

Construction Noise Management Guideline for Major Transport Infrastructure Projects

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ABSTRACT

This paper presents an overview of the Queensland Department of Transport and Main Roads (TMR) draft Construction Management Code of Practice: Part 1 Noise 2010. The Guideline sets noise and airborne vibration limits for the contractor and provides guidance on source, pathway, and receptor noise control options. One of the biggest challenges facing urban roadway and tunnelling construction projects at present is the need to mitigate environmental noise and vibration impacts. The general approach adopted by this guideline is one of minimising overall disruption from road and tunnel construction operations. Disruption refers to effects on people, their activities, property and environment associated with road and tunnel construction activity and can occur as a result of works within the road reserve, materials processing at temporary fixed facilities, truck movement on off-site haul routes and effects on general traffic and utilities within the wider area. A two level hierarchy of controls is adopted - standard controls and project specific controls. The guideline's intent is to address noise and vibration pro-actively whenever possible; to anticipate and avoid creating undue noisy and undesirable vibration conditions, but also to allow proper mechanisms to control noisy conditions without sustaining costly claims from contractors.

INTRODUCTION

This paper has been prepared as a summary of a noise assessment guideline in the Construction Code of Practice Part 1: Noise [2] and is intended to reflect the intent of the revised Guideline. Part 2: Vibration Management [1] is the second component and will be prepared by Transport's and Main Roads Geotechnical Services and is presently in draft form and included as a reference only.

The general approach adopted by this guideline is one of minimising overall disruption from road construction operations. Disruption refers to effects on people, their activities, property and environment associated with road construction activity and can occur as a result of works within the road reserve, materials processing at temporary fixed facilities, truck movement on off-site haul routes and effects on general traffic and utilities within the wider area.

The guideline is applicable to the management of noise associated with construction and maintenance road work conducted by or on behalf of Queensland Department of Transport and Main Roads.

The guideline is applicable to:

- Road maintenance activities
- Construction, upgrade or demolition of road infrastructure. Figure 1 illustrates earth moving equipment used in construction of road infrastructure.
- Construction, maintenance or demolition of public utilities within the road reserve.

- Temporary fixed facilities established on a short term or semi-permanent basis to meet the specific requirements of a road construction or maintenance project.



Figure 1. Bottom dump scraper stripping soil and gravel
Source: (Alcoa 1982) [5]

Temporary fixed facilities include 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.

For the purpose of determining applicable noise and vibration criteria and controls, temporary fixed facilities are considered part of the road construction or maintenance activity, whether or not the facilities are located in the road reserve.

Noise and Airborne Vibration Sensitive Sites

For purposes of management of noise and airborne vibration from construction operations, noise and airborne vibration sensitive sites (or sensitive receptors) include any dwelling, hotel, hostel, caravan park or other temporary accommodation, hospital, medical clinic, school or other place of education, place of public worship, library, court of law, museum, dramatic arts centre or other community facility which requires relative quiet and minimal perceptible vibration in order to be utilised for its intended purpose.

Outdoor recreational facilities are not considered to be noise and airborne vibration sensitive sites but may be included as such on a project specific basis.

Critical Facilities, Infrastructure and Utilities

Specific assessments to determine appropriate noise and airborne vibration controls are required for these categories. Critical facilities include hospitals and research institutions, schools and Courts of Law while critical infrastructure and utilities includes dams, electrical and telecommunications facilities, oil and gas pipelines and other petrochemical installations and utilities such as water mains and sewers.

Activity and Equipment Categories

Construction plant and equipment are grouped into four broad categories in terms of their overall characteristics and potential for noise and airborne vibration impacts ranging from Category I (smaller hand held power tools) to Category IV (blasting, impact pile driving and other high energy processes).

Noise and Airborne Vibration Limits

Construction noise limits are set for temporary fixed facilities (which include sites such as depots, plant maintenance, batch plants, asphalt plants and other materials processing and handling sites), temporary fixed plant (mechanical plant or equipment for example, pumps, generators and compressors, ventilation or dust handling installations) required to operate at one site more or less continuously.

A two level hierarchy of controls is adopted - standard controls and project specific controls. Special management controls apply for short-term periodic road work carried out at night.

Permitted hours for blasting and for impact pile driving of ground stabilisation are specified together with acceptable noise and ground vibration limits in terms of dB (peak) Z weighting and peak particle velocity (mms^{-1}) for blasting and $L_{Aeq(5\text{ min})}$ and L_{Amax} for pile driving.

Noise limits are specified at 1m from the most exposed façade and for purposes of assessment from general construction activities, haul trucks or from pile-driving, the measured level is compared directly with this limit without any adjustment for particular audible characteristics (tonality or impulsiveness).

Sleep disturbance

For critical facilities and other noise sensitive sites with residential character, such as dwellings and short-term residential accommodation such as hotels, the relevant internal acoustic requirements during night time restricted hours are usually determined by sleep disturbance considerations.

The design ambient noise level for sleeping areas is used in establishing the relevant external noise limit. The design

ambient noise level for sleeping areas is the measured minimum ambient noise level in the particular sleeping area during the relevant hours of sleep or a minimum ambient level of 35 dB(A) L_{Aeq} , whichever is greater.

Depending on the type of construction activity and the particular details of the relevant building envelope, it may also be necessary to specify a limit on the maximum instantaneous noise level L_{Amax} .

NOISE MEASUREMENT

Noise Indices

The preferred sound pressure level index, for the purposes of assessment of ambient sound level and for purposes of monitoring noise from construction and maintenance operations, is the A-weighted equivalent continuous sound pressure level (denoted L_{Aeq}). This mean energy level is always associated with a specific time period for example 15 minutes, 1 hour, 9 hour night-time period or 24 hours. For certain purposes, measurement of the maximum instantaneous noise level, L_{Amax} is also required.

The sound pressure level index for the background noise level is the L_{A90} or that noise level exceeded for 90% of the selected time period. The background noise level is the minimum ambient level, in the absence of the noise source under investigation.

The background ambient noise level (denoted $L_{Aeq(bg)}$), at any particular measurement position and time, comprises the contribution to the measured ambient sound level, due to sources other than the noise source under investigation.

Noise measurements are generally conducted with a sound level meter set to A-frequency weighting and Fast (or F) time response.

Measurement positions

For the guideline, the preferred noise measurement position for assessment purposes is at 1m from the most exposed façade of the relevant noise sensitive building. The microphone height used is the greater of:

- 1.5m above any horizontally reflecting surface (ground or floor) or,
- that elevation above local ground level which corresponds to the height of the centre of the window on the relevant storey of the building.

If measurement is made in front of a window, the window is closed. Measurements may also be made at a "free-field" position, at a position in the plane of an open window of an affected building or from a position inside a room.

Time of measurement

Measurements are conducted at a time which is relevant to the particular noise source of interest and as far as practicable, coincide with the time at which disruption due to noise from an activity would be "worst case". The sample time utilised for noise measurement is sufficient to obtain a representative sample of the noise from the particular construction activity or other relevant noise source, however for purposes of compliance assessment the minimum period for measurement is 15 minutes.

Adjustments for particular audible characteristics

For purposes of assessment of noise from general construction and maintenance activities, haul trucks or from impact pile-driving, the measured noise level is compared

directly with the applicable noise limit without any adjustment for particular audible characteristics.

A noise limit means that level (either sound pressure level or sound power level) associated with a construction or maintenance operation, activity or item of plant which should not be exceeded. Noise limits may be established on a standard or project specific basis.

Two types of noise limit are utilised, the site noise limit and the equipment noise limit.

For purposes of assessment of noise from temporary fixed facilities (including operations of mobile plant at such facilities) and from temporary fixed plant, adjustments to the measured noise level $L_{Aeq(m)}$ to account for particular audible characteristics are made, where the noise:

- (a) contains perceptible tonal components (whistles, hums, screeches, ringing, buzzing)
- (b) contains perceptible impulsive components (bangs or thumps).

In either case, the adjustment is 5 dB(A) for each audible characteristic (that is, where both characteristics are present, a total adjustment of 10 dB(A) is made to the measured noise level.

These adjustments which, if present, tend to increase the intrusiveness of the noise are made to the measured noise level $L_{Aeq(m)}$ to obtain the adjusted measured level $L_{Aeq(adj)}$. It is this adjusted level which is compared to the noise limit to determine compliance.

Adjustments to the measured noise level, for particular audible characteristics, are not applicable to the measured maximum noise level L_{Amax} .

NOISE CONTROLS

General construction and maintenance activities

This means all construction and maintenance activities which are not directly concerned with blasting, impact pile-driving, transport of materials to and from a work site or with the operation of a temporary fixed facility or with temporary

fixed plant. A hydraulic excavator loading burden into a 77 tonne truck typical of general construction is shown in Figure 2.



Figure 2. Hydraulic excavator loading burden into 77 tonne truck

Source: (Griffin Coal 1982 [4])

Standard Hours

Standard controls

Specific noise limits are not required during standard working hours provided that:

- (a) the standard requirements for mechanical plant are maintained;
- (b) construction activity affecting any one noise sensitive receptor will not extend beyond two weeks;
- (c) the construction operation does not occur in the vicinity of a critical facility such as a hospital or school.

For Clause (b) where construction activity occurs for periods in excess of two weeks, standard noise limits $L_{Aeq(15\text{ minute})}$ as detailed in Table I apply.

However, for those areas where the existing average minimum background ambient noise level ($L_{Aeq(avbg)}$) during standard hours exceeds the standard noise limits, the noise limit is the existing ($L_{Aeq(avbg)}$) during standard hours.

Table 1. Standard Noise Limits – General Construction during Standard Working Hours ($L_{Aeq(15\text{ minute})}$)

General Construction during Standard working Hours		
Construction Noise Limit $L_{Aeq(15\text{ minute})}$, dB(A)	Duration of Activity	
	Medium Term	Long Term
		70

Source: (Construction Code, 2010)

Project Specific Controls

In all cases where construction operations would occur in the vicinity of a critical facility such as a hospital or a school, noise limits are set on a project specific basis.

Factors to be considered in setting such limits include:

- (a) the extent of noise reduction likely to be provided by the building envelope of the relevant building(s) or facility, and
- (b) the specific activities carried out within that facility.

For hospitals and related residential health care facilities, sleep disturbance considerations may be relevant.

Where commercial premises such as restaurants, cafes, hotels and other eating places (particularly outdoor) are affected by construction noise, noise limits or hours of operation may be

varied in order to minimise disruption to normal trade during defined busy times of the day.

Similar considerations apply where construction noise would affect a place of worship during normal times of service.

Restricted Hours

Standard Controls

General Activities

For operations during restricted hours, noise limits will normally be required where the operation will affect residential or other noise sensitive sites.

The standard noise limits for restricted hours are given in Table II.

Table II. Standard Noise Limits – General Construction during Restricted Hours ($L_{Aeq,(15\text{ minute})}$)

Time Period	General construction activities during restricted hours		
	$L_{Aeq,(15\text{ minute})}$ dB(A)		
	Duration of Activity		
	Short term	Medium term	Long term
Daytime restricted hours	65	60	55
Evening period, 6.00pm to 10.00pm, on any day	60	55	50
Late night/early morning period: 10.00pm to 7.00am, on any day.	45	45	45

Source: (Construction Code, 2010)

Restricted hours means the period between 6.00pm and 7.00am Monday to Friday and 1.00pm to 12.00 midnight Saturday and at any time on a Sunday or a Public Holiday. Standard working hours allow noise limits 10 dB(A) greater than those presented in Table II for medium to long term activities. However, for those areas where the existing average minimum background ambient noise level ($L_{Aeq(avbg)}$) during restricted hours exceeds the standard noise limits, the noise limit is the existing ($L_{Aeq(avbg)}$) during the relevant time period in restricted hours.

Short term construction and maintenance activities are those which would affect any one noise or vibration sensitive site for up to 14 days, medium term for more than 14 days and up to 20 weeks while long term activities exceed 20 weeks but less than 18 months.

Short term Periodic Night work

Maintenance road works carried out during night-time restricted hours, on a short-term periodic basis, (i.e. maintenance road works carried out on a major arterial road, where activities would not affect any one site for more than two consecutive nights in any seven day period) are not subject to the standard noise limits for restricted hours.

In all cases where short-term periodic night work is to be undertaken, notification must be given to those adjacent residents and property owners likely to be affected by noise from the activity. Such notification must state:

- the reason for the activity;
- types of equipment required;
- the expected hours of operation;
- the likely duration 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 the above items, in particular to hours of operation or to the likely duration of operation, affected residents and property owners must be notified.

These requirements are additional to any separate community engagement procedures adopted at an overall project level.

IMPACT PILE-DRIVING

Impact pile-driving means pile-driving by sinking or driving a pile by direct or indirect hammering or impact. It includes pile-driving by means 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. Figure 3 presents an impact pile-driving device.

ICA 2010

Activities relate to ground stabilisation methods and include specifically, dynamic compaction, rapid impact compaction, impact placement of stone columns or other ground stabilisation by use of equipment normally or typically utilised for impact pile-driving.



Figure 3. Impact pile driver

Source: (Cedric 1982)

Noise Controls

Standard Controls

Impact pile-driving is generally not permitted outside standard working hours. However, in exceptional cases, with sufficient justification and subject to detailed assessment, impact pile-driving may be permitted during extended hours on Saturday.

For operations during the above hours, where the noise from the activity is received at a noise sensitive receiver (including the occupants of commercial buildings), the standard noise limits for impact pile-driving, are as presented in Table III.

Table III. Standard Noise Limits – Noise from Impact Pile-driving ($L_{Aeq,(5\text{ minute})}$)

Noise Sensitive Building Type	($L_{Aeq,(5\text{ minutes})}$) dB(A)
(a) Noise sensitive building of masonry or concrete construction with no windows or other openings on those facades of the building potentially affected by noise from impact pile-driving	100
(b) Noise sensitive building of masonry or concrete construction with central air-conditioning system	90
(c) Naturally ventilated, noise sensitive building of masonry or concrete construction with windows or other openings on those facades of the building potentially affected by noise from impact pile-driving	85
(d) Naturally ventilated, noise sensitive buildings of light-weight construction.	75

Source: (Construction Code, 2010)

As an alternative to a reduction in hours, it may be possible to reduce noise levels to the required limit by:

- provision of additional noise control for the proposed piling rig;
- substitution of a quieter piling rig;
- where geotechnical and other conditions permit (including potential vibration impacts), substitution of a quieter piling system may also be considered.

In the situation that the relevant standard noise limit for impact pile-driving cannot be met at the adjacent noise sensitive sites, the permitted hours for impact-piling using the proposed piling equipment can be reduced.

For weekdays and Saturday operations, permitted hours of operation are reduced in accordance with the relative degree of exceedance of the relevant standard noise limit.

HAUL ROUTES AND TEMPORARY FIXED FACILITIES

The basic approach to selection of haul routes and temporary fixed facilities sites should be to maintain the greatest possible separation between these project types and residential and other noise sensitive facilities. A method is included in the guideline to rank available options for haul routes and access points by identifying the number of noise and vibration sensitive receivers within a distance of 300m of each haul-route option to which an equivalent receptor number is assigned. Each sensitive site is then assigned to a receptor zone and given a zonal rating factor. A haul route receptor rating for each route option is determined. The higher the rating, the greater the potential for noise and vibration impacts and the lower the option's ranking in terms of suitability as a haul route.

Construction traffic should be routed via arterial and other major roads to the maximum extent possible. Project planning must ensure that haul routes avoid use of secondary and local residential streets wherever it is practically possible to do so.

Temporary fixed facilities should not be located in the near vicinity of educational, medical or other critical facilities. Where at all practicable, these facilities should be located at sites that are remote from residential or other sensitive areas; for urban areas, sites located in industrial areas are preferable in all cases.

SCREENING PROCEDURES

A comprehensive section is devoted to noise screening procedures for:

- General construction and maintenance activities
- Impact pile-driving and related activities
- Haul routes, and
- Temporary fixed plant

Screening procedures are intended to assist in identifying those projects or activities within a project, where noise impact should be assessed at a detailed level. Where screening indicates that noise issues are not significant, further noise assessment is not required and the standard controls will apply, otherwise detailed assessment is required.

AIRBORNE VIBRATION

When of sufficient amplitude, sound can result in vibration in light-weight panels and fittings within buildings. Sound associated with such vibration is typically low frequency and can be in the audible or in the sub-audible frequency ranges; the latter is referred to as infra-sound. Depending on the frequency and level, persons exposed to such low frequency airborne vibration may hear the disturbance as sound or may 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 at the level of a direct sensation, but may be noticed in terms of "rattles" or other similar high frequency noise associated with the induced vibrations of a light-weight building element such as a window or door.

Another form of airborne vibration is construction blasting. The standard limit for airblast overpressure is 115 dB(Z) peak externally. This applies at noise sensitive receptors potentially affected by overpressure from the construction blasting. Figure 4 illustrates construction blasting at a quarry. This limit is adopted on the basis of the consideration of minimising discomfort to persons.



Figure 4. Construction blasting
Source: (Cedric 1982)

Where noise sensitive receivers are not present and where there is a need to ensure that structural damage is not caused, a limit of 133 dB(Z) peak would apply at the nearest structures.

Appendix D of the guideline provides details of measurement procedures which will be required in those cases where for the purposes of a particular project, assessment is required inside buildings. Details of indoor noise level criteria for airborne and ground-borne noise are discussed.

CONCLUSIONS

One of the biggest challenges facing urban roadway and tunnelling construction projects at present is the need to mitigate environmental noise and vibration impacts.

This paper presents an overview of the Construction Code of Practice: Part 1 Noise 2010. The Guideline sets noise and airborne vibration limits for the contractor and provides guidance on source, pathway, and receptor noise control options. The guideline's intent is to address noise and airborne vibration pro-actively whenever possible; to anticipate and avoid creating undue noisy and undesirable vibration conditions, but also to allow proper mechanisms to control noisy conditions without sustaining costly claims from the contractors.

The affected community needs to be actively involved and informed regarding noise and vibration producing operations and proposed noise/vibration mitigation measures.

A 24 hour a day hotline must be available to receive and act upon noise/vibration complaints.

Through these key measures and by consistently implementing the specifications and strategies of a comprehensive noise control program as described in the guideline, construction noise and airborne vibration can be successfully managed both physically and politically on a large scale urban construction project.

REFERENCES

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