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A Study on Assessment of Noise Levels in Various Construction Activities

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Abstract: Construction industry is one of the occupational hazardous workplaces. Most of the construction activities are involved with various risks, prone to occupational hazards. Noise is a physical hazard, resulting from simple headache to permanent hearing loss. Noise is not only confined to work involved but also involves surrounding activities like traffic, commercial activities of the construction sites. Each construction activity is associated with various tools, machinery, producing moderate to severe noise. Workers are exposed to repeated noise levels during worktime. The present study is to identify the machinery and tools producing high noise levels, calculating the average noise exposure levels, the dose levels pertaining to time weighted average levels during high work time. The survey, interview, observation based method adopted in collection and analysing the data .A collective number of noise levels were measured using Noise meter during the study . Ms excel sheet was used to analyse the dose levels and Time weighted average (TWA) . Construction activities exceeding the OSHA standards 85 dB, identified as noise hazard. Analysis concluded that concrete pouring activity produces a noise of 90 dB, exceeded the OSHA limit and carpentry activity just exceeds the limit. Based on survey 44.4% of the construction workers are responded as construction noise is not tolerable and 61.1% are not showing interest towards wearing of PPE.
Key Words: construction activities, noise levels, worktime, tools, machinery, exposure levels

1. Introduction

Construction industry is a hazardous industry involved with various types of Physical, chemical, and biological hazards. Noise is a physical hazard shows its effects from Headache - temporary effects-permanent hearing loss. Noise a temporary phenomenon, environmental pollutant will disappear when their sources stop, and its distribution is dispersive (2). Noise at workplace is referred to as occupational noise, which is a common occupational hazard (4). The amount of acoustic energy that is exposed to an employee's auditory system while working in each industry is known as occupational noise. With uncertain dangers and warning signs noise can be a contributing factor at workplace communications, increasing the risk of accidents and reducing productivity (15). Workers in proximity working at the primary sources exposed to high levels of noise undoubtedly (5). On-site noise control is impacted by the prevalence of noise sources, the variability of the noise itself, the presence of material and human flow, the limited efficacy of most solutions in the low frequency range, and the challenge of determining the impact of mitigation measures (3). Construction noise has an adverse effect because it is rapid, transient, intense, concentrated, and difficult to control (1). The most common type of occupational hearing loss is sensorineural hearing loss where root cause lies in inner ear and 90% reported hearing loss, is a permanent loss caused due to long-term exposure of high frequency noise (18), can lead to the disability (8).

The physiological reactions during the task tests were more notable than those at rest, indicating that more effort was required to deal with the challenging conditions when performing the tasks (10). Physiological data including heart rate parameters, Respiratory Rate (RR), and Electrodermal Activity (EDA) shows the negative effects of construction noise on human health. exposure to construction noise can have negative effects on human health. (9) . The effects of high-intensity noise exposure on the cardiovascular system of the worker are significantly greater than those of the control group who were not exposed to the noise (13). Additionally, it has been hypothesised that noise has an impact on several organs and systems, including the gastrointestinal, respiratory, immunological, reproductive, and nervous systems (14). Numerous studies have been conducted with the goal of identifying the risk factors that lead to headache and eye strain, and physicochemical factors are among the most extensively examined, headache can be triggered by noise, a common source of physical

discomfort(6).National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA),has set standards on occupational noise ,for respective industries . The workers task and equipment involved in it is varying with type of industry, but commonly noise is hazardous when it goes beyond to 85dB, for a time exposure of 8-hour work shift. Permissible exposure limit (PEL)shows a relationship between allotted noise level and exposure time, it is an inverse, exponential relationship. A time duration of 15 minutes with 100 decibels noise and 85 decibels for 8 hours will be same risk level (18). The noise level variations should be regarded as continuous if they involve maxima at intervals of less than one second (17). The problem statement in the study is identifying various construction activities involved with the workers, the noise produced by the instruments, tools in the activity and calculating the TWA. The present study is to identify the various activities involved with noise hazard.

2. Study Area

The study area selected for measuring the noise levels are the different construction sites, adapted with latest technologies, tools, machinery in various construction activities. A noise level meter is used for measuring noise levels in Decibels weighted(A) with slow response. The interval is considered from seconds to minutes continuously along the working hours of the worker completely in his daily activity. Variations in single exposure to multiple exposures is also noted. Some of the construction activities are not involved with any machinery or tools like painting, foundation works but the data was collected to identify the surrounding noise levels, exposed to the worker.

3. Materials And Methodology

Three types of noise pollution occur are outside noise, inside noise, and neighborhood noise. Neighborhood noise comprises noise from industrial facilities, construction sites, and street noise. Construction site noise is included in this category. Noise can be produced at construction sites because of the huge machinery involved, in activities produces different levels of noise. The workers working with different kinds of machinery and different tools in construction sites are being affected by high noise levels during working hours. Among the different Data collection methods, the onsite survey , interview and observation method was adopted in order to extract the exact information from construction sites and construction workers .

The present study is to identify the various activities involved with noise hazard. The various construction activities, the tools, and machinery involved in the present study are tabulated below.

Table 1: construction activities related to tools and machinery.

Sl. no	**Name of the work**	**Name of the tool /machinery involved in the construction activity**
1	Excavation	JCB
2	Laying of foundations	----
3	Bar cutting	Bar cutting machine
4	Colum shuttering	Joining the shuttering
5	Bar bending	------
6	Reinforcement	---------
7	concrete pouring	Concrete mixture
8	Removing of Shuttering	Removing of shuttering, chisels were used in some places
9	Brick work	Manual lifting
10	curing	Can be done with water pipe
11	Lintel /framing	Chisel, plumb bob

12	Flooring work	Finishing machine
13	Electrical work	Drilling machine was used to drill holes
14	Plumbing work	Drilled machines, chisel
15	Plastering	Float, sprit level (plumb bob) Gauging trowel
16	Painting	-----
17	carpentry	Chisel, hand drill, cutter machine, Grinder Machine, Router machine

The above table shows the tools /machinery only producing noise.

3.1 Steps involved in calculating the noise levels and Hazardous construction activity:

Step 1: Identifying the workers involved in each construction activity.

Construction sites were selected and workers involved with various machinery in construction activities, their response towards the data collection was identified.

Step 2: Identifying the various tools and machinery with some physical activities like hammering digging etc. involved in each activity.

Each construction activity is involved with single tool or machinery or multiple tools varying with worker ‘s activity. Worker exposing to single source or multiple sources of noise were observed.

Step 3: Measuring the noise produced by the tool and machines involved in activity using noise meter.

Since the worker is exposing to the direct noise without attenuation, noise meter is kept nearer to the worker and the noise levels were noted with frequency according to the changes shown in the meter.

Step 4: Calculating the dose levels and TWA (Time Weighted Average) using MS Excel

The noise levels are noted and the dose levels are calculated by the formulae

D=100*(C1/T1+C2/T2+C3/T3+----------+Cn/Tn) (OSHA STANDARDS)
$TWA = 16.61 \log_{10} (D/100) + 90$
Where TWA = Time Weighted Average noise level (dB*)*

Step 5 : Comparing the TWA levels with OSHA Standards (less than 85 dB)

The TWA shows a worker's daily exposure to occupational noise (normalized to an 8-hour day), considering the average levels of noise and the time spent in each area. This is the parameter that is used by the OSHA Regulations and is essential in assessing a worker’s exposure.

Fig 1: Flow chart explaining steps involved in calculating TWA.

The noise levels were calculated and noted according to variations displayed in the noise meter with slow response. These noise levels variations respond in and around sounds in the construction sites. The onsite survey also involved with the type of hearing protection adopted by the worker during worktime. Survey includes with questionnaire related to noise hazards, consequences and effects experienced by the worker at the end of the day work, Types of hearing protection equipment and its suitability in construction sites.

3.1.1 Noise Dose(D):

It is the percentage of time a person is exposed to noise that is potentially damaging to hearing. Zero represents no exposure, and 100 represents complete exposure. Noise dose is calculated by dividing the actual time of exposure by the allowed time of exposure. When the daily noise exposure consists of periods of different noise levels, the daily dose can be calculated as:

The dose levels(D) can be calculated by the formula D=C/T
C is actual exposure time, T=permissible time.
The noise levels were calculated from starting to ending of the day work.

D=100*(C1/T1+C2/T2+C3/T3+----------+Cn/Tn). (17)

Where 1 to n is varying from start to last exposure of the work.
C is actual exposure (hrs)
T is permissible exposure (hrs)
D is daily exposure in percentage
Permissible exposure can be calculated as
$Tn = 8 / 2^{(L-90)/5}$, where L is sound produced by the tool or machinery at the site (worker) in decibels (dB).

3.1.2 Time Weighted Average (TWA):

The TWA is a worker's daily exposure to occupational noise , accounting for the typical noise levels and the amount of time spent in each location.
According to OSHA regulations the workers exposure to occupational noise can be assessed by TWA
The daily dose can be converted to an 8-hr TWA by the formula.
$TWA = 16.61 \log_{10} (D/100) + 90$. (17)
The Average noise levels were also calculated from the observations to determine the average exposure noise levels involved by the worker in construction activity.

3.1.3 Average Exposed Noise Levels:

It is the result obtained by summation of noise levels noted during the worktime by total number of noise levels considered for the activity.

4. Results And Discussions.

The noise levels measured during construction activities are calculated with MS-excel for determining the Dose Levels and TWA -Time Weighted Average.

Table 2: Excel sheet data calculation for sample Excavation work

Type of work :Excavation with JCB									
Sl.No	noise in decibel (dB) L	Exposure time in minutes	Exposure time in hours C	L-90	L-90/5	2^(L-90)	T=8/2^(L-90)/	D= C/T	
1	83.3	5	0.083333333	-6.7	-1.34	0.395021	20.2521055	0.004114798	
2	82.2	6	0.1	-7.8	-1.56	0.339151	23.58830748	0.004239389	
3	83.2	3	0.05	-6.8	-1.36	0.389582	20.53481436	0.002434889	
4	84.1	5	0.083333333	-5.9	-1.18	0.441351	18.12614216	0.004597411	
5	82.2	2	0.033333333	-7.8	-1.56	0.339151	23.58830748	0.00141313	
6	83.7	3	0.05	-6.3	-1.26	0.417544	19.15965927	0.00260965	
7	87.2	2	0.033333333	-2.8	-0.56	0.678302	11.79415374	0.002826259	
8	83.4	4	0.066666667	-6.6	-1.32	0.400535	19.97328878	0.003337791	
9	85.4	5	0.083333333	-4.6	-0.92	0.528509	15.13692235	0.005505302	
10	86.4	4	0.066666667	-3.6	-0.72	0.607097	13.17745628	0.005059145	
11	82.7	5	0.083333333	-7.3	-1.46	0.363493	22.00866909	0.003786387	
12	84.5	6	0.1	-5.5	-1.1	0.466516	17.1483754	0.005831456	
13	75	2	0.033333333	-15	-3	0.125	64	0.000520833	
14	87.8	4	0.066666667	-2.2	-0.44	0.737135	10.85283462	0.006142788	
15	87.4	2	0.033333333	-2.6	-0.52	0.697372	11.47164198	0.002905716	
16	74	3	0.05	-16	-3.2	0.108819	73.51669472	0.000680118	
17	67	5	0.083333333	-23	-4.6	0.041235	194.0117205	0.000429527	
18	74.3	6	0.1	-15.7	-3.14	0.11344	70.52192742	0.001417999	
19	87.2	5	0.083333333	-2.8	-0.56	0.678302	11.79415374	0.007065648	
20	87.1	4	0.066666667	-2.9	-0.58	0.668964	11.95879399	0.005574698	
21	84.7	5	0.083333333	-5.3	-1.06	0.479632	16.67945217	0.004996167	

Excavation work | Bar cutting | Laying of foundations | Column shuttering | Reinforcement | Bar ber

Table 3 : Excel sheet data calculation showing average noise levels and Dose

91 =100*190

	A	B	C	D	E	F	G	H	I
43		90	3	0.05	0	0	1	8	0.00625
44		85.4	5	0.08333333	-4.6	-0.92	0.5285	15.13692235	0.005505302
45		65	5	0.08333333	-25	-5	0.0313	256	0.000325521
46		76	8	0.13333333	-14	-2.8	0.1436	55.71523605	0.002393122
47		68.3	9	0.15	-21.7	-4.34	0.0434	162.016844	0.00092583
48		87.4	2	0.03333333	-2.6	-0.52	0.6974	11.47164198	0.002905716
49		87.6	2	0.03333333	-2.4	-0.48	0.717	11.15794933	0.002987407
50		68.3	5	0.08333333	-21.7	-4.34	0.0434	162.016844	0.00051435
51		87.3	5	0.08333333	-2.7	-0.54	0.6878	11.63178014	0.00716428
52		84.5	4	0.06666667	-5.5	-1.1	0.4665	17.1483754	0.003887637
53		84.3	4	0.06666667	-5.7	-1.14	0.4538	17.63048185	0.00378133
54		68.4	5	0.08333333	-21.6	-4.32	0.0501	159.7863103	0.00052153
55		78.9	2	0.03333333	-11.1	-2.22	0.2146	37.27147477	0.000894339
56		85.3	6	0.1	-4.7	-0.94	0.5212	15.34822591	0.006515411
57		68.4	3	0.05	-21.6	-4.32	0.0501	159.7863103	0.00031918
58		83.7	6	0.1	-6.3	-1.26	0.4175	19.15965927	0.005219299
59		89.5	4	0.06666667	-0.5	-0.1	0.933	8.5741877	0.007775275
60		82.7	5	0.08333333	-7.3	-1.46	0.3635	22.00866909	0.003786387
61		69.2	5	0.08333333	-20.8	-4.16	0.0559	143.0127537	0.000582699
62		79.3	2	0.03333333	-10.7	-2.14	0.2269	35.26096371	0.000945332
63		89.7	5	0.08333333	-0.3	-0.06	0.9593	8.339726087	0.009992335
64		85.4	4	0.06666667	-4.6	-0.92	0.5285	15.13692235	0.004404242
65		83.4	3	0.05	-6.6	-1.32	0.4005	19.97328878	0.002503343
66		78.5	4	0.06666667	-11.5	-2.3	0.2031	39.39662123	0.001692192
67		76.2	1	0.01666667	-13.8	-2.76	0.1476	54.19169999	0.00030755
68		77.2	3	0.05	-12.8	-2.56	0.1696	47.17661495	0.001059847
69		76.4	3	0.05	-13.6	-2.72	0.1518	52.70982511	0.00094859
70		78.5	2	0.03333333	-11.5	-2.3	0.2031	39.39662123	0.000846096
71		87.3	3	0.05	-2.7	-0.54	0.6878	11.63178014	0.004298568
72		85.4	5	0.08333333	-4.6	-0.92	0.5285	15.13692235	0.005505302
73		83.2	3	0.05	-6.8	-1.36	0.3896	20.53481436	0.002434889
74		89.4	1	0.01666667	-0.6	-0.12	0.9202	8.6938789	0.001917058
75		87.6	2	0.03333333	-2.4	-0.48	0.717	11.15794933	0.002987407
76		88.5	2	0.03333333	-1.5	-0.3	0.8123	9.849155307	0.003384385
77		87.5	6	0.1	-2.5	-0.5	0.7071	11.3137085	0.008838835
78		84.3	7	0.11666667	-5.7	-1.14	0.4538	17.63048185	0.006617327
79		87.6	5	0.08333333	-2.4	-0.48	0.717	11.15794933	0.007468517
80		84.4	5	0.08333333	-5.6	-1.12	0.4601	17.3877578	0.004792644
81		90.2	2	0.03333333	0.2	0.04	1.0281	7.781239579	0.004283808
82		89.7	3	0.05	-0.3	-0.06	0.9593	8.339726087	0.005995401
83		78.4	4	0.06666667	-11.6	-2.32	0.2003	39.94657756	0.001668896
84		80.6	5	0.08333333	-9.4	-1.88	0.2717	29.44600482	0.002830039
85		84.5	4	0.06666667	-5.5	-1.1	0.4665	17.1483754	0.003887637
86		81.6517647							0.301567727
									30.15677268

Table 4: Results of noise levels in TWA and Dose levels

Sl.no	Construction activity	TWA (dB)	DOSE (%)
1	Excavation	81.35	30.15
2	Laying of foundations	45.87	22.22
3	Bar cutting	95.75	34.67
4	Column shuttering	77.83	18.52
5	Bar Bending	43.56	0.162
6	Removing of shuttering	63.15	2.42
7	Reinforcement work	52.98	0.59
8	Concrete mixing & pouring	90.5	107
9	Brickwork	44.48	0.182
10	curing	33.50	0.397
11	Lintel framing	63.01	2.41
12	flooring	57.97	1.18
13	Electrical working	68.94	5.4
14	Plumbing work	72.05	8.31
15	Plastering	53.21	0.61
16	Painting	50.75	0.434
17	carpentry	85.88	56.5

Fig 2: Tools in carpentry

Fig 3: Bar cutting machine in open atmosphere

Table 5: Results of average noise levels in dB

Sl.no	Construction activity	Average exposed noise levels (dB)
1	Excavation	81.64
2	Laying of foundations	45.8
3	Bar cutting	81.92
4	Column shuttering	70.97
5	Bar Bending	44.13
6	Removing of shuttering	56.04
7	Reinforcement work	49.75
8	Concrete pouring	82.97
9	Brickwork	43.74
10	curing	36.49
11	Lintel framing	61.53
12	flooring	54.51
13	Electrical working	60.7

14	Plumbing work	62.67
15	Plastering	54.57
16	Painting	50.8
17	carpentry	81.54

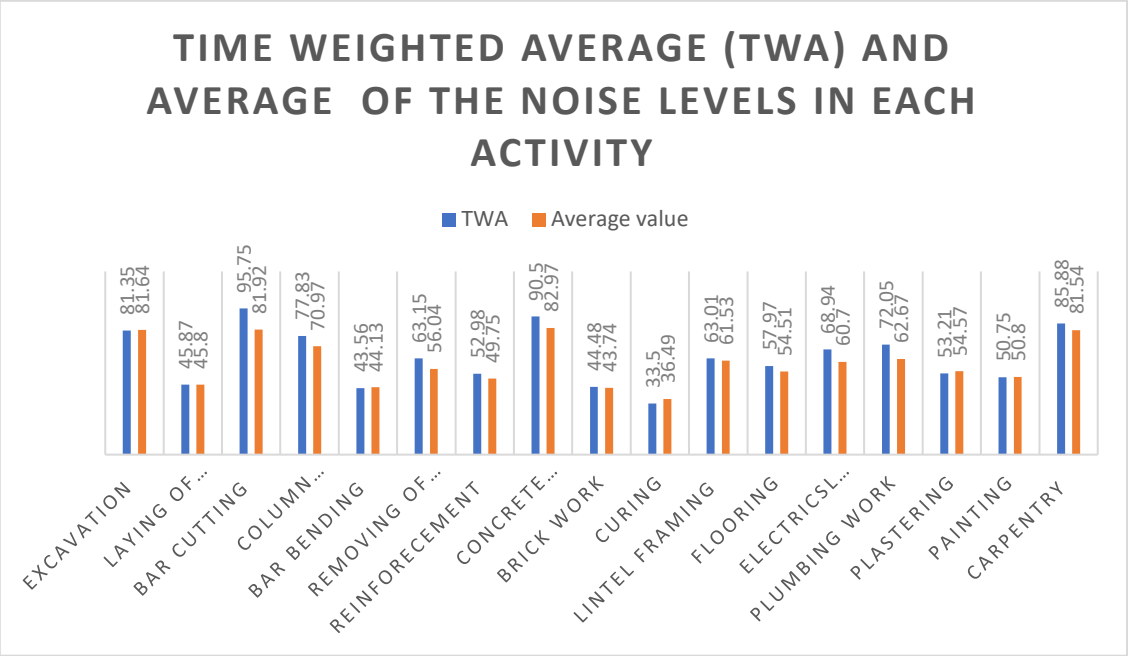

Fig 4: Graph comparing the TWA and average noise levels in construction activity

Workers were asked to certain questions in order to identify the effects of noise at the end of day. Total 180 workers involved in the survey.

1) Do the worker think the work involved is a tolerable noise

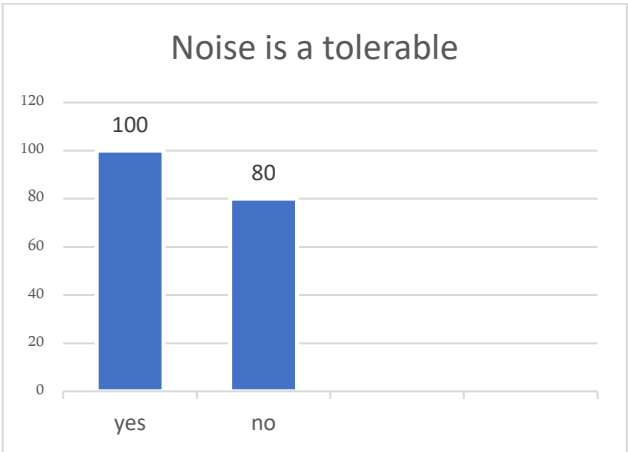

Fig 5: Graph explaining the response of noise is tolerable

2) Do they have any effects by the end of the day.

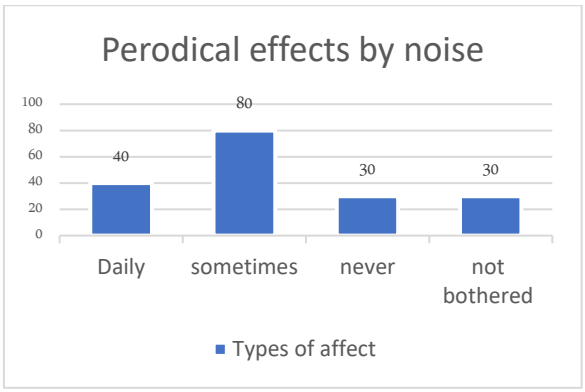

Fig 6: Graph showing the effect of noise at the end of the day.

3) Do the worker interested in wearing PPE for Hearing protection.

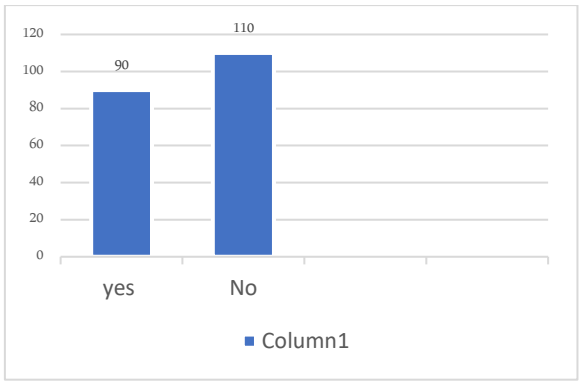

Fig 7: Graph showing workers interested in PPE.

5. Conclusions

According to OSHA, the dose values should be less than 100 %, from the study results, the construction activity concrete mixing and pouring dose values observed beyond the limits and the TWA values also more than the limits. The TWA values of carpentry also slightly more than the limits. The average exposed values of the carpentry activity slightly deviated from the TWA of value. It shows that carpentry workers must use suitable PPE to avoid the permanent loss and major injuries. The construction activities like excavation, bar cutting, concrete pouring in open area shows higher valves, the effect on the worker may be less as compared to the closed area works like carpentry. Continuous exposing of noise in a closed area increases the stress, irritation on the worker at the end of the day the worker may affect with psychological changes may either decrease the quality of work, leads to causing of minor injuries and may extend to major injury. Hand drill machine generates a noise of 80 dB, Router generates 85 dB exceeds the OSHA limits. From the above study it was observed that the carpentry work in a closed area demands the Protective equipment. Day exposures to noise will shows effect on the health condition of the worker indicates the impact of noise on the health condition of the worker. 80 out of 180 workers gave a response of not interested in wearing hearing protection equipment, with a reason of inconvenient, not necessary, not available resulted worker is not seriously responding towards the consequences of the noise exposure.

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