



Environmental management during metro railway construction especially in highly polluted and densely populated city

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Abstract

The construction of new metro project or expansion of existing metro systems are being planned in several densely populated and highly polluted cities of the world. The metro systems after construction and commissioning will certainly reduce the pollution level and add convenience to the public, but such project may grossly aggravate the pollution problem during construction stage, especially in respect of noise and air pollution which are generally at their peak in the city just before such projects are taken up for implementation. To compound the problem further, the metro alignment generally passes through densely populated areas and high vehicular traffic zones; thus the construction activity has to be taken up mostly in the vulnerable areas of the city, which are the most densely populated as well as generally having the highest pollution level. Now-a-days the project implementation period is getting further compressed resulting in more intense activity of construction and much more increase in pollution level in the shorter period of construction.

In such situation, large population of city which is already suffering from high pollution level may be further exposed to considerably increased pollution level due to the major construction activity, which may lead to very prolonged adverse affect on the public health in general. The paper deals with all the aspects of minimising the negative environmental affects in planning and implementation of major metro project in a highly polluted city – especially when the pollution level of certain elements of pollution are already above the acceptable level. The paper also throws light on the environmental management system including the planning for the route alignment, structures, material used, method of construction, monitoring and other innovative ideas with a special reference to Delhi Metro which is under



implementation in New Delhi having a population of almost 14 million people and being one of the most polluted cities of the world.

1 Introduction

Ever increasing population pressure on cities, especially in developing countries, are rendering the existing infrastructure facilities totally inadequate and pushing the pollution level to a new high. To mitigate the problem of city dwellers, infrastructure projects are under taken on a large scale including the construction metro system to relieve the city from problem of transportation and consequent reduction in pollution. The existing level of pollution in such cities for most of the parameters like suspended particulate matter (SPM), CO₂, CO, SO₂, NO_x etc is either already on higher side or above the acceptable level causing serious concern to the health of city dwellers. Major construction activity, by its very nature cannot be environmentally friendly and is known to grossly aggravate the existing problems due to pollution especially when such activities are underway in a dense habitation.

Any rise in pollution level even for a short period say of one or two years, at places where it is already on a higher side or beyond the prescribed limit, is bound to leave adverse effect for a long period to a large cross section of people. A recent study report of "Centre for Occupational and Environmental Health" in University of California, Los Angeles (UCLA) says "Smog can harm the health of babies... This should make us pause. Air pollution does not just impact asthmatics and old people but it can also impact people at the beginning of their life and can put them to a disadvantage for the rest of their life". The study to be published in the American Journal of Epidemiology found that "the greatest risk occurred during the second month pregnancy indicate that increase in pollution level even for very short period has serious implications.

Apart from human health in general, the affect on certain historical structures, patients in hospitals and children in the school in the area where there is sudden increase in the pollution level are likely to be much worse.. Therefore, any increase in pollution level even during the construction stage of metro system in the populated and polluted locality will cause immense and irreparable damage to the health of people from womb to old age. As such the major construction activity of metro network in above circumstances needs systematic consideration from the assessment of existing and expected pollution during planning and implementation of the project with a well defined environmental management system with proper monitoring.

2 Assessment of existing level of pollution

For a methodical environmental control, assessment of the existing environmental status the density of population, socio – economic consideration, traffic pattern etc. is required with focus is on areas where the metro is planned, so that already polluted areas are not overburdened and inhabitable pollutants are widely dissipated in less

polluted areas. It would be useful to have a “contour” of pollution level of the city. Figure I gives the “contour” of SPM for Delhi along with planned metro alignment. Such details may be further integrated with population density and increase in pollution during the planned construction. This will enable the metro planning to have a overall view of the problem of pollution as well as the project’s requirements.

2.1 Air pollution in Delhi and national standards

Suspended Particulate Matter content in Delhi, which is primarily responsible for giving the City the opprobrium as the fourth-most polluted city in the world, is much higher than the acceptable norms and other pollutants have also almost doubled in less than a decade but remain within acceptable level which is amply clear from table - I. As during the construction of a metro, air pollution is one of the most adversely affected pollution item, all its parameters of air pollution needs to be assessed in detail both locationwise and levelwise.

Table 1. Annual Average of Pollutants in Delhi

Parameter	Annual Average ($\mu\text{g}/\text{m}^3$)				National Standards
	1989	1995	1998	1999 ($\mu\text{g}/\text{m}^3$)	
Suspended Particulate Matter	373	409	341	351	200
Sulphur dioxide	8.7	16.5	16.3	16.2	80
Nitrogen dioxide	18.5	32.5	28.4	26.5	80

2.2 Noise pollution

Noise, apart from other adverse affect, impedes learning process, psychological development, social activity and verbal communication and impairs job performance and safety in work place. Table 2 shows the ambient noise levels in Delhi at a few representative locations mainly along the metro alignment for each category of area, and then compares them with the ambient noise standards. This clearly brings out the noise level is higher by even about 20d B(A) from the national norms.



Table 2. Ambient Noise Levels in Delhi

Location	Noise Level dB (A)			
	Day Present	Standard.	Night Present	Standard
Along Metro Alignment		55(residential)		45
Delhi University	73		71	
Shyamnath Marg	69		62	
		65(commercial)		55
Connaught Place	80		60	
Chandani Chauk	75		69	
50 (Silence Zone)			40	
Delhi Assembly	69			61
Sant Paramanand Hospital				64

2.3 Project Implementation Agencies should carry out an assessment with major sources for other relevant pollution parameters and population density not only along the locations where environment is likely to be affected because of construction but on the alternative routes for movement of materials. The above information can form a key input for further planning, design, execution and monitoring of metro rail system.

3 Planning aspects

While the general horizontal alignment and the vertical alignment, i.e., underground, elevated or at grade of the proposed metro network is by and large decided on the traffic requirements, availability of land, economic consideration, further growth, etc. there are still several ancillary systems which if planned keeping in view the impact on environment will result in considerable reduction in pollution levels. A few examples below will illustrate the above point further.

Every two km of underground metro construction, during its intense period of physical activity of say two years, will add to the pollution level which will be equivalent to plying 500 bus trips per day for only transporting men, material and machine. Therefore, in a tunnel construction the location of shaft to bring out the excavated material (mucking) and supply of construction material should not be

decided merely on economy and convenience in construction but also on the impact on existing pollution level at the exit point as well as all along the route of movement. Hence selection of the route for movement of material etc. should avoid polluted and congested areas even if amount to some detour and additional costs.

Similarly the location of, 'off' the site activities like concrete batching plant, casting yard, spoil dump etc. must take into consideration the existing level of pollution along the route and in the location where they are planned to be set up. The 'contour' of pollution level of city, as mentioned above, will be of great help in such planning to ensure that pollution levels are contained. As the car depot, spread over several hectares of land generally need large filling, if overall project planning permits, it is preferable to locate the car depot near the river so that land may be filled by hydraulic fill, which is most environmentally friendly method for filling. As air pollution level along the river is generally low, addition of pollution during operation of depot will be having lesser adverse affect than locating the depot in already polluted areas.

In cities of high population density, generally the infrastructure facilities and civic amenities specially in developing countries, are inadequate. Therefore, several major construction projects could be under execution by different agencies alongside metro rail construction. As an example, in New Delhi, more than 60 flyovers, 40 subways, 70 kms long large diameter water supply and drainage system, hundreds of multi-storied building etc. apart from innumerable smaller projects are simultaneously under different stages of planning and construction. These are mostly concentrated in the densely populated and polluted part of the city where metro rail system is already in an advance stage of implementation. Though the environmental impact of individual major projects are assessed and necessary mitigation is planned but an overall comprehensive planning, taking all construction activity together is generally lacking which results in unplanned increase in pollution level in an already polluted area. In absence of overall planning of construction activity from environmental considerations at city level, metro construction being generally the biggest construction project in the city, it becomes the responsibility of metro planners to take into account all construction activities of the area in their assessment of environmental impact and plan remedial measures accordingly.

Keeping in view the above, in New Delhi, the Government has directed all executing agencies of construction activities being planned in metro network areas to obtain no objection certificate from metro planners which is enabling proper and comprehensive planning from environmental considerations also.

4 Method of construction and type of materials used

At locations where pollution level has already exceeded the permitted level or is on higher side, every construction activity needs very close scrutiny to ensure that there is no further environmental degradation. Planning for method of construction and



type of materials used plays a very vital part in containing the adverse environmental impact which is clear from a few following examples.

Maximising use of 'precast' concrete structural members will provide a big relief from adverse environmental impact. In an elevated metro construction, by using latest techniques and high capacity cranes, all the members of super structure, even the columns and pier head can be precast, thus reducing the adverse environmental impact specially SPM and noise pollution by 20% to 30%.

Use of high strength concrete to optimum level will substantially reduce not only transportation and erection cost but will also mitigate pollution. Similarly, by appropriate use of 'prestressing' in concrete structure, economy is invariably achieved as there is reduction in volume from 20% to 40% in most of the cases, which in turn results in a positive impact on environment during construction. The technique reduces the weight and volume of structure thus correspondingly reducing pollution in transporting, assembly, manufacture, etc.

In 'cut and cover' method of construction for underground metro, designing 'diaphragm wall' as a permanent structural member instead of only a temporary structural member will reduce volume of excavation transporting of spoil and quantity of concreting. With availability of better quality of water proofing chemicals rubber/metal water stoppers along with advanced techniques of construction; the structure so designed will prove to be environment friendly as well as economical also. Even the environmental damage due to construction of temporary diaphragm walls can mostly be reduced by using of steel sheet piles driven by modern 'vibrohammers' which are powered by 'noisless' and 'green' power packs for the locations where suitable soil strata exists. This has been followed in Delhi Metro near the Old Secretariate and Delhi University (an historical building area) and it is resulting in desired improvement. Even the use of "Jack Down Method" for well sinking will be a positive step towards reducing pollution as it will reduce the construction period, deployment of cranes to handle the kantilage, trucks for transporting of kantilage, etc.

As the transportation of 'spoils' to dumping area and movement of precast or ready mix concrete is a major transportation activity to be carried out for a considerably long duration, use of 'battery operated' truck is an excellent environment friendly option which planners must look into while finalising transportation scheme as it will alone reduce burden of pollution as generated from plying of thousands of trucks per day for construction of underground metro.

Similarly electrically operated crane hoists wherever possible should be given preference. As in several developing countries, there is shortage of electricity in cities, to complete the construction activity remain as to be dependent on 'diesel generators', therefore, the need for maximising the use of electrical energy in place of fossil energy right from the planning stage needs special mentioning. In such



environmentally sensitive locations, the older diesel operated machineries should not be allowed to be used and the same should better be a contract condition for construction itself.

Use of durable materials and structures would obviate the need for frequent repair and replacement, which would again lessen the burden on environmental resources.

On a green road such as Mall Road in Delhi, cutting of long rows of fully grown green tall trees along the under ground alignment could be avoided by judiciously reducing the width of digging for construction in a 'cut-cover' stretch by replacing outside extension of bottom slabs of the box by providing piles below the box to counter buoyancy. Such innovative method of construction keeping the site condition in view will always give opportunity of reducing avoidable increase in pollution. The availability of versatile and powerful machines for 'trenchless' laying of pipes and cables is also helping in long way to contain the pollution in sensitive locations of the city. The use of longer length of temporary 'liners' in construction of pile foundation to avoid use of Bentonite from environment point of view must be adopted in such environmentally sensitive location and minor economic consideration should not come in the way of such decisions. Some of the latest pile driving machineries are equipped to have full length temporary liners in the pile foundation construction which has been deployed in Delhi Metro Rail Project specially in sensitive areas.

5 Public interaction and accountability

Sudden spurt of such large construction activity in the heart of the city is seen more as prolonged inconvenience. Therefore, the people and press are to be properly kept informed about all such construction activities, which has any impact on the public. This could be achieved by ensuring following steps. The overall scheme of the work affecting the public should always to be informed to the public through press. The regular community interaction programme, the information on construction activity should be disseminated and discussed for not only the works being done by implementation agency but also by the other agencies in the area which are connected with the project. A more personal approach is required for those persons whose living conditions are getting directly affected due to the construction activity such as minor vibration in their building, movement of large number of trucks, temporary blocking of their path way, etc. Engineers and their representative along with Public Relation Personnel should directly meet such persons and keep them informed about the steps being taken to ensure safety and environment.

6 International Standard Certification (ISO 14001)

Carrying major construction activity in densely populated areas needs high assurance to the public about environmental issues. While steps mentioned in the above para



will certainly mitigate the adverse affect on the environment but to have “Systematic” and “Continued Improvement” in the environment management, ISO 14001 Certificate for the construction activities would have a great relevance and benefit to the project as well as to the densely populated and highly polluted city.

New York Metro is the first transit metro authority of the world who has got ISO 14001 Certification for their CPM division. Delhi Metro has already taken steps for ISO 14001 Certification for its construction works in phases.

7 Conclusion

The pollution level in highly populated and polluted city is generally already at its peak when a major construction activity like metro rail is planned. Such major construction activity that too compressed in short period for completion will result in further increase of pollution level. Recent studies shows that an increase in pollution level even for short duration in already polluted areas of city has extremely adverse affect on the health of foetus in womb to old person. Adequate consideration to environmental aspects are to be given in all aspects of planning and construction of metro project to match with the special circumstances that prevail in highly polluted and populated cities. By proper planning and execution, the adverse effect on highly polluted and populated zones of the city can be minimised so that health hazards are minimised. Such planning acted upon effectively will also should the public opinion in favour of increased public cooperation and good will.

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