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Environmental Assessment of Blasting Noise and Vibration in Residential Area

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An investigation of noise and vibration caused by the reclamation of the foreshore around J village resulted in noise measurements of 56-84 dB at the first point, 62-81 dB at the second point, and 68-78 dB at the third point. These measurements were higher than the standard level of environmental noise that is 55 dB at noon and 45 dB at night. The vibration measurements were 61-83 dB at the first point, 63-88 dB at the second point, and 58-77 dB at the third point. These measurements were also higher than the standard level of environmental vibration that is 60 dB at noon and 54 dB at night. The measurements of scattering dust were 80 μg/m at the first point, 120 μg/m' at the second point, and 169 μg/m' at the third point. These measurements were lower than the standard level of environmental dust that is 300 μg/m /day. Although the maximum vibration level was higher than the standard level of environmental vibration, it had no influence on the construction.

Key words : noise, vibration, scattering dust

1. Introduction

Noise is undesirable sound which disturbs the traveling of music or voice. It can also produce pain and cause hearing loss. The main sources of noise pollution are automobiles on the road, excavators at a construction place that is close to a housing area, factories, and construction work. Examples of traffic noise include exhaust pipes, engine noise, and klaxons. examples of construction work noise include compressors, file hammers, and explosive compounds, and examples of factory noise include machine tools, power saws, and ventilators[1]. The environmental assessment of noise and vibration with legal limits for environmental noise initiated from a study on equivalent continuous sound level (L_{eq}) in 1950. The Traffic Noise Index (TNI) was established in 1960, and various assessment methods for considering the source of noise and vibration were introduced from 1970. Reports have been produced on the characteristics of noise caused by concentric pipe resonators[2] and the control of radiated duct noise using control sources and microphones[3]. The acoustic analysis and design of a direct- radiator-type loudspeaker has also been suggested[4]. Counter plans for noise preservation include diesel combustion noise

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reduction based on a numerical simulation[5], the prediction of train noise propagation from an elevated railway[6)7)], the effects of absorptive treatments for highway noise barriers[8], and the sound transmission loss of double panels[9].

Vibration is a type of shaking resulting from the use of heavy machinery. The sources of vibration pollution can be divided into underground wave propagation and air wave propagation. Sources of landing vibration include factories, construction work, traffic, and railroads, etc. Examples of plant vibration include presses, metal processing machines, forgers, shearing, crushers, compressors, concrete blocking machines, and weaving machines. Examples of construction work vibration include diesel file hammers, drop hammers, chippers, concrete block machines, and vibration file drives, etc[10]. Previous reports relating to vibration include studies on structural dynamic analysis using a multi-FRF synthesis method[11], a coupled vibration analysis of the railway track system considering contact stiffness[12], the vibration control of beams using distributed PVDF sensors and PZT actuators[13], and the modeling of a towed line array using a finit element method and vibration analysis of VIM[14]. Counter plans for vibration preservation include vibration reduction using sound isolation facilities, the active vibration control of multi-mode forced vibration using a PPF control technique[15], and the effects of a dual dynamic vibration absorber for a damped vibration system[16].

Scattering dust is suspended particulate matter that is lower than 100 ㎛. This includes splinters of matter from machines and is bad for health. The sources of scattering dust include the blasting of construction work, cement factories, frame factories and coal factories [10].

The purpose of this research was to make an environmental assessment of the blasting noise and vibration resulting from a work place in a residential area.

2. Methods

Three measurement locations were selected that had expectations of high level noise, plus the measurement height for each place was 1.2-1.5 m from the ground. Noise measurements were taken 65 times at the selected places. If there were building obstacles over 1.5 m in height, the locations were chosen 1.5-3.5 m away from the obstacle toward the source of noise. A sound level meter (IEC651 Type I, NL-11) was used to measure the blasting noise. This was followed by an official environmental pollution test. The sound level meter was positioned facing the direction of the noise and sheltered from any wind. No measurements were taken when the wind velocity was more than 5 m/sec. However, a wind velocity of over 2 m/sec will still influence the measurements, therefore, in this case a wind shield was positioned around the sound level meter. In addition, if there was a lot of vibration or an electromagnetic field (big electronic machines, or around high-tension wire), a protector (dust proof, shelter) was also used. The timings of the measurements were divided between the day time maximum blasting vibration period (06:00-22:00) and night time (22:00-06:00).

A vibration level meter (JISC 151-1976, VM-51) was used for measuring the blasting vibration. Vibration measurements were performed 60 times at three selected places where high levels of vibration were expected. The installation location for the vibration pick-up was at ground level, and had to be firm with no slope or unevenness. There had to be adequate space with no buffers or influences from extraneous magnetic or electron vibration, accordingly, spaces where reflection or diffraction were expected were avoided. The vibration pick-up was installed to measure the vibration in a vertical direction, and measurements were taken during blasting. This was followed an official environmental pollution test. Measurement were only taken and recorded after the vibration level meter was connected to the vibration level recorder. After the output of the vibration level meter and input of vibration level recorder were connected to each other, the power and operation of the machine was checked and corrections were made as needed. The level range converter of the vibration level meter pre-investigated the vibration level of the measurement location, and then maintained it. The recording velocity of the vibration level recorder then made corrections to match those characteristics. The connector of the vibration pick-up was designed to protect from static, it was installed horizontally on the ground. Measurements were taken in the day time during the maximum blasting vibration (06:00-22:00) and at night (22:00-06:00), at more than one location among the measurement places. The measurements also recorded the number of explosions as they occurred (12:00-13:00).

The scattering dust was measured using the High Volume Air Sampler method. This method uses a High Volume Air Sampler to pile up the suspended particulate matter in the air and then produces a weight concentration. The dust passes through the air aspirator and filter holder (15×22 cm). A current meter (1.0-2.0 m^3/min rang) determined the number of scattering dust particles. Therefore, this method was used once a month and a total of 3 times. The selected measurement places had no wind and had high concentrations of dust in the surrounding area. The height of the sample selections was 3-10 m. This was then followed by an official environmental pollution test[10].

3. Results

The maximum levels of blasting noise were 79.8 dB on Feb. 12 at the second point, 78.0 dB on Feb. 13 at the third point. 70.2 dB on Feb. 14 at the first point, 77.9 dB on Feb. 15 at the first point. 68.0 dB on Feb. 28 at the first point, 75.6 dB on Mar. 6 at the second point, 83.8 dB on Mar. 13 at the first point, 82.0 dB on Mar. 16 at the first point, 70.7 dB on Apr. 2 at the first point, 72.0 dB on Apr. 3 at the first point, and 81.0 dB on Apr. 12 at the second point. These measurements were higher than the standard acceptable levels of environmental noise that are 55 dB at noon and 45 dB at night.

The maximum levels of blasting vibration were 85 dB on Feb. 12 at the second point, 77 dB on Feb. 13 at the third point, 71 dB on Feb. 14 at the first point. 74 dB on Feb. 28 at the first point, 88 dB on Mar. 6 at the second point, 73 dB on Mar. 13 at the first point, 83 dB on Mar. 16 at the first point, 70 dB on Apr. 2 at the first point, 74 dB on Apr. 3 at the first point, and 84 dB on Apr. 12 at the second point. These measurements were also higher than the standard acceptable levels of environmental vibration that

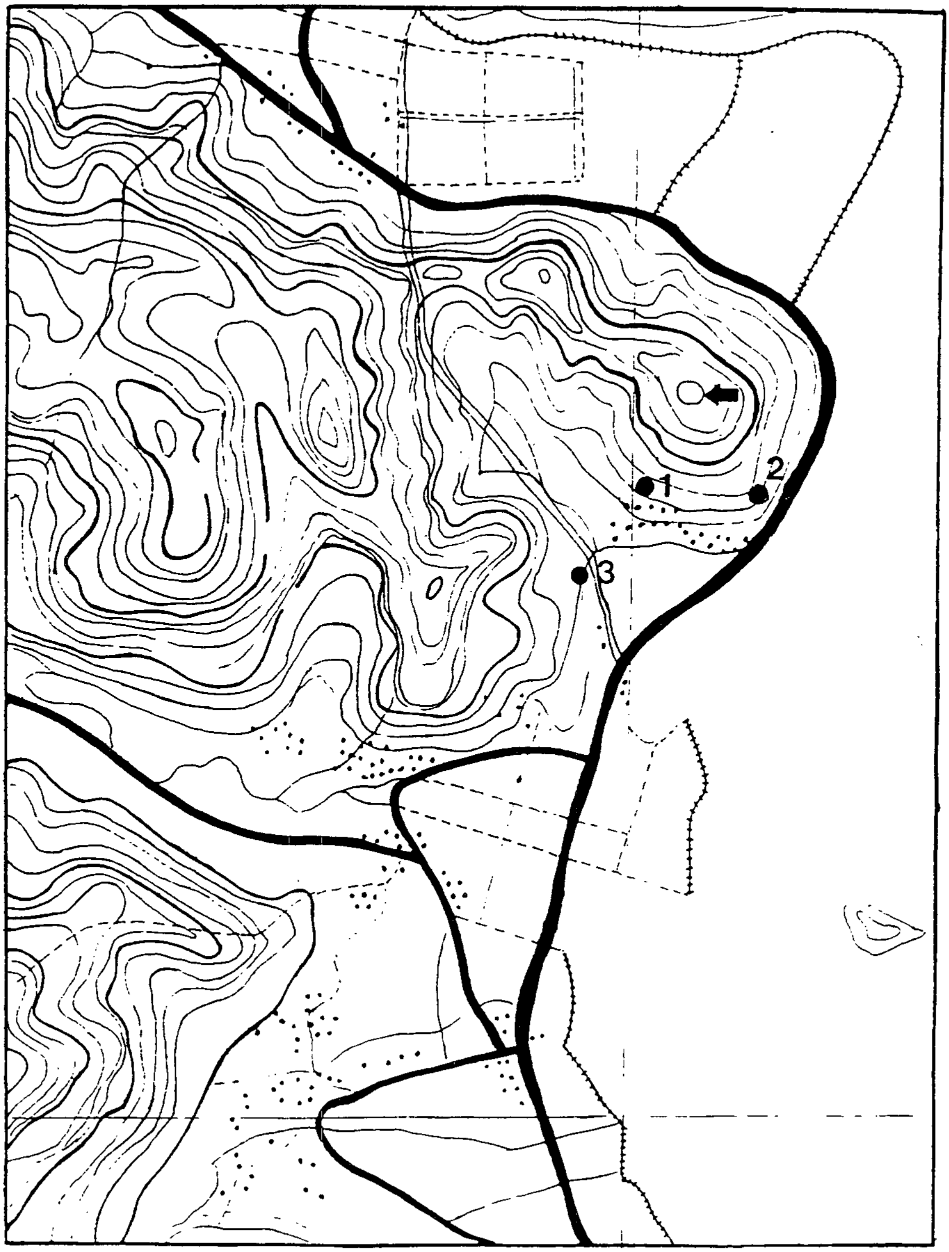

Fig. 1. Measurement points for blasting noise, blasting vibration, and scattering dust.
●1: first point, ●2: second point, ●3: third point, ◀ : work location

are 60 dB at noon and 54 dB at night. When the maximum vibration level is 85 dB, the vibration velocity (V) can be followed by this equation. Y= 20logV + 71, V= 10(Y-71)/20 = 7 mm/sec, where Y is the maximum vibration level. When this result is applied to the vibration intensity of public works, 7 mm/sec is lower than 10 mm/sec, and will not affect any buildings.

The measurements of scattering dust were 80 $\mu g/m^3$ on Feb. 13 at the first point, 120 $\mu g/m^3$ on Mar. 6 at the second point, and 169 $\mu g/m^3$ on Apr. 12 at the third point. These measurements were also lower than the standard acceptable level of environmental dust that is 300 $\mu g/m^3$/day. The average wind velocity was 2.2 m/sec, 2.7 m/sec, and 3.0 m/sec at the three loctions, respectively. The third location recorded the highest level of dust, because it was located just beside a road.

4. Discussion

Concerning temporary hearing loss, if a person works 8 hours in noise about 85-95 dB, normal hearing can be fully recovered by next morning[17]. In particular, hearing loss will start at a high frequency area(3,000-6,000 Hz) and it effects both ears at the same time[18]. However, any sound can be considered as noise. If a sound is below 80 dB, there will be no hearing loss no matter how long the sound is heard[17]. From these theories it is possible to derive a counter plan to block any hearing loss and discomfort. The construction of a noise-blocking project requires an initial observation of the noise source and measurement of the noise damage. To identify the location where the noise is caused, 3 independent spots should be set and their noise levels measured. Second, the actual condition of noise at those 3 selected spots should be investigated through hearing judgements, results from a noise meter, and the outcome of frequency analyses. According to these results, it is possible to determine the difference between personal hearing judgements that are emotionally and environmentally affected and numbers from a noise meter. Third, noise problems can be recognized from sound and tone frequencies. High frequencies of about 3,000-6,000 Hz cause hearing loss. Fourth, the cause of frequencies should be determined, thereafter, the cause can be blocked or removed. Accordingly, in J village, to reduce the noise from explosion, the explosions should be condicted when the weather is clear rather than cloudy. Since when the weather is cloudy and there is a low atmospheric pressure, the noise is reflected and the discomfort index is higher than on a clear day. The construction of a soundproofing wall and the establishment of sound-absorbing walls between the village and the explosion site would also reduce the effects on humans and animals by more than half and would prevent any hardness of hearing. The soundproofing wall would result in a noise degradation from 80 dB to 60 dB, and there would be no living discomfort. To degrade vibration, the vibration power needs to be lowered at the vibration site. To move at a *dv/dt* acceleration a machine with *m* weight needs *m(dv/dt)* power. The motion energy derived from this power is 1/2*mv*2. If a spring is set at a vibration site and it is assumed that the spring can absorb the motion energy, the following formula can be derived,

$$(1/2)mv2 = (1/2)F\delta$$

where, F is the highest impact power and δ is the highest displacement of the spring. Let the spring integral number, namely F/δ's value be K, from the formula above,

$$F = (mKv)1/2$$

Namely, if K is set as 1/4, then F becomes 1/2 so the vibration power is decreased by half.

Vibration waves which are transmitted from the ground are not transmitted deeply underground, instead they are usually transmitted along the surface. Their velocity of propagation is commonly 80-140 m/sec. Accordingly, if ditches are constructed near vibration-receiving spots, the effects from the vibration waves will be decreased. For vibration reduction or vibration production in J village there were some difficulties encountered with using vibration-isolating rubber mounts. For the prevention of noise and vibration in the future, different applications for different ground configurations are need as there are different effects when the source of noise and vibration occurs lower or higher than the residential area.

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