STRUCTURES DATA SHEET 11
Vibration Monitoring

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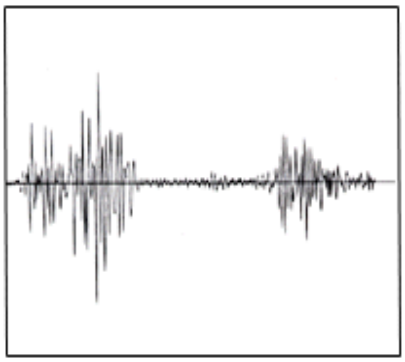
Purpose of Monitoring

There is a very clear division between Human Annoyance and possible damage to a structure. As a general rule, vibrations rarely cause damage to structures. Humans are however, very sensitive to vibration and can detect very low vibration levels. This is also a subjective problem, where some people will be more affected than others. At the same time, humans can become conditioned to vibration and miss it if it is not there. There are no absolute limits for what is and is not acceptable for humans or for structures, however there are some guidelines that have been published to point out levels likely to cause annoyance or damage to structures.

Measurement of Vibration



Vibration occurs in different forms.

Transients are short shock type vibrations, the sort of thing you would expect from a pile impact, a blast from a quarry etc. Steady state is the sort of thing you would get from a compressor in a factory.
Vibration is simply movement of a surface, often in three directions, vertical, longitudinal and transverse. The easiest way of thinking about vibration is simply in terms of displacement. But vibration is usually measured in terms of velocity or acceleration, using a geophone or accelerometer. Displacement units are mm or microns, Velocity units are mm/sec or m/sec, acceleration units are m/sec^2 or g or micro g.

The rate of movement up and down of a surface is the frequency, Hz. for instance if the surface moves up and down in a sinusoidal motion, 20 times in one second, then the frequency is 20Hz. So vibration can be defined by four parameters, frequency, displacement, velocity and acceleration.

But very few vibrations are single frequency vibration. Typical vibrations from road or rail traffic for example, are normally in the range 20-60Hz.

Machinery

Sensitive instruments, machinery and structures often require monitoring to assess the level of vibration being received and special anti vibration mountings and foundations can be specifically designed to alleviate and minimise externally generated vibration. Surveying the site will determine critical vibration frequencies enabling design of adequate mounting systems. Frequency analysis of the fundamental vibration of rotating machinery such as pumps and motors can be used as part of a preventative maintenance program. Proposed EC legislation will require all employers using industrial equipment to carry out a vibration risk analysis. If vibration levels are above predefined limits preventative measures must be taken, including reducing operators' daily exposure time.

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Monitoring Equipment

When capture and analysis of complex vibration data is required, computer controlled data acquisition units can be employed, with transducers and software specially tailored to suit the particular application. Spectrum analysers can be used to determine the frequency response of a structure, and hence the likelihood of vibrations occurring. This will enable recommendations to be made on how to reach compliance with regulations. Portable, self powered units with tri-axial velocity transducers can be installed rapidly on site and can be set to operate in a variety of modes.

Continuous mode - enables a continuous print-out of vibration levels in terms on Peak Particle Velocity.

Standby mode - is used to record a particular event in greater detail. The recorder is triggered when a pre-set level is exceeded. Peak particle velocity for each axis is then printed together with resultant velocity, acceleration, amplitude and frequency of vibrations. The recorder then resets itself and awaits another event. Some monitors enable both the continuous and standby modes to operate simultaneously.

Sources of vibration

Typical situations where vibration can be a cause of annoyance or damage are:

Piling Work – Bored piles will cause ongoing vibration, Vibration levels are not expected to be very high. Driven piling causes repetitive transients, which are likely to be disturbing to people and vibration levels will be higher than for bored piles. As well as ground borne vibration, there may well be air borne vibration (noise) that can cause doors to rattle and loose plaster to fall of walls. With vibrated sheet steel piles, the machine used will have a discrete frequency of operation that is quite high. High frequencies do not travel through soil very well and are unlikely to cause a problem.

Demolition – Mechanical demolition will be semi-continuous with vibrations of approximately 20-60Hz. Blasting will, of course be single transient events, which have to be captured first time, so it is crucial to set up trigger levels correctly.

Quarries – Blasts at quarries may be multiple charges, so long capture times have to be set up. Again, there is only one chance of capture, to trigger levels are critical.

Road/Rail – Trains generate a vibration of about 50Hz, with the amplitude increasing as the train approaches. Long capture periods have to be used, generally about 30 seconds to ensure a complete record.

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Recommended Guidelines

Din Standard 4150 part 4

Line	Type of structure	Guideline values for velocity, v_i, in mm/s			
		Vibration at the foundation at a frequency of			Vibration at horizontal plane of highest floor
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz *)	at all frequencies
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10	8
*) At frequencies above 100 Hz, the values given in this column may be used as minimum values.					

Table 1: Din Standard 4150 Part 4 – 'Structural vibration in buildings'

British Standard BS 5228: Part 4

This standard is the code of practice relating to vibration control for piling operations and recommends the following thresholds in mm/sec, Peak Particle Velocity, for minor damage occurring:

Structure	<10Hz Int	<10Hz Cont	10-50Hz Int	10-50Hz Cont	>50Hz Int	>50Hz Cont
Soundly Constructed Residential properties	5	2.5	10	5	20	10
Industrial and Commercial - Light	10	5	20	10	40	20
Industrial and Commercial - Heavy	15	7.5	30	15	60	30

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