

Equipment Handling and Guidelines to Minimize the Accidents with Special Reference to Pune Metro

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ABSTRACT: It is the right of every worker to work in a safe and healthy environment. Every worker must protect his or her own health and safety by working in compliance with the Occupational Health and Safety Act and applicable Regulations and safe work practices and procedures established by his company, its clients, and the general contractor(s). It is the responsibility of every worker to assist in maintaining a safe work environment. In this project focus is on the responsibility of every worker to assist in maintaining a safe work environment during Pune metro Construction and to study and analyse main factor behind accident at sites and measure to prevent them. The use of various new technologies and deployment of project management strategies has made it possible to undertake projects of mega scale. Main aim of this project is to study highly mechanized tunnelling methods like Tunnel Boring Machines, which are commonly used in construction of Pune. In this project our main aim is to find out Pimpri-Chinchwad Crane accident analyses along with mathematical calculations. So this paper shows some main factor behind accident at sites and measure to prevent them. The TBM has been proved to be a cost effective and faster alternative to conventional Drilling and Blast method (DBM) and found suitable for any type of rock with varying degree of ease. One of the most positive factors in favour of TBM is faster and smooth tunnelling without much disturbance to surrounding rock mass. Pune Metro construction sites were selected for a safety education program targeting worker safety related to material handling equipment.

Keywords-

KEYWORDS: Material handling equipment (MHE), Drilling and Blast method (DBM), Pune Metro, Mass Rapid Transit System (MRTS).

I. INTRODUCTION

Material handling equipment (MHE) is a necessary requirement in construction sites and improper operation of it would result in operator injury or even casualties. Several studies have shown that majority of accidents occur during material transfers involving MHE. Proper safety management systems and procedures for MHE safety should be implemented at the construction sites to prevent these accidents.

1.1 Introduction

It insisted that workers must be educated to identify and report on hazardous conditions and practices. Another study done by among 1566 employees working in process industrial units, measured the perceptions of employees on self-reported safety knowledge, safety management practices, compliance, and participation in safety activities. In addition to these works, studies have been carried out by several researchers [7–11] on safety with MHE. In this paper, a safety survey is carried out among sixty construction sites located at different parts of India through questionnaire survey consisting of twelve elements of safety. The results were then analysed and taken up for conducting safety education program at two of the construction sites that scored least among all the other sites. The objective of this program is to develop a knowledge base interface for safety and health management of workers at construction sites. The safety

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program has been developed with three self-instructional modules which are used to educate nineteen workers each, at site 1 and site 2, respectively.

1.2 Background

The sector is made up of five main segments: earthmoving equipment, metro construction equipment, concrete equipment, material handling equipment, and material processing equipment. Earthmoving equipment and road construction equipment account for close to 70 per cent of India's construction equipment market.

1.3 What is Accident?

An "accident" is an unplanned, undesired event which may or may not result in injury or property damage that interferes with the completion of an assigned task. A "near miss" is a form of an accident that does not result in injury or property damage. The causes of accidents can be broken down into two basic components, unsafe conditions and unsafe acts. Unsafe conditions are hazardous conditions or circumstances that could lead directly to an accident. An unsafe act occurs when a worker ignores or is not aware of a standard operating procedure or safe workpractice designed to protect the worker and prevent accidents.

1.4 Causes of the fatal accident

Besides the quantitative analysis of the accident itself, the causes of the fatal accidents in the construction industry can be perceived in different points of view vis: the personal factor, and the job factor. All these causes are discussed below in tabular form.

1.5 Hazard assessment

The subject of hazard recognition is enormous. It is limitless. It is immense. A condition on one day would not be a hazard, but on the next day it might cause a fatal accident. A construction site changes daily. The first step in recognizing hazards is to understand what causes accidents. A safety hazard is something that has the potential to cause an injury. All accidents or incidents, whether incurring injury or not, should be investigated to determine the cause, so that the necessary corrective action may be taken to prevent a similar occurrence and/or to prevent a near miss of becoming a real injury. Good hazard recognition automatically leads to good accident prevention. Safety hazards can be controlled by using the three main components of safe work procedures.

1.6 Accident prevention

Accident prevention involves the identification and elimination of causes before an accident occurs. Accident reaction is what most supervisor's practice, that is, investigating the accident to determine the causes and then implementing corrective actions to avoid reoccurrence. This helps eliminate future accidents from a specific cause, but does nothing to address avoiding the accident that just occurred. One method of accident prevention that can be used by the supervisor is the Job Safety Analysis (JSA). A JSA takes a specific job and identifies the following:

1. Sequence of basic job steps.
2. Potential hazards at each step.
3. Recommended action or procedure to correct the potential hazards.

1.7 Accident control

In the event that an accident does occur, Supervisors will be instrumental in the control of the accident. Accident control can be broken down into three phases:

- i. Accident response
- ii. Accident investigation
- iii. Corrective actions

1.8 Objective of the project

1. To study responsibility of every worker to assist in maintaining a safe work environment during Pune metro Construction.

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Vol. 8, Issue 7, July 2019

2. To study and analyse main factor behind accident at sites and measure to prevent them. The use of various new technologies and deployment of project management strategies has made it possible to undertake projects of mega scale.
3. To study highly mechanized tunnelling methods like Tunnel Boring Machines, which are commonly used in construction of Pune Metro Railways are well known throughout the world for achieving very high tunnelling rates.
4. To focus on Equipment Handling and Guidelines to minimize the accidents with Special Reference to Pune Metro the adoption of TBMs in projects can speed up considerably the completion of the project within the stipulated time schedule.
5. In this project our main aim is to find out Pimpri Chinchwad Crane accident analyses along with mathematical calculations.

1.9 Need of the project

The need of this project to minimize the accidents with Special Reference to Pune Metro the adoption of TBMs in projects can speed up considerably the completion of the project within the stipulated time schedule.

II. RESEARCH METHODOLOGY

In research methodology we are working on different major equipment used in Metro construction

1. Tunnel Boring Machine for Metro Construction

The tunnel boring machine is a machine which has been developed in recent years and has revolutionized the metro tunneling industry both making tunneling a safer, more economical solution for creating underground space and opening the possibility of creating tunnels where it was not feasible before. The choice of machine to be used depends mainly on the geotechnical characteristics of the grounds, on the level of the water table, rock abrasiveness, and maximum settlement allowed at the surface. Some of these parameters may not be known depending on the level of geological information available. Ground conditions vary, sometimes dramatically, along the tunnel alignment. The final choice of machine is always a compromise in which one of the key parameters is the speed of excavation. Tunnel Boring Machine is a complete single unit moving factory enabling to do the work such as drilling systems, concrete spraying, segment lining, rock supporting etc. A tunnel boring machine (TBM) typically consists of one or two shields (large metal cylinders) and trailing support mechanisms.

- At the front end of the shield a rotating cutting wheel is located.
- Behind the cutting wheel there is a chamber, where depending on the type of the TBM, the excavated soil is either mixed with slurry (so-called slurry TBM) or left as it is.
- Behind the chamber there is a set of hydraulic jacks supported by the finished part of the tunnel which push the TBM forward. The action here is very much like an earthworm. The rear section of the TBM is braced against the tunnel walls and used to push the TBM head forward. At maximum extension the TBM head is then braced against the tunnel walls and the TBM rear is dragged forward.

1.1 Difference between Open and Closed Shield TBM

- Open shield type TBM refers to those providing lateral support only. They can be further classified into single shield and double shield.
- Closed shield type TBM refers to those providing lateral support and frontal support. Some common TBM method under this category includes compressed air TBM, slurry shield TBM, earth pressure balance machine and mixed confinement shield.
 - Compressed air TBM is suitable for cohesive soils under water table (e.g. ground with low permeability with no major discontinuities).
 - Slurry shield TBM is suitable for soft ground and soft rock under water table and also for ground for high permeability.

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Vol. 8, Issue 7, July 2019

- Earth pressure balance machine is suitable for soft ground and soft rock under water table. It is not recommended for very abrasive and hard ground.
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1.2 Difference between Single and Double Shield TBM

- In single shield TBM, it extends and moves forward by thrust cylinders on the last segment ring installed. Single shielded TBMs, which are less expensive, are more suitable to hard rock strata.
- In double shield TBM, it consists of an extendable front shield which enhances the cutter head to be extended. The gripper in the middle section of TBM is mobilized so that it pushes against the tunnel wall to react the boring forces. As these forces are dissipated, it allows the installation of lining segments during tunnel so that it increases the speed of tunneling.
- Upon completion of a thrust stroke, the grippers are retracted and the end portion of TBM is pushed against the front shield by thrust cylinders. Double shielded TBMs are normally used in unstable rock strata, or where a high rate of advancement is required.

1.3 Selection of TBM for Pune metro.

The choice of a single or double shielded TBM depends on the type of rock strata and the excavation speed required. Modern TBMs typically have an integrated shield. Shielded TBMs are generally used for fractured rocks with the help of concrete segments to support the unstable tunnel walls behind the machine. Selection of the type of pressure-face TBM, an EPB or Slurry-Face TBM may be determined based on the expected performance of the TBM in the anticipated ground conditions. To some extent, EPB TBMs are better suited to less permeable soils (clays), while Slurry-Face TBMs are better suited to more permeable soils (sands and gravels). There are five main types of TBMs that have been used to bore tunnels in rock: Main Beam, Single Shield, Double Shield, Earth Pressure Balance (EPB), and Slurry-face.

1.4 Pune Metro Tunnel Constructions

The Tata joint venture (JV) with Turkish company Gulermak, Gulermak-Tata Projects Ltd JV, has bagged the tunnelling projects for the underground section of the Pune Metro Rail project. The JV has bagged contracts for both the packages worth Rs 2,283 crore with Package 1 of 2.5 km worth Rs 1,127 crore and Package II of 2.5 km worth Rs 1,156 crore, AtulGadgil, ED, Maharashtra Metro Rail Corporations (MahaMetro), said. The tunnelling work will see 7,900 shots with 30 to 40 blasts on an average per day, Gadgil said. This 5.019-km stretch is the most challenging part of the 16.56 Corridor-I PCMC-Swargate Pune Metro rail line, as it passes through densely populated parts of KasbaPeth, BudhwarPeth and Mandai market of the old city of Pune.

- **TBM Safe Staging Areas**

Typically, a tunnel staging site of roughly 1 to 2 acres is required at the starting point of each tunnel drive for loading/unloading facilities, construction equipment, worker facilities and offices. Construction staging areas would be necessary for tunnel construction, similar to what is required for stations and ancillary facilities.

1.5 Safe Grouting at Pune metro

Prior to grouting, surface preparation would likely be required to allow space for drilling equipment, installation of grout pipes, and injection of grout. In cases where large structures are over the tunnel, access into the metros or basements could be required. In such cases, the use of the metro could be restricted during grouting operations. After grouting is completed, the area would be restored. These grouting methods can in some cases use directional drilling, which can be done from off-street locations and can allow for horizontal orientation of grout holes along the tunnel alignment.

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Vol. 8, Issue 7, July 2019

2. Safety Tips when using Metro Heavy Equipment

Heavy equipment can make for a very impressive and intimidating sight. Resembling large beasts of metal and wire, these constructs enable humans to complete tasks that would otherwise be impossible. However as with any powerful tool, caution must be taken when handling construction equipment. It's important to stay safe when handling any type of heavy equipment including lifts, excavators, etc. This is especially true if you're new to handling heavy equipment and machinery. Here are 10 tips to keep you, everyone around you, and the equipment safe.

1. Ensure you have the proper training before you even get on the piece of equipment are extremely careful when mounting a construction vehicle.
2. Ensure there are no people in the operation area.
3. Always wear protective gear.
4. Never exceed the prescribed payload of the vehicle.
5. When operating a machine, wear your seat belt.
6. Be vigilant when backing a construction vehicle.
7. Be aware of overhead or subterranean obstructions.
8. Keep an eye open for construction vehicles' blind spots.
9. Communication is key.

3. Mathematical Modeling

In this document is explained how a "Crane Capacity Index" (CCI) can be determined. The CCI basically is calculated as follows: "Radius * Lifting Height * Capacity". The result CCI is in $Te \cdot m^2$.

To clarify calculations a **Liebherr LTM 1100-5.2** is used as an example.

Units:

Distance meter m

Angle degree °

Weight Metric Ton Te

CCI $Te \cdot m^2$ Base dimensions;

In order to get a fair "Crane Capacity Index" we need to set some constraints:

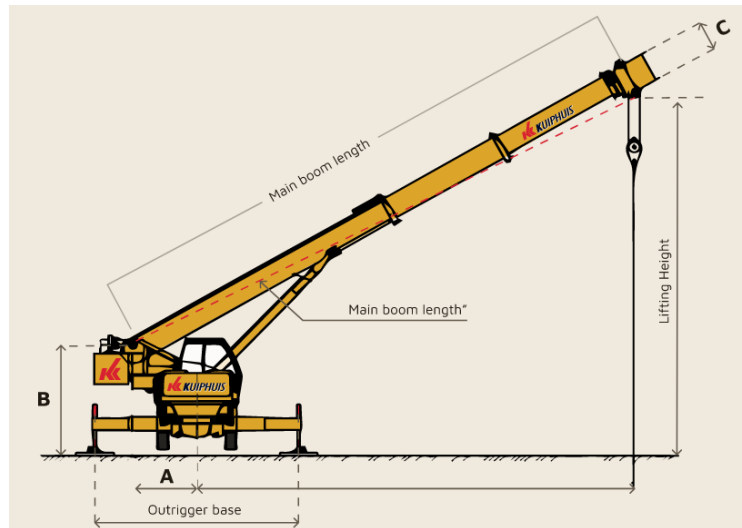
- Lifting height is height of the centre of lower sheave
 - Maximum radius = Maximum main boom length with angle of 30°.
 - Minimum radius = $\frac{1}{2}$ *outrigger base
 - 360° swing angle
 - Only with standard equipment (no heavy lift attachment, centre support, etc.)
 - Main boom only (no jib, no guyed main boom)
- A: Crane center – pivot point main boom
B: Height of crane pivot point On standard tires, 100mm between ground and tires
C: Sheaves distance

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Vol. 8, Issue 7, July 2019



For the **Liebherr LTM 1100-5.2** the base dimensions are:

$$A = 2.0 \text{ m}$$

$$B = 3.83 \text{ m}$$

$$C = 1.1 \text{ m}$$

Calculations:

Minimum radius

$$\text{Minimum radius} = \frac{1}{2} * \text{outtrigger base}$$

$$\text{Liebherr LTM1100-5.2: } \frac{1}{2} * 7.0 = 3.5 \text{ m}$$

Maximum radius

$$\text{Maximum radius} = \text{Maximum main boom length with angle of } 30^\circ.$$

$$\text{Maximum main boom length} * \cos(30^\circ) + C * \sin(30^\circ) - A$$

$$\text{Liebherr LTM1100-5.2: } 52.0 * 0.866 + 1.1 * 0.5 - 2.0 = 43.58 \text{ m}$$

Lifting height

$$\sqrt{\text{Main boom length}^2 + C^2 - (\text{radius} + A)^2} + B$$

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Vol. 8, Issue 7, July 2019

Liebherr LTM1100-5.2 (example with 30.1m main boom at 15m radius:

$$\sqrt{30,1^2 + 1,1^2 - (15 + 2,0)^2} + 3,83 = 28,69 \text{ M}$$

The base formula for the Crane Capacity Index is:

$$\frac{\text{Average (Radius * max(Lifting height * Capacity))}}{100}$$

III RESULTS AND DISCUSSIONS

Material handling during metro construction

Implementation and strengthening of the safety management of MHE are a thought ask and MHE being used in construction sites requires continuous and extensive studies to improve its operation safety. Construction sites are classified as three types: small scale, medium scale, and large scale. Each of these types has a unique safety management system peculiar to its own construction sites. The first part of this research work has been carried out considering two segments of the construction sites: small and medium scale sites. Construction sites employing less than 50 workers are termed small scale and those which employ between 50 and 100 workers are termed medium scale construction sites. Since most of the large scale sites follow all necessary safety procedures, they are not considered for this study.

Elements of Safety

For this study, the MHE safety management system of small and medium scale sites has been divided into twelve separate elements constituted in two parts: administrative management system and technical management system. The elements of safety were derived from the literature and general risk assessments in construction sites. Each of the elements had a questionnaire in its related field with ten questions for each element total 120 questions overall. The first six elements come under safety management system which include general working standards, health and hygiene, personal protective equipment, hazard and risk identification, inspection of cranes, and worker behavioural safety and the other six elements come under technical management system which are tower crane and hydra crane inspection, operation of industrial trucks and dumpers, safety of passenger and builder hoist, safety during storage and material handling, safety of earth moving equipment, and prevention of fire and fire protection.

Effectiveness of the Program

A different set of questionnaire was once again issued to the workers before and after the program to find out its effectiveness. The questionnaire consisted of three parts: general worker safety, inspection and operation of MHE, and safety of MHE environment with 40 questions for each part total to 120 questions and each "yes" contributes to 0.25 points. Then, the points acquired by each worker before and after the test were compared to find out the improvement in the knowledge level of the workers. The mean, standard deviation, and correlation coefficient of the results of both the questionnaire sets before and after the program were calculated and the significance value was found out using a two tailed *t*-test analysis. Results of the point so brainied by the workers for the questionnaire before the program are shown in Table . It shows the points obtained by workers before training.

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Vol. 8, Issue 7, July 2019

IV. CONCLUSION

The safety education program for MHE workers was carried out with an aim to improve their self-awareness and change the cultural mindset to mitigate all actions that will lead to harm and educate them more on preventative control methods. And the program was successful in improving safety awareness and culture by educating the workers at the two construction sites. The modules focused more on engineering and administrative and management control, training the workers to avoid hazards rather than relying on personal protective equipment for their protection. Although the self-instructional modules were used for worker's educational purposes, the program's success was solely dependent on their motivation to learn. Another was the lack of management commitment towards educating their workers about safety. In the future, the safety education program is to be extended with additional modules covering other unsafe areas at the construction sites and to inculcate commitment among management towards safety.

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