The measurement of the underwater radiated noise from a marine piling operation

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Assessment of the underwater acoustic radiated noise during a marine piling operation was carried out in UK coastal waters in April 2006. A 2 m diameter, 65 m long test pile was driven into a 'hard chalk' sediment. The pile was placed in an area of average water depth of 10-15 m approximately 3 km offshore.

The measurements made include full characterisation of the 'soft start' period at the beginning of the piling sequence, where the hammer energy was gradually increased from 10% to 100% of the final hammer energy level (800 kJ). Detailed measurements of underwater noise levels were made throughout the entire piling sequence at two locations corresponding to ranges of 57 m and 1,850 m.

Figure 1 shows typical time domain waveforms recorded at the short range of 57 m during the main piling sequence using (800 kJ) hammer energy for two successive hammer strikes. Typical pulse periodicity was around 2 s with a pulse duration between 150 – 200 ms. With the shorter pulses at shorter ranges In figure 2 shows the spectrogram of the two pulses shown in figure 1. Note that although the energy is concentrated at low frequencies, there is still some higher frequency content present up to the 22 kHz limit shown in the plot.

At the short range (57 m) the typical peak pressure level of just under 20 kPa was observed. At a range of 1850 m this level had dropped to around 1.5 kPa. At both ranges the peak levels were observed at frequencies 200 – 500 Hz. A significant roll off in pulse energy was observed above 8 kHz with the higher frequencies (1-8 kHz) more highly attenuated at greater distances..

The soft start sequence (800 hammer strikes), lasted for approximately 68 minutes during which time the hammer energy was incrementally increased from 80 kJ to 800 kJ. A steady increase in acoustic amplitudes during the soft start period was seen, with the peak-to-peak pressure levels showing an increase of about 12 dB from beginning to end of the soft start, figure 3.

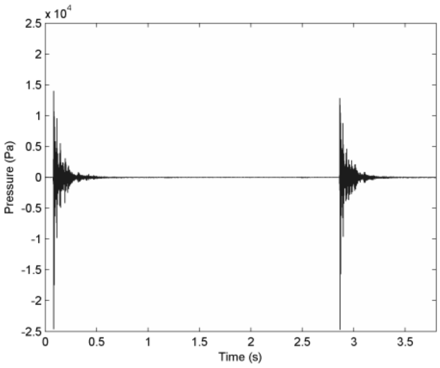

Fig. 1 Time domain waveforms for two pulses at full power (hammer energy 800 kJ) at the location of the piling vessel (range 57 m).

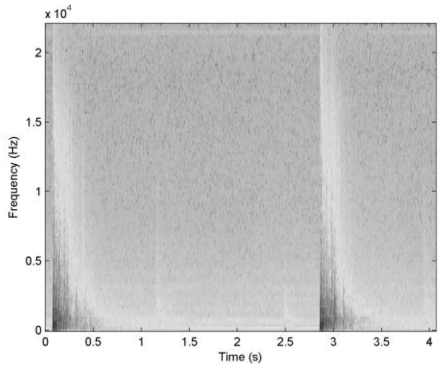

Fig. 2 Spectrogram of the time waveform shown in figure 1. Note that the frequency axis extends up to 22 kHz.

The RMS pressure levels increased by approximately 13 dB, and the energy flux density (EFD) level in the pulses increased by approximately 8 dB. Pulse length, RMS and EFD levels were calculated using a 90 % energy criteria. (Madsen, 2005).

The pressure amplitude levels for the main piling sequence at a hammer power setting of 800 kJ were fairly stable with mean peak-to-peak pressure levels of 211 dB re 1 μPa (pk-pk) and 191 dB re 1 μPa (pk-pk) observed at ranges of 57 m and 1,850 m respectively, with corresponding energy flux density levels of 178 dB re 1 $\mu Pa^2 s$ and 164 dB re 1 $\mu Pa^2 s$.

Figure 4 shows the recorded levels during the main piling sequence at the shorter range and figure 5 at the longer range. Impulse to impulse some variation in levels was observed at the shorter range with these levels becoming much more stable at the higher range.

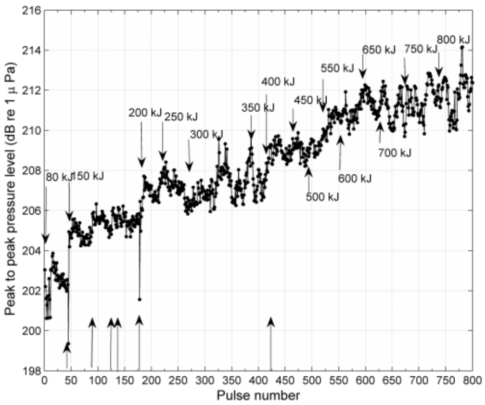

Fig. 3 Variation in peak-to-peak acoustic pressure level during the soft start period showing the hammer energy level. The arrows denote breaks in the piling sequence. Recorded at a range of 57 m.

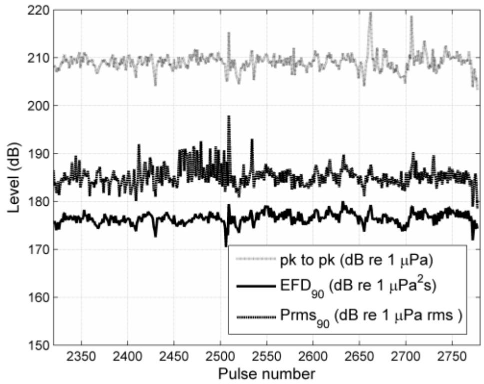

Fig. 4 Received level amplitude from the end of the piling sequence at 57 m. Note the increased variability as the pile reaches refusal.

Direct comparison of the hammer energy versus the received energy in a pulse at the shorter range during the soft start period showed a reasonable linear dependence between the two, as shown in figure 6. With received levels ranging from around 0.5 to 2.5 kJ for hammer energies 80 – 800 kJ. The gradient of the linear best fit line gives a hammer to acoustic pulse energy conversion of 0.3 %.

Although measurements on this occasion were limited to two ranges an estimate of source level was made for the various metrics discussed.

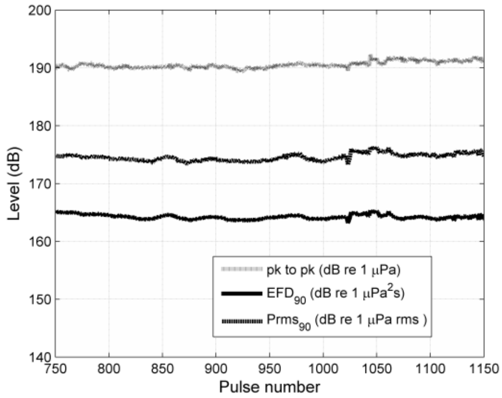

Fig. 5 Received level amplitudes during the main piling sequence at 1,850 m.

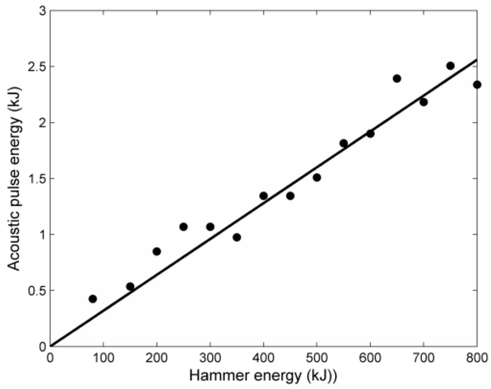

Fig. 6 Acoustic pulse energy as a function of hammer energy. (Acoustic energy calculated from the EFD data for a range of 57 m.)

Typical transmission loss characteristics in two dimensions were calculated using a parabolic equation based transmission loss model based on the RAM code (Collins, 1994). This model included local seabed topography and sediment and water column acoustic characteristics. Taking the derived transmission losses the received levels were back propagated to the source giving an estimated *peak-to-peak* source level in the range from 224 dB re 1 µPa.m to 236 dB re 1 µPa.m for a 800 kJ hammer energy.

Acknowledgment

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