IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⁜ Impact Factor 7.105 ⁜ Vol. 9, Issue 5, May 2022

DOI: 10.17148/IARJSET.2022.9568

ANALYSIS OF RISKS AND CONTROL MEASURES IN THE USE OF TOWER CRANES AND MOBILE CRANES IN HIGH RISE BUILDING CONSTRUCTION

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Abstract: The construction industry today is greatly different from the one of the past. There have been many remarkable changes and advancement not only in terms of the structures that are today being build and the tools that are being used, but most importantly in the techniques and methods that are available now for the actual construction works. Tower cranes and Mobile cranes are considered as the centrepiece of construction equipment in building projects. They play a key role in transporting a variety of materials vertically and horizontally. The efficiency of tower cranes and mobile crane largely depends on their type, number, location, operator skill and many more. But considering the safety related Tower crane, Tower crane and Mobile crane accidents are high in numbers and taking more than 5 persons life in a year in India.There are many improvements developed in Tower crane designs and mobile crane operations but still the control measures implemented in the Tower crane and Mobile crane is not making the effectiveness in many construction sites.The aim of the present research work was to analysis the past incidents related to Tower cranes and Mobile cranes and identify the root causes of each incidents. Based on the root cause analysis, inspection done on a construction site to check the implementation status of control measures in the Tower cranes and mobile cranes. Based on the site inspection, we will identify the requirements of advanced control measures and implement those control measures to avoid further accidents related to Tower cranes and Mobile cranes.

Keywords: Mobile and Tower Cranes, Safety, Lift Plan, Construction Industry.

1.INTRODUCTION

India is witnessing construction of a large number of high rise structures including Tall buildings, Power station chimneys, Natural Draught Cooling Towers, Elevators Towers and the list goes on. The use of Tower cranes and Mobile Cranes in all such cases becomes an absolute necessity. While some Tower cranes and Mobile Cranes are being manufactured and assembled in India, cranes to serve the upper end of the construction spectrum are being imported.

Tower cranes and Mobile Cranes are being extensively used for material handling and concreting. Their configuration offers several advantages over more traditional cranes, including reduced space requirements, higher vertical lift, increased capacities and quiet electrical operation. In high rise buildings, Tower cranes and Mobile Cranes can available in several common types, each with its own advantages.

Tower cranes and Mobile Cranes now- a- day are sophisticated items of construction equipment, requiring detailed planning in procurement and utilization.

They are electrically operated and come with wide variety of options both in terms of working range. Jib arrangement. Mass configuration etc. some aspects of the various issues are now dealt with in the paper.

Tower cranes and Mobile Cranes is the only type of crane specially designed for buildings and other high rise structures. They can distribute material for whole plan area of a tall structure. Tower cranes and Mobile Cranes can be fitted with a derricking jib or horizontal jib with traversing trolley. A derricking jib is necessary if required to be raised to clear obstructions. A horizontal jib is easier to operate, faster and has lower power consumption. In such cases the

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DOI: 10.17148/IARJSET.2022.9568

designer of the building should permit attachment with resultant loads, at appropriate points. With winches of higher capacity, the maximum height of the attached crane can be increased.
Cranes play an integral role in the construction industry. These machines are used to lift, move, lower and raise the objects. Cranes have become the most essential and important mechanism in construction sites. Cranes which works normally works with hoist, chains, ropes, wires and sheaves are not only fast but they make the work easier and faster for the projection of work.

Working in construction sites has always been considered as hazardous, Thanks to the innovation and technological development that working on these site with the help of machines have eased the life of labors.

Cranes being an important part of lifting mechanism and plays an important role in the overall project. Cranes helps in moving materials in different directions and locations.
These days with advancement in technology cranes use hydraulic systems, electric motors and internal combustion engines with improved capabilities for its users. Different types of cranes can be hired as per need. From a small Jib Crane to work inside a workshop to Tower cranes and Mobile Cranes to construct high buildings and mini cranes to reach difficult spaces during construction, never the less floating cranes for harbours and ships.

Tower cranes and Mobile cranes are extensively used for lifting materials in construction sites. Most construction sites are very confined and close to public. Tower crane and Mobile crane accidents not only hazard workers in construction sites, but also pedestrians.

In many cases, crane accidents are a direct result of someone's negligence. According to the Crane Inspection and Certification Bureau (CICB), 90% of crane accidents happen because of human error. It is incredibly important for employers to properly train their workers and make sure the crane is safe to use.

Lifting operation is an integral part of any construction, ship-building, ship-repairing or manufacturing process. Every lift carries a set of risks that needs to be managed in order to prevent an accident from occurring. Unsafe lifting operations can result in catastrophic outcomes involving multiple fatalities and serious injuries as well as extensive damage to properties and facilities.

Due to their size, weight, and capacity to carry large and heavy objects, it is easy for cranes to cause major damage in an accident. There are several different types of crane accidents; the below are some of the most common.

- Dropped loads
- Failure to use a signal person
- Contact with power lines
- Improper maintenance and inspection procedures
- Improper disassembly and assembly.

2. LITERATURE SURVEY

Safe and efficient crane operations play a significant role in successful delivery of construction projects, and thus meticulous planning of crane lifts becomes increasingly critical. Crane lift planning involves a series of complex decisions to be made, while satisfying a wide range of criteria and constraints. Conventionally, making these decisions is time-consuming and to a large extent relies on the planner's experience. To make more informed and optimized planning decisions, past research works investigated various automated planning techniques and optimization algorithms. However, most studies focus on an individual planning decision or a particular lifting scenario, which makes the findings hard to be generalized. Thus, the knowledge in lift planning is rather fragmented and the state-of-the-art in lift planning is not explicitly presented. This study, therefore, aims to conduct a critical review and assessment on the literature on crane lift planning automation and optimization and to establish a solid foundation to inform future research. It first presents an overview of the literature in crane lift planning with respect to the planning decision and the type of cranes the studies focus on. Secondly, for each lift planning decision, the assumptions, objectives, decision variables, and constraints are formulated based on the literature and analyzed from the perspectives of problem formulation coherence. Furthermore, each problem-solving method is evaluated with regard to a tri-axial evaluation diagram to allow an in-depth discussion on the efficacy and practicality of planning results. Finally, based on the discussion and existing literature, a BIM-based lift planning framework is presented and future research directions are recommended to further improve the effectiveness and efficiency of lift planning practice.

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3. EXISTING SYSTEM

Reviewed the existing system for the crane safety. Following control measures they are following in the site,

- Cranes used must have valid test certificate.
- Crane operator must have competency certificate from third party agency.
- Before starting the work, operator must check the crane visually
- Ensure that electrical connections are routed through MCB and ELCB's.
- Power cables to the crane shall be protected from damages.
- Trained and skilled person to be involved in the lifting activity.
- Adequate supervision to be made all the time.
- Warning horn fitted to the crane to be in working condition.
- Check for overhead power lines (if any overhead power lines; maintain required distance from power lines.)
- Give hazard information and training to the operator and others about activity through Tool Box Talk.
- Before use, lifting tackles to be inspected by visually and valid test certificates to be made available at site.
- Use tag line to guide the load.
- Clear visibility to be maintained between signalman and lifted load. Walkie-talkie shall be used whenever the signaller/ operator cannot see each other clearly.
- Proper access ladder must be available to operator cabin.
- Avoid the use of crane in strong windy conditions. (more than 22 knots)
- Use proper PPE like safety helmets, safety shoes, and hand gloves.
- Adequate drinking water facility to be made available in operator cabin.
- Place packing material below the load to avoid finger and toe trap

From the past incident analysis, the major categories of incidents are human error and the existing system of control measures and not able to fulfil for avoiding further accidents.

4. PROPOSED WORK

As a part of project, I inspected the tower crane and mobile of the construction site and checked the implementation status of the control measures in Tower crane as well as in mobile cranes

It is concluded that existing system for cranes safety is not making any roles in minimizing the Tower crane and Mobile crane accidents. Still we need to improve the safety systems and safe operating procedures to avoid further accidents. From the root cause analysis, we made a decision that implementing of Safe Operating procedures shall improve the safety systems of the Cranes.

Future work includes finding the scope of safety features for all root causes of the past incidents. This will include developing of Lifting plan and Harmonization of the Lifting Plan vis-à-vis Risk Assessment and Permit-To-Work.

Lifting Plan

General

The Lifting Plan is a set of plans which is created for use in any crane lifting operation. All lifting operations shall be accompanied by a lifting plan supported by a risk assessment, a safe work procedure and/or method statement, and PTW. Frequent or routine lifting operations may only require a basic lifting plan (Annexure 1) supported by an on-site risk assessment and briefing to related personnel. High risk or complex lifts however, requires additional engineering design efforts to ensure that the lifting is conducted safely

Importance of Lifting Plan

The lifting plan aims to facilitate consensus amongst all stakeholders including the lifting crew for a safe outcome. The lifting plan encapsulates all the important information that must be considered in a lifting operation thus ensuring that the lifting operation is carried out safely.

Ownership and Usage of the Lifting Plan

Every member of the Lifting Crew shall be familiar with the Lifting Plan and ensure that the operation is carried out according to the plan. The Lifting Supervisor must take ownership of the lifting plan and make it available to other members of the Lifting Crew. This is to allow common understanding amongst the lifting crew for a safe outcome. The

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underlying principle is that all foreseeable risks had been assessed and eliminated or mitigated.

The lifting plan can be developed by persons who have the expertise and relevant knowledge of the intended lift. After which, the team involved has to sign and agree upon the developed lifting plan.

Elements of a Lifting Plan

The lifting plan shall include but not be limited to the following considerations:

• The personnel required
• The personnel's roles, responsibilities and competencies
• Compliance to statutory requirements and manufacturer's operation manual for the lifting equipment • Permit-to-Work system which is mandatory for all lifting operations.
• Nature and weight and dimension of load – including the NET and GROSS weights.
• Type and location of lifting / rigging points.
• Selection of appropriate lifting equipment, lifting gear and appliances.
• Application of the correct lifting methods
• Position of lifting equipment, personnel and of the load, before and after the lift operation.
• The work site operation including proximity of other lifting equipment and work activities.
• Requirements to erect / dismantle the lifting equipment.
• Assessment of the need for tagline to control movement of the suspended load.
• Means of communication during lifting operations.
• Environmental factors detrimental to the lifting operations such as ground conditions, adverse weather, wind, and poor illumination.
• Ensuring a system for reporting any defects is in place.
• Provision of a safe place of work for all personnel during lifting operations.
• The necessity to cordon off or not the area where lifting is being carried out and in particular where members of the public (anyone not concerned with the lifting operation) may be present

Factors that Affect Lifting Plan

The factors which may affect lifting plan include:

• Load
• Rigging Methods
• Equipment
• Physical and Environmental Factors
• Means of communication
• Sequence/special precautions
• Sketch of zone of operation
• Personnel involved in the lifting operation

It is important to note that the factors above are not exhaustive and personnel involved in planning lifting operations must consider other factors that are specific to the situation, especially in complex lifting operations.

Harmonization of the Lifting Plan vis-à-vis Risk Assessment and Permit-To-Work

A RA for lifting operation shall specify control measures such as appointment of competent personnel, usage of appropriately maintained lifting gears, demarcation of the lifting zone, and taking into account the physical environment. These factors are necessary and useful for the RA.

The Lifting Plan and the PTW are part of the Risk Control stage of the RA process. The purpose of a proper Lifting Plan/ PTW is to verify that the necessary control measures have been taken. They are complementary and shall not be seen as mere paper exercises.

If the sample of basic Lifting Plan/ PTW template recommended in Annexure is used properly, it would meet the legislative requirements for basic Lifting Plan and PTW

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5. LIFT PLAN

5.1 Critical Lift Plan

Form 16-3

CRITICAL LIFT PLAN

For use of this form, see EM 385-1-1, Section 16. Proponent is Crane HHWG.

Date:	Prepared By:
Location:	USACE District:

A "critical lift" is defined as any non-routine crane lift requiring detailed planning and additional or unusual safety precautions. Critical lifts include: lifts made where the load weight is greater than 75% of the rated capacity of the crane; lifts which require load to be lifted, swung or placed out of the operator's view ; lifts made with more than one crane; lifts involving non-routine/technically difficult rigging arrangement; hoisting personnel with a crane or derrick; or any lift which the crane operator believes should be critical.

A. TOTAL LOAD

1. Load Weight		lbs
2. Wt. of Aux. Block		lbs
3. Wt. of Main Block		lbs
4. Wt. of Lifting Beam		lbs
5. Wt. of Sling/Shackles		lbs
6. Wt. of Jib/Ext. (erected/stowed)		lbs
7. Wt. of Hoist Rope		lbs
8. Other:		lbs
TOTAL WEIGHT		

Note: Source of load weight (Drawings, Calcs, etc.) must be attached on Page 2.

B. CRANE

1. Type of Crane	Mobile Hydraulic Truck	
2. Maximum Crane Capacity		lbs.
3. Radius (Maximum)		ft.
4. Radius (Minimum)		ft.
5. Boom Length (Maximum)		ft.
6. Boom Length (Minimum)		ft.
7. Crane Capacity (Max Radius)		lbs.
8. Crane Capacity (Min Radius)		lbs.
9. Boom Angle (Maximum)		deg.
10. Boom Angle (Minimum)		deg.
11. Gross Load of Crane		lbs.
12. Lift is _____ % of the Crane's rated capacity		
13. If Jib/Ext. is to be used:		
Length		ft.
Offset		ft.
14. Rated Capacity of Jib/Ext.		lbs

C. HOIST ROPE

	Main	Aux 1	Aux 2
1. # of Parts			
2. Rope Diameter			
3. Capacity			

D. RIGGING

1. Hitch Type(s)		
2. No. of Slings:	Size:	
3. Sling Type:		
4. Sling Assembly Capacity:		lbs.
5. Shackle Size(s):		
6. Shackle Rated Capacity(s)		lbs.

E. CRANE PLACEMENT *(Mobile Cranes Only)*

1. Maximum Bearing Pressure	PSF
Note: Bearing Pressure Calculations must be attached on Page 3.	
2. Ground Conditions Suitable for Load?	___ YES / NO
Note: Ground Condition Calculations must be attached on Page 3.	
3. High Voltage or Electrical Hazards?	___ YES / NO
Note: If Electrical Hazards are present they must be shown on Page 4.	
4. Obstructions to Lift or Swing?	___ YES / NO
Note: If Obstructions are present they must be shown on Page 4.	
5. Travel with Load Required?	___ YES / NO
6. Other?	

F. OPERATOR QUALIFICATIONS

1. Certified Operator?	___ YES / NO
2. Option?	
3. Certified for Type, Class & Capacity?	___ YES / NO
4. Designated in writing by employer:	YES / NO

G. PRE-LIFT CHECKLIST

	(YES)	N/A	(NO)
1. Crane Inspected			
2. Rigging Inspected			
3. Crane Set-up			
4. Overhead Hazard Check			
5. Swing Check			
6. Counterweight Check			
7. Operator Qualifications			
8. Signal Person Qualifications			
9. Rigger Qualifications			
10. Load Chart in Crane			
11. Load Test			
12. Tag Lines			
13. Wind Conditions			
14. Traffic Hazard Check			
15. Site Control			
16. Signatures			

H. SIGNATURES

1. Crane Operator	
2. Rigger	
3. Signal Person	
4. Lift Supervisor	
5. Other	
6. Other	

ACKNOWLEDGEMENT

The author would like to thank **Dr.A.K.NATESAN M.Com.,(NIT) M.Phil**., Ph.D., FTA., Honourable chairman and **Dr .N.MATHAN KARTHICK M.B.B.S., MISTF., PHF.,** Vice chairman**,** Excel group of institutions, for providing all the necessary facilities made available in the institutions .

We express our whole hearted thanks to our beloved principal **Dr.R.NALLUSAMY, B.E., M.E., Ph.D., M.B.A., F.I.E.,** for having rendered us moral support in our endeavour.

We are extremely grateful to **Mr. P. NITHIYANAND M.E.** Head of the department,Department of Mechanical Engineering, advice right from the day one which has contributed to a great extend to the completion of Project work.

Our sincere thanks to our guide **Mr. S. SARAVANAKUMAR M.E,** Assistant Professor, Department of Mechanical Engineering, Excel College of Engineering & Technology, for his support and guidance throughout this project work.

My sincere thanks are due to my Friends, Teaching, Non-Teaching Staff members and the well-wishers for their constant support all the time.

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