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DESIGN DIVISION

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Client : JOHN PERKINS CONSTRUCTION

Scheme : SHEET PILING.

ASSESSMENT OF GROUND BOURNE VIBRATIONS DURING SHEET PILE INSTALLATION.

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INTRODUCTION

Sheet Piling (UK) Ltd have tendered to John Perkins Construction for the supply and installation of steel sheet piles as permanent earthworks support in connection with the Proposed Newport Transporter Bridge Visitor Centre.

An assessment of the theoretical ground borne vibration levels has been requested.

ASSESSMENT OF VIBRATION DURING SHEET PILE INSTALLATION.

The installation of steel sheet piles using vibratory installation techniques will inevitably result in ground borne vibrations. The vibration level is a function of the power rating and frequency of the vibrohammer (from which peak particle velocities and particle accelerations can be calculated), and to some extent, the type and nature of the soils. The vibration levels at the source will naturally attenuate with distance.

ESTIMATION OF GROUND BORNE VIBRATIONS.

REFERENCES

1. BS. 5228 (1992) Part 4 – Code of Practice for Noise & Vibration Control applicable to Piling
2. BS. 5228 (2009) Part 2 – Code of Practice for Noise & Vibration Control applicable to Piling
3. British Steel (CORUS) – Control of Vibration & Noise during Piling.
4. BS. 7385 Part 1 – Guide for measurement of Vibrations and evaluation of their effects on Buildings.
5. BS. 7385 Part 2 – Guide on damage levels from ground borne vibration.

PROPOSED METHOD AND PLANT FOR SHEET PILE INSTALLATION

Currently, it is proposed that the sheet piles will be installed to level using a tracked excavator base machine mounted with a high frequency MOVAX SG-60 sidegrip vibratory hammer.

PROPOSED PILE8

The proposed sheet piles are ESZ19-700 “Z” Profile sections varying between 12.0m and 14.0m in length. The 700mm wide piles are to be installed in singles due to the weight limit of the Movax Hammer.

SOILS CONDITIONS

- Made Ground overlying
- Soft to Firm CLAY onto
- Dense SAND

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VIBRATORY INSTALLATION

The sheet piles are to be installed using an **MOVAX SG-60** Vibratory Hammer.

Therefore, an assessment of the possible vibration levels can be undertaken using the traditional methods given in BS5228, Pt 4, Appendix B (1992).

For vibratory driven sheet piles, the maximum Peak Particle Velocity (PPV) can be derived from the given empirical formula: -

$$V_{res} = \frac{C * \sqrt{W}}{r}$$

Where :-

- V_{res} = Maximum Peak Particle Velocity (vertical component) (mm/sec)
- C = Soil. Hammer Factor (BS5228 (1992) Part 4 recommends that for vibratory hammers in all soil conditions = **1.0**)
- W = The maximum hammer energy per cycle (J)
(Power Rating from data sheet = 140kW, Ave. Frequency = 2750rpm (45 Hz)
Energy = 140kW/45Hz = 3111 J/cycle. Assume 90% efficiency = 3111 J x 0.90 = **2800 J**)
- r = Horizontal distance from piling operation (m)

Distance (m)	1.0	2.0	3.0	5.0	10.0	15.0	20.0	50.0
Predicted PPV (mm/s)	52.91	26.45	17.64	10.58	5.29	3.53	2.64	1.06

Table 1 – Peak Particle Velocities (PPV) to BS5228 Pt 4 - 1992.

Notwithstanding the above, within the revised / updated standard, BS5228 Pt 2 (2009), Table E.1 sets out the predicted peak particle velocity equations to use. For vibratory installation of piles, the equation is now based on percentage confidence levels that the predicted values will **not** be exceeded. This method does not take account of the hammer type and/or power levels etc, and is entirely empirical. Experience and correlations with this revised method of prediction is limited and therefore, the results are to be considered accordingly.

The revised relationship is given as :-

$$V_{res} = \frac{k_v}{x^\delta}$$

Where,

- V_{res} = Maximum Peak Particle Velocity (vertical component) (mm/sec)
- k_v = Scaling Factor (50% Exceedance Probability = 60, 33.3% = 126, 5% = 266)
- x = Horizontal distance from piling operation (m)
- δ = 1.3 for all operations

Distance (m)	Probability of Exceedance	1.0	2.0	3.0	5.0	10.0	15.0	20.0	50.0
Predicted PPV (mm/s)	50%	60.00	24.36	14.38	7.40	3.00	1.78	1.22	0.37
Predicted PPV (mm/s)	33.3%	126.00	51.17	30.21	15.54	6.31	3.72	2.56	0.78
Predicted PPV (mm/s)	5%	266.00	108.03	63.77	32.83	13.33	7.87	5.41	1.64

Table 2 – Peak Particle Velocities (PPV) to BS5228 Pt 2 -2009.

It is proposed that for the purpose of this study, the PPV values in Table 1 are used in the assessment of any effects on structures. The later calculation methods and results given in Table 2 for the 33.3% & 5% confidence values are generally deemed to be overly pessimistic for this type of vibrohammer, and the PPV values stated will almost certainly not be experienced in practice.

Therefore, Table 1 can be revised to include the theoretical associated Particle Accelerations for the relevant distances from the piling source – See Table 3 below :-

Distance (m)	1.0	2.0	3.0	5.0	10.0	15.0	20.0	50.0
Predicted PPV (mm/s)	52.91	26.45	17.64	10.58	5.29	3.53	2.64	1.06
Acceleration (g)	1.52	0.76	0.51	0.31	0.15	0.10	0.08	0.03

Table 3 – Peak Particle Velocities (PPV) & Equivalent Particle Accelerations.

CONCLUSIONS.

The theoretical peak levels of ground-bourne vibrations ie. PPV Values, (and equivalent particle accelerations) from the piling source, and attenuated levels at specified distances from the piling source have been assessed using the empirical methods given in BS5228, (1992) and (2009).

These reported vibrations levels at various distances from source can be reviewed by any interested Third Party whom may have interest in reviewing expected vibration levels adjacent any existing sensitive structure/service.

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