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Occupational Noise Exposure Among Road Construction Workers

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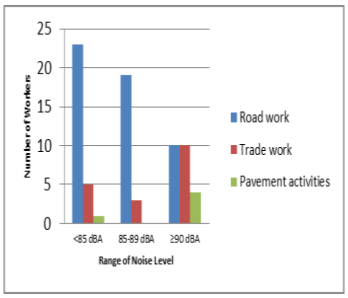
Graphical abstract



Abstract

This study aims to evaluate noise exposure and prevalence of hearing loss among typical road construction workers. Personal noise dosimeter was used to obtain the noise exposure profile of heavy equipment operators that are working on various stages; road work, trade work and pavement work. Symptoms of hearing loss among workers were observed through interview session. It was a degradation in human hearing ability. Workers with symptoms of hearing loss may have problem in understanding speech or conversation. There are 73 construction workers that were evaluated, 60 of them are machine's operators, 7 are site supervisors and 6 are premix workers. The results show that in road works stage there are 6.9% workers exposed to action level ≥85 dBA and 1.4% workers exposed to noise ≥90 dBA. 4.1% workers from trade work and 13.7% workers from pavement work were exposed to noise ≥85 dBA. There are 5.48% of workers from pavement work exposed to hazard level of noise with only 2.74% of worker used Hearing Protection Devices (HPD). There is a prevalence of symptoms of hearing loss among workers with 45% of workers from road works, 32% from trade works and 23% from pavement stage. These exposed workers suggested to have an audiometric testing program annually in order to identify deterioration in their hearing ability as early as possible.

Keywords: Noise exposure; Factory and Machinery Noise Regulation 1989; road construction worker; hearing loss; hearing protector

1.0 INTRODUCTION

Construction is an information intensive and complex industry[1] which constitutes an important element of the Malaysian economy.[2] Construction sector normally generates noise and put workers at an overexposed risk. In the early 1980s, almost 421 000 construction workers were exposed to daily noise levels above 85 dBA.[3] and this number increased to 500 000 construction workers in 1999.[4] In 2002, about half a million to 750,000 workers had daily noise level exceeded 85 dBA in most trades.[6] However, only less than 1% of noise inspections were carried out in the construction sector from average of 22,700 construction inspections in 1994.[7] Safety and health protection among construction workers seems challenging.[8] Therefore, civil engineers also hold the responsibility to build a safe and economic constructions.[9] Knowledge and awareness of project with regards to impacts of construction needs to be enhanced[10] is a responsibility to carry out.[11]

Noise from various heavy-equipment used in construction which range between 80 to 120 dBA[12,13] may resulted in the risks of overexposure among operators.[7,13,14,15,16,17] An association between noise exposure and hearing loss has been recognized with major causes of construction accidents were found to be related to the attitude of the workers.[18] Most construction workers lose their hearing ability after years of working in the sector. Age is one of the common causes of hearing loss among older workers known as *presbycusis*[19] while hardly understand speech[20] related with loss of hearing ability in the middle of the frequency range of human voices.[21] Noise exposure is also associated with other health effects such as an increase in diastolic blood pressure[22,23] and cardiovascular disease risk[3,24,25]. In preventing hearing loss, engineering noise control is a priority but in some industry it is hard to implement which makes the use of hearing protection to become a solution.[26] Safety is important in daily work,[27] yet current enforcement of noise regulations were poor in the construction sector[5,7,28,29] although those working in the field of industrial noise control have struggled to educate people.[30] According to Kerr *et al.* (2002), there is a lack of existing studies on noise exposure in the construction sector[31] with limited information on construction workers' exposure, their use of hearing protection, and the existence of hearing conservation programs provided by employers.[32]. A successful construction safety and health performance requires accurate identification and investigation of construction hazards.[33] This study intends to evaluate the daily 8-hours noise exposure levels of heavy equipment operators (TWA) of road construction workers, prevalence of exceeding the permissible limits and the prevalence of symptom of hearing loss among the operators.

2.0 METHODOLOGY

2.1 Evaluation of Worker's Noise Exposure

Noise exposure level of typical heavy equipment operators in road construction were measured using Personal noise dosimeter. The Edge Quest Technologies satisfied the requirements of *ANSI S1.25-1991(R1997)*–Specification for personal noise dosimeters and *IEC 1252-1993*–Electroacoustic. Noise dosimeter was clipped onto worker's shoulder or at any position close to the ear that receive much noise. The measurement was conducted for 8-hours in order to get the full shift exposure (8-hour time weighted average (TWA) or daily noise exposure. Data recorded by noise dosimeter were generated and analysed using Quest suite Professional software. Before and after measurements were conducted, noise dosimeter was calibrated at 114 dB in order to control measurement errors and uncertainties to an acceptable level. The measurement followed guidelines from ISO 9612, *Acoustics-Determination of occupational noise exposure-Engineering Method*.

2.2 Compliance with the Regulation

Noise exposure level of heavy equipment operators was compared with existing regulation on occupational noise. Malaysia implemented Factory and Machinery Regulation (FMR) 1989 that recommended standards to protect workers safety and health from occupational noise exposure. According to FMR 1989, worker TWAs should fall below the recommended exposure limit of 85 dBA to classify it as a safe working environment. The worker should also not be exposed to maximum permissible exposure limit which is above 90 dB for more than 8 hours without wearing hearing protection. It uses a 5dB time‐intensity trade off which mean for every 5 dB increase in noise level, the allowable exposure time is reduced by half, and for every 5 dB decrease in noise level, the allowable exposure time is doubled.

2.3 Determination of Prevalence Symptoms of Hearing Loss

Questionnaire surveys contain information on hearing impairment and interview session was used to assess hearing loss among workers.[34] In this research, workers' hearing ability were determine as good, poor and moderate through observation during interview session as well as from questionnaire distributed. All the data were recorded and the rating of hearing ability among workers ranked based on Table 1.

Table 1 Indicator of worker's hearing ability

Hearing ability	Observation
Poor	Most common causes of hearing loss in adults that is associated with noise exposure and *presbycusis* [19]
Moderate	Workers that hardly understand the questions and discriminate speech.[20,21] Prevalence symptoms developing hearing loss which makes them unable to hear sound at certain frequencies.
Good	Workers that are able to hear and understand the questions clearly

3.0 RESULTS AND DISCUSSION

3.1 Descriptive Analysis of Noise Exposure

Several types of road construction machines were used during this research including excavators (10), dump trucks (7), roller-compacters (7), motor graders (3), backhoes (12), mobile crane (1), breaker (1), back-pushers (2), premix roller-compacters (6), tyre rollers (4), back-pushers (2), *and* pavers (5). The workers were grouped into different construction stages from road work, trade works and pavement stages according to the job performed during measurement. Mean values for daily noise exposure (Lepd), sound power level (Lw) and peak level (Lcpk) of respondents were show in Figure 1. Road work stage recorded the lowest exposure of daily noise and peak level of noise with 81.31 dBA and 120.76 dBC. However, this stage recorded the lowest machine's sound power level with 101.1 dB. Pavement stage recorded the highest mean of daily noise exposure while trade work stage recorded the highest mean of noise peak level.

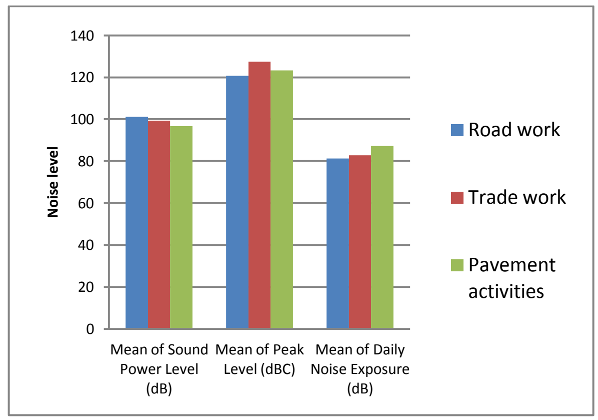


Figure 1 Mean noise emission levels, noise peak level and daily noise exposure measured during road construction stages

Noise exposure of general workers such as site supervisors (7) and premix workers (6) were measured since they were exposed consistently to noise from construction machines. Site supervisors were grouped into road work stage and premix workers grouped into pavement stage. Daily noise exposure of workers from road work stage is shown in Figure 2. Excavator's operator recorded the lowest exposure of peak level (Lcpk) with 102.53 dBC, daily noise exposure (Lepd) with 77.2 dBA and both maximum and minimum level of exposure to noise with 66.3 dBA and 81.7 dBA. Dump truck's operator recorded the highest mean of peak level with 132.17 dBC while roller compacter's operator recorded the highest maximum level and daily noise exposure with 83.4 dBA and 90.7 dBA compared to other machine's operators.

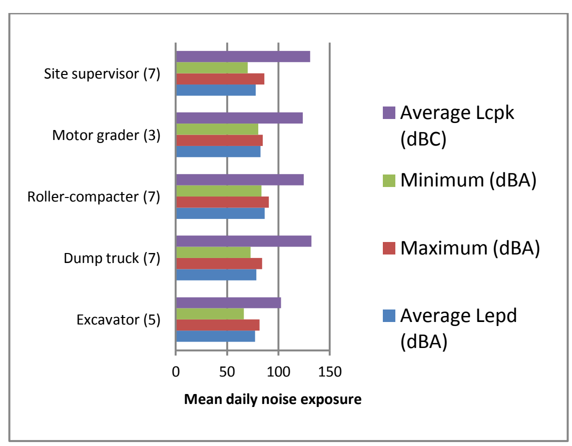


Figure 2 Noise exposure levels of workers in road work stage

21 machine operators from backhoe, excavator, mobile crane, breaker and back-pusher were grouped into trade works stage according to their tasks which is associated with drainage and manhole construction activities. In this stage, excavator's operator recorded the highest peak level (Lcpk) with 125.4 dBC but the lowest minimum level of exposure with 78.5 dBA. Highest daily noise dose recorded by back-pusher's operator (85.15 dBA) and lowest daily noise exposure recorded by excavator's operators. Backhoe's operator recorded the maximum level of exposure with 85.7 dBA as shown in Figure 3.

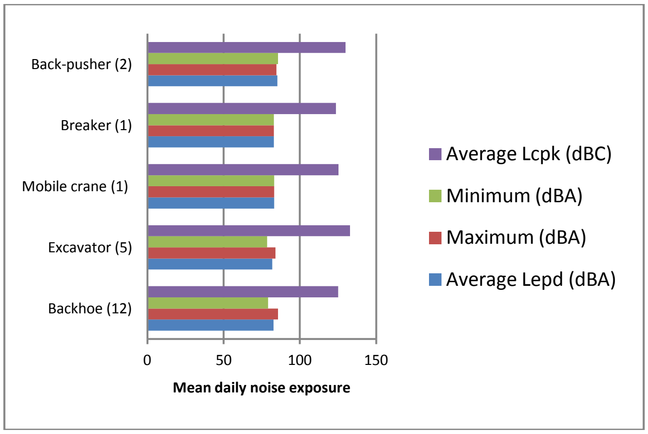


Figure 3 Noise exposure level of workers in trade work stage

Pavement stage was the last stage performed in road construction. 17 machine's operators including 6 premix workers in this study were grouped into this stage. Worker's noise exposure levels were measured and the highest daily noise exposure and peak level recorded by premix roller-compacter's operators with 89.98 dBA and 130.6 dBC. Premix workers recorded the lowest daily noise exposure (82.93) and minimum level of exposure (73.4 dBA) Tyre-roller operator recorded lowest peak level with 118.33 dBC and lowest maximum daily noise exposure with 87.9 dBA as shown in Figure 4. This finding may be consistent with Blute *et al.* (1999)[15] and Hong (2005)[35] where the average noise levels of operating engineer may reach up to 85 dB(A) which is unsafe.

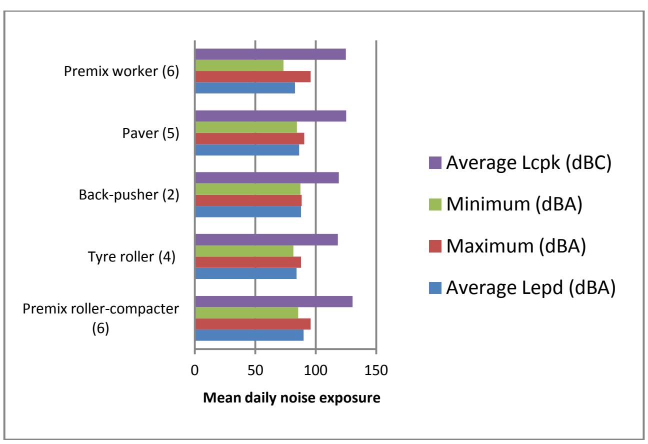


Figure 4 Noise exposure level of workers in pavement stage

The significant difference in average daily noise level (Lepd) between stages were analysed using Kruskal-Wallis test since the data were not normally distributed while the significant difference in the average peak level of noise were analysed using ANOVA since the data is normally distributed. Results shows that there is no significant difference in peak level of noise ($p>0.05$) between stages but there is a significant different for daily noise exposure between stages ($p<0.05$).

3.2 Compliance with Regulation

Factory and Machinery Noise Regulation 1989 requires the workers to be protected when their daily noise exposure exceeded 85 dBA and maximum duration allowed for exposure at and above 90 dBA is 8 hours. Yet, workers are still exposed to these levels without any hearing protection. Figure 5 shows the percentage of road construction workers from heavy equipment operators, site supervisors and premix workers who are exposed to noise according to Factory and Machinery Noise Regulation 1989 (FMR 1989). According to the regulation, 62% of sample workers were working in a safe noise level which is below 85 dBA and 30% of them working above 85 dBA which known as an action level where the risk of hearing loss development is started. These workers were assumed to develop 8% material hearing impairment according to NIOSH 1997 by assuming 5 working days every week over 40 years working lifetime. Another 8% of workers are working in hazard noise level since the level were above permissible exposure level 90 dBA. At this level, NIOSH 1997 predicts that these workers were at risk of developing 25% material hearing impairment by assuming 5 working days every week over 40 years working lifetime.

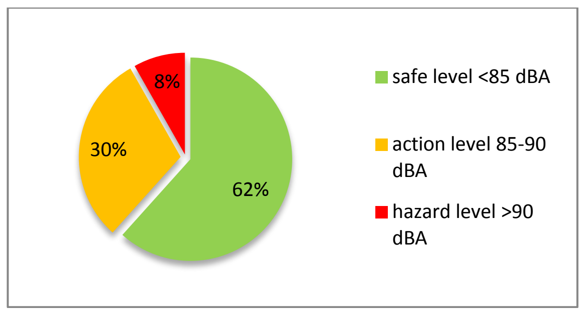


Figure 5 Percentage of exposed workers according to FMR (1989)

In this research, road construction activities divided into 3 stages; road work, trade work and pavement activities. In road works, there are 31.5% of respondents exposed to safe noise level which is below 85 dBA, 6.9% exposed to action level (≥85 dBA) and 1.4% exposed to hazard level of noise (>90 dBA). In trade works, 26.1% of workers are exposed to safe noise levels, 4.1% workers are exposed to action level of noise and none exposed to hazard level of noise. Pavement stage recorded the same percentage for workers exposed to safe noise level and action level which is 13.7%. However, 5.48% of workers are exposed to hazard level of noise as show in Figure 6.

All workers' daily noise exposure levels among paver, premix roller compacter and back-pusher's operators exceeded FMR 1989 action level. Workers with noise exposure levels above permissible level were excavator (1) and premix roller-compacter operators (2). However, none of these workers wear any hearing protection devices in order to protect their hearing from noise hazard.

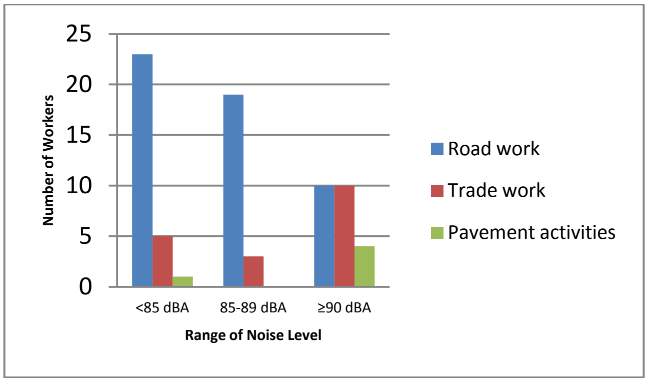


Figure 6 Percentage of exposed workers according to construction stages

3.3 Prevalence Symptoms of Hearing Loss

Worker's demographic data were recorded including age and working experience in construction industry. Since the workers are exposed to hazard levels of noise, hearing ability of these workers in three different construction stages was observed. Every road construction stages recorded prevalence of hearing loss symptoms from all workers except for tyre-roller, back-pusher operators and site supervisors. Figure 7 shows that 32% of workers with hearing loss came from road work stage. Another 45% of workers with positive symptoms of hearing loss came from trade work and 23% from pavement activities stage.

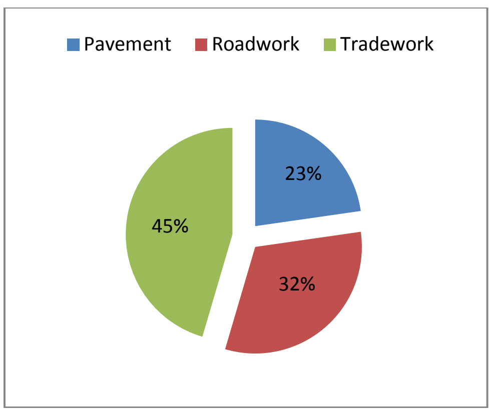


Figure 7 Prevalence symptoms of hearing loss among workers according to stages

Workers with prevalence symptoms of hearing loss came from various age ranges from 29 years old to 58 years old and their hearing ability were assessed and rated based on observation through interview session. Almost 12.3% of workers aged above 51 years shows symptoms of hearing loss which may suggest an association between *presbycusis* and prolong exposure to noise which is consistent with previous research by Ciobra *et al.*,[12] Results shows that 54.8% workers recorded good hearing ability, 41% workers shows moderate hearing ability while another 4% workers were rated with poor hearing ability (Figure 8). There is an association between worker's on-field experience and hearing loss as suggested by Hong.[8] Worker's experience in construction sector ranged from 2 years to 26 years with rating of poor hearing ability usually occurred after 20years in construction as shows in Figure 9.

Figure 8 Relation between workers hearing ability and age

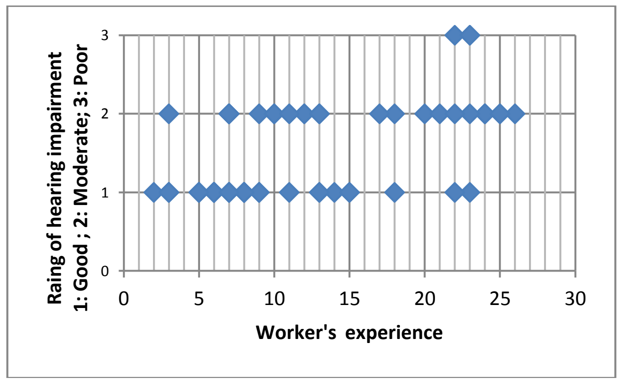


Figure 9 Association on hearing ability and work experience

4.0 CONCLUSION

Road construction was divided into three stages which were road works, trade works and pavement activities and these stages were associated with the use of various heavy-equipment. In general, there are 6.9% sampled workers from road work stage exposed to noise action level (≥85 dBA) and 1.4% exposed to hazard level of noise (≥90 dBA). In trade works, 4.1% of workers were exposed to noise action level. 13.7% of workers from pavement stage were exposed to noise action level and 5.48% of workers exposed to hazard level of noise (≥90 dBA) while only 2.74% of workers used hearing protection devices (HPD). From all 73 respondents in this study, 4% of workers were rated with poor hearing ability and 54.8% workers recorded moderate hearing ability. The rest of workers show symptoms with good hearing ability. 12.3% of workers aged above 51 years shows positive symptoms of hearing loss.

As long as the prevention action to reduce the noise were taken; isolation or wearing hearing protection, workers will be protected from hazardous noise and risk of hearing loss. 45% of workers that show prevalence symptoms of hearing loss were working in road work stage, 32% were working in trade works and 23% were working in pavement stage. Engineering controls and noise mitigation actions are required to reduce the employees' exposure if exposed to this level. According to FMR 1989, if a worker's initial noise monitoring shows exposure to noise levels at or above the action level, follow up measurements after six months are required. An employer shall establish and maintain an audiometric testing for overexposed worker in order to identify deterioration in their hearing ability as early as possible in addition to a training program.

Acknowledgement

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