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Construction Noise and Its Impact on Workers in Rajshahi City, Bangladesh

Md. Alamgir Hasan[1], Md. Abul Kalam Azad[1*], Md. Moniruzzaman[2], Md. Kamruzzaman[3]

[1]Institute of Environmental Science, University of Rajshahi, Rajshahi - 6205, Bangladesh.

[2]Department of Geography and Environmental Studies, University of Rajshahi, Rajshahi-6205, Bangladesh.

[3]Department of Civil Engineering, Rajshahi University of Engineering and Technology, Rajshahi-6204, Bangladesh.

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Abstract

The construction industry is vital to a nation's development, but it generates noise pollution, which poses a serious threat to public health and the environment. Construction workers with poor socio-economic backgrounds are easily exposed to miscellaneous noise at workplaces and become the victims of noise. The present study was conducted to assess the construction noise level at selected construction sites in Rajshahi City, Bangladesh. A total of 10 construction sites were selected based on project type and the stage of construction. The noise level at different distances from the construction sites (5, 10, 20, 50 m) during the working period (9:00 to 17:00) was measured with the help of a digital sound level meter. Simultaneously, a survey of construction workers was carried out. The noise levels at construction sites varied from 76.0 to 91.5 dBA. About 40% of the noise levels exceeded the allowable limit of 85 dBA, prescribed by the World Health Organization (WHO). As per the questionnaire survey, many workers treated the construction sites as “moderately noisy” and “slightly annoyed”. Due to the noisy environment, most workers had to raise their voices during work. They also had “moderate” communication interference at work sites. Noisiness and annoyance at work were negatively correlated with age and work experience. This study found that one-third (34.3%) of workers suffered from headaches and 8.6% experienced sleeplessness.

***Corresponding author:** Md. Abul Kalam Azad, email: akazad-ies@ru.ac.bd.com

1. Introduction

The construction industry is vital to a nation's development and affects every individual, whether directly or indirectly. The detrimental effects of construction work have disgusted those employed in this sector and attracted global interest. In developing nations, most building site operations are controlled by laws that control pollution. Animals, people, and the environment are all impacted by the different pollutions this industry produces (Jain *et al*., 2016). Noise pollution is now posing a serious threat to public health and the environment (EEA, 2020). One of the most persistent pollutants in the human environment is noise, and many development projects have significantly impacted the rise in noise pollution. Loss of hearing is the effect of noise exposure that has been investigated the most. The issue is that individuals who are exposed to it are hardly aware of the cause-and-effect relationship that develops gradually but steadily (Leather *et al*., 2003). A noise footprint, like a carbon footprint, could quantify and comprehend the effects of human actions and people's decisions on the environment concerning noise pollution (Health-Europe, 2023). Since noise pollution is a global problem, environmental noise research has gained popularity (Fyhri and Avasang, 2010) in terms of occupational noise exposure (Liu *et al*., 2017; Jang *et al*., 2015).

Rapid growth and urbanization have resulted in many construction projects that generate noise for the local people. This noise is produced during specific times and is combined with everyday background noise and traffic noise (Li *et al*., 2016). Additionally, the impacts of noise-induced hearing loss indirectly contribute to the health consequences of noise that aren't directly related to hearing, which include stress, restlessness, and elevated blood pressure (Sinclair and Haflidson, 1995). Construction workers with poor socio-economic backgrounds are randomly exposed to miscellaneous noise at workplaces. Additionally, noise is one factor that increases the risk of accidents in the workplace. (Smith *et al*., 2003).

Practically, construction noise is easy to control and mitigate through regulation, but enforcement of legislation is often very rare in developing countries like Bangladesh. Moreover, the construction period is often extended to another 2–3 years. It is very common in urban areas like Rajshahi City for a single project to have construction periods of 3 years or more, which has a long-term impact on the nearby communities. Eventually, noise from construction works would be a concern for city dwellers; construction noise-related complaints are frequently heard at the under-construction sites. In this context, the present study aimed to assess the construction noise level and its impact on the workers at the selected construction sites in Rajshahi City, Bangladesh.

2. Materials and Methods

2.1 Survey Site

The study was carried out in Rajshahi City, which is the divisional headquarters and the fourth-largest city in Bangladesh. It is situated in the western region of the country. Many construction projects, including those involving public buildings, real estate developments, and urban infrastructure including road extensions, have been underway in recent years. In the last three years, 3100 building construction plans and 5547 land use orders have been approved, and development projects are under construction (Rajshahi Development Authority, 2023). Besides, a few hyped projects in the infrastructure, education, health, agriculture, and communication sectors have been taken to shape a smart Rajshahi city (Abdullah, 2023).

Figure1. Photographs of noise measurement construction sites.

Construction is a multi-step process. Stages of construction are various, including preconstruction, demolition, foundation, framing, exterior finishes, interior finishes, and landscaping phases (Fernandez *et al*., 2009). Pile drivers, concrete mixture, stone crushers, concrete vibrators, compressors, monkey hoists or mini lift mini cranes, power cutters, hammer drills, excavators, and locally made diesel-run vehicles (Votvoti or Nosimon) were seen to be used in construction sites. These frequently used construction machines related to foundation, demolition, and structure stages were selected as noise sources for the specific noise measurement in this study as representative construction machines at various stages of construction.

A total of 10 construction sites located in different parts of the city were selected based on project type and the stage of construction in a convenient way. The study was conducted from January 2023 to October 2023. The sites were in Mirzapur(S1), Padma Residential (S2), Vodra (S3), Uposhohor (S4), Talaimari

(S5), Rajshahi University campus (S6), Bonolata residential (S7), Chondrima residential (S8), Borokhuthi (S9), and the TB Pukur (S10) area in Rajshahi City. The selected survey sites were comprised of residential apartments, commercial buildings, and road and park construction. The selected constructions were up to eight stories tall, and all the sites were constructed of concrete. Table 1 presents the study locations' profile.

Table1. Construction site profiles of the study

Site ID	Type of project	Construction stage	Area (m^2)	Number respondents surveyed
S1	Road construction	1.Excavation and land movement	2000	10
S2	Residential apartments	2.Foundation and structure	900	8
S3	Residential apartments	2.Foundation and structure	220	10
S4	Commercial	3.Walls and brickworks	1200	7
S5	Education	3.Walls and brickworks	5000	25
S6	Residential	4. Paving and Tiling	300	8
S7	Residential	4. Paving and Tiling	300	10
S8	Residential	5. Facilities: Electricity, plumbing	390	7
S9	Residential	6. Carpentry and finishes	400	5
S10	Recreation	7. Auxiliary activities loading unloading	40000	15

2.2 Noise Measurement

Noise measurement was carried out at four distances (5, 10, 20, 50 m) from the noise source during working hours (9:00 to 17:00). The noise parameter equivalent noise Leq represents both the intensity and length of all sounds happening during a specific time, and Lmax means maximum time weighted sound pressure level within a stated time. The construction noise (both Leq and Lmax) was obtained by measuring the 15-minute equivalent continuously at an interval of 10 seconds at the A-weighted sound pressure level of each hour for 8 hours (from 09:00 to 17:00) of working time. The measurement height was 1.5 m and held in a way to avoid reflection from nearby surfaces. Since all respondents live or work within the measurement points, the values obtained in this way provide a good representation of the exposure values from the site. The digital sound level meter Lutron SL 4033SD was used to measure the noise levels for the investigation.

2.3 Questionnaire Survey

Simultaneously with the assessment of noise levels, a face-to-face questionnaire survey of construction laborers at the selected locations was carried out. A pretested, self-administered questionnaire was created and split into three pieces. The first section contains general socio-demographic information concerning the worker's age, gender, work experience, education, and use of a hearing protective device. The second section focuses on the response to construction noise, such as the potential impact, worker evaluation, and attitude toward construction noise in their working environment. The third section contains hazard-to-human health symptoms-related questions. The primary items in the ICBN standard questionnaire (in both Bengali and English) are phrased using a 5-point verbal scale (Clark *et al*., 2021; Yano and Ma, 2004). On a five-point scale, where 1 represents "not at all" and 5 represents "extremely," the self-reported attitude toward the construction noise was measured. The developed and pre-tested addressed three types of questions: workers' personal information, perception of noise, and awareness of noise impacts. The workers who were willing to respond were considered for the study, and thus, within the time frame (January to October 2023), a total of 105 workers from the mentioned 10 construction sites were finally interviewed. The questionnaire was processed for analysis using SPSS and Microsoft Excel.

3. Results and Discussion

3.1 Noise Level at the Construction Sites

The noise descriptor equivalent noise level (Leq) and maximum noise level (Lmax) of the ten construction sites are presented in Table 2.

Table2. Equivalent noise (Leq) and maximum noise level (Lmax) in dBA of construction sites by distances.

Site	Construction stage	5 (m)		10 (m)		20 (m)	
		Leq	Lmax	Leq	Lmax	Leq	Lmax
S1	1.Excavation and land movement	85.8	108.0	80.6	103.0	75.1	98.3
S2	2.Foundation and structure	91.5	114.7	85.7	106.0	80.1	100.5
S3	2.Foundation and structure	90.1	113.0	84.6	107.0	78.2	101.0
S4	3.Walls and brickworks	79.3	103.0	73.7	94.2	71.4	88.3
S5	3.Walls and brickworks	78.6	100	73.3	94.2	70.3	88.2
S6	4. Paving and Tiling	83.0	105.2	78.2	99.1	73.0	93.2
S7	4. Paving and Tiling	85.6	109.0	80.5	103.5	75.0	97.6
S8	5. Facilities: Electricity, plumbing	78.0	104.0	72.0	98.2	67.1	92.3
S9	6. Carpentry and finishes	76.0	101.2	71.0	95.3	67.1	90.0
S10	7. Auxiliary activities loading unloading	80.0	105.0	74.5	99.0	70.2	93.0

From the findings (Table 2), it shows that the Leq, which is treated as the average noise level, by measuring distance ranged between 76.0 dBA and 91.5 dBA at 5m away from the sources. At 10 m, it ranged from 71.0 dBA to 85.7 dBA, and at 20 m, it ranged from 67.1 dBA to 80.1 dBA. On the other hand, the highest Lmax was found to be 114.7 dBA at the construction site of Padma residential area (S2) during the foundation and structure stages. It shows that noise level decreased with increasing distance from the noise source. The maximum sound level (Lmax) ranged from 101.o to 114.7 dBA, and the average noise level (Leq) ranged from 80.0 to 91.5 dBA in the foundation and structure stages when heavy equipment like pile drivers and mixture machines were in operation. However, a comparatively low average sound level (Leq) was recorded from 67.1 to 76.0 dBA at Borokhuthi site (S9) during the carpentry and finishing stages when light machines like circular saws, hand hammers, and power drills were in use. The noise levels of different construction stages were not the same. In terms sound level foundation and structure>excavation and land movement>paving tiling>Auxiliary activity > facilities >carpentry and finishes. Foundation and structure included heavy machine such as pile drivers, compressor-mixture, vibrator, etc. which produced a higher noise during operation. The excavation and land movement stage used excavator and locally made diesel run loader vehicle widely known as Votvoti or Nosimon made second highest noise during the study at Vodra (S3). The paving and tiling stage created the third highest noise as tiles cutting produced annoying noise. The construction stage of walls and brickworks, facilities like plumbing, electricity: carpentry and finishes produced less noise as less sound producing hand-held machineries were used and due to interior work, they had a barrier effect on sound transmission.

A relevant study revealed that at a flyover constructing site in Patna, India, the average noise level was 86.7 dBA. (Kumari *et al*., 2023). According to a study conducted in China, construction machine jackhammers and breakers produced the most noise during construction, which ranged from 75.82 to 93.87 dBA (Yang *et al*., 2021). A study in Egypt, it was found that construction sites had high noise levels ranging from 82.1 dB to 112 dB, and 81% of the workers there were exposed to noise doses greater than 100% throughout the course of a workday (Ali, 2011). The Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) guidelines are used in an occupational setting, where they are based on an 8-hour workday over a 40-year working career, the OSHA allowable limit is 90 dBA and the NIOSH recommends 85 dBA (Neitzel *et al*., 1999; OSHA,1983). The results showed that 40% of the readings (4 sites) exceeded the allowable limit of 85 dBA for occupation, as mentioned by the World Health Organization (WHO). The remaining six sites were within the limit. According to the WHO, workers who were exposed to noise exceeding 85 dB should wear hearing protection devices (HPD) if their daily working hours are more than 8 hours per day (Bakhori *et al*., 2017).

ANOVA results (Table 3) illustrate a statistically significant difference ($F= 10.088$, $p<0.05$) between the noise level (Leq) in different distances of 5m, 10m and 15m from the source of sound in the surveyed construction sites. It meant that noise at distances varied.

Table 3. Analysis of variance (ANOVA) test of noise level (Leq) in different distances

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	504.872	2	252.436	10.088	0.001
Within Groups	675.663	27	25.025		
Total	1180.535	29			

3.3 Noise impact on Construction Workers.

The impact of the construction noise on workers is presented in Table 4. The worker's perceptions about noisiness, annoyance, raising of voice, and interference in communication were revealed. The respondents who thought that the site was very noisy, moderately noisy, and slightly noisy were 20%, 29.5%, and 48.6%, respectively, where the mean value was 2.6 (SD 0.8), which was close to "moderately noisy". In the results of annoyance due to noise at the workplace, 55.2% (mean 2.5, SD 0.84) of workers responded that they were "slightly" annoyed at work due to noise. In terms of interference in communication, one-fifth (20%) of the workers experienced "very much interference," but in general, they were moderately (mean 2.6, SD 0.82) interfered due to noise.

In most cases (58.1%), the workers responded that they had to raise their voices "sometimes" to be heard in construction sites; their average value was 3.1 (SD 0.82), which was close to "very often," indicating the noisy environment of the sites. Higher annoyance (51.46%) among academicians due to construction and demolition noise was found for a 5 m distance at Surat, India (Shukla, 2023). Another study in China found that the national level of construction noise pollution was more severe in the morning than in the afternoon, with the highest levels occurring at 4:00 am and there was a slight positive association between the intensity of construction noise and the growth of the local economy was investigated (Wang *et al*., 2022).

Table 4. Perception of the construction workers about noisiness and the effects of noise on them

Variables	Type of response	Respondents	%	Mean (SD)
How noisy is your workplace (Noisiness)?	Not at all	2	1.9%	2.6(0.8)
	Slightly	51	48.6%	
	Moderately	31	29.5%	
	Very much	21	20.0%	
	Extremely	0	0.0%	
Does noise from construction site annoy you (Annoyance)?	Not at all	3	2.9%	2.5(0.84)
	Slightly	58	55.2%	
	Moderately	23	21.9%	
	Very much	21	20.0%	
	Extremely	0	0.0%	
Does noise interfere your communication during work (Interference of communication)?	Not at all	2	1.9%	2.6 (0.82)
	Slightly	59	56.2%	
	Moderately	23	21.9%	
	Very much	21	20.0%	
	Extremely	0	0.0%	
Do you need to raise your voice during work (Raise of Voice)?	Never	0	0.0%	3.1 (0.62)
	Almost never	12	11.4%	
	Sometimes	61	58.1%	
	Fairly often	32	30.5%	
	Always	0	0.0%	

3.4 Noise and Health of the Workers

The health perception of the surveyed construction workers is stated in Figure 2. Nearly one-third (34.3%) suffered from headaches, and one-fourth (23.8%) did not diagnose themselves. The noise exposure caused headaches among the workers. It is also evident that a good number of workers did not get a regular health checkup. The workers (8.6%) were also concerned about the lack of sleep. The self-reported diseases and symptoms of the construction worker are shown in Figure 2.

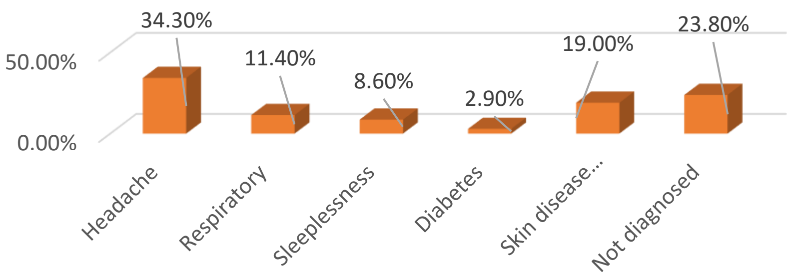

Figure 2. Self-reported diseases and symptoms of the construction worker.

To explore the factors affecting the self-reported noise perception of the construction workers, the variables of work experience, noisiness, communication interference, and hearing impact were used to perform a Pearson product correlation analysis (Table 5). There was a significant negative correlation between work experience and the feeling of noisiness (r = -0.638, p<0.001). Likewise, the relationship between work experience and the interference of communication due to construction noise (r = -0.627, p<0.001) was negatively correlated. So, workers' perception of noise and interference in communication decreased with time, and it could be the adaptability of the workers toward noise.

Table 5. Correlation in evaluation results and related variables

Variables	Work experience	Noisiness	Interference of communication	Impact hearing
Work experience	1			
Noisiness	-0.638**	1		
Interference of your communication	-0.627**	0.947**	1	
Impact on hearing	0.185	0.057	0.106	1

** Correlation is significant at the 0.01 level (2-tailed).

There was a very low positive correlation (r = 0.185, p<0.001) between work experience and impact on hearing. The feeling of noisiness and the impact on hearing also had a markedly low positive correlation (r =0.057, p<0.001). It was found that the impact of hearing had a very low positive correlation (r =.106, p<0.001) with interference in communication. In Korea, it was found that individual and combined noise correlated well with the equivalent sound level (Leq), but that the annoyance caused by combined noise was significantly higher than the annoyance caused by individual noise (Lee, 2015). A similar investigation conducted at an auto industry discovered a substantial relationship (p<0.001) between the cognitive capacity of the workers and their level of discomfort. The findings of linear regression also revealed a significant relationship between cognitive ability and sound intensity (Alimohammadi, 2019).

5. Conclusion

According to this study, the noise levels caused by construction works were between 76.0 and 91.5 dBA at different locations of Rajshahi City. The permissible level of 90 dBA was violated at 2 sites (Padma residential area and Vodra) during the foundation and structure phases, while 40% of the readings at the construction sites exceeded the allowable limit of 85 dBA as mentioned by the World Health Organization (WHO). The noise of construction sites was found as “moderately noisy” and “slightly annoyed”. The noisiness and annoyance at work were negatively correlated with age and work experience. The impact of the hearing was markedly low, with a positive correlation with work experience and age. Thus, it was evident that reducing construction noise is a very important aspect. Therefore, the construction authority should take the necessary steps to reduce noise pollution. The findings of this study will help policymakers and builders in maintaining a safe working environment for workers.

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