Mitigation and management options

Mitigation and management measures which may be used to control noise and vibration from construction are provided in this Appendix.

In addition to the information provided, qualitative guidance on engineering noise and vibration controls applicable to construction are given in:

- Australian Standard AS 2436-1981, Appendices A and E
- Australian Standard AS 2436-2010, Appendices C and D
- British Standard BS 5228: Part 1:2008, Section 8
- British Standard BS 5528: Part 2:2008, Section 8.

It is important to note that any mitigation and management measures shall be determined on a project specific basis and shall be reasonable and practicable.

B.1 Administrative procedures

Administrative procedures for the general management of a site relate to general measures which may be used to reduce noise and vibration impacts, as follows:

- Provide an induction to site personnel (including sub-contractors) addressing the requirements of the NVMP and their responsibilities with regard to noise and vibration management ensuring:
  - work occurs within approved hours
  - appropriate mitigation and management measures are being utilised.
- Provide ongoing education of supervisors, operators and sub-contractors on the need to minimise noise and vibration through toolbox meetings and on-site training.
- Include clauses that require minimisation of noise and vibration in sub-contractor agreements.
- Provide a protocol for handling noise and vibration complaints that includes recording, reporting and acting on complaints.
- Organise work to be undertaken during the Standard hours where reasonable, practical and safe to do so.
- Include an outside Standard hours works procedure to minimise the impact of any significant noise and vibration works outside Standard hours.
- Avoid the use of radios or stereos outdoors where neighbours may be affected.
- Avoid the overuse of external public address systems or link these systems to the telephone system where neighbours may be affected.
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.

- Avoid the use of horns within the construction area, except in the case of emergency or a requirement for safety.
- Where noise assessment indicates reverse beepers/warning signals are likely to result in adverse impacts on amenity, minimise mobile equipment reversing/movement or use alternative beepers, such as ‘broadband noise' beepers or warning systems. All warning signals must meet the relevant occupational safety requirements. This should be implemented for plant operating during Non-Standard hours where reasonable and practicable.

B.2 Construction traffic and deliveries

Construction traffic and deliveries mitigation and management procedures may include the following:

- Setting the site entry and egress points as far from sensitive receptors as practical. If sensitive sites surround the construction area, the entry and egress points should be designed to distribute the movements rather than directing all movements through a single entry/exit point.
- Providing on-site parking for staff and on-site truck waiting areas away from residences and other sensitive receptors.
- Avoiding unnecessary revving of engines and switching off equipment when not required.
- Positioning loading and unloading points away from sensitive receptors.
- Avoiding traffic calming devices which may cause loads to shift or secure loads to limit shifting.
- Ensuring traffic movement is kept to a minimum (for example, ensuring trucks are fully loaded so that the volume of each delivery is maximised) and nighttime construction traffic is redirected away from sensitive receptors where possible.
- Regularly grading unsealed areas or filling potholes in sealed access roads and hardstand areas to reduce noise and vibration from vehicles.
- Refilling aggregate bins prior to the bins being completely empty.

B.3 Plant and equipment

Plant and equipment mitigation and management procedures may include the following:

- Selecting plant and equipment based on noise and vibration emission levels.
- Turning off plant and equipment or throttling them down to a minimum when not in use.
- Selecting appropriately sized equipment for the task, such as vibratory compactors and rock excavation equipment.
- Avoiding use of plant and equipment simultaneously adjacent to sensitive receptors where possible.
- Using alternative construction methods to minimise noise and vibration levels (for example, during clearing, excavators with grabs and rake attachments may be used instead of chainsaws; for piling, an alternative piling method may be selected, refer to Appendix B Section B.3.1 of this Code).
- Using mufflers and engine covers/screens where appropriate.

- Ensuring equipment is operated in the correct manner and correctly maintained, including replacement of engine covers, repair of defective silencing equipment, tightening of rattling components, repair of leakages in compressed air lines and shutting down of equipment not in use.
- Avoiding where possible the nighttime use of equipment which generates impulsive noise:
  - impact piling
  - dropping materials from a height
  - metal-to-metal contact on equipment.
- Lining aggregate bins and chutes with a rubber material to dampen the vibration of the structure.
- Minimising drop height of materials when transferring (for example, loading and unloading vehicles and storage areas).
- Using damped tips on rock breakers where appropriate.
- Replacing noisy fatigued sealed bearings on conveyor rollers.
- Silencing dust extraction fan exhausts and orienting them away from sensitive receptors.
- Enclosing standby generators or fitting them with an effective muffler.
- Isolating stationary plant located near sensitive receptors with resilient mounts.

B.3.1 Piling and compaction

The selected piling technique should minimise noise and vibration impacts but still allow work to proceed without placing unreasonable restriction on the activity.

It should be noted that the selection of a quieter method may prolong the piling operation, and therefore the overall disturbance to the community may not necessarily be reduced.

Piling and compaction mitigation and management procedures may include the following:

- Avoiding impact pile driving where possible near noise and vibration sensitive receptors, buildings, structures and building contents. Continuous flight auger injected piles, pressed-in preformed piles, auger bored piles, impact bored piles or vibratory piles may be an alternative. However, some alternative methods (for example, vibratory piles) provide continuous fixed frequency characteristics that may give rise to resonance responses in structures and potentially be more perceptible at lower vibration levels. Substitution should be carefully considered, and trial assessments may be required to gauge the potential impacts (all impacts, for example, soil stability, should be reviewed including change in vibration levels). In some instances, a combination of approaches may be necessary as distance to sensitive locations varies across the site.
- Avoiding dynamic compaction using large tamping weights near sensitive receptors, buildings, structures and building contents.
- Providing acoustic screens to hammer head and top of pile.
- Providing acoustic damping to sheet steel piles to reduce vibration and resonance.

- Using a resilient pad between pile and hammerhead. Care should be taken when selecting a resilient pad as energy is transferred to the pad in the form of heat. Refer to Australian Standard AS 2436-2010 for further details.
- Providing careful alignment of pile and rig.
- Minimising cable slap and chain clink.
- Providing mufflers and engine covers/screens where appropriate.
- Removing obstructions which may exacerbate vibration transmission (for example, old foundations) where appropriate, prior to piling operations.
- Providing cut-off trenches to interrupt the direct transmission path of vibrations between source and receptors where reasonable and safe to do so. Refer to British Standard BS 5228 Part 2:2008 for further details.
- Reducing energy per blow when piling (consider first whether this may result in prolonged exposure with no realised reduction in community disturbance).
- Restriction of vibratory roller size/type and piling method to maintain safe working distance.
- Restriction of vibratory roller operating mode (that is, static rolling only).

B.3.2 Blasting

Blasting mitigation and management procedures may include the following:

- Reducing the maximum instantaneous charge (MIC) by use of delays, reduced hole diameter, and/or deck loading.
- Ensuring adequate stemming and eliminating exposed detonating cord.
- Avoiding secondary blasting where possible; the use of rock breakers or drop hammers may be an acceptable alternative.
- Avoiding toe shots where appropriate.
- Avoiding blasting during heavy cloud cover or temperature inversions where possible.
- Avoiding blasting during strong winds blowing towards sensitive receptors.
- Establishing a blasting timetable through community consultation; for example, blasts times negotiated with surrounding sensitive receptors.

B.4 Transmission path

Transmission path mitigation and management procedures may include the following:

- Locating construction equipment in a position that provides the most acoustic shielding from buildings and topography.
- Scheduling construction of permanent acoustic barriers as early as possible (for example, mitigation provided by operational noise barriers may be of use during construction phase).
- Locating temporary noise barriers between the construction site and sensitive receptors. Temporary barriers may be constructed using soil stockpiles, shipping containers, and so on. The barriers should be positioned to limit gaps.

- Constructing temporary enclosures/screens around especially noisy activities, or clusters of noisy equipment (for example, loaded vinyl or plywood temporary acoustic barriers). Further guidance may be obtained in Australian Standard AS 2436-2010.
- Constructing an enclosure around significant points of construction activity (for example, tunnel portals). It is important that any ventilation is designed to ensure that it does not compromise transmission loss of the enclosure.

It should be noted that temporary acoustic barriers are not subject to MRTS15 requirements. If the acoustic barriers are to be permanent, then this specification shall apply.

B.5 Facility layout

Facility site layouts should be planned and include the following:

- Maximising acoustic shielding from existing topography and buildings and from structures and buildings associated with the facility (for example, storage units and temporary offices may be grouped together to form an effective acoustic barrier), for the nearest adjacent sensitive sites.
- Planning site entry and egress locations as per Appendix B Section B.2 of this Code.
- Mitigating plant and equipment as per Appendix B Section B.3 of this Code.
- Minimising reversing movements (and use of audible reversing alarms); for example, sites should be designed so that delivery vehicles can drive through the site and not be required to reverse. With asphalt plants and batch-plants, use drive-through loading bays, rather than backup loading.
- Considering the layout and orientation of individual items of plant and equipment to ensure that, where at all practicable, intake and exhaust vents from fans, blowers and other items of powered mechanical plant are orientated away from noise sensitive sites (that is, maximise use of ‘directivity’ effects).
- Avoiding onsite fabrication work where possible. The use of enclosures (for example, well-sealed shed) may be an alternative, but ventilation should be adequate and not degrade the acoustic performance of the enclosure.

B.6 Respite

Where all administrative and construction activity related control measures are implemented and noise and/or vibration impacts are unavoidable and significant, reasonable and practicable respite measures shall be used. The provision of respite periods involves scheduling work during periods when people are least affected to minimise exposure. Provision of respite periods shall follow consultation with the affected community and may include the following:

- Scheduling work when premises are not in operation (for example, commercial and educational facilities may not operate outside typical business hours).
- Restricting the number of nights per week that the works are undertaken near sensitive receivers.

- Restricting the number of continuous hours for construction noise or vibration intensive activities (restrictions should consider the overall duration of the project's activities for a given area).
- Restricting the work periods (that is, Standard hours vs Non-Standard hours) for which specific construction activities are allowed to operate. This would include providing curfews for activities/work methods (including plant and equipment items) that are particularly noise and/or vibration intensive (for example, concrete sawing, piling and so on). Such activities/plant items may warrant curfews to avoid their use during periods of sensitivity (for example, the nighttime period).

Careful consideration is required when scheduling respite periods as it may increase the overall duration of exposure due to additional mobilisation/demobilisation activities.

B.7 Temporary relocation and architectural treatment

Where noise and/or vibration impacts are unavoidable and significant after all administrative and construction activity related control measures and respite periods are implemented, reasonable and practicable temporary relocation and architectural treatment shall be used.

Temporary relocation involves the relocation of affected occupants for short periods of time. Examples of temporary relocation may involve the offer to affected occupants of an alternative activity or accommodation which is not impacted by construction noise and vibration. Alternative activity in the context of temporary relocation is the offer of an activity which would allow the occupants at a sensitive receptor to attend an alternative venue or place.

Architectural treatments may involve the provision of alternative ventilation and air conditioning where the windows and openings are to remain closed. However, the performance of the building envelope may be limited by specific elements (for example, windows and doors) and architectural treatments should primarily focus on those elements.

13 QGOV (13 74 68)
www.tmr.qld.gov.au | www.qld.gov.au