ICSBE2016-235

INVESTIGATION ON CHARACTERISTICS OF NOISE GENERATED BY PILLING ACTIVITIES

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Abstract: Noise, which is inevitable from piling activities, interferes with sleep, speech and cause discomfort and other non-auditory effects. The level of noise due to the piling activity varies with the number of parameters including the type of piling, soil condition, age and types of machineries and driver experience. Objective of this study is to investigate the noise level variation in different piling methods namely, Impact/Hammer piling and Bored Piling, in different soil layer, namely, soft soil layer and hard rock. The sound levels were measured by using a Sound Level Meter (SVAN_971), for the duration of 10 min at 1.5 m above the ground level. For all these two types of piling activities, noise level was above 60 dB(A) during the day time (6.00 am to 6.00 pm).

It was found that especially during the hard rock driven the sound level is high, and when releasing the soil from auger (Soil bucket) induced large amount of noise. The maximum noise level in Hammer piling activity is found to be 101.0 dB (83.4 dB(LAeq)), which is significantly larger than that of bored piling activity, 84.8 dB (77.3 dB(LAeq)). The designers can predict the noise levels by using the proposed equations and assess the relative environmental impact of each installation method of piling.

Keywords: Noise level; Noise Pollution; Noise Characteristics; Construction Noise; Piling Noise

1. Introduction

The construction industry is an important contributor in sound pollution, and more number of noisy illnesses every year. Construction sites bring out lots of noise, mainly from heavy equipment and machinery used in construction field, such as pile drivers, hammering, welding process, demolition etc. This noise can affect not only the workers but also surrounding residencies and the environmental ecosystem. The over noise can lead to loss of hearing, hypertension, and irregular heartbeat for human.

There are several studies related to the assessment of piling noise level on various category in different cities around the world ([1], [2], [3], [4]). David [5], has found that the embodied energy of a pile is the sum of the energy required to extract the raw materials, carry out any manufacturing or construction processes. An impact pile contains less embodied energy than a bored pile of similar capacity and also the noise produce during installation is higher for impact piling than the bored pile.

Pile driving produces more than 100 dB of noise at 50 feet distance ([7], [5], etc.) that may extend thousands of feet away from the driving activity. People have become increasing intolerant of these effects. Usually, people complained to government agencies and tend to oppose development projects that use pile elements. Their opposition is beginning to seriously affect the pile driving industry in the developing countries including Sri Lanka.

The driving hammer produce noise with each blow delivered to the pile. The sounds of consequence are caused by waves of energy travelling away from the pile. Each blow to the pile transfer energy from the pile to the surrounding soil. As much as 70% of the energy transferred to the soil by pile driving travels away from the pile in the form of surface wave. The human ear perceives a 10 dB increase in noise level as a doubling in loudness [5]. Hearing loss begins at 80- 90 dB(A), 140 dB(A) is painful and 180 dB(A) can even kill a person.

Exposure to piling installation noise is often higher in the developing countries due to improper planning and poor enforcement of regulations. Thus action to limit and control exposure to piling installation, understanding and prediction of noise induced by different types of pilling is essential. The preliminary data collected in selected piling installation sites were found to have the equivalent of sound pressure levels exceeding 63 dB (A) [6] in day time. However, no systematic survey on noise induced by piling has been conducted to determine the noise levels in all effected environmental conditions.

The main objectives of the study were to investigate and compare noise variation induced by different types of piling installation in construction sites, and to predict the amount of noise level reaches to the surrounding residencies with the distance.

2. Methodology

The present study covered the noise levels of piling activity in different categories:

a) Bored piling during hard rock driven and soft soil layer driven,

b) Impact piling/ hammer piling during hard rock driven.

The measurements were carried out on selected pile installation areas (i.e., construction sites) in Galle and Colombo. For hammer pilling, the 5 tone of hammer was dropped from 1m of height.

The noise measurements were carried out about 10 minutes' period of time and 1.5m above the ground level by using a Sound Level Meter (SVAN_971) in day time. When recording the readings, the other sound sources considered, as ambient condition and the reflections due to other buildings and walls were avoided as much as possible with in 50 m of distance. The measurements were recorded (Figure 1) at different radial directions at 5m, 10m, 15m and 25m distance from the source (Figure 2). All noise level data were saved during measurement and the data were analysed offline by using the SVANTEK Supervisor software.

Figure 1: Noise measuring in different Piling installation.

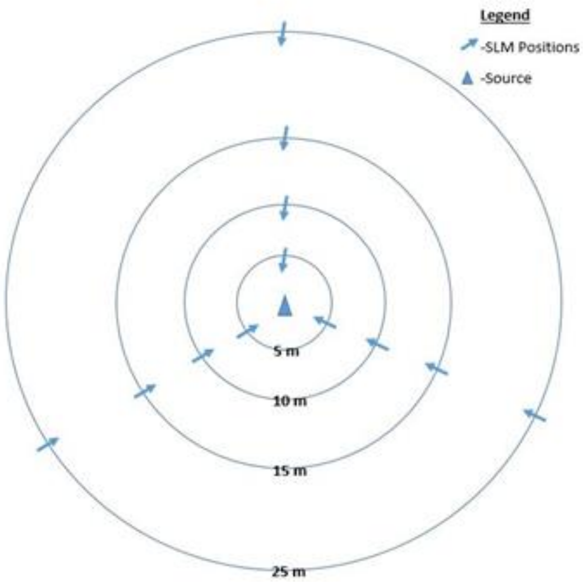

Figure 2: Noise measured in radial direction at different distances

Several noise level descriptors (L_{eq}, L_{max}, L_{min} and L_{peak}) were recorded during the noise level survey in different piling installation activities. There were three data collected around the source in each and every known distance to increase accuracy of the readings. The data were collected during Day time (6.00 am to 6.00 pm). The ambient value also measured during the data collection.

3. Results and Discussion

3.1 Noise Level Variation in different Piling activity.

Table 2 explains the noise level variation between Hammer piling and Bored piling during Hard Rock installation. The effect of

Table 1: Noise level in different pile drive category

Piling Category	L_{peak} (dB)	L_{max} (dB)	L_{min} (dB)	L_{eq} (dB)
Hammer Piling	96.40	82.40	51.70	64.50
Bored Piling	77.20	50.90	49.50	50.10

Hammer pile drive is larger than the Bored pile drive at 15m distance from the source. The similar trend has been found for the noise levels at other distances from the source also.

Table 2: Noise Level variation in different piling activity at 15 m.

Piling category	L_{peak} (dB)	L_{max} (dB)	L_{min} (dB)	L_{eq} (dB)
Hammer Piling	114.33	97.97	54.40	80.33
Bored Piling	98.30	80.63	74.83	77.30

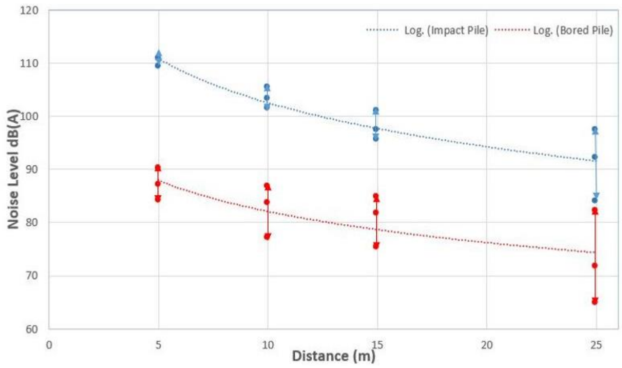

Figure 3 : Maximum Noise Level variation with distance in different piling activities.

Figure 3 explains the maximum noise induced by different piling activity varies with the distance. It is necessary to analyse the maximum noise level variation, because, the maximum values most contribute in health effect, sleep disorder and high blood pressure.

The average maximum Noise level varying range in the Hammer piling is ±3dB. while in the Bored piling the variation is ±5dB. It can be observed (Figure 3) that the measured data symmetrically spreads around the mean value and can be reasonably fitted by Gaussian distributions with squared correlation coefficients of **R^2 = 0.8321** and **0.5102** for Hammer piling and Bored piling activities, respectively. The logarithmic equations with the distance are

For hammer pilling;

$$NL_{max} = -11.93 \times \ln(x) + 130 \tag{1}$$

For bored pilling

$$NL_{max} = -8.45 \times \ln(x) + 101.52 \tag{2}$$

Where, NL_{max} is the predicted maximum noise level, x is distance from the source. These equations can be used to predict the maximum noise level reaching to the residencies.

However, the equivalent noise level is the allowable noise level which is limited in standards [6]. Figure 4 compares the $L_{equivalent}$ noise level value induced by different piling activities. These also vary with the distance for Hammer pilling and bored piling.

For hammer pilling;

$$NL_{eq} = -12.67 \times \ln(x) + 114.4 \tag{3}$$

For bored pilling

$$NL_{eq} = -8.8 \times \ln(x) + 101 \tag{4}$$

Where NL_{eq} is the predicted equivalent noise level, x is distance from the source. The above equations fitted by Gaussian distributions with squared correlation of **R^2 = 0.8380** and **0.5748** for Hammer piling and Bored piling, respectively. These equations can be used for determining the limiting value at the required boundary whether the value is satisfying the value which is recommended by the urban council or relevant authority.

Figure 5 shows the L_{peack}, L_{max}, L_{min} and $L_{equivalent}$ variation of Hammer piling and Bored piling activities. The noise variation in hammer piling installation is greater and

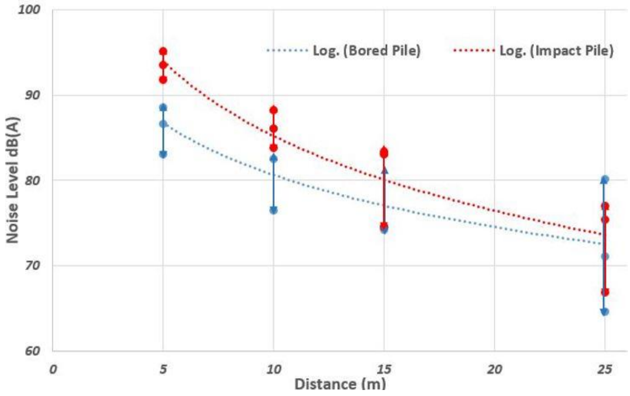

Figure 4 : Equivalent Noise Level variation with distance in different piling activities.

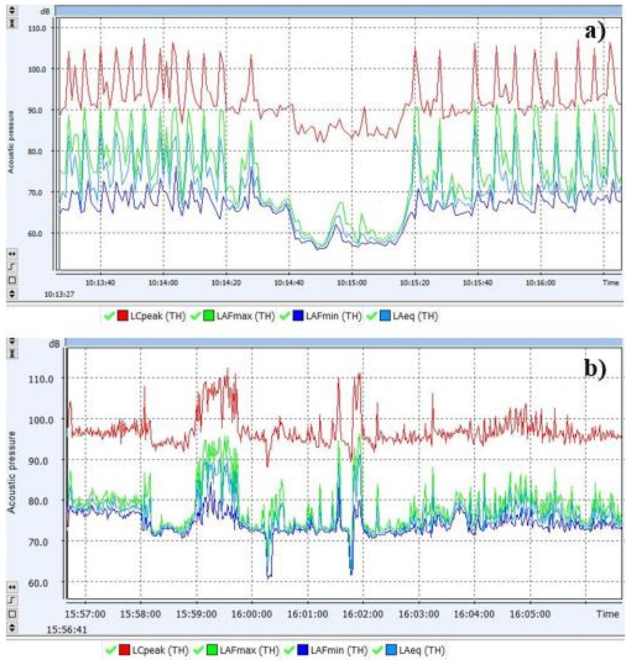

Figure 5 : Individual Characteristics of noise induced by

a) Hammer piling and b) Bored Piling

highly fluctuated than Bored piling, possibly because sudden noised generated often due to hammering. Hammer pilling induced noise would affect more on health affect (High blood pressure, irregular heartbeat, etc.) than that from Bored piling.

3.2 Noise Level Variation with pile driven in different soil conditions

The noise level may vary with the pile driving in different soil layers. Table 3 explains the Noise level variation in pile driving during hard rock installation and soft soil (Top Layer) installation at 15m distance from the source. Here the effect of these two soil conditions changed on noise levels marginally. Because the large noise produced during release the soil from the auger and hard rock driven activity is approximately the same.

Table 3: Noise Level variation at 15 m with different soil conditions

Piling category	L_{peak} (dB)	L_{max} (dB)	L_{min} (dB)	L_{eq} (dB)
Soft Soil driven pile	98.30	80.63	74.83	77.30
Hard Rock driven pile	97.03	80.90	77.77	80.50

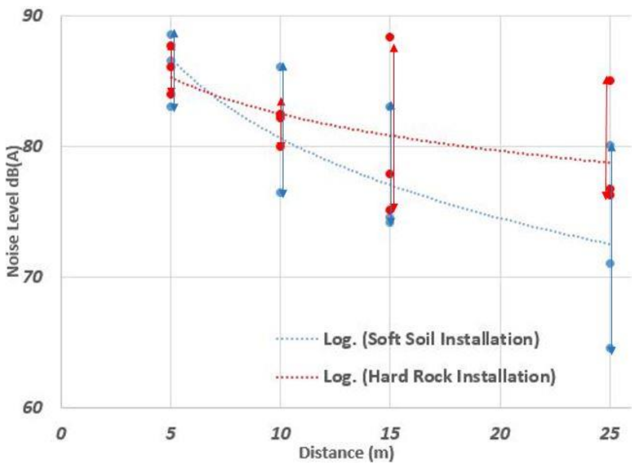

Figure 6: Equivalent Noise Level variation with different soil conditions.

From the data collection the average $L_{equivalent}$ Noise level varying in the range when the hard rock driven is ±5dB. However, when the soft soil driven, the variation is ±8dB. From Figure 6, it can be observed that the measured data symmetrically spreads around the mean value and can be reasonably fitted by Gaussian distributions with squared correlation coefficients of R^2 **= 0.5748** and **0.4432** when Hard rock driven and Soft Soil driven, respectively. The logarithmic equations with the distance are

During Hard Rock installation;

$$NL_{eq} = -8.45 \times \ln(x) + 101.52 \tag{5}$$

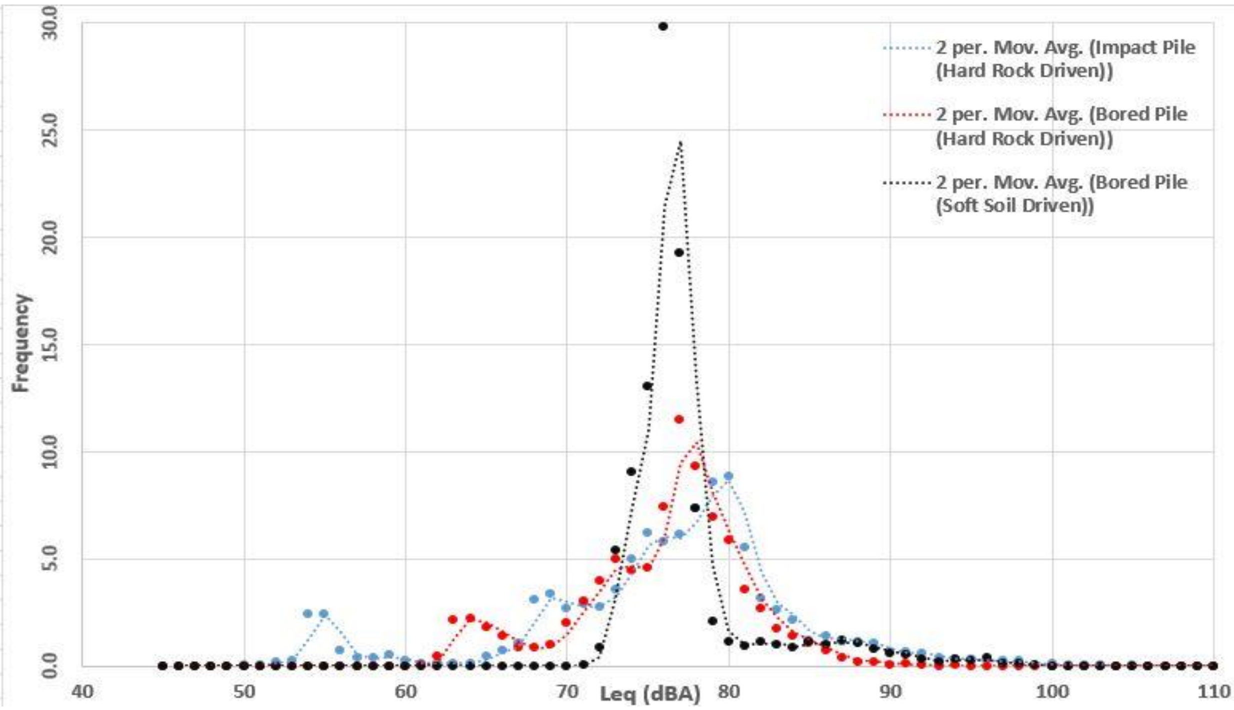

Figure 7 Difference in Noise Level L_{eq} between three categories of piling

During Soft Soil installation;

$$NL_{eq} = -4.1 \times \ln(x) + 91.8 \qquad (6)$$

where NL_{eq} is the predicted equivalent noise level, and x is distance from the source.

The noise level difference among the three categories of piling activities can be depicted by calculating the frequency distribution of the measured Leq value at 1 dB(A) intervals as shown in **Error! Reference source not found.**. It can be observed that the measured data symmetrically spreads around the average fitted curve.

4. Conclusions

The study revealed that the noise level variation in different piling activities namely Impact piling/Hammer piling when hard rock driven and bored pile when Hard rock driven and soft soil driven. The noise levels are significantly high for all those three types of piling activities. People who are resident close to the piling area, and also the worker who are working in the piling site are exposed to noise level reaching 63 dB(A) during day time (6.00 am to 6.00 pm), which is the maximum recommended permissible noise level for residential area. The level of noise due to piling activity varies with the number of parameters including the soil condition, age of machineries and driver experience. Specially during the hard rock driven the sound level is high but when releasing the soil from auger (Soil bucket) also induces large amount of noise. From the above result the maximum noise level in Hammer piling activity induced significantly large amount of noise than that of Bored piling activity.

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