

APPENDIX 11.1

INTRODUCTION TO NOISE AND VIBRATION

Appendix 11.1: Introduction to Noise and Vibration

Noise is defined as unwanted sound. The human ear is able to respond to sound in the frequency range 18Hz (deep bass) to 18,000Hz (high treble) and over the audible range of 0dB (the threshold of perception) to 140dB (the onset of pain). The ear does not respond equally to different frequencies of the same magnitude, but is more responsive to mid-frequencies than to lower or higher frequencies. To quantify noise in a manner that approximates the response of the human ear, a weighting (filtering) mechanism is used. This reduces the importance of lower and higher frequencies, approximating the response of the human ear.

Furthermore, the perception of noise may be determined by a number of other factors, which may not necessarily be acoustic. Noise can be perceived to be louder or more noticeable if the source of the noise is observed; e.g. roads, trains, factories, building sites etc. In general, the impact of noise depends upon its level, the margin by which it exceeds the background level, its character and its variation over a given period of time. In some cases, the time of day and other acoustic features such as tonality may be important, as may the disposition of the affected individual. Any assessment of noise should give due consideration to all of these factors when assessing the significance of a noise source. Various noise indices have been derived to describe the fluctuation of noise levels that vary over time. Usually, these noise indices relate to specific types of noise, and as such different noise indices are used to describe road traffic noise, background noise, construction noise, etc.

The weighting mechanism that best corresponds to the response of the human ear is the 'A'-weighting scale. This is widely used for environmental noise measurement and the levels are denoted as dB(A) or L_{Aeq} , L_{A10} , etc, according to the parameter being measured.

Noise is measured on the decibel scale, which is logarithmic rather than linear. As a result of this, a 3dB increase in sound level represents a doubling of the sound energy present. Judgement of sound is subjective, but as a general guide a 10dB(A) increase can be taken to represent a doubling of loudness, whilst an increase in the order of 3dB(A) is generally regarded as the minimum difference needed to perceive a change.

Table A11.1.1 sets out examples of noise levels typically experienced during everyday activities.

Table A11.1.1: Typical sound levels found in the environment

| Sound Level | Location |
|-----------------|-------------------------------|
| 0 to 10dB(A) | Threshold of hearing |
| 10 to 20dB(A) | Broadcasting studio |
| 20 to 30dB(A) | Quiet bedroom at night |
| 30 to 40dB(A) | Living room during the day |
| 40 to 50dB(A) | Typical office |
| 50 to 60dB(A) | Inside a car |
| 60 to 70dB(A) | Typical high street |
| 70 to 90dB(A) | Inside a factory or noisy pub |
| 100 to 110dB(A) | Burglar Alarm at 1m |
| 110 to 130dB(A) | Pneumatic drill at 1m away |
| 140dB(A) | Threshold of Pain |

Vibration is defined as a repetitive oscillatory motion. Groundborne vibration can be transmitted to the human body through the supporting surfaces; the feet of a standing person, the buttocks, back and feet of a seated person or the supporting area of a recumbent person. In most

situations, entry into the human body will be through the supporting ground or through the supporting floors of a building. Vibration from road traffic can also be airborne. Such airborne vibration is transmitted as a low-frequency sound wave and is often perceived when the sound wave causes windows or other objects to rattle.

Vibration is often complex, containing many frequencies, occurring in many directions and changing over time. There are many factors that influence human response to vibration. Physical factors include vibration magnitude, vibration frequency, vibration axis, duration, point of entry into the human body and posture of the human body. Other factors include the exposed persons experience, expectation, arousal and activity.

Experience shows that disturbance or annoyance from vibration in residential situations is likely to arise when the magnitude of vibration is only slightly in excess of the threshold of perception.

The threshold of perception depends on the frequency of vibration. The human body is most sensitive to vibration in the frequency range 1 to 80Hz and especially sensitive to vibration in the range 4 to 8Hz. As with noise, a frequency weighting mechanism is used to quantify vibration in a way that best corresponds to the frequency response of the human body. In general, vibration is only perceptible in residential situations when the building is close to a railway, construction Site or very close to a road that carries large and heavy vehicles

Table A11.1.2: Glossary terms for Noise Chapter

| Term | Description |
|------------------------------------|--|
| CRTN | Calculation of Road Traffic Noise |
| DMRB | Design Manual for Roads and Bridges |
| BS | British Standard |
| HGV | Heavy goods vehicle |
| WHO | World Health Organisation |
| Sound Pressure | Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure. |
| Sound Pressure Level (Sound Level) | The sound level is the sound pressure relative to a standard reference pressure of 20µPa (20x10 ⁻⁶ Pascals) on a decibel scale. |
| Decibel (dB) | A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s_1 and s_2 is given by $20 \log_{10} (s_1/s_2)$. The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20µPa. |
| A-weighting, dB(A) | The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear at some frequencies. |
| Noise Level Indices | Noise levels usually fluctuate over time, so it is often necessary to consider an average or statistical noise level. This can be done in several ways, so a number of different noise indices have been defined, according to how the averaging or statistics are carried out. |
| L_w | The L_w , or sound power level, is a measure of the total noise energy of a source. |
| $L_{Aeq,T}$ | A noise level index called the equivalent continuous noise level over the time period T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded. |

| Term | Description |
|---|---|
| $L_{max,T}$ | A noise level index defined as the maximum noise level during the period T. L_{max} is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response. |
| $L_{90,T}$ or Background Noise Level | A noise level index. The noise level exceeded for 90% of the time over the period T. L_{90} can be considered to be the "average minimum" noise level and is often used to describe the background noise. |
| $L_{10,T}$ | A noise level index. The noise level exceeded for 10% of the time over the period T. L_{10} can be considered to be the "average maximum" noise level. Generally used to describe road traffic noise. |
| Free-field | Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5 metres |
| Façade | At a distance of 1 metre in front of a large sound reflecting object such as a building façade. |
| Fast Time Weighting | An averaging time used in sound level meters. Defined in BS5969. |
| Displacement, Acceleration and Velocity Root Mean Square (r.m.s.) and Peak Values Peak Particle Velocity (PPV) | Vibration is an oscillatory motion. The magnitude of vibration can be defined in terms of displacement (how far from the equilibrium position that something moves), velocity (how fast something moves), or acceleration (the rate of change of velocity). When describing vibration, one must specify whether peak values are used (i.e. the maximum displacement or maximum velocity) or r.m.s. / r.m.q. values (effectively an average value) are used. Standards for the assessment of building damage are usually given in terms of peak velocity (usually referred to as Peak Particle Velocity, or PPV), whilst human response to vibration is often described in terms of r.m.s. or r.m.q. acceleration. |
| Root Mean Square (r.m.s.) | The r.m.s. value of a set of numbers is the square root of the average of the squares of the numbers. For a sound or vibration waveform, the r.m.s. value over a given time period is the square root of the average value of the square of the waveform over that time period. |
| Root Mean Quad (r.m.q.) | The r.m.q. value of a set of numbers is the fourth root of the average of the fourth powers of the numbers. For a vibration waveform, the r.m.q. value over a given time period is the fourth root of the average value of the fourth power of the waveform over that time period. |