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Aircraft Noise Intrusion Assessment

17 Marion Street, Leichhardt 2040

Annesley House

Report Number 610.16528

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Uniting Care c/o City Plan Services
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1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Uniting Care c/o City Plan Services to undertake an Aircraft Noise Intrusion Assessment at 17 Marion Street, Leichhardt (the site), where a 5-storey seniors housing redevelopment is proposed. The purpose of this noise assessment is to satisfy the requirements of clause 6.8 in Leichhardt LEP 2013 so that the site can be rezoned, and following approval be assessed for subsequent DA approval.

This aircraft noise assessment includes noise level predictions from aircraft traffic arriving and departing to and from Sydney Airport in accordance with the procedures and criteria prescribed in *AS 2021:2015 Aircraft Noise Intrusion – Building Siting and Construction* which supersedes *AS 2021:2000* (that which the Leichhardt LEP 2013 refers to), and subsequently establishes in-principle acoustic design recommendations. This report only addresses the assessment of aircraft noise impacts. Other design considerations with respect to DA assessments such as those discussed in the National Construction Code (NCC) are not included in this report.

A glossary of the acoustical terminology used throughout this report is contained within **Appendix A**.

2 SITE DESCRIPTION

The site currently operates as a 3-storey nursing home under the same name – Annesley House. The proposed Annesley House seniors housing redevelopment comprises a basement carpark and 20 apartments spread over 5 floors.

The project site lies north of the Main North-South runway at Sydney Airport as shown in **Figure 1**.

Figure 1 Project Site Location

Images courtesy of Nearmap

3 ASSESSMENT CRITERIA

3.1 Leichhardt LEP 2013 Clause 6.8

Development in areas subject to aircraft noise

1. The objectives of this clause are as follows:

    a) to prevent certain noise sensitive developments from being located near the Sydney (Kingsford Smith) Airport and its flight paths.

    b) to assist in minimising the impact of aircraft noise from that airport and its flight paths by requiring appropriate noise attenuation measures in noise sensitive buildings.

    c) to ensure that land use and development in the vicinity of that airport do not hinder or have any other adverse impacts on the ongoing, safe and efficient operation of that airport.

2. This clause applies to development that:

    a) is on land that:

        i) is near the Sydney (Kingsford Smith) Airport, and

        ii) is in the ANEF contour of 20 or greater, and

    b) the consent authority considers it likely to be adversely affected by aircraft noise.

3. Before determining a development application for development to which this clause applies, the consent authority:

    a) must consider whether the development will result in an increase in the number of dwellings or people affected by aircraft noise, and

    b) must consider the location of the development in relation to the criteria set out in Table 2.1 (Building Site Acceptability Based on ANEF Zones) in AS 2021-2000, and

    c) must be satisfied the development will meet the indoor design sound levels shown in Table 3.3 (Indoor Design Sound Levels for Determination of Aircraft Noise Reduction) in AS 2021-2000.

3.2 AS 2021:2015 Aircraft Noise Intrusion Procedure

AS 2021:2015 ranks sites as "unacceptable", "conditionally acceptable" or "acceptable" developments based on the site location relative to the ANEF (Australian Noise Exposure Forecast) contours. Sites located between the ANEF 20 and ANEF 25 contours are classified acceptable conditional on the residence being designed to control noise from aircraft to indoors.

For conditionally acceptable sites, it is then required that the aircraft noise level at the site be determined. The aircraft noise level can be found using tables of aircraft noise data provided in the Standard, and taking into consideration the distance of the site from the closest end of the nearest runway (DS), the distance from the furthest end of the nearest runway (DT) and the distance to a projection of the flight path on the ground (DL).

The aircraft noise reduction (**ANR**), that the is the level of sound attenuation provided by the building envelope, is determined for the site based on the identified external aircraft noise level and the indoor design noise levels (given later in this report). Procedures for determining the necessary acoustic rating, expressed as a Weighted Sound Reduction Index (**R**w), of individual building elements are also included in the Standard. Calculations take into consideration room size, the area of each façade element, the orientation of the façade with respect to noise from the runway and room use.

The project site is shown in **Figure 2**.

Figure 2 Australian Noise Exposure Forecast (ANEF) 2033

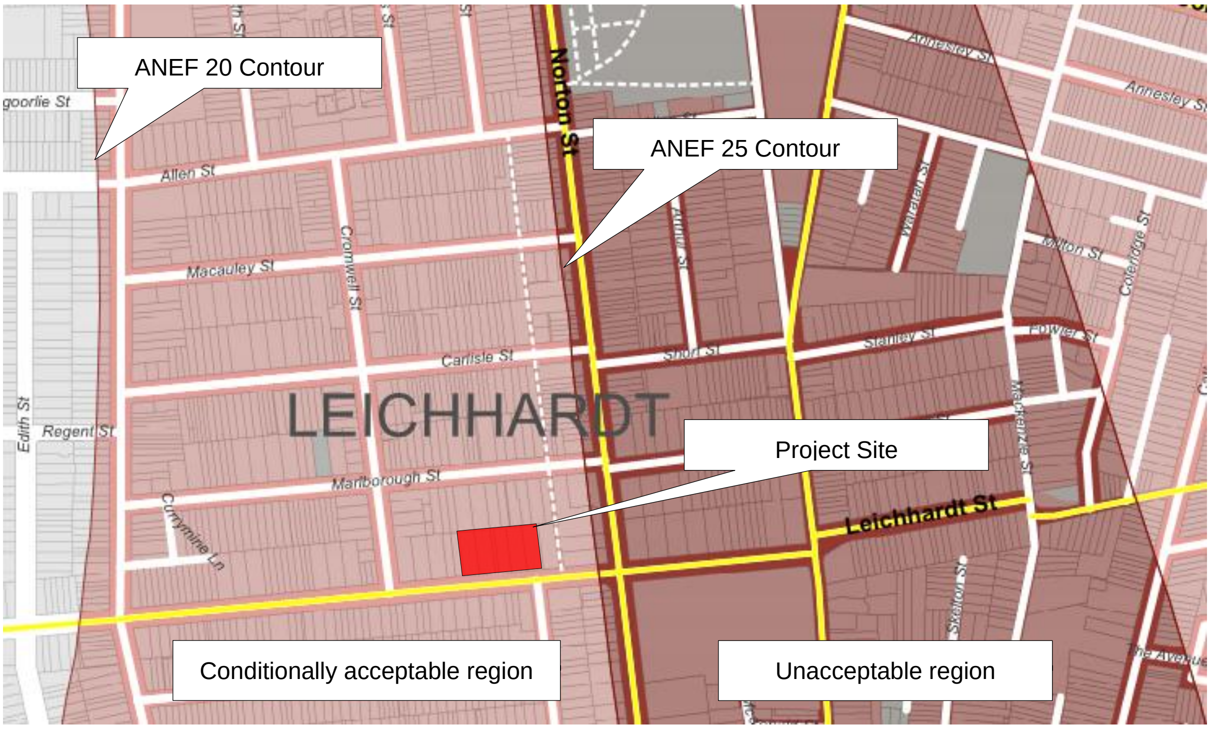


Image courtesy of Leichhardt Municipal Council

From **Figure 2** it can be seen that the development site is between ANEF 20 and ANEF 25 contours, north of the flight path of aircraft using the main north south runway. As such, the site is acceptable for residential development provided that an assessment of aircraft noise is made in accordance with the Standard.

3.3 Maximum Internal Noise Levels due to Aircraft Noise Intrusion

Recommended indoor design sound levels (effective maximum levels) for various areas of occupancy are provided in Table 3.3 of *AS 2021:2015*. The appropriate sound levels for this development are presented in **Table 1**.

Table 1 Indoor Design Sound Levels

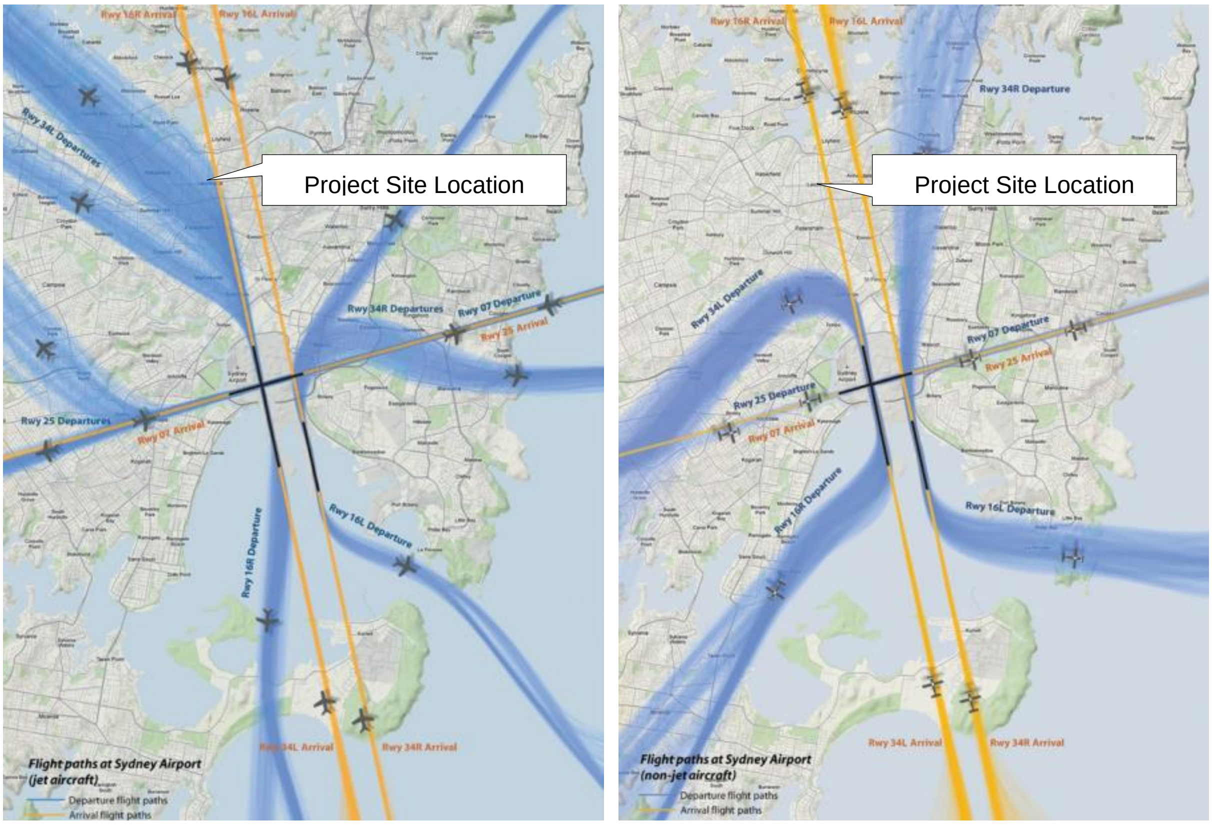
Occupancy Type	Area of Occupancy	Indoor Design Sound Level[1]
Nursing home / Home units	Sleeping areas, wards, consulting rooms	50 dBA
	Other habitable spaces	55 dBA
	Bathrooms, toilets, laundries, wet rooms	60 dBA

Note 1 The indoor design sound levels are hypothesised values based on Australian experience. A design level is the maximum level (dBA ‘slow’ speed rectification) from an aircraft flyover which, when heard inside a building by the average listener, will be judged as not intrusive or annoying by that listener while carrying out a specified activity.

4 EXISTING AIRCRAFT ACOUSTICAL ENVIRONMENT

The project site lies approximately 5,350 m, 6,650 m and 8,200 m north of the Main North-South, East-West and Parallel North-South runways at Sydney Airport respectively. Arrival and departure jet aircraft and non-jet aircraft flight paths to and from Sydney Airport are shown in **Figure 3**.

Figure 3 Flight Path Maps of Sydney Airport (Jet Aircraft and Non-jet Aircraft respectively)



Images courtesy of Sydney Airport Master Plan 2033

Reference to the flight path maps above indicates that the project site is mostly affected by arrivals and departures on the Main North-South runway. For both of these flight paths, calculations as stipulated in *AS 2021:2015* have been performed to predict the noise emissions from aircraft flyovers. A land height correction of 40 m has been applied to account for the difference in elevation between the project site and Sydney Airport.

In accordance with the methods provided in *AS 2021-2015*, distance coordinates for the site relative to the two Sydney Airport flight paths have been determined. Results are presented in **Table 2** below.

Table 2 Distance Coordinates for 17 Marion Street, Leichhardt

Runway	Distance coordinate (inc. Elevation Adjustment)		
	DS	**DL**	**DT**
Main North -South runway 16R Arrival flight path	330 m	5,500 m	9,200 m
Main North -South runway 34R Departure flight path	1,400 m	4,860 m	8,260 m

The calculations revealed that the loudest charted aircraft with considerations to the distance coordinates above, a Boeing 747-400, was predicted to contribute maximum noise levels of **80 dBA** and **70 dBA** ('Slow' speed rectification) to the project site from the 16R arrival and 34L departure flight paths respectively. For conservativeness in this assessment, maximum noise levels are herein assumed to be those predicted for from a Boeing 747-400 (**80 dBA**).

The aircraft noise level is an average maximum level and it should be recognized that a percentage of aircraft movements may produce noise that exceeds the derived level. Higher noise levels are possible from curved flight paths and variations in altitude resulting in aircraft directly over the site.

5 ATTENDED AIRCRAFT NOISE MEASUREMENTS

To further quantify predictions undertaken in accordance with the standard, short-term attended noise measurements were conducted on Friday 12 August 2016 at the location shown in **Table 3**.

Instrumentation for the survey comprised one Brüel & Kjær 2260 sound level meter (Serial No. 2115053), fitted with a microphone windshield. Calibration of the sound level meter was checked prior to and following measurements. Drift in calibration did not exceed ± 0.5 dB. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates. Measurements were conducted in accordance with AS 1055.1-1997: *"Acoustics - Description and measurement of environmental noise - General procedures"*.

The maximum measured aircraft noise level of **80 dBA** ('Slow' speed rectification) was attributed to a Boeing 747-400 on the 16R arrival flight path. This result correlates with the predicted level derived using *AS 2021-2015.*

5.1 Aircraft Noise Reduction

The indoor design sound levels in **Table 1** have been used to derive the aircraft noise reduction (ANR), in dBA, to be incorporated in the building's envelope. **Table 3** presents the required ANR for this development.

Table 3 Aircraft Noise Reduction

Occupancy Type	Area of Occupancy	Aircraft Noise Reduction
Nursing Home / Home units	Sleeping areas, wards, consulting rooms	30 dBA
	Other habitable spaces	25 dBA
	Bathrooms, toilets, laundries, wet rooms	20 dBA

5.2 Alternative Ventilation Requirements

The internal design sound levels and the ANR derived from the above levels assume that the windows and external entry doors are closed. As it is necessary for the windows and doors to remain closed to comply with *AS 2021:2015*, ventilation approved by Leichhardt Municipal Council and in accordance with relevant regulations such as the Building Code of Australia will need to be installed.

When specified, the ventilation system will require review from an acoustic consultant such that the design does not adversely affect the amenity of nearby sensitive receivers or compromise the acoustic integrity of the building envelope construction recommended in this report.

5.3 Noise Insulation Requirements

The calculation procedure in *AS 2021:2015* establishes the required noise insulation performance of each building envelope component so that the internal noise level is achieved whilst an equal contribution of aircraft noise energy is distributed across each component. Thus, building envelope components with a greater surface area must offer greater noise insulation performance.

As the project is seeking the site to be re-zoned, detailed design of the façade envelope has not been undertaken. Preliminary designs (Young + Metcalf Architects: SK01 Rev: A) showing indicative site arrangements have been used for the purposes of this acoustic assessment. All recommendations made within this report will need to be verified following completion of the detailed design layouts.

Typical noise reduction of each component of the building is presented as a Weighted Sound Reduction Index (Rw) rating in decibels shown in **Table 4** and **Table 5**. These Rw values are only intended as a preliminary indication of the acoustic performance requirements of the main components of the building envelope.

A range of Rw values for each building element has been provided in **Table 4** and **Table 5**. The range represents the highest and typical Rw for a given element and is dependent on the size and orientation of the particular area of occupancy for each façade. These are intended to be used as a guide as to the acoustical requirements which will need to be consider for a given facade during DA design.

Table 4 Acoustic Rating (Rw) for External Building Components – Levels 1-4 with rooms above

	Area of Occupancy	Wall	Glazing	Roof / Ceiling
North Facades				
Nursing Home	Sleeping areas, wards, consulting rooms	46-51	33	n/a
	Other habitable spaces	34-43	29-33	n/a
	Bathrooms, toilets, laundries, wet rooms	33-42	n/a	n/a
East Facades				
Nursing Home	Sleeping areas, wards, consulting rooms	45	33	n/a
	Other habitable spaces	n/a[1]	n/a[1]	n/a
	Bathrooms, toilets, laundries, wet rooms	33-42	n/a	n/a
South Facades				
Nursing Home	Sleeping areas, wards, consulting rooms	45-46	33-36	n/a
	Other habitable spaces	53	28	n/a
	Bathrooms, toilets, laundries, wet rooms	33-42	n/a	n/a
West Facades				
Nursing Home	Sleeping areas, wards, consulting rooms	44	32	n/a
	Other habitable spaces	53	28	n/a
	Bathrooms, toilets, laundries, wet rooms	33-42	n/a	n/a

Note 1: Architectural layouts do not differentiate between sleeping rooms and living rooms at this preliminary stage

Table 5 Acoustic Rating (Rw) for External Building Components – Levels 4-5 without rooms above

	Area of Occupancy	Wall	Glazing	Roof / Ceiling
North Facades				
Nursing Home	Sleeping areas, wards, consulting rooms	49-53	39-41	44
	Other habitable spaces	39-47	30-36	38-39
	Bathrooms, toilets, laundries, wet rooms	42	n/a	34
East Facades				
Nursing Home	Sleeping areas, wards, consulting rooms	47-53	36	44
	Other habitable spaces	44	35	39
	Bathrooms, toilets, laundries, wet rooms	42	n/a	34
South Facades				
Nursing Home	Sleeping areas, wards, consulting rooms	47-48	37-38	44
	Other habitable spaces	42-47	32-35	39
	Bathrooms, toilets, laundries, wet rooms	42	n/a	34
West Facades				
Nursing Home	Sleeping areas, wards, consulting rooms	42-53	31-41	44
	Other habitable spaces	46-47	35-36	39
	Bathrooms, toilets, laundries, wet rooms	42	n/a	34

6 SUMMARY

An assessment of aircraft noise at 17 Marion Street, Leichhardt for the Annesley House redevelopment site has been carried out in accordance with AS 2021:2015 for the purpose of evaluating the site for re-zoning purposes. The maximum level of aircraft noise predicted at the proposed residence is **80 dBA**. Preliminary façade Rw values based on concept site layouts (Young + Metcalf Architects: SK01 Rev: A) have been provided in **Table 4** and **Table 5**. It is essential that the Acoustic Ratings (Rw) presented in this report are reviewed during detailed design of the project.

Based upon the findings of this assessment, the development as proposed appears satisfactory in terms of its general planning arrangement.

1 Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2 x 10^{-5} Pa.

2 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

3 Sound Power Level

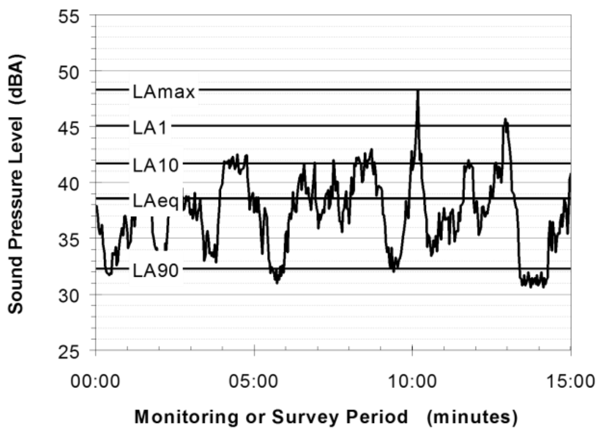
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

L_{Aeq} The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the 'repeatable minimum' L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or 'average' levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than 'broad band' noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

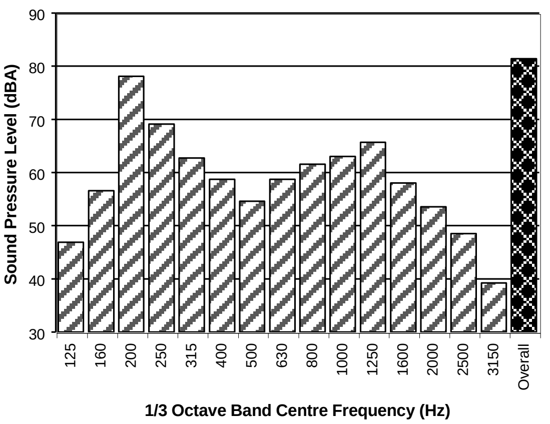
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/V_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

9 Human Perception of Vibration

People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

10 Over-Pressure

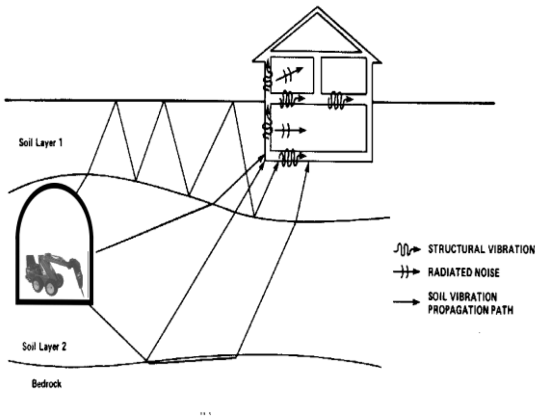
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise