



NOISE AND VIBRATION LEVELS ASSOCIATED WITH ACSW TESTING

Guidance Note SSGN025

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Sources of Noise and Vibration from ACSW Testing

Advanced Continuous Surface Wave (ACSW) testing is a fast, non-intrusive means of obtaining in-situ ground profiles in a construction environment developed and operated by SoilSafe Ltd. ACSW uses a vibratory source or 'shaker' to generate surface (also known as Rayleigh) waves across a range of frequencies and measures the speed at which these travel through the ground using a short 3m length array of surface geophones.

The velocity of surface waves is a function of the ground stiffness, and the wavelength of the surface wave determines its depth of penetration. Therefore, by measuring surface wave velocities over a range of frequencies (and consequently a range of wavelengths), a stiffness profile of the ground can be obtained.

The SoilSafe standard vibratory source is a mechanical shaker employing a pair of reciprocating eccentric weights driven by a speed controlled electric motor and resulting in a vertically polarised sinusoidal force being applied to the ground surface. This arrangement is highly efficient in generating surface waves which propagate away from the source and resulting in soil particles moving with a vertically polarised elliptical retrograde motion (see Figure 1 below). The magnitude of particle motion not only attenuates with depth but also as an inverse square function of the distance from the source.



The energy produced by the shaker increases as a square of the angular velocity and therefore the highest vibration levels are associated with the highest frequency tests (90Hz). To increase energy at low frequencies, SoilSafe mechanical shakers are tuned to resonate at the lower end of their operating frequency range (8-12Hz). However, the energy generated at these frequencies remains below the energy generated at the upper end of the shaker frequency range.

The SoilSafe mechanical shaker internal drive mechanism uses rubber self-lubricating drive belts to reduce noise. The shaker motor is powered by a portable 4.5kVA petrol generator which is normally operated from within the GSS test vehicle but can also be operated remotely from the vehicle when testing at locations without vehicle access.



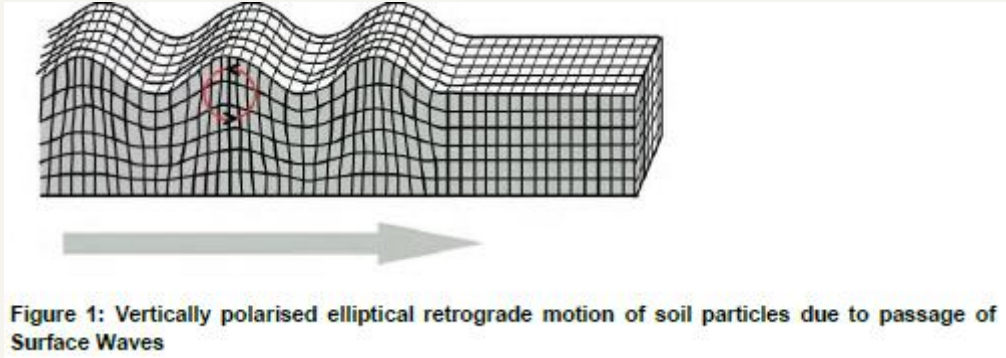
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Measurement of ACSW Noise Levels

Ambient noise levels have been recorded using a portable sound level meter in proximity to both the SoilSafe standard shaker and petrol generator. Measurements were made at 1.5m height. The results of this testing are illustrated below in Figure 2.

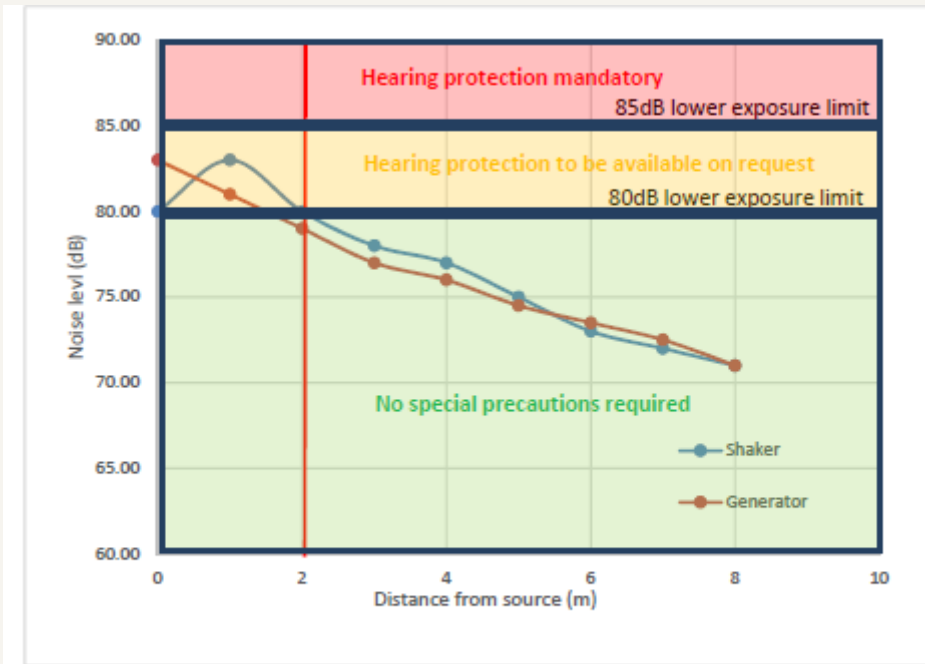


Figure 2: Noise levels in proximity to GSS standard shaker and petrol generator

Acceptable Noise Levels

The Control of Noise at Work Regulations 2005 (the Noise Regulations) came into force for all industry sectors in Great Britain on 6 April 2006. The upper exposure limit above which mandatory hearing protection is required is 85 dB (daily or weekly average exposure) and the lower exposure limit is 80dB at





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which employers must assess the risk to workers' health and provide them with information, training and hearing protection upon request.

It can be seen from Figure 2 that at 2m distance the noise level from both the SoilSafe Standard Shaker and generator are below 80dB and therefore no specific precautions are required. Within 2m noise levels for both the shaker and generator can rise to 83dB falling between the lower and upper exposure limits. ACSW testing does not require operatives to be within 2m of the standard shaker and only briefly within 2m of the generator during the starting and stopping operation. As such for testing in accordance with the SoilSafe standard method statement there is no specific requirement for hearing protection.

Measurement of ACSW Vibration Levels

Ground vibration is measured in terms of Peak Particle Velocity (PPV) with units in mm/s and defined for sine waves as follows;

$PPV=2 \pi f a$ where f = frequency in Hz and a = displacement in mm

Ground vibration levels are directly measured as part of the ACSW testing process through the use of an array of 6 vertical axis geophones. Measurement of the output voltage from the geophones can be used to directly determine the PPV through knowledge of the geophone sensitivity.

For example, an output voltage of 0.01V (10mV) for a geophone with a sensitivity of 28.8 V/m/s translates to a PPV of $28.8/0.01 = 0.00035\text{m/s}$ or 0.35mm/s. Due to the vertically polarised nature of the surface waves generated in the ground, the vertical plane of measurement corresponds to the maximum plane readings as referred to by British Standards.





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The recorded maximum PPV values for the SoilSafe standard shaker at 90Hz and 10Hz are illustrated below in Figure 3.

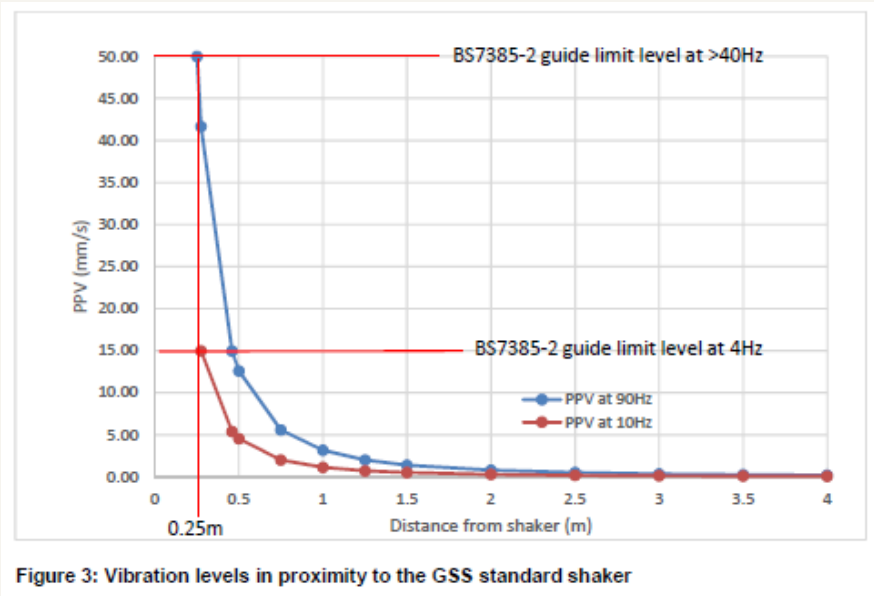


Figure 3: Vibration levels in proximity to the GSS standard shaker





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Acceptable Vibration Levels

Acceptable vibration levels depend not only upon the PPV but also the frequency. Any detrimental effect on structures and buried services is greatest at low frequencies as indicated by BS7385-2 Table 1 (see Table 1 below) which reduces the guide PPV limits for cosmetic damage for the most sensitive structures from 50mm/s at 40Hz to 15mm/s at 4Hz.

It can be seen from Figure 2 that at 0.25m distance from the SoilSafe standard shaker PPV levels are below the BS7385-2 guide limits for cosmetic damage at both 10Hz and 90Hz. Within 0.25m of the shaker PPV levels can rise above cosmetic damage levels and therefore checks are made of the client and visually on site to ensure the shaker is sited more than 0.25m distance from any highly sensitive services or materials. Practical experience has demonstrated that the shaker may be directly placed on common low strength construction materials such as HDPE and clay pipes without damage and therefore the risk of damage to any buried services is extremely low.

Table 1: Extract from BS7385-2 Table 1

Line (see Figure 1)	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures; Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures; Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

NOTE 1 – Values referred to are at the base of the building (see 6.3)
NOTE 2 – For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded

References

- BS7385-2:1993 Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration.
- The Control of Noise at Work Regulations, 2005

For More Information

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Email – info@soilsafe.co.uk

Call Us – 0800 774 7414



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