The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)

Volume 1, Pages 213-217

ICONTES2017: International Conference on Technology, Engineering and Science

ABOUT THE SAFETY BY USING OF MOBILE CRANES

Krasimir Krastanov
Todor Kableshkov University of Transport

Abstract: Mobile crane incidents can cause devastating results in terms of production, property damage, and loss of human life. The paper presents analysis of different critical elements in operation of mobile cranes, exploration of problems related to stability and increasing of safety by work with mobile cranes.

Keywords: Safety, mobile cranes, stability

Introduction

Mobile crane incidents can cause devastating results in terms of production, property damage, and loss of human life. Mobile cranes are characterized by their high maneuverability and transport speed, allowing for quick and easy adjustment from transport to work and independent of energy sources [4]. They are swinging cranes where the load hanging on the hook, ignoring its swing around the tip of the dart, has three degrees of freedom - lifting, radial and angular displacement.

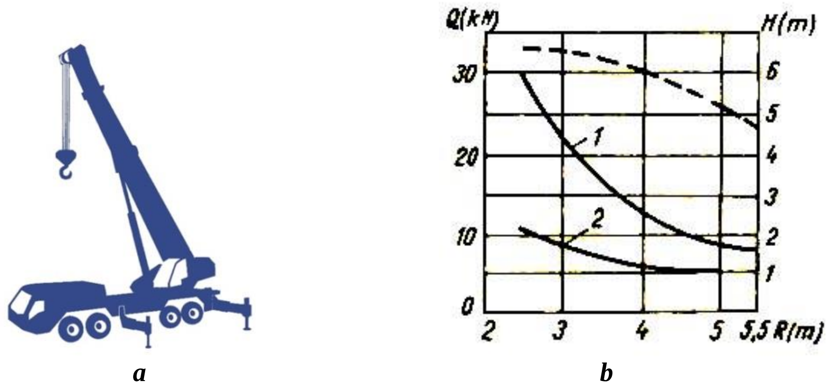

Figure 1 Mobile crane a - general appearance; b - correlation dependencies Q, R and H:
1- load diagram of crane with exported pumps; 2 - load crane diagram without extensions

For the purpose of safety in the operation of these cranes, the radial displacement of the load (the hook with a load) can be done only one way - from a large to a small radius,. it is not allowed to lower the boom when a hook is hung on the hook.

About the Accidents with Mobile Cranes

Mobile cranes have been shown to represent 88.4% of all crane related fatalities and 100% of crane related electrocutions. [1]. A major problem in the operation of mobile cranes is the loss of stability, but the number and description of categories used to classify crane failures varies significantly.

The main types and causes of mobile crane failures are:

- *Struck by Load (Other than Failure of Boom)* - Being struck by a load accounted for 30% of fatal crane events. The most common contributing factors to this proximal cause in order were rigging failures, loads being dropped, equipment damage, unbalanced loads, and accelerated movement.

- Selection and peer-review under responsibility of the Organizing Committee of the conference
*Corresponding author: Krasimir Krastanov - E-mail: kkrastanov@vtu.bg

- *Electrocution* - accounted for 39 % of fatal crane events. All recorded electrocutions involved mobile cranes and were the result of a cranes boom or wire rope getting to close to high voltage power lines.
- *Crushed During Assembly/Disassembly* - 21% of crane related fatalities were contributed to being crushed during crane assembly or disassembly. Lattice boom cranes were involved in all of these deaths. The most common contributing factors to this proximal cause in order were improper disassembly and pin removal, improper boom support, and improper assembly..
- *Crane Tip Over* - Crane Overturning was the cause of 11% of fatal crane events. The most common contributing factors to this proximal cause in order were overload, loss of center of gravity control, outrigger failure, high winds, side pull, and improper maintenance.

Table 1. Reasons about the mobile crane accidents in the world

Reason	**%**
Electrocution	39
Struck by Load (Other than Failure of Boom/Cable)	30
Crushed During Assembly/Disassembly	20
Crane Overturning	11

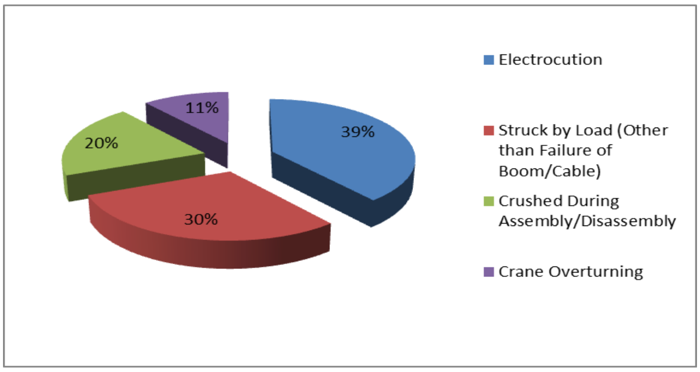

Figure 2

A crane tipping over we often automatically assume that it was caused by lifting an object heavier than what the crane can endure. However, crane tipping accidents frequently occur with loads below the threshold of the crane.

If the ground is found to be not suitable, additional measures must be taken before proceeding with task.

Table 2 Typical maximum permissible ground pressure for different ground types.

Ground type	**Maximum permissible ground pressure (t/m^2)**
Hard rock	200
Shale rock and sandstone	80
Compacted gravel—with up to 20% sand	40
Asphalt	20
Compacted sand	20
Stiff clay (dry)	20
Soft clay (dry)	10
Loose sand	10

When outriggers exert pressure on the ground, it is important that the outrigger feet do not sink into the ground, or cause nearby excavations to collapse – as this could lead to the crane tipping over. Outriggers put stresses onto the ground beneath them, sometimes called the “zone of influence”. This angle can vary depending on the nature of the ground beneath the outrigger, and the design of the outrigger support [5].

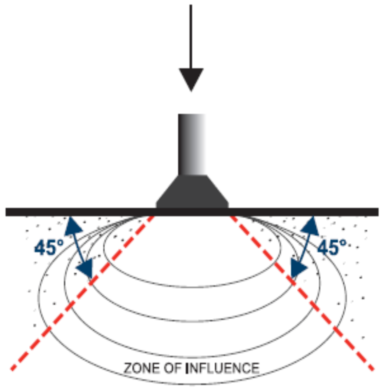

Figure 3. “Zone of influence“

When examining the ground contact pressure, the maximum reaction of the outrigger is calculated to check stability and the available mobile cranes are identified. When the mobile cranes are selected, the reinforcement of soil bearing force is reviewed based on the ground shape. At the reinforcement planning of soil bearing force of flat site as illustrated in Plate type (steel, timber), rigidity of plate, soil bearing force, and bending moment and shearing force acting on plate should be reviewed [3].

Table 3. Review items for ground contact stability

Step		Items reviewed
Basic Items	Review of the objects to be lifted	Type, material and weight
	Equipment information	Working radius, the maximum height of objects, crane weight and outrigger radius
Ground contact stability	Review of ground contact pressure	Work direction, ratio of impact load and the maximum reaction of outrigger
	Reinforcement of soil bearing force (flat site)	Plate type (steel, timber), rigidity of plate, soil bearing force, bending moment, and shearing force acting on plate
	Reinforcement of soil bearing force (slopping site)	Additional data including slope data such as slopping angle, slopping length, slopping height, and distributed load on soil

The crane operation plan is classified into reviewing lifting conditions, mobile crane selection, and reviewing ground contact stability. When reviewing lifting conditions, the shape, section, and weight of lifting objects should be checked.

Stability as Element of Safety by Using of Mobile Cranes

The stability of the crane must be ensured for all its positions under any possible combinations of loads. These loads for the mobile rotary crane are:
- weight of lifted cargo;
- inertial forces during start-up or braking of crane mechanisms;
- centrifugal forces arising when the rotary part of the crane rotates;
- the force of the wind pressure on the cargo and the elements of the crane.

The stability of mobile cranes relies on the following factors:

-That the ground is suitably compacted and levelled. Underground services or constructions may suffer damage or collapse due to a crane passing over or nearby, which in turn may lead to the crane overturning;

- That adequate support material has been positioned under the outrigger jacks to prevent them sinking into the ground whilst lifting loads;

- If there is doubt about the ground condition, the Crane Operator should be instructed to fully retract the main boom derrick to minimize radius and then slew the counterweight in the direction of each outrigger in turn for two minutes to simulate actual lift.

The stability of the mobile crane on tires varies with respect to the boom's horizontal angle position to the longitudinal axis of the machine.

A required condition for safe operation is that the weight of the load does not exceed the load diagram given in the load chart, as otherwise the crane will lose its stability. A criterion for the stability of the mobile crane is the coefficient of resistance K_y [2].

$$(1) \quad K_{yI} = \frac{M_G}{M_Q} \geq 1{,}4$$

where:

M_G - is the retention moment of the weight of the crane;

M_Q - is the crushing moment of the weight of the nominal load.

The crane counterweight is critical in ensuring crane stability. A counterweight that is too light for a load and boom configuration will cause the crane to overturn in the direction of the suspended load.

Toppling over happens mostly because of mathematical miscalculation. Therefore, it is essential to set the correct weight and size prior to the manufacturing process during the design phase. This is the only way to secure the safe performance of the crane counterweight.

Using the following mathematical formula, while designing the component, we can minimize possible risks and secure reliable counterbalance:

$$(2) \qquad P = V.\mu.g$$

where:

P is the weight of the required counterweight;

V – its volume;

μ – is the density of the material of which the counterweight was made of

g – the gravitational constant

The important for safety by using mobile cranes is load moment indicator (LMI). The load moment (or rated capacity) indicator means a system which aids the equipment operator by sensing (directly or indirectly) the overturning moment on the equipment, i.e., load multiplied by radius. LMI technology gives the crane operator a continuous read-out of the boom length, boom angle, and the radius – and usually an actual load weight.

Figure 4 Load moment indicator

The system operates on the principle of reference/real comparison. The real value, resulting from the pressure measurement is compared with the reference data, stored in the central processor memory and evaluated in the micro processor. When limits are reached, an overload warning signal is generated at the operator's console. At the same time, the aggravating crane movements, such as hoist up, telescope out and boom down, will be stopped [6].

The fixed data regarding the crane, such as capacity charts, boom weights, centers of gravity and dimensions are stored in memory chips in the central processor unit. This data is the reference information used to calculate the operating conditions. Boom length and boom angle are registered by the length/angle sensor, mounted inside the cable reel which is mounted on the boom. The boom length is measured by the cable reel cable which also serves as an electrical conductor for the anti two-block switches.

The crane load is measured by pressure transducers attached to the piston and rod side of the hoist cylinders.

Conclusion

Mobile cranes play an indispensable role in the construction industry, especially in high rise structures. Standard safety inspections are more than just for compliance of regulation: they are potential life saving procedures. There are a continuing number of mobile crane incidents involving crane rollovers, structural failures and loads falling. Many of these incidents have occurred due to poor planning of the lifting operation – often because basic factors have been overlooked. All mobile cranes should have a load moment indicator. The stability of mobile crane is always important and all operators should understand the requirements for this for safety in their work.

References

Beavers, J.E., Moore, J.R., Rinehart, R., Schriver, W.R. (2006). "Crane Related Fatalities in the Construction Industry." *Journal of Construction Engineering and Management*, 132(9), 901-910.

Krastanov Kr., Stability and safety in mobile cranes, *Bulgarian Magazine for Engineering Design*, volume.14 August 2012, page.35- 42, ISSN 1313 – 7530

Kim HH, Lee K (2007) An analysis of the accident types and causes of construction cranes**.** *Korea Institute of Construction Engineering*, **7**(1):109–112.

Spassov, V. (2014). Book Engineering Logistics – Material Handling Machines and Systems. *Sofa, Technika*

CICA & CANZ (2017) Guidance Note Crane Stability and Ground Pressure, *The Crane Industry Council of Australia*

Operator's Manual iFLEX5 (2005)