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VIBRATIONS FROM PILING - METHODS OF ASSESSMENT AND CASE HISTORIES

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INTRODUCTION

The Control of Pollution Act is not only directed at noise control but equally at vibration control. One of the major sources of vibration in the Construction Industry is piling. In particular hammer driven operations often generate relatively high levels of groundborne vibration in their immediate vicinity. They are often cited as the cause of superficial and even structural damage in buildings and generally create concern to people living or working in properties where the vibration is felt. Whether such claims are justified is a matter for some conjecture. In the authors experience very few claims of damage can be substantiated and the vibration has to become intolerable to property occupants before significant damage occurs.

This paper discusses vibration damage and comfort criteria which the author has found to be appropriate to piling operations. It also describes the measurement techniques that have successfully been used to assess piling vibrations, presents some case histories and discusses various methods of vibration control.

DAMAGE & COMFORT LIMITS

Vibration standards fall mainly into two categories:

i) those appropriate to human comfort

ii) those appropriate to damage to buildings

There is a wide disparity in the standards proposed in the various references on this subject.

It is generally accepted that humans are particularly sensitive to vibration stimuli and any perception tends to lead to concern if not direct disturbance. A good deal of this concern is associated with fear of damage to property and much can be done to alleviate such fears through good public relations on the part of the contractor. Experience has indicated that provided measurement surveys are carried out to demonstrate vibrations are not excessive in terms of damage, a vertical peak particle velocity of up to 2.5mm/s will be tolerated during the day-time from piling operations.

It is, however, unreasonable to expect people to withstand such intrusion either for extended periods or during the evening or night-time.

Vibration velocities of this magnitude are not likely to lead to even superficial damage to structures although if they are continued over extended periods, say several years, fatigue failures may occur. For normal piling programmes, however, vibration levels below 10mm/s peak particle velocity should not cause damage to sound buildings. A summary of the vibration limits that the author has found appropriate to piling vibration is given in Table 1.

Table 1.

	Peak Particle Velocity mm/s
Threshold of perception	0.3
Strongly felt	1.0
Complaints	2.5
Onset of Architectural damage	10
Onset of Structural damage	25

VIBRATION MONITORING

Two areas of vibration monitoring which are often overlooked are:

i) adequate definition of the parameters monitored and ground conditions

ii) adequate mechanical coupling between the transducer and the structure of the surface being monitored

The first factor is important since lack of such information can lead to ambiguities when comparing the levels measured with existing standards or contract specifications. It is therefore essential that the following should be stated whenever quoting vibration levels:

a) the measurement parameter, velocity, displacement or acceleration

b) the units of measurement, i.e. whether mm/s, m/s^2, etc.

c) whether the measurements are in terms of peak, peak to peak, rms or any other factor

d) the direction of measurement, vertical, horizontal, radial or resultant

Poor mounting of transducers can lead to misleading results. Care must be taken to ensure the measured levels are representative of the response of the structure being monitored rather than those of resonances in the mounting system. For example, a heavy metal spike driven into the ground with a vibration transducer mounted on top to measure vertical vibration will provide a good representation of the vertical vibration response of the ground. Results from the same spike with a vibration transducer mounted on top to measure horizontal vibrations may, however, give misleading results due to resonances in the spike.

Provided such precautions are taken, successful vibration monitoring can be carried out using accelerometers coupled to suitable calibrated integrating amplifiers.

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VIBRATION FROM PILING: ASSESSMENT PROCEDURES

Piling and ground consolidation operations rank amongst the major sources of vibration generated by the construction industry. They will rarely be intense enough to cause structural damage and observations of even superficial damage are very limited. Disturbance and annoyance is the major concern over vibration from such sources.

If, however, there is doubt regarding the levels of vibration which are likely to occur from piling operations, measurement surveys should be carried out either prior to the development commencing, through site trials and/or during critical stages of the works programme. Such an approach will show compliance with acceptable standards and often alleviate the laymans justified fear of damage to his property which is often the root cause of complaints regarding vibration.

Site trials prior to development commencement should be carried out using the piles and rigs typical of those to be used during actual works. Piles should be driven at points remote from any sensitive locations.

Ground vibrations should be monitored at various distances from the pile such that the level of groundborne vibration at sensitive buildings from the nearest piles to be driven can be extrapolated. Information on pile positions can usually be obtained from the nominated piling contractor.

During contract piling operations, checks on vibration levels in the structure of adjacent buildings should be made throughout the piling programmes and especially when operations are carried out close to sensitive areas. It is essential in many exercises of this kind to carry out a full survey of existing building damage before piling operations commence. During piling operations the width of existing cracks in appropriate locations should be monitored so that any significant increases in crack width can be identified at an early stage.

CONTROL OF VIBRATION

There is relatively little that can be done to control the magnitude of vibrations from a given piling method apart from the following:

i) For drop hammers - limit the distance through which the hammer drops. This leads to somewhat unpredictable results although the general trend is for peak particle velocity to reduce as the distance to drop reduces.

ii) For drop hammers - reduce weight of the hammer. This can have a significant effect: for example reducing hammer weight from 2.75 to 1 ton reduced peak particle velocity in a structure from a clearly perceptible level to a barely perceptible level.

A method of controlling the propagation of vibration by digging trenches between the vibration source and receiver has been tried but such techniques do not produce significant benefits.

CASE HISTORIES

The author has experience of many case hsitories concerning piling vibrations ranging from their effects on a 17th century building, where maximum structural velocities of 4mm/s were experienced, to various cases where occupiers of houses have expressed concern over comfort and potential damaging effects of nearby operations. These and other cases will be discussed in detail during presentation of the paper.

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