Risk Management in Metro Rail Construction

Case Study : Delhi Metro Corridor from Kalkaji to Botanical Garden

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Abstract— This paper deals with a method of identifying project risk associated with various construction stages in overhead metro rail construction and the processes required or existed to control the risks. The sources of major risk are quantified in terms of probability and severity rating in the construction of metro railways. A case study of the Delhi metro corridor of DMRC magenta line of phase-3 from botanical garden to Okhla NSIC in the capital city of India has been considered for this project work. The methodology for this work is based on the risk response extracted from the experts who were associated and involved in this metro railway projects.

Keywords—Project risk, Probability and Severity rating,Risk response, Metro rail.

1. INTRODUCTION

Project risk management is the art and science of identifying, analyzing, and responding to risk throughout the life of a project and in the best interests of meeting project objectives. Risk management is an essential and integral part of project management in major construction projects. For an infrastructure project, risk management can be carried out effectively by investigating and identifying the sources of risks associated with each activity of the project. These risks can be assessed or measured in terms of probability and impact. Depending upon the severity of each of the risks obtained, specific risk mitigation measures are proposed. It includes the recognition of potential risk event conditions in the construction project and the clarification of risk responsibilities. Risk identification develops the basis for the next steps: analysis and control of risk management. Corrects risk identification ensures risk management effectiveness. The responsible entity/authority of the project should take appropriate decision/action pertaining to the adoption of the mitigation measures for reducing the likelihood of occurrence of the identified risks involved in the project.

In this project report, Construction of Elevated metro of DMRC magenta line of phase-3 from botanical garden to Okhla NSIC has been considered for formulation of Project Risk Management. The major activities consist of survey works, launching of parapets, piling works, geotechnical investigation, pile cap and pier works, pier caps ,construction of decks, casting of segments, launching of segments, plate load test of pile, initial pile load test, minor repairing and repairing of segments etc. In each activity , various risks are identified and their hazard concern is analysed with severity and probability explanation and their rating on risk level 1 to 5.

2. METHODOLOGY

A. Collection of Data

Collection of data is based on the survey and questionnaire of Construction Company namely - Delhi Metro Rail Corporation Limited and Afcons Infrastructure Limited, which includes the risk factors at the construction site. The data is collected from Delhi Metro Rail line - Construction of Elevated metro of DMRC magenta line of phase-3 from botanical garden to Okhla NSIC.

B. Questionnaires and Risk Identification

The risk factor of questionnaire were based on different construction methods that are adopted in overhead metro construction such as method of piling, erection and fixing of parapets, construction of pile cap, construction of pier and pier cap, grade slab construction, casting of segments, launching of segments, stressing of girders etc. covering risks as work at height , hit by person, hit by equipment , hit injury to workmen, road accident, improper handling of heavy reinforcement bars, transportation of girders from casting yard to site location, traffic control, launching of segments at night, shifting of launching truss, presence of unauthorized person .

C. Risk Analysis

The mean and average value of the risk factors from the questionnaire survey is assessed in the form of risk severity and probability rating as High, Medium and Low. Risk Level is defined according to their severity from 1 to 5.

D. Risks Response Planning

Having recognized the risk and evaluated probabilistically its possible impact, the contractor will prepare appropriate risk management strategies and precautions. These

strategies are usually based on the nature and likely consequences of the risk. The aim of these strategies is to eliminate as much as the possible impact and to increase manage of risk. With this in mind, the methodology of erection and fixing of parapet and their risk mitigation and control are discussed here:

Method for erection and fixing of parapet

Brief method of construction.

The precast parapet units will be transported from the casting yard to the location with help of trailer. As the launching of segments is progress ahead, the precast parapet units will be placed with the help of a service crane or with the EOT or marsh crane as per the site condition. Parapet shifted from trailer to feeder point with the help of 15 T capacity hydra crane of directly lifting with the help of EOT hoist as per the road clearance. Make sure that the parpet edges will not be damaged during shifting from casting yard to erection location. Proper care shall be taken during placing on trailer also.

Erection procedure

The parapet will be erected by crane/EOT or other suitable methods. Over erected segment and is tied up with levelling M50-Bolts. After erection of parapets for one span, the same will be aligned and fixed with permanent M24-Bolts. After complete checking of alignment and approved by DMRC, inject grout with approved mix in between segment and parapet is poured through 25mm dia sleeve, which are already fixed in pre-cast parapet. After 24 hours or completion of initial setting time of grout, remove levelling bolts and embedded sleeve must be filled with grout. Then the EOT/ crane will be moved to next span.

Risk involved.

a. Traffic
b. Working at height.
c. Trespassing of other workers in the working zone
d. Working with heavy equipment.

Safety precautions

a. Proper barricading should be done with suitable traffic signs (warning sign diversion sign) to avoid any vehicles on the road barging in to the working area.
b. The equipments will be operated within the safe working radius and all the equipments will be properly maintained and checked. No personnel will be allowed in the area of working / swing radius of the crane and other equipment.
c. All workers would be made aware regarding the methods of workers and safety awareness through toolbox talks.
d. Employing safe working practices.
e. Unauthorized / outside persons will not be allowed to enter inside /near during the erection of parapet and at the time of test.
f. All the workers will be provide with necessary safety equipments.
g. Availability of site first aid facilities.
h. Proper lighting arrangement during the night.
i. Dedicated and experienced safety officer and team will be deployed to ensure that erection shall be carried in safe condition.
j. Safe access will be provided for stair case which is erected for the safe access during the launching operations.
k. Formal risk assessment will be conducted and the suitable control measures will be identified and adopted.
l. Proper control measures as per SHE policy phase III version 1.2 will be adopted for the working at height hazard controls.

Operators, supervisors, safety staff and labour will be provided in house training in the form of Tool Box meeting on regular basis so that they can be aware of the risk involved and their control measures in the erection process.

Risk Assessment

SR =severity rating when it can lead to fatality of permanent disability or when property loss is more than Rs100,000	**High=H**	**PR=Probability Rating- When it occurs frequently or Chances approx. more than 50%**	3	4	5
when it can lead to temporary disability or doctor visit is required or when property loss is more than 10,000 but less than 100,000	**Medium=M**	**When it occurs occasionally or chances between 10% to 50%**	2	3	4
When it can Lead to First aid Injury or When property Loss is Less than Rs 10,000	**Low=L**	**When it has never occured before or Chances Less than approximately 10%**	1	2	3
			L	M	H

Table 1: Risk Assessment of erection and fixing of parapet

RL= Risk Level, 1= Trivial, 2 =Tolerable, 3 = Moderate, 4 =substantial, 5 = Intolerable

TABLE 2 : SEVERITY ASSESSMENT AND RISK SCORES

S No	Activity, Product, Service	Hazard, Concern	Severity Explanation	Severity Rating H/M/L	Risk Level 1/2/ 3/4/ 5
1	Loading/Unloading of parapet on or from trailer	Cuts, Bruise,serious injuries during material handling	Physical injury,Material Damage	L	2
2	Transportation of parapet from stacking yard to site	Cuts, Bruise, serious injuries during material handling	Physical injury, Material Damage	L	2
3	Erection/ fixing of parapet on erected segment span	Cuts, Bruise, serious injuries during material handling	Physical injury, Material Damage	L	2
4	Alignment & jointing of Parapet units	Fall of person/ material from height	Physical injury, Material damage	L	2
5	Concreting of Jointing Portion	Fall/Tripping of person	Physical injury	L	2
6	Dismantling of shutter and jacks	Cuts, Bruise, serious injuries during dismantling of staging jacks	Physical injury, Material damage	L	2
7	Work at height	Trips falling from height	Injury	M	2

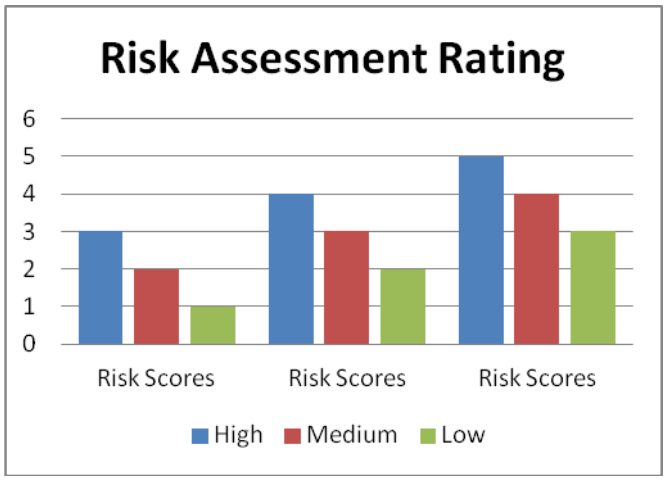
TABLE 3: PROBABILITY ASSESSMENT AND RISK SCORES

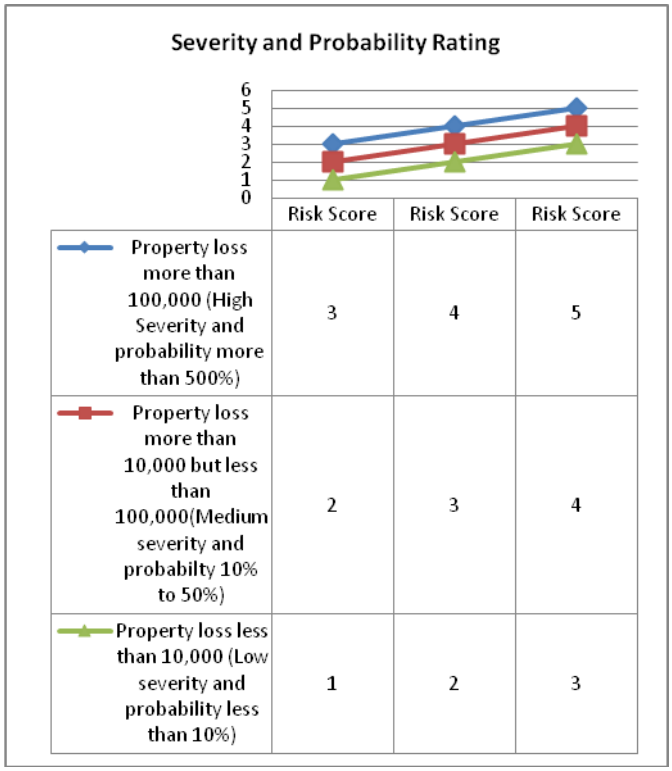
S No	Activity,Product,Service	Hazard, Concern	Probability Explanation	Probability Rating H/M/L	Risk Level 1/2/ 3/4/ 5
1	Loading/ Unloading of parapet on or from Trailer	Cuts, Bruise,serious injuries during material handling	Can Happen	M	2
2	Transportation of parapet from stacking yard to site	Cuts, Bruise,serious injuries during material handling	Can Happen	M	2
3	Erection/ fixing of parapet on erected segment span.	Cuts, Bruise,serious injuries during material handling	Can Happen	M	2
4	Alignment & jointing of Parapet units.	Fall of person/ material from height	Can Happen	M	2
5	Concreting of Jointing Portion	Fall/Tripping of person	Can Happen	M	2
6	Dismantling of shutter and jacks	Cuts, Bruise, serious injuries during dismantling of staging jacks.	Can Happen	M	2
7	Work at height	Trips falling from height	May Happen	L	2

TABLE 4: Risk Controls or Measures

S No	Activity ,Product	Risk Controls – Existing/Required
1	Loading/ Unloading of parapet on or from Trailer	a) Crane which will use for loading or unloading of parapet segment at both places (stacking yard & site) shall SWL should be more than lifting load and shall be certified by competent person. b) Trained Rigger & signal man Provided with Proper PPE's shall be engaged for loading unloading activity. c) Material shall be unloaded at defined, level surface and on wooden sleeper. d) Tools and Tackle used for loading or unloading of material shall be certified and colour coded. e) During unloading of parapet working area shall be barricaded and such activity shall be carried out under supervision of senior person.
2	Transportation of parapet from stacking yard to site	a) Trailer condition/ fitness shall be of good condition which will use for transportation of parapet. b) Parapet which is loaded for shifting shall be fully tied -up/ secured. c) Approach road condition shall be of good condition. d) Trailer speed shall be slow (Approx 5 or 10 KM /Hrs) During shifting of parapet. e) During shifting of parapet, Marshals/Trained Riggers shall control the traffic and such operation of senior person.

3	Erection / fixing of parapet on erected segment span.	a) Crane which will used for erection of parapet and fixing of supporting accesories shall be certified. b) Tools and Trackles which will use shall be certified and colour coded. c) Trained Riggers/Signal man provided with proper PPE's shall be engaged for Parapet Erection.
4	Alignment & jointing of Parapet units.	a) For fixing /jointing/Alignment of Parapet , proper supporting arrangement shall be provide b) All nut-Bolts of supporting arrangements shall be properly tightened. c) Area at ground level shall be barricaded and banks man shall be Provided to warn the unauthorized person. Trained Riggers shall be used for this activity.
5	Concreting of Jointing Portion	a) Trained workmen provided with proper PPE's shall be engaged for concreting work. b) concreting work shall be carried out in supervision of Engineer/foreman.
6	Dismantling of shutter and jacks	a) Crane which will use for such activity shall be certified. b) Tool & Tackles which will use for such activity shall be certified and colour coded. c) Trained Riggers/ Signal man shall be engaged for dismantling of shutter and other accessories. d) Area at ground level shall be barricaded and banks man shall be provided to warn the unauthorized entry.
7	Work at height	Proper access ladder provided for workers working at height and safety harness ensured and tied with fixed structure. Proper scaffolding provided. Safe working Platform Provided on the slab.





	Risk Score	Risk Score	Risk Score
Property loss more than 100,000 (High Severity and probability more than 500%)	3	4	5
Property loss more than 10,000 but less than 100,000(Medium severity and probabilty 10% to 50%)	2	3	4
Property loss less than 10,000 (Low severity and probability less than 10%)	1	2	3

5. CONCLUSION

There is a huge scope for the construction of metro rails in India as it is a second most populous country and foremost developing country in the world. In every work there will be certain amount of risk especially in infrastructure projects there will be more number of risks and uncertainties because of its scope and cost. Since there is technological advancement in construction and year by year new equipments and machineries are being developed to cater the progress of various infrastructure projects , this study will be helpful to the contractor as well as client to be prepared in advance so as to plan their overall progress of constructional activities considering risk assessment. This study shall focus on how the construction industry is taking the care of risk management in infrastructure projects. This study shall reveal how the risk management analysis during

construction has to be done and how they are affecting the project.

6. ACKNOWLEDGMENT

The Author would like to acknowledge Mr. TABISH QUADRI and Mr. MASOOM REZA, for their valuable suggestions, support and findings.

To God be all the glory for the great things He has done.

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