Evaluation Of Noise And Incurred Social Cost Due To Infrastructure Construction Activity

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Abstract: Construction activities result in various types of hazards and discomforts at the time of operation. These problems may seem quite low in comparison with the benefits of any project, but economically they affect the environment around the site. This, in monetary terms, is known as social cost, often not taken into account while evaluating the total cost of the project. Of many different parameters for social cost, Noise pollution due to construction activity is identified as one of the few major threats to the environment surrounding the site of construction. Any Construction project benefits the society as a whole. Yet the problems of Noise due to its construction activity are faced by a very small part of the society, under-influence population. This study is focused on the evaluation of Noise levels due to Metro Construction project, evaluating area under influence and population under influence of Noise. This data is a requirement in evaluating the social cost with the help of Contingent valuation technique. The study gives the framework in evaluating the Noise levels and incurred social cost due to Metro Infrastructure construction project. The site taken for the survey was Nal square to Paud Phata of Pune Metro Reach 2. Noise levels are evaluated for equivalent values of noise at equal intervals for various hours. The day-time Noise levels were evaluated which were found to be as high as Leq 80-85dB (A), equivalent to sensitive to human hearing. The Social cost accounted for about 0.29% that of the project cost from Paud Phata to Nal square with 0.015% increase in the project cost for every single rise of decibel.

Index Terms: *Noise Evaluation, Pune Metro Construction, Social Cost*.

1 INTRODUCTION

Construction activities result in various types of hazards and discomforts at the time of operation. They also result in other unchecked troubles at the time of construction, to the population. These problems may seem quite low in comparison with the benefits of any project, but they economically affect the environment around the site. This, in monetary terms, is known as social cost, often not taken into account while evaluating the total cost of the project. Of many different parameters for social cost, Noise pollution due to construction activity is identified as one of the few major threats to the environment around the site of construction. Noise pollution due to construction activity and its effects on traffic is identified as one of the major threats to the environment surrounding the site of construction. Social cost is incurred due to various parameters, such as Noise, which can't be directly evaluated at the time of Bid evaluation of a construction project. This study is focused on Evaluation of Noise due to various construction related activities. Though the project does benefit to society as a whole, the Noise pollution is mainly faced by a very small frontier population. Thus, it becomes very important to evaluate this Noise induced social cost in Infrastructure Construction project.

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1.2. Problem Identification

he Noise produced as a result of any infrastructure construction activity not only disrupts the environment around the site but also invokes measures taken by the residents around the site to avoid or at least reduce its intensities. This, in turn, results in the cost borne by the society or the population under the influence of Noise, directly and indirectly, due to the Construction activity. This area of influence is known as Noise influence area. Traditional contractual and bid evaluation practices do not account for economic losses resulting from construction-related activities that are borne by parties not engaged in the contractual agreement (Gilchrist et. al., 2005). There can be identification and valuation of these costs borne by non-competent authorities. The seldom countable parameters such as Noise due to construction activity often lead people to adjust with the problems, irritation and discomfort. If the project is beneficial to society as a whole then the total cost must be borne by society, i.e. government (in turn, contractor) by taking measures to avoid such cost. To understand the significance of noise, the social cost incurred due to its effects shall be found out in terms of construction cost of any project.

1.2. Literature Survey

Various studies were conducted to find out the partial or complete effects of noise pollution on human health. Studies have shown ill effects on health of human exposure to noise. Various others gave different ways to evaluate it as a social cost.

1.2.1. Effects of Noise on human health

The use of heavy construction equipment results in a higher noise level in the vicinity of the work area (Gilchrist et al., 2003). Due to high intensity of traffic noise people not only in day but also in night could not sleep properly. As a result, awakening from sleep is very common factor which leads to decrease their working efficiency and health status. The effects of Noise pollution can be adverse headache, stress, loss in concentration, irritation. The adverse effects can be High blood pressure, cardio-vascular diseases, anxiety, abnormal heartbeat, hearing deficiency, etc. Apart from these,

sufficient evidences are also found in the literature for the relationship between traffic noise and heart diseases like myocardial infarction and ischemic heart diseases (Srimanta Gupta and Chitralekha Ghatak, 2011). Lowering the production of people at work, the decrease in happiness and leisure and lowering the property values are the common effects of noise pollution. It is caused by Heavy construction machinery, vehicles and increased traffic noise (John C. Matthews and Erez N. Allouche, 2010).Exposure to noise levels of relatively high degrees can lead to direct hearing loss and/or hearing impairment (Prasher, 2003). Significant hearing impairment occurs on exposure to prolonged exposure to noise levels of 70-85 dB (Jamir et. al 2014). The study has shown the different effects of noise pollution on human health and their relation in significance (Srimanta Gupta & Chitralekha Ghatak, 2011).

Table 1 *Effects of Significant effects of Noise Pollution on Human health (Srimanta Gupta & Chitralekha Ghatak, 2011)*

Effects	Relation
Headache	Not Significant
Anxiety	Not Significant
Elevated Blood Pressure	Not Significant
Abnormal Heartbeat rate	Significant
Hearing Deficiency	Significant
Blood Sugar	Not Significant
Problem in speech communication	Significant
Interference with sleep	Significant
Irritation	Not Significant

Another study has shown that the noise levels variation between 85-106dB, due to the heavy traffic and high-pressure horns, had major psychological effects, found in wardens, as aggravated depression 58%, stress 65%, public conflict 71%, irritation and annoyance 54%, behavioral affects 59% and speech interference 56%. Physiological effects found were hypertension 87%, muscle tension 64%, exhaustion 48%, low performance levels 55%, concentration loss 93%, hearing impairment 69%, headache 74% and cardiovascular issue 71% (Tabraiz et al. 2015).

1.2.2. Evaluation of Social Cost due to Noise in construction activity

A study shows that home owners are willing to pay from 2.4% to 4.2% more of their property to avoid an increase of one decibel of noise. Following equation describes the social costs caused by noise pollution (WANG et. al. 2012). In another study the evaluation of cost is identified by reduction of housing property value with the help of Noise Depreciation Index (NDI). This NDI varied according to the construction period, lowest being 0.02% for 2 weeks to 0.2% for 1year and beyond.

$$Cnp = (Nc - Nn) \times NDIadj \times APV \times Nh$$

The noise due to the construction equipment (*Nc*) and the normal level of the noise (*Nn*) in the affected area must be known in decibels to calculate the social cost. Nn is the default value or allowable limit as set by the government (Matthews and Allouche, 2010).Researchers have mostly used the hedonic price method (HPM) and the contingent valuation method (CVM) for calculating noise costs. On the micro level (local level), researchers have used reduction in property values as a means for estimating noise costs. The impacts averaged 0.5% for Organization of Economic Cooperation and Development (OECD) countries and ranged between 0.15% (in North Virginia) and 1.26% (in Basel, Switzerland). The following estimation method is adopted from a research project conducted by Ozbay et al. (2001) for the New Jersey Department of Transportation (NJDOT). The subsequent formulas can be used for estimating depreciation in value of residential units as a result of traffic noise. ND = *Nh* . (*L*eq – *L*max) . *D* . *W*avg where ND=house value depreciation due to noise ($); *Nh* =number of houses affected by noise (number of houses per acre); *L*eq=equivalent noise level in dB (A); *L*max=maximum acceptable noise level in dB (A) = 50 dB (A) assumed; *D*=percentage reduction in value of residential unit per dB (A) increase in the ambient noise level (0.40%), as recommended by Nelson (1982); and *W*avg=average house value.

1.2.3. Noise rules in India

Back in February 2000, Noise Pollution rules were established in the Gazette of India, Extraordinary, Part-II –section 3(ii), vide S.O 123 (E) dated 14.2.2000. Following table shows the Category of area and permissible Noise levels for the same:

Table 2 *Ambient Air Quality Standards in Respect of Noise is notified under Noise Pollution (Regulation and Control) Rules, 2000*

Area Code	Category of Area/Zone	Limit in dB(A) Leq*	
		Day Time	Night time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Note:
Day time shall mean from 6 AM to 10 PM Night time shall mean from 10 PM to 6 AM Silence Zone is defined as areas up to 100 meters around such premises as hospitals, educational institutes and courts. The Silence Zones are to be declared by competent authority. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority. dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

2 Methodology to calculate Noise induced Social Cost

The following methodology is proposed in evaluation of Social cost: The site selected for the evaluation of Noise and execution of the Research work is Pune Metro Phase 2 Construction. Evaluation of Noise levels and Noise influence area. Equipment used- Sound Level Meter. Willing to Pay Questionnaire Survey was done for percentage of house values in terms of Social cost. Techniques used- Contingent

Valuation technique.

2.1. Method:
Following methodology may be adopted for the evaluation of Noise levels and incurred social cost.The site having traffic congestion and the foundation work going on was selected to cover construction era of start, then the same area was used for evaluation of Noise at superstructure work.The Noise levels were measured for day time hours from 8am to 10pm in 10 minutes interval to check for the variations.To find the Noise Influence area, the sound level meter was used to measure noise levels in the inner parts of society until the drop of noise became null. This gave the range of Noise pollution due to the activity thus selected as the baseline. This in turn gave the Noise Influence zone. Following table shows the Noise influence values as per survey results as a Metro construction site at Pune.

Table 3 *Noise at various points identified for Noise influence zone calculation*

Duration (Hrs)	A1	A2	B1	B2	C1	C2	D1
10:00 – 12:00	70.9	70.9	60.2	61.0	69.2	68.7	58.6
15:00 – 17:00	73.0	72.9	63.1	62.8	68.4	67.9	59.4
18:00 – 19:00	71.1	70.7	60	60.1	69.7	70.0	61.9
20:00 – 21:00	68.0	67.8	56.3	56.6	67.6	67.2	56.5

The population was found out under Noise influence zone. The Social cost would be evaluated by the help of Contingent valuation technique of Willing To Pay (WTP). The hypothesis was done for Average Household area and house using terms. Based on this the social cost was calculated for Metro Infrastructure construction Project.

2.2. Evaluation of Social Cost
After the field surveys, various parameters were to be found out for the evaluation of Social cost as per one study. The following formula would give the Social cost incurred due to Noise pollution (Wang et. al., 2012) F_{NP} =WTP x d/T_{hut} x (N_C – N_N) x T_{AV} x N_H Where, WTP - % extra of their property values people are Willing to Pay to avoid 1 dB increase in Noise.
F_{NP} - the total costs of noise pollution, Rupees; d - the construction days, d; T_{hut} - the house using terms, days.; N_C - the noise due to the construction (Noise at construction), dB;
N_N - the normal level of the noise, dB; T_{AV} - the average property value for each family in the construction areas, Rupees; N_H - the number of affected families

1 Population under Influence area
As the influence zone is known, the Population can be found out with the help of “Data of census 2011 Pune Municipal Corporation”. The population of Ideal colony, Kothrud, is given for Ward No. 65. The area of Ideal colony can be evaluated by Google Maps (figure. This would give the population of the area as per 2011 census. The average population growth rate of Pune can be calculated with the help of past growth rates data as per annexure I under demographic survey (Fire Hazards Response and Mitigation Plan for Pune Municipal Corporation, Feb 2011). The population can be forecasted with the help of Arithmetic increase method (Dinesh et. al. 2016). Thus, the Population density can be evaluated. This population density in aide of the Area under influence will give the Population under the influence Zone of Noise. The average household size as per Pune DPR Nov 2015, is 4.31. This would give the number of families under noise influence zone.

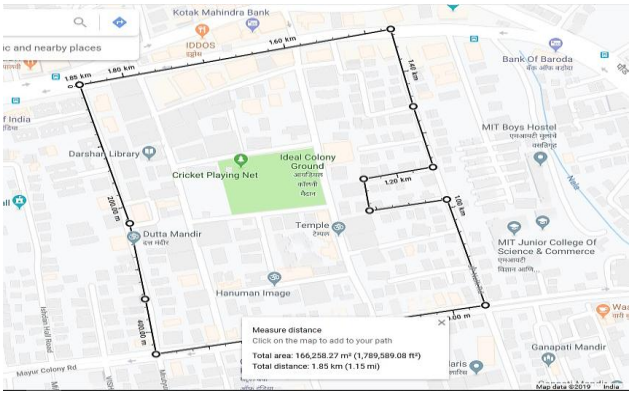

Figure 1. *Known population area (ward no. 65; Data of Census of PMC, 2011)*

i. Cost of Construction for the stretch
Cost of Construction of the Pune Metro Corridor 2 can be found out in Pune Metro Project Report (Pg. 328, Final Detailed Project Report for Pune Metro Rail Project, 2015). Also, the total stretch under construction can be spotted on google map as show in the figure 1, as shown below.

Figure 2. *Stretch selected as a site for the Survey*

The construction cost for the selected stretch of site can be found out with the help Total construction cost and the total stretch of the project as per Pune Metro Report.

ii. Housing value
The Housing value can be found out with the help of Property values in cost per area (Ready Reckoner rates Pune for 2019). The carpet area or the housing area is different for various households. Thus, for calculation purpose various average housing areas (30sqm., 40sqm, 50sqm, 60sqm, 70sqm, 80sqm, 90sqm, 100sqm) were taken in consideration

for the calculation of social cost. The average would give the mean housing value and social cost, respectively.

iii. Construction days and House using terms

The Construction days is the duration of the construction as estimated for the Construction of project. The house using term is the duration of using the property. To counter this, the social cost was calculated using various assumed housing terms (40 years, 50 years and 60 years). The evaluated social cost can be termed as F_{NP40}, F_{NP50} and F_{NP60} respectively.

iv. Percentage of Housing value people are "Willing To Pay"

The cumulative WTP of housing value percentage can be known by Questionnaire survey. The number of Questionnaires done on an average will give the percentage willing to pay per households. Social Cost Evaluation can be done with the help of People willing to pay a part more of their property value, calculated in percentage (Wang et. al. 2012).

2.3. Results and Analysis

Following results are obtained from the study. The Average Noise levels at the selected site came to be 79.5 dB, being the average of Pile Foundation works and Pier construction works noise levels. Total area under influence was found to be about 35777 m^2.

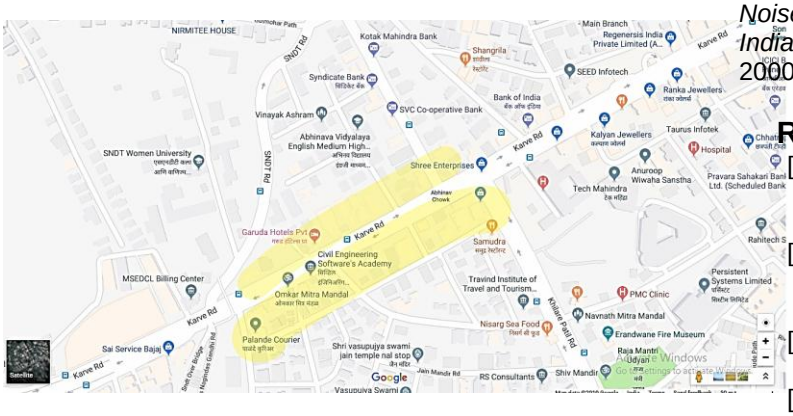

Figure 1 *Area Under influence of Noise*

Population under Noise influence zone for a stretch of 410 m came to be about 3568 individuals equivalent to 828 families. The percentage of housing values people are willing to avoid Noise due to construction activity is 0.51% per household with a 0.0255% of cost per decibel of increase in Noise. The Social cost variation decreases as the House using terms increases. Following figure shows the variation of the Noise incurred Social Cost for various housing terms and housing areas.

3. CONCLUSION

As per the study at the taken site at Pune metro Construction phase 2 and the results obtained, following conclusions can be drawnThe Noise levels in the environment around construction zone are extreme with the on an average magnitude of 79.5 dB. The Noise due to construction is affecting more than 3500 people under its influence zone in such a small stretch alone which accounts for 0.03 per cent of the total length of construction. This gives a brief idea on the considerable size population exposed to the hazards due to Metro Infrastructure Construction activity. An increase of 0.29% of construction cost of site means the social cost if taken for the whole stretch may come up to 0.29 % of the total construction cost people are willing to pay. This is too much of a distress and discomfort to be denied of consideration (project construction cost is more than 2200crore Rupees). For every decibel increase in Noise levels social cost of 0.015 % of total project cost is inflicted. This gives an urge to the need of finding precise way to reduce the impact of noise as much as possible around site of construction. New technologies may be adopted like Noise barriers and Noise attenuation devices to deal with high noise levels. More precise formulation for social cost is needed, so as to counteract the non-sincere behavior in consideration of Noise as an important parameter for social cost. The Noise levels control shall be considered in legal documentations and procedures, such as Bid Evaluation, in any infrastructure project. Any other legal methods are a need to tackle and reduce the Noise disturbance due to infrastructure construction.

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