

15 Vibration

15.1 Introduction

Vibration effects may cause concern to some residents, primarily during the construction phase of the proposed Northern Expressway. DTEI is committed to minimising the potential for vibration effects on the community.

15.2 Vibration assessment

The effects of vibration can vary according to a number of factors including: the magnitude of the vibration source, the particular ground conditions between the source and receiver, the foundation-to-footing interaction and the large range of structures that exist in terms of design (e.g. dimensions, materials, type and quality of construction, and footing conditions). The intensity, duration, frequency and number of occurrences of a vibration all play an important role in both the annoyance levels caused and the strains induced in structures.

Sources of ground vibration include pile drivers, bulldozers (ripping), hydraulic rock breakers and vibratory rollers during road construction and bridge work.

Vibration generated from construction activities is characteristically greater in magnitude than that generated from operational road traffic post-construction of the road. This is particularly the case with a road surface in good condition where there are no potholes or significant irregularities in the road surface.

Groundborne vibration from traffic on arterial roads is not normally of a level that affects residents or buildings and is commonly confused with high levels of low frequency airborne noise.

Ground vibration effects may:

- disturb occupants of buildings – vibration in which the occupants or users of the building are inconvenienced or possibly disturbed (human exposure)
- disturb contents of buildings – vibration where the building contents may be affected (i.e. rattling, shaking or movements)
- affect structural integrity of the building – vibration in which the integrity of the building or structure itself may be compromised.

Table 15.1 provides an indication of the approximate vibration levels that may be expected for various vibration sources.

Vibration measurements were undertaken along Port Wakefield Road in January 2007, in the Globe Derby Park area. The measurements were undertaken adjacent to smooth and rough sections of the asphalt surface, at distances of 10 m and 20 m from the edge of the carriageway where current traffic volumes are higher than those expected on the Northern Expressway.

The vibration measurements ranged in magnitude from 0.02 to 0.3 mm/s. Note that these vibration levels are indicative only as the transfer of vibration from the ground to the building foundation and other building elements is variable; however, the vibration level is not expected to vary significantly.

Table 15.1

Approximate generated vibration levels for various sources

| Activity | Typical levels of ground vibration |
|---|--|
| Vibratory rollers | Up to 1.5 mm/s at distances of 25 m Higher levels could occur at closer distances; however, no damage would be expected for any building at distances greater than approximately 12 m (for a medium to heavy roller) |
| Hydraulic rock breakers (levels typical of a large rock breaker operating in hard sandstone) | 4.50 mm/s at 5 m 1.30 mm/s at 10 m 0.4 mm/s at 20 m 0.10 mm/s at 50 m |
| Compactor | 20 mm/s at distances of approximately 5 m, 2 mm/s at distances of 15 m. At distances greater than 30 m, vibration is usually below 0.3 mm/s |
| Pile driving/removal | 1 to 3 mm/s at distances of 25 m to 50 m depending on soil conditions and the energy of the pile driving hammer These levels are well below the threshold of any possibility of damage to structures in the vicinity of these works. At closer distances to the piling operations, some compaction of loose fill would occur due to vibratory effects |
| Bulldozers | 1 to 2 mm/s at distances of approximately 5 m. At distances greater than 20 m, vibration is usually below 0.2 mm/s |
| Air track drill | 4 to 5 mm/s at a distance of approximately 5 m, and 1.5 mm/s at 10 m. At distances greater than 25 m, vibration is usually below 0.6 mm/s, and at 50 m or more, vibration is usually below 0.1 mm/s |
| Truck traffic (over normal (smooth) road surfaces) | 0.01 to 0.2 mm/s at the footings of buildings located 10 to 20 m from a roadway |
| Truck traffic (over irregular surfaces) | 0.1 to 2.0 mm/s at the footings of buildings located 10 m to 20 m from a roadway |

15.3 Effects of vibration

15.3.1 Categories of ground vibration

As identified above, the effects of ground vibration are classified into three categories being human exposure, building contents and building structures.

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

Human exposure

Table 15.2 gives an indication of typical human perception of vibration.

Table 15.2

Vibration and human perception of motion

| Approximate vibration level (mm/s) | Degree of perception |
|---------------------------------------|-------------------------|
| 0.10 | Not felt |
| 0.15 | Threshold of perception |
| 0.35 | Barely noticeable |
| 1.0 | Noticeable |
| 2.2 | Easily noticeable |
| 6.0 | Strongly noticeable |

Note: The approximate vibrations (in floors of buildings) are for vibration having frequency content in the range of 8 Hz to 80 Hz.

The Australian Standard AS 2670.2–1990: Evaluation of human exposure to whole-body vibration, Part 2: Continuous and shock induced vibration in buildings has been adopted as the relevant standard for nuisance vibration levels. The standard provides a collection of curves that specify acceptable vibration levels, at each frequency, for different circumstances.

Residents nearest to roadworks (i.e. <75 m), particularly during vibratory compaction of earthworks, may perceive vibrations although for a relatively short period considering the mobile nature of earthworks plant. Resident perception of vibration is accompanied typically by concerns of structural damage, thus increasing annoyance levels.

Vibration effects on building contents

Typical ground vibration from road and bridge construction activities occurs in the frequency range of approximately 8 Hz to 100 Hz. Within this frequency range, building contents such as blinds and pictures would commence visible movement at 0.5 mm/s. At vibration levels higher than 0.9 mm/s, rattling of windows, crockery or loose objects would be audible and annoying.

Given the proximity of residential buildings adjacent to the proposed Northern Expressway alignment, this vibration symptom is not likely to occur for the majority of residents.

Structural damage to buildings

There is no Australian Standard currently for assessment of building damage caused by vibrational energy. However, the British Standard 7385: Part 2 1993: Evaluation and measurement for vibration in buildings can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur. Further to this, the German Standard DIN 4150 – Part 3: Structural vibration in buildings – effects on structures, also provides recommended maximum levels of vibration to reduce the likelihood of building damage caused by vibration.

Table 15.1 shows that the highest levels of vibration are generated by compactors, vibratory rollers and pile driving. In most cases, the generated vibration levels are too low in magnitude for the likelihood of structural damage to occur for buildings greater than 25 m from the construction activity.

Given the proximity of residential buildings adjacent to the proposed Northern Expressway alignment, structural damage is not probable.

15.4 Vibration management

15.4.1 Measures to minimise effects during construction

A detailed vibration management plan will be developed prior to construction outlining the vibration mitigation measures to be implemented. Mitigation will most likely include the following actions:

- vibration monitoring at selected residences less than 25 m from construction activities
- regular community (or affected residents') updates advising when and where construction activities may generate perceptible levels of vibration
- minimisation of piling energy (i.e. reduced hammer drop distance) as necessary depending upon receptor distance
- establishing a complaints hotline and implementing a procedure to effectively deal with any issues raised by the community.

15.4.2 Building condition inspection

The vibration resulting from some construction activities (such as pile driving, excavation by hammering or ripping, dynamic compaction or demolition of structures) may cause damage to nearby public utilities, structures, buildings and their contents. If these are located in the vicinity of the construction activity as specified in Table 15.3, a building condition inspection may be undertaken before construction. The outcome of the building condition inspection will be a Dilapidation Report.

Table 15.3

Distance from construction activity for building condition inspection

| Activity | Distance |
|--------------------------|--------------------|
| Pile driving | 100 m |
| Vibration compaction | > 7 t plant – 50 m |
| Vibration compaction | < 7 t plant – 25 m |
| Demolition of structures | 50 m |