Journal of Engineering Research and Application
https://dx.doi.org./10.55953/JERA.2025.01
Volume 4, July. 2025
pp 1-14

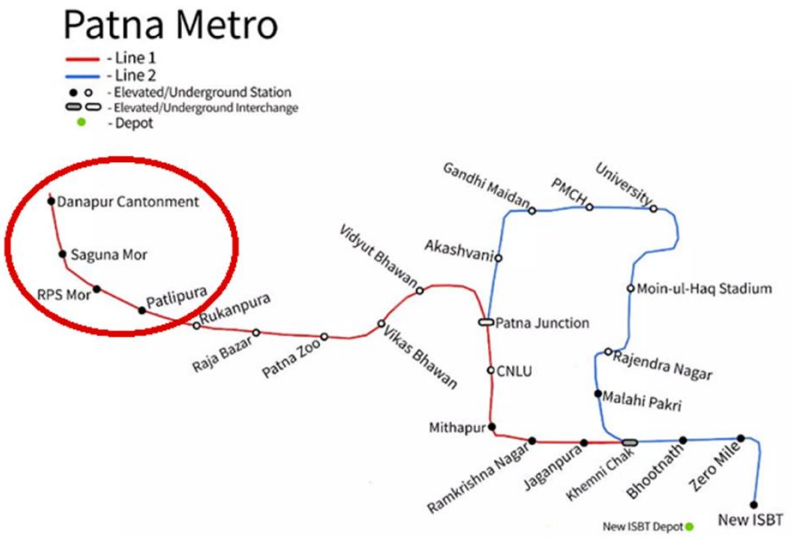
Risk Identification and Management of the Patna Metro Corridor PC-04 of Phase-1 from Danapur to Patliputra at Patna in Bihar

Sakir Khan[a] (corresponding author), Gaurav Shukla[b]
[a]Department of Civil Engineering, Maharishi University of Information Technology, India.
shakir.khan595@gmail.com
[b]Assistant Professor, Department of Civil Engineering, Maharishi University of Information Technology, India.
gaur.knit@gmail.com

Abstract

This paper analyses a study of the Patna Metro corridor PC-04 of phase-1, which runs from Danapur to Patliputra in Patna, Bihar, to examine how different hazards related to metro construction are measured and managed. Identification of risks associated with various project activities is made possible in large part by project risk management. The Metro Rail organisation and its officials have recognised certain risks that can emerge during construction and raise the possibility of collisions, especially on busy roads. It is particularly difficult to manage these risks in the metro rail system when it comes to crucial operations. In order to reduce the likelihood of accidents, strict risk and safety management criteria are followed, given the metro's relevance to national pride. These rules must be followed by all contractors working on the project in order to reduce deaths and guarantee safety.

Graphical Abstract



Keywords: Safety; Metro Rail; Risk Identification; Management; Construction

1. Introduction

Risk management is the management technique in which we identify different modes of risk for different activities and the probability of their occurrence so that we become aware and are always ready to overcome risk. Risk is defined as uncertainty in the project, which may come during the execution of work. Some

uncertainties are good for the project, so this is known as positive risk, and when the uncertainty is bad or dangerous for the project, then it is known as negative risk.

A dedicated team is engaged in a project, which is known as the risk management team, for continuously tracking the project, whether risks will arrive or not during any activity before its start.

Sometimes we violate the risks, or we are not aware of the risks which may arise during construction as a result major incident happens which causes death. With the help of experts, we listed out the risks which may arise during any work and then proceeded accordingly. Risk management is also helpful to enhance the quality and progress of a project. For the **Patna Metro** project, we find out the risks which may occur during each activity like piling work, Launching of the girder, road diversion, utility diversion and also for many more.

Williams, Walker and Dorofee (1997) worked to develop various ways so that risk management becomes a practice. Their methods were based on software-intensive programs (SEI), along with which specific road maps were designed. These could guide and help identify various risk management methods which could be easily put into practice. Complex projects like the construction of an underground corridor for metro rail operations involve risks in all the phases of the project, starting from the feasibility phase to the Operational phase. These risks have a direct impact on the project schedule, cost and performance.

Reilly (2005), Reilly and Brown (2004), and Sinfield and Einstein (1998) carried out their research on underground tunnel projects. Reilly and Brown (2004) state that infrastructure underground projects are inherently complex projects with many variables, including uncertain and variable ground conditions. As per Reilly (2005), for a complex infrastructure project like underground construction, it is very important to identify the risk events in the early phases of the project. A proper risk mitigation plan, if developed for identified risks, would ensure better and smoother achievement of project goals within the specified time, cost and quality parameters. Further, it would also ensure better construction safety throughout the execution and operational phase of the project.

Anna Klemetti [5] explains that risk can be evaluated by estimating risk probability and impact on a simple scale, for example, from 1 to 5 or high to low. The risks can be mapped in a probability–impact grid. On the grid, risks that require the most attention are easily detectable, wherein actions to control them can be taken only if there are sufficient resources or if mitigating the risk costs are less than the product of the possibility of risk occurrences and their impact on project objectives (expected values).

2. Objectives of the study

- Identify the risks involved in various project activities and conduct a detailed analysis of these risks.
- Develop and implement strategies to eliminate or reduce identified risks by using various risk management techniques and tools.
- Categorise the risks based on their influences and conduct a comprehensive survey to understand the potential impact on the project.

3. Methodology

The methodology describes the erection and fixing of precast Pier cap, U girder, T girder, and Pie girder for the construction of an elevated viaduct from Danapur to Patliputra stations, including a ramp for the PATNA METRO Project.

3.1 Brief method of construction

The precast Pier cap, U girder, T girder, and Pie girder units are transported by multi-axle trailer from the Stacking yard to the appropriate launching point. The segments are launched by various capacities of cranes with capacities of 300 tons to 500 tons.

3.2 Erection procedure

Precast Pier cap, U girder, T girder, and Pie girder are erected by cranes or other suitable methods. The pier caps should be aligned as per the general alignment of drawing (GAD), and U girders, T girders, and Pie girders are lifted and placed on pedestals by taking proper coordinates and level. After doing the erection work, the area and roads need to be cleared for the movement of vehicles.

4. Risks involved in the projects

a. Traffic diversion from the main line to the other service lane
b. Overhead working
c. Trespassing of other workers in the working zone
d. Handling of heavy pieces of equipment.
e. Settlement and bending of the base plate.

4.1 Important safety precautions during erection work for elevated work

a. First of all, the area where the work will be executed needs to be covered by proper barricading so that unauthorised persons may not enter.
b. The base of the jack, where we will keep the base plate, needs to be properly compacted.
c. All the equipment which are being used should be inspected by a third party like the Automatic Safe Load Indicator (ASLI) of cranes, loading chart of cranes, rope wire of cranes, man lifters, etc.
d. All workers would be aware of the work, so they need to give TBT (Toolbox Talk) before any work.
e. Employing safe working practices.
f. Availability of site first aid facilities and Ambulance facilities at the site.
g. Proper lighting arrangement during the night.
h. A safety representative from Clint's side and also from the contractor's side should be available during working hours.
i. Proper access should be available during the launch work
j. Operators, supervisors, safety staff and labour will be provided with in-house training in the form of Tool Box meetings regularly so that they can be aware of the risks involved and their control measures in the erection process.

5. Methods for the construction of different components

5.1 Method for the construction of the grade slab

This method provides details of the construction of the Grade slab at the station location. This method deals with the construction of a grade slab with GSB (Granular Sub Base) filling and blinding concrete. The basic activities described in this method statement are for backfilling by suitable material, compaction of the fill material, and blinding concrete will be carried out as per the drawing, and grade

slab concreting with reinforcement as mentioned in the drawing.

5.1.1 Construction Equipment

Table 1: The following equipment to be used for the casting of the grade slab.

Equipment	Quantity in numbers
Batching Plant 60cum/ Hr	1
Batching Plant 30cum/Hr	1
JCB for material feeding	1
Transit mixer 4/6cum	3
Plate compactor	1
Needle vibrator (60/40mm)	1
Diesel Generator	1
Concrete Pump /Bucket	1

5.2 Methodology for bored cast-in-situ concrete pile

The pile is the load-bearing structure which transmits the load from the pile cap to the ground bottom strata by means of friction force or end-bearing force. In this project, piles of 1200 mm diameter are done with the help of a Rig machine.

5.2.1 Equipment and materials used for construction

1. Survey instruments for layout setting of piles.
2. Hydraulic Piling Rig (MAIT/CASAGRANDE/Equivalent Make) for pile boring.
3. Boring bucket.
4. The steel casing of 1200 mm inner diameter and the length of the casing will be as per the soil condition at the site.
5. Polymer with polymer tank, compressor, pump, etc.
6. Steel reinforcement cage.
7. Transit mixers and batching plant/ RMC with slag/OPC.
8. 200/250mm dia. Tremie pipes and concreting funnel of 1.5 to 2.0 cum capacity.
9. Tyre-mounted Crane/ 320 Crane for flushing and concreting.
10. Welding machine for welding cage laps.
11. Sounding chain for checking & measuring the level of the borehole.
12. Excavator/loader for the handling of muck.
13. Tripper for muck disposal.

5.2.2 Safety Precautions

1. The working area should be properly barricaded.
2. All site personnel shall be provided with safety helmets, safety jackets, safety shoes and other personal safety devices as required.
3. Traffic marshals shall guide the traffic during the progress of work.
4. The swing area of the rig should be barricaded or demarcated.
5. Ground stability/levelling will be checked before the rig.
6. Overhead electric cables and wires are to be checked before the marching/swing of the rig.
7. All swing alarms and swing lights should be in working condition.
8. Pile bore muck should not be staked too high.
9. Pile cage/ muck is not to be loaded on the barricades.
10. All idle pile bores should be covered with grating.

11. Polymer should not be spilt from the working area to the outside of the road.

Fig. 1 Rotary drilling rig in operation for borehole excavation at a construction site, preparing the foundation for structural support

Fig. 2 Workers installing a reinforcement cage into a drilled borehole for deep foundation piling during nighttime construction.

Fig. 3 Concrete being poured from a transit mixer into a suspended bucket for placement in deep foundation construction using the tremie method

5.2.3 Key Points of Pilling:

1. The lifting hook and resting hook need to be strong enough to take the load of the whole reinforcement cage.
2. Always use a good-quality welding electrode to weld the cage and maintain a uniform voltage for welding.
3. Never stand beneath the rigging machine because the cover block or rope wire may get damaged and hit the worker. Always use proper safety PPE
4. Always do the third-party inspection of the Rig machine to check the loading capacity or any faults of the crane.
5. Ensure proper compaction and support at the bottom of the rigging machine, and also ensure sufficient space for the movement of the rigging machine so that a major accident may not occur.
6. Always hire trained operators.

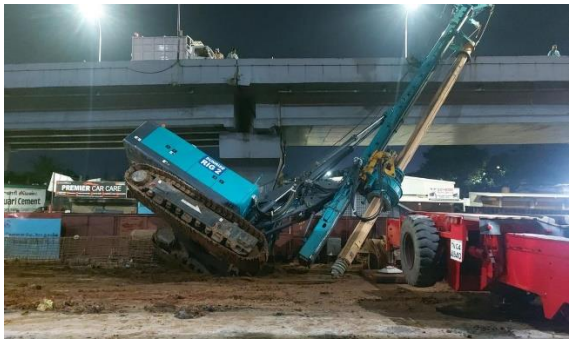


Fig. 4 A toppled piling rig at a construction site, with recovery efforts underway to stabilize the equipment and ensure site safety.

5.3 Method of Cast-In-Situ Pile Cap

5.3.1 Introduction

The pile cap is the foundation part which is helpful in transmitting the superstructure load to the pile. In the project, we use a group of piles of four, six, nine and twelve for pile cap purposes. A pile cap is placed over the pile cut-off level to a depth of 1.5 times of pile diameter. The shape and size of the pile cap are changed as per site conditions.

5.3.2 Equipment and Materials Used for Construction

1. Survey instruments for layout setting of pile cap.
2. Batching plant / RMC with OPC.
3. Transit mixer
4. Needle vibrator.
5. Welding generator.
6. Jack Hammer.
7. Compressor
8. Crane
9. Dewatering pump.
10. Excavator for the excavation of earth.
11. Tripper for earth disposal
12. Static concrete pump
13. Static concrete pump (stand by)

5.3.3 Safety Precautions

a. The working area should be properly barricaded.
b. All site personnel shall be provided with safety helmets, safety jackets, safety shoes and other personnel safety devices as required.
c. Traffic marshals shall guide the traffic during the progress of work.

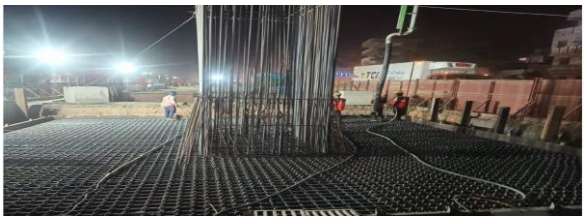


Fig. 5 Nighttime concreting and reinforcement work for a foundation, ensuring structural stability and load-bearing capacity

5.4 Method of Cast In-Situ Pier & Pier Cap

5.4.1 Introduction

The pier is the part which can take the load of the pier cap and girders and transmit the load to the pile cap. The pier is designed strong enough to take the load Pier cap is the part which is simply placed over the pier, and the stitching work is done to connect the pier with the pier cap. Afterwards to get the design strength, post tension is done utilising the fascinating method. The curing process of the pier is shown in Figure 6.

Fig. 6 Curing in progress: A concrete column wrapped in hessian cloth is kept moist to ensure structural strength and durability

5.4.2 Equipment and Materials Used for Construction

1. Survey Instrument for layout setting of pier &pier cap.
2. Batching Plant / RMC with OPC, -2 Nos.
3. Transit mixer
4. Needle vibrator
5. Welding Generator
6. Crane of suitable capacity
7. Concrete pump/Boom Placer (Static pump for standby).

5.4.3 Safety Precautions

1. The working area should be properly barricaded.
2. All site personnel shall be provided with safety helmets, safety jackets, safety shoes and other personnel safety devices as required.
3. Traffic marshals shall guide the traffic during the progress of work.
4. Proper safety railing must be provided when working at height.

Fig. 7 Nighttime construction: Workers engaged in high-altitude structural work with safety measures in place

6. Methodology for Minor Repair/Rendering of Segments

6.1 Introduction

Repair work is the most important thing in construction. Whenever there is a honeycomb or any defect then we do an NDT (non-destructive test) to detect the quality of the structure, and thereafter we do repair work as per requirement. For repair work, we use grouting work, Conbextra GP2 (cementitious, free-flow, non-shrink grout), repair work, etc.

6.2 Equipment and Materials Used for Construction.

1. OPC cement: - As a primer over the concrete.
2. CONBEXTRA GP-2, ATGROUT: - For Non-shrink repair, Making Mortar.
3. Trowel
4. Brush the width of 100 mm.
5. Mixing Pan of capacity 5 kg.
6. Medium-density foam pad or jute Rag.

6.3 Safety Precautions

1. The working area should be properly barricaded.

2. All site personnel shall be provided with safety helmets, safety jackets, safety shoes and other personnel safety devices as required.

7. Methodology for Widening of the Existing Road

7.1 Introduction

Whenever we need to work on the road, we should give access to the public for smooth driving by widening the road. This is the most common work which needs to be done before any work is started.

7.2 Equipment and Materials Used for Construction

1. Survey Instrument for maintaining Levels and alignment.
2. Excavator for dismantling and excavation of the existing road.
3. Static/ Vibratory roller for compaction.
4. Tippers for transportation.
5. Tractor Grader for grading and levelling.
6. Drum-type Hot mix plant for mixing of BM.
7. Paver/ hand tools for spreading bituminous material.

7.3 Safety Precautions

a. The working area should be properly barricaded.
b. All site personnel shall be provided PPE.
c. Traffic marshals shall guide the traffic during the progress of work.

8. Methodology for Plate Load Test

8.1 Introduction

In this test, we find out the load-bearing capacity of the pile by finding out the ratio of the original ground / compacted ground with the help of a loaded truck using a 300X300 mm test plate. Test arrangement will cater for an additional 25% above the test load.

Table 2: Summary of Design, Test, and Test Arrangement Loads for 300×300 mm Plate

Size of Plate	Design Load (MT)	Test Load (MT)	Test arrangement caters for (MT)
300X300 mm	1.8T	5.4T	10T

8.2 Equipment Used for Construction: -

1. Plate 300X300mm, 25mm thick
2. 25 T Capacity Hydraulic Jack.
3. Truck
4. Dial Gauge

9. Brief Method of Construction

In this method, we use a loaded truck of the desired weight which is placed over a jack. With the help of a jack, the truck is lifted till the design load is achieved. The settlement is measured with the help of a dial gauge which is set on a datum bar. This test is useful to find out the load-bearing capacity of the soil. The legs of cranes are placed on the place where the tests are conducted.

9.1 Job Break Down

9.1.1 Survey

After the finalization of the location and cut-off level by the client for the test pile, the survey will be done, concrete pedestal position will be marked.

9.2.2 Test arrangements

1. Compact the backfilling material in the loose layer thickness of 25mm with a plate compactor, so as to get a compacted layer thickness of 150mm for each layer.
2. If required, some excavation may have to be done at the test location, to accommodate the test arrangement, beneath the rear axle of the truck. This excavation may be 500mmX500mm in plan and 150-200mm in depth.
3. Place a 300mm X 300mm X 25 mm (Thick) test plate at the desired test location.
4. Place 250mm X 250mm X 25mm (Thick) plate on top test place concentrically.
5. Place 200mm X 200mm X 25mm (Thick) plate on top of 250mm X250mmX 25mm plate concentrically.
6. Bring a dumper/MT (minimum laden weight of 20T) and park it so that the rear axle is positioned, centrally above the 3 plates arranged at the test location.
7. Put 25T/50T capacity hydraulic jack centrally on top of 200mm X 200mm plate.
8. Put packing plates between the top of the hydraulic jack and the underside of the central part of the rear axle of the parked truck.
9. Place 1.5 to 2.0 m long datum bars with proper supports symmetrically on either side of the test plate.
10. Place 4 nos of Dial gauges of 50 mm range x 0.01 mm LC, symmetrically at 4 corners of the test plate, to measure settlement.
11. Connect the hydraulic jack to the hydraulic pump and apply some nominal pressure to make perfect contact between the hydraulic jack & underside of the axle.
12. Note down the initial readings of all 04 Dial gauges.
13. Note down the RAM area of the hydraulic jack and apply the calculated amount.
14. Application of pressure with a hydraulic pump, as indicated in the table shown below. Use a pressure gauge of 200 KG/CM2 at least count.

9.2.3 Test sequence

1. Apply load in a proper sequence in steps.
2. Maintain each load for a period of 10 minutes and take observations of settlement at 1 minute, 5 minutes and 10 minutes for each loading step of all 4 dial gauges.
3. After reaching the final load, do unloading in the following manner:
4. During unloading, maintain each load for 10 minutes and take readings of settlement at 5 minutes for each unloading step of all 04 gauges.
5. After completion of the test, remove the hydraulic jack, pump, test plates, dial gauges, datum bar etc., and store in a safe place.
6. Remove the parked truck safely.

Table 3: Load Vs pressure on plate

Pressure on plate	10 T/M2	15 T/M2	20 T/M2	25 T/M2	30T/M 2	35 T/M2	40 T/M2	45 T/M2	50 T/M2	55 T/M2	60 T/M2
LOAD	0.9T	1.35T	1.8T	2.25T	2.7T	3.15T	3.6T	4.0T	4.5T	4.95T	5.4T

9.2.4 Result

The test results are shown in Table 3. With the help of this test, we can determine the graph between load and settlement and then we can calculate the design bearing capacity.

9.2.5 Risk Involved

1. Interference or presence of unauthorized persons inside the area during work.
2. The sudden increase in the application of Load.
3. Failure of leeks.

9.2.6 Safety Procedure

1. The area for the plate load test will be temporarily barricaded.
2. Outside persons will not be allowed to enter at working area zone.
3. All the workers will wear proper PPE.
4. Ensure the truck is locked during conducting the test.
5. The safety personnel will be present throughout the period of the test to prevent any lapse in Safety.

10. Methodology for Conducting Geotechnical Investigation

10.1 Introduction

In this test, we generally determined the behaviours of soil till the depth where we can get a design strength. This is the most important test which is done at the earliest stage of the project there after we make a design for any project. We have done 55 boreholes to take the sample of the soil to get the data of different boreholes to the different depths from Danapur to Patliputra for the Patna Metro Project.

This method statement covers the methodology of geotechnical investigation and report preparation for ascertaining the soil properties for the design of foundations for the Construction of the Elevated Viaduct from CH.KM.26.739 to KM.34.344 including the entry exit line to the depot, elevated ramp at Kalkaji & Special spans and construction of six elevated stations.

The objective of this method statement is to clearly understand the job and the step-by-step procedures of the geotechnical investigation along with safety precautions, which are necessary to avoid any kind of injuries/accidents to personnel and any damage to any equipment or property.

10.2 Purpose

The purpose of this method is to describe the procedure of field investigations and tests, laboratory tests, analysis and interpretation of data and results to be followed during geotechnical investigation.

10.3 Types of Equipment

The following types of equipment/accessories will be used for Geotechnical Investigation work:

1. Shell & Auger Rigs with Power Winch and all accessories
2. Casing Pipe 6” ID
3. Drilled Rod (Standard)
4. Casing Pipe Nx Size
5. Barrel
6. Diamond / TC bits Nx
7. Core Boxes
8. Undisturbed Sampling Tube
9. Split Spoon Samplers
10. Drop weight

10.4 Risk Involved

The following are the risks involved in Geotech work

1. Failure of the borehole may lead fatal accident
2. Failure machine during the execution work
3. Failure or running roads due to settlement
4. Accidents during execution

10.5 Safety Precautions

1. The working area should be properly barricaded with wire rope so that at night visibility may not be hampered
2. Fill the all boreholes after taking samples.
3. Workers should be in proper PPE.

11 Methodology for Initial Pile Load Test

11.1 Introduction

The pile load test is the way by which we can find out the load-carrying capacity of a pile by various means. The pile is tested for vertical and lateral means. For the working pile, the factor is taken 1.5 times to the design load and for the test pile 2.5 times to the design load.

The load is applied to the piles in two ways.

a) By Kentledge method: Suitable when the working area is more. It is cheaper than the anchorage method.
b) By Anchoring method: Suitable when the working space is less.

11.2 Brief method of construction

a) **In the kentledge method,** the pile head is tested by applying the load on the pile by using a concrete cube over the support assembly on the pile. The loads are applied on a regular interval by hydraulic jack and the settlement of the pile is measured by dial gauges which are placed on the datum bar.
b) **In the anchorage method,** anchoring is done by means of cable for a predetermined depth and a predetermined no of quantity. The load is applied by the reaction of anchorage which is provided surrounding the piles and settlement is measured by the dial gauge.

Fig. 8. Pile load testing setup at a construction site, featuring a reaction frame, tensioning rods, and hydraulic jacks to assess foundation strength and stability

11.3 Risk Involved

1. Interference or presence of unauthorized persons inside

the area during work.

2. Swing of crane boom during erection of heavy structural steel girders.
3. The sudden increase in application of Load.
4. Failure of Jack.
5. Failure of Structural steel girders.
6. Anchorage failure

11.4 Safety Procedure

1. The area for pile load tests will be temporarily barricaded.
2. Always try to engage skilled manpower for this test.
3. Workers should be in proper PPE.
4. An Anchorage test needs to be done after certifying the cube test of the anchorage cable.
5. The crane swing zone will be always ensured free from personnel and other objects.
6. All lifting Equipment like cranes and structural steel members etc. will be checked from the safety point of view at least one day before the Test and cleared by the Safety Engineer.
7. Safety personnel will be present throughout the period of the test to prevent any lapse in Safety.

12. Methodology for Prestressing and Grouting of Post-Tensioned Segment Girder Spans

12.1 Introduction

Stressing is the technique by which we can enhance the load-carrying capacity of the RCC structure by producing the force on the structure. There are two ways of stressing.

a) Prestressed is suitable for higher grades of concrete above M35 grade.
b) Post-tensioning anchorage system in a precast concrete structure, showing steel tendons and a hydraulic jack used for tensioning operations.

Fig. 9. Post-tensioning of multi-strand tendons using a hydraulic jack in a prestressed concrete element.

12.2 Brief Method of Construction

In the prestressed method, we generally use the fascinate method. In this method, we apply cables into the concert by using a duct which is already placed during the concreting work. The cable is placed and then it is fixed on wedges by applying the load by jack we applied the load and then it is locked.

12.3 Risk Involved

The following are the risks which may arise during construction

1. Failure of cable
2. Failure of jack
3. Failure of wedges and wedge plate
4. Punching of anchored cone
5. Failure of the working platform

12.4 Safety Precautions

1. Always use a solid and good working platform during any work.
2. Check the jack and hosing pipes before this activity. Before any work, we need to do a third-party inspection.
3. Never stand near the prestressed cable because if it is slipped it will kill anyone.
4. Use a safety belt whenever a person is working at elevated.
5. Always try to engage skilled people.

Fig. 10. Precast concrete U-girders stored at a construction site, with one covered for curing and the other showing post-tensioning ducts for cable installation

Fig. 11. Reinforcement cage assembly for a precast U-girder at a construction site, with workers preparing for concrete casting

Fig. 12 . Workers performing post-tensioning of multi-strand tendons using a hydraulic jack in a construction site.

13. Conclusions

Risk management has a vital role in metro construction for elevated, at grade and underground. We find out various types of risk during various activities like pilling work, erection work etc. We try to minimize the all the risk by setting up various types of safety guidelines, management software etc. As metro has a most common and important part for daily life for each person. Most of metro work is going on running road so the chances of accident will lead fatal accident. DMRC has categorised different type of risk in different category and then make a list of their precautionary action during construction.

Always start any activity by doing proper planning. It also helps to minimize the chances of accident, reducing the cost of project and time. It also helpful to enhancing the work progress.

14. References

1. Dey, P.K. (2001) “Integrated Project Management in Indian Petroleum Industry” NICMAR
2. Journal of Construction Management, Vol. XVI, pp. 1 – 34.
3. Dey, P.K. (2002) “Project Risk Management: A Combined Analytic Hierarchy Process and Decision Tree Approach” Cost Accounting, Vol. 44, pp. 13 – 26.
4. Dey, P.K. and Ogunlana, S.O. (2002) “Risk-based Decision Support System for Effective Implementation of Projects” International Journal of Risk Assessment & Management Vol. 3, pp. 189 – 204.
5. Jannadi, O.A. and Almishari, S. (2003) “Risk Assessment in Construction” Journal of Construction Engineering and Management, Vol. 129(5), pp. 492-500.
6. Mulholland, B. and Christan, J.(1999) “ Risk Assessment in Construction Schedules” Journal of Construction Engineering & Management, Vol. 125(1), pp.8 – 15.
7. Nehru, R. and Vaid, K.N. (2003) Construction Project Management, NICMAR Publication Mumbai.
8. Nicholas, J.M. (2007) Project Management for Business and Technology: Principles and Practice, Second edition, Pearson Prentice Hall, New Delhi.
9. Rahman, M.M. and Kumaraswamy, M.M. (2002) “Risk Management Trends in the
10. Construction Industry: Moving Towards Joint Risk Management” Engineering
11. Construction & Architectural Management, Vol. 9(2), pp.131-151.
12. Reilly, J. and Brown, J. (2004) “Managing and Control of Cost and Risk for Tunneling and Infrastructure Projects” Proceedings of International Tunneling Conference, Singapore pp.703 -712.
13. Reilly, J.J. (2005) “Cost Estimating and Risk Management for Underground Projects”
14. Proceedings of International Tunnelling Conference, Istanbul.
15. Sarkar, D. (2009) “Project Management for Urban Infrastructure: A Study of Application of Statistical Quality Control and Project Risk Management” Ph.D.
16. Thesis, D. D. University, Gujarat, India.
17. Sinfield, J.V.and Einstein, H.H. (1998) “Tunnel Construction Costs for Tube
18. Transportation Systems” Journal of Construction Engineering & Management, Vol.
19. 124(1), pp.48 – 57.
20. Sarkar, D and Bhavnani, G. (2014). “Risk Analysis of Elevated CorridorProject Using Failure Mode and Effect Analysis (FMEA) and Combined Fuzzy FMEA”, Journal of Construction Management, NICMAR, vol. 29(2), pp 5 - 22.