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Determination of the Hazard Area of Crane and Hurdle-using Method for Accident Prevention

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Abstract

Thanks to the mobility and compact, crane is increasingly popular in the manufacturing sector. However, if the technical characteristics of the equipment, and technical process of operation are not known clearly, the workers do not strictly comply with technical standard safety when using, as well as perform well the safety, they can cause occupational accidents. Accidents occur while using crane in general and automotive crane is very diverse, and they occupy a relatively high proportion of the total number of occupational accidents. Therefore, when using crane trucks, safety must be placed on the top. This work is not only to protect human life, protect the machinery, ensure the progress of construction and labor productivity, but also to work legally. Accidents caused by this incident have many causes, of which there are two basic causes, being incorrect determination of insecure area of the crane when working and erroneous technical measures to prevent accidents. Therefore, identifying insecure areas as using automotive crane to design and implement barriers to ensure the safety of people and equipment around the crane is a significant issue. This article presents the method of determining the insecure area of the crane based on determining the extent of impact of the dropping cargo and proposes the solution to prevent accidents when using crane.

Keywords: Crane, insecure area, hurdle method, standard safety.

INTRODUCTION

In construction, the operation process of crane is a complicated task, which greatly depends on the skill of the operators. This issue shows the factors affecting the safety of crane operation. Safety is an important factor to eliminate the insecurity sources of users. Safety is considered as the most critical issue in the success of any crane operation.

Insecure areas and technical measures to prevent accidents as using cranes are essential to ensure the safety of people and vehicles operating around the crane installation [1], but there is no clear basis for defining the danger zone around the crane. In the regulations of lifting equipment as Vietnamese Standard 4244-86, Vietnamese Standard 5863-1995 and Vietnamese Standard 4244-2005, there are regulations for users of lifting equipment is "must know the insecure areas" and requirements "must have safety measures in the work area lifting device". However, there is no specific regulation on how to identify the insecure area and the safety measures to be taken in the lifting area [2]. That makes it a lot of trouble for the user, for the manager to use the lifting device and to determine the responsibility when the problem occurs [2].

Identification of insecure areas and preventive measures for accidents have not been mentioned much in the technical discipline and occupational safety of lifting equipment. The article is based on mathematical, mechanical, lifting and theoretical principles of lifting equipment use, and investigates the operation of the crane to determine the extent of the impact of the goods. When it falls, it identifies the insecure area of the crane and proposes a safety barrier. Goods generally have many types, so depending on the type of goods that many mechanical, physical and chemical phenomena can occur such as horizontal splashing, shaking, collision, fire, break, splashing fall. Referring to these issues is quite complex, so this study determined the ability to fly off the line when falling as a purely mechanical block. At the same time, correctly identifying the insecure areas of the crane has important scientific, practical and economic significance. If identified incorrectly, the specified insecure area may be too small, or too large. If it is too small it will not be safe, if it is too big will increase the cost of fence and other costs [3].

Cranes are self-propelled, full-turn, rotary mounted on the base frame cars, is used quite commonly in most production areas, for loading and unloading goods in the warehouse. , in yards or to serve the assembly of machinery and equipment in industry, construction, traffic ....Highly mobile crane, independent working independently of external power source, can operate in many different terrains, especially can work in narrow areas where other cranes are difficult to implement. is now Lifting capacity of the crane varies with the reach, so the crane is not allowed to carry goods when changing range. Basic specifications of the crane include: Q (T), r (m), h (m), V_h, variable speed V_c, crane travel speed V_d, crane rotation speed n (rpm), crane weight G (T). Lifting capacity is usually from 4T to 16T. Currently, the automobile crane is designed with high lifting capacity and height. The lifting speed is from 0.032 to 2 m/s. Rotational speed 0.5 -1rpm. Movement speed is from 50 to 90 km/h [2]. The overall structure of the crane as H1, the rotation mounted on the base car frame. The rotation of the system is the need, racks, lifting devices, lifting, rotary, counterbalance and other equipment of the crane. The moving system is the moving system of the base vehicle. Moving to the crane structure can be mechanical, diesel-electric or diesel-hydraulic transmission. The most popular are diesel-electric, diesel-electric-hydraulic systems. The crane's crane has a truss structure or box structure, consisting of several sections interconnected by bolts or bolts. For structural need the box structure can be cramped, the segments need to be able to stretch or shrink due to the hydraulic cylinder arranged in the box. The change-over structure is often used with cable lugs or hydraulic cylinders. In order to increase the stability of the anti-roll and the ability to lift, in the car crane is equipped with 4 auxiliary legs. Normally, the crane can only be lifted when the crane is fully down, so the lifting, loading and unloading operations of the crane are usually in a fixed position [4].

The result of the article is the basis for identifying the insecure area of the crane for people and equipment operating around the installation area of the crane, from which to take measures to prevent accident, ensuring the safety of people and equipment in the area using crane trucks to transport goods, ensuring the economy. The article also adds to the knowledge of an issue that is not yet addressed in the technical regulations and occupational safety of lifting equipment.

HAZARD AREA

The danger area of the crane is generally the space in which frequent or unexpected factors can cause occupational accidents. Hazardous areas on the crane are mainly located near the drive mechanisms: the area between the cables, the rollers in the winch or pulley, the pulley, between the chain and the chain, between the two gears. These mechanisms can be clamped into clothing, body parts (hair, arms, legs) causing accidents. Hazardous area around the crane: When the machine is in operation, the rotating parts (pedestrian platform, needh arm) can be impacted on the person or cargo lifting into the lower body within the range or range of the cargo [5].

When the crane works, if the person and equipment underneath is within the range where the cargo code may fall, dangerous accidents may occur. Survey the work of the automobile crane with Q hanging on the cable at height h and the r range, the crane at speed n. We see that when the cable is still hanging, under the effect of rotational inertia force and the wind load, the cable girder Q will be inclined at an angle α out of the range r, increasing the distance of the goods to the rotation axis. a piece of t. When the break occurs, due to the effect of inertial force on rotation, wind load and gravity, the cargo code falls from the elevation h to the bottom and throws away a further segment S [6]. Therefore, The range of possible impact when falling is the distance of the crane including the distance increase due to the tilt of the cable t when the crane spins and the distance S of the cargo when falling to the ground.

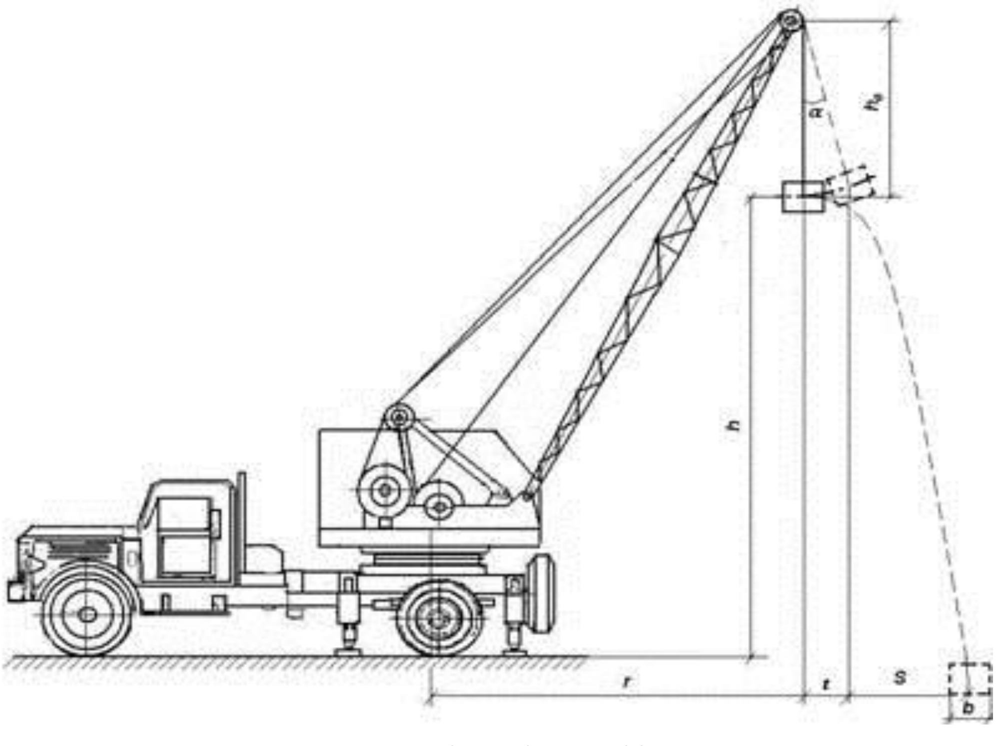


Figure 1. Schematic of the influence of falling cargo

From Figure 1, the maximum distance that the code can affect when falling can be determined by the following expression:

$$R = r + t + S + \frac{b}{2}\text{(m)} \quad (1)$$

Where:

r-range of the crane when lifting the cargo, m

b-half-length of cargo, m

t- increase of distance of row due to cable tilt, m

S- the maximum distances in the radius line in case of dropped goods

From the Eq.(1), the maximum distance that the goods can affect as falling depends on the maximum range, the maximum length of the row, the increase in distance due to the tilt of the cable t and the cargo as dropping S.

In the general case, investigate the work of the crane with Q hanging on the cable at elevation h, and the r range. When starting the mechanisms, there appear inertia forces when rotating, changing range, or moving effects on the cargo. The T-force of the inertia forces and the wind load cause the cargo hanging on the cable to oscillate around the suspension point (which may be perpendicular or overlapping), the cable will be tilted at an angle α (Figure 2). The inclination angle α is defined by the following equation:

$$tg\alpha = \frac{T}{Q} = \frac{a_T + a_e + a_c}{g} + \frac{P_g}{Q} \qquad (2)$$

P_g - Load of wind effect on cargo, N

$$P_g = 2{,}5.q.F \qquad (3)$$

F- Windbreak area of the goods, m^2

q- The wind pressure at the calculated position, $q = 250 N/m^2$

a_T, a_n - tangent acceleration and average centrifugal acceleration when starting or braking, m/s^2

a_c - average acceleration when starting or braking, changing range, or moving mechanism, m/s^2. Value a_T; a_n; a_c determined by the following equation:

$$a_r = \frac{\pi.l.n}{30.t_k} \quad a_n = \frac{r.\pi^2.n^2}{30^2} \quad a_c = \frac{v_c}{t_k} \qquad (4)$$

n - crane speed, rpm

v_c- speed change range or move, m/s

t_k - start time (or braking) of structure, s

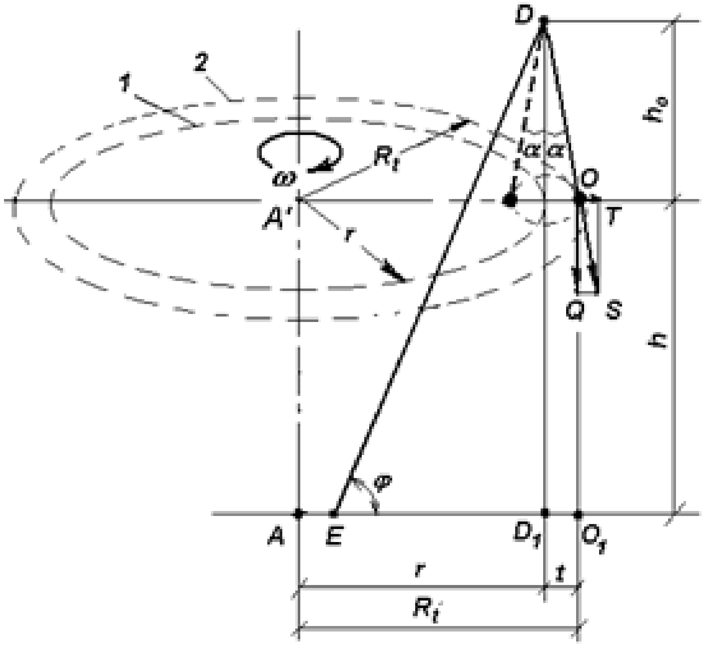


Figure 2. Diagram for determining the distance increase due to cable tilt

The likelihood of simultaneously coinciding with all the greatest values of inertial forces is very low, so in Eq. (3) only the average acceleration is achieved. The angle of inclination is greatest at about 1/3-1/2 of the maximum angle of calculation, calculating angle α_{max} can reach 6°, if the angle α is defined as α <60°, then α = 60° can be obtained. For crane, when hanging only the rotation of work, the largest cable angle can calculate [7]:

$$tg\alpha = \frac{T}{Q} = \frac{a_T + a_e}{g} + \frac{P_g}{Q} \qquad (5)$$

To calculate the most distant range of goods, consider the inclined angle cable α deflected out of reach, then the distance of the goods code to the spin axis will increase by a segment $t = h_0.tg\,\alpha$. The rotational radius of the row will then be:

$$t = h_0.tg\alpha$$

$$R_t = r + t = r + h_0.tg\alpha \qquad (6)$$

When starting or braking, the crane has a cargo, the cargo is affected by tangential inertia and centrifugal force in rotation, gravity Q and wind loads [8].

$$\vec{P}_1 = \vec{P}_L + \vec{P}_g$$

$$\vec{P}_n = \vec{P}_t + \vec{P}_1 \qquad (7)$$

Let β be the angle between the tangent inertial force P_t and the force P_n then β is defined by the following equation:

$$tg\beta = \frac{P_1}{P_t} = \frac{\dfrac{Q.r.\pi^2.n^2}{g.30^2} + P_g}{\dfrac{Q.\pi.r.n}{g.30.t_k}} = \frac{\pi.n.t_k}{30} + \frac{30.P_g.g.t_k}{Q.\pi.r.n} \qquad (8)$$

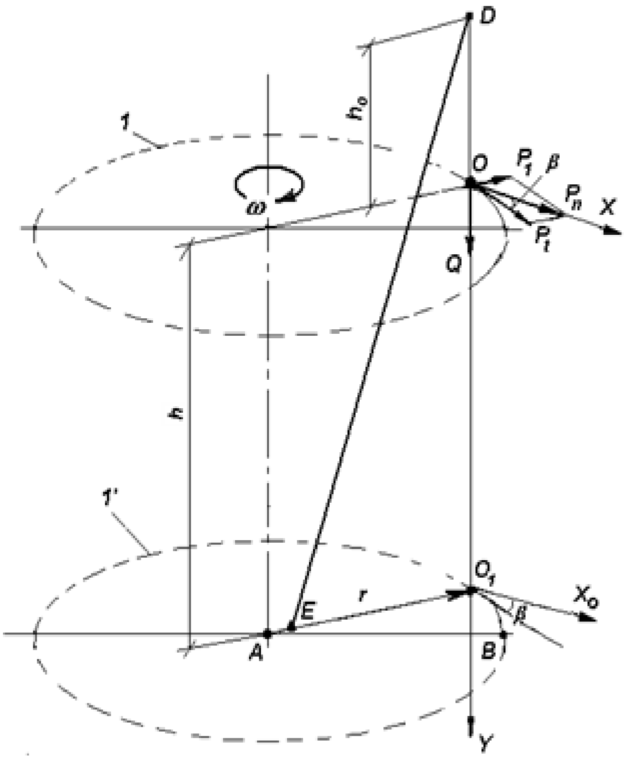


Figure 3. Force chart affecting the cargo

Thus, when starting or braking the rotating mechanism, the P_n force causes the tendency of the motion to deviate from the tangent plane at an angle β to the velocity Vo. If the item code falls in this case, the item tends to move in a plane containing the force P_n, deviating from the tangent plane at an angle β to the initial velocity V_o.

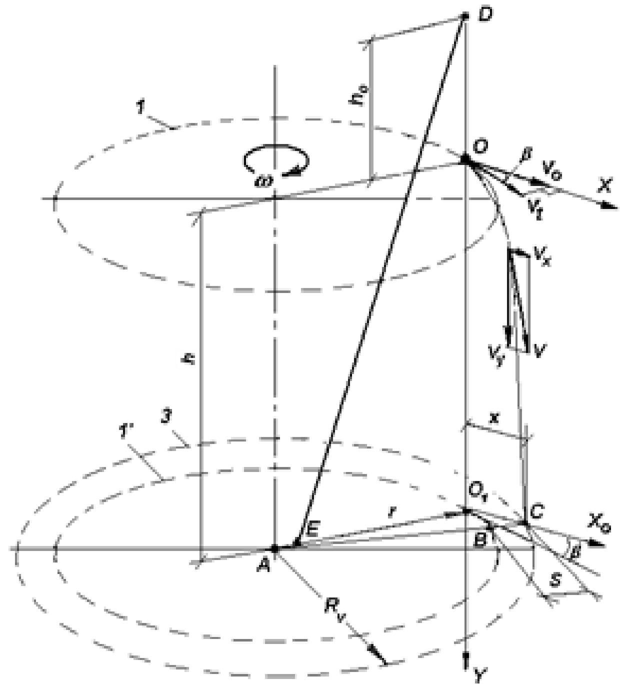


Figure 4. Move of dropping cargo

Cargo moves in a parabola, having a vertex at O, the concave facing downwards. When the cargo falls to the ground corresponding to height h, h is calculated as:

$$h = \frac{g.x^2}{2.v_0^2}$$

$$x = v_0.\sqrt{\frac{2.h}{g}} \qquad (9)$$

$$R_v = AC = \sqrt{r^2 + x^2} \qquad (10)$$

$$R_v = AC = \sqrt{r^2 + x^2} = r.\sqrt{1 + \frac{\pi^2.n^2}{450}.\frac{h}{g}} \approx r.\sqrt{1 + \frac{n^2.h}{450}} = k.r \qquad (11)$$

$$S = r.\sqrt{1 + \frac{n^2.h}{450}} - r = r.(\sqrt{1 + \frac{n^2.h}{450}} - 1) = (k-1).r \qquad (12)$$

$$k = \sqrt{1 + \frac{n^2.h}{450}} \qquad (13)$$

Combined formulas, the range of falling in case of broken cable is:

$$R = r + t + S + \frac{b}{2} = R_s + h_0.tg\alpha + \frac{b}{2} = k.r + h_0.tg\alpha + \frac{b}{2} \qquad (14)$$

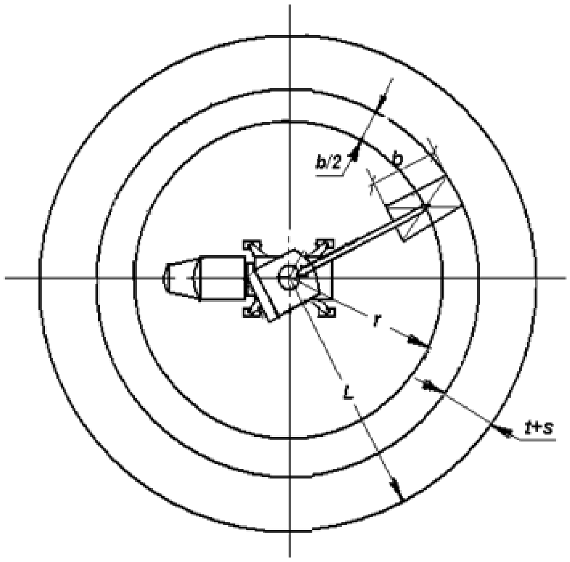


Figure 5. Hazardous area diagram of the crane

From the above calculations, if the person and means are within the greatest range that the cargo may be falling, it can be dangerous for the person and the means. That area is the danger zone of the crane. Therefore, the dangerous area radius of the crane will be:

$$L = R = k.r + h_0.tg\alpha + \frac{b}{2} \qquad (15)$$

The dangerous area around the crane is the circle of radius L equal to the maximum range of the crane, plus the distance of the largest cable tilt and the maximum distance of the largest S (Figure 5).

HURDLE-USING METHOD

Fencing and barriers generally have the effect of isolating and preventing people and means from entering dangerous areas of the crane while working to ensure the safety of people and means of operation around the area. Cranes, prevent accidents occurring when the crane breakdown cable, cable, fall, fall parts break machine. Any type of barrier must meet the following requirements:

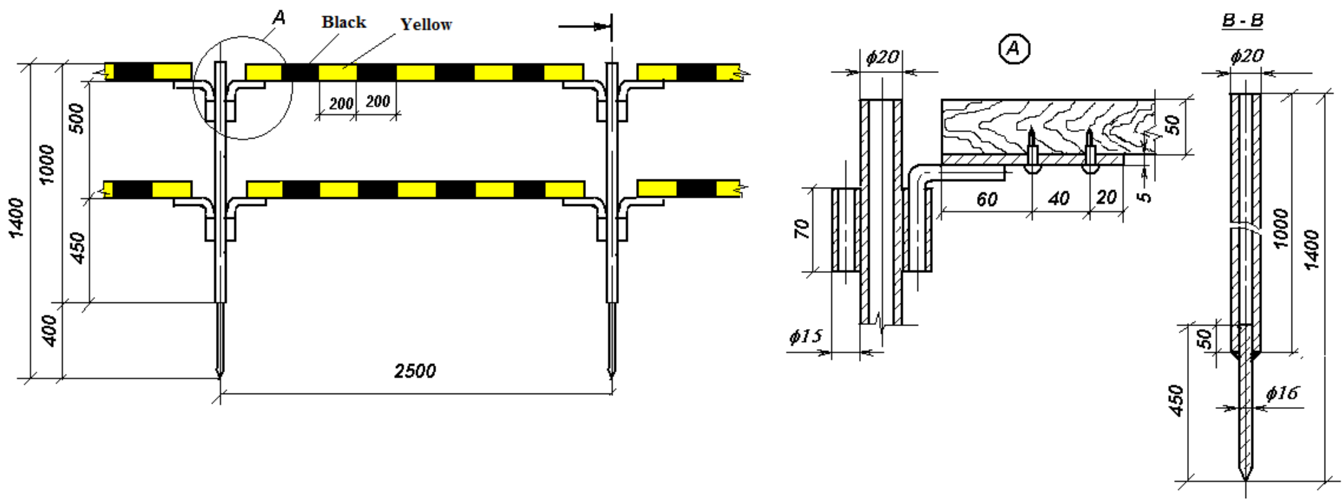
- The effects of human risk factors must be prevented.
- It must be durable by mechanical, thermal, chemical (impact, deformation, melting, corrosion).
- It is convenient for removal, maintenance, repair, replacement.
- Little or no obstruction to the observation, cleaning, grease lubricated parts are covered.
- Low price is considered.

In the course of use, the fences may be damaged or lost. Thus, to ensure the safety, it needs to be replaced, repaired immediately, not to lack of long-term barrier equipment. From the above reasons, in order to ensure safety against falling cargos into the people below, one of the deterrent measures is to use a fence around the dangerous area of the crane, the fence area around the crane needs to have a radius large enough to ensure the safety. If L_a is the fence radius, then:

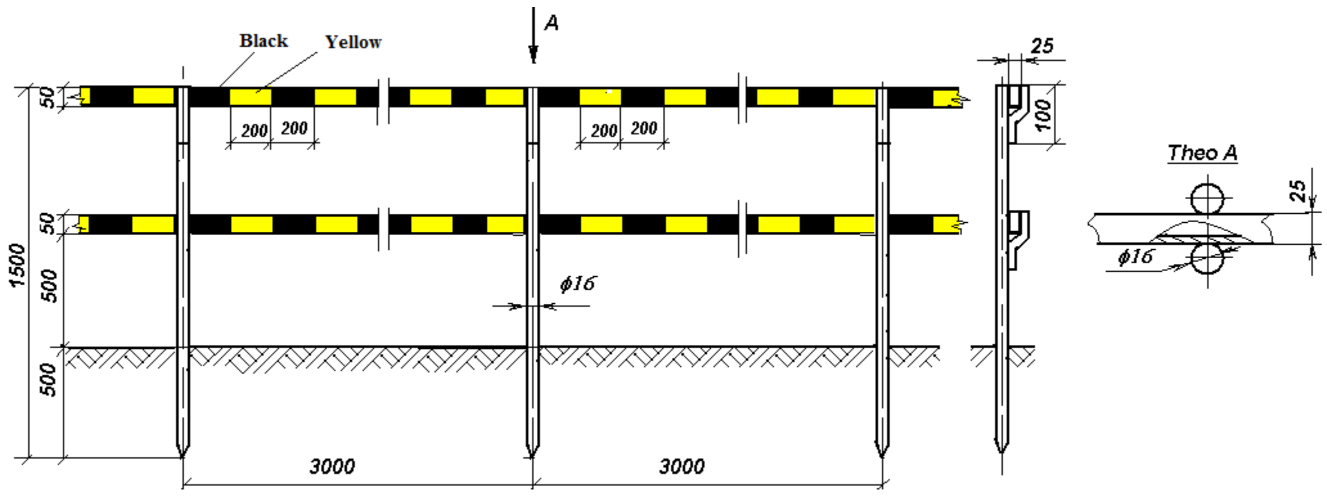
$$L_a = L + a \qquad (16)$$

Where: a-safe distance, m.

Structural barrier can be fixed or removable and movable. If the danger area is temporary for a short period of time, the pile can be pivoted. At the entrance and every 30 meters around the perimeter of the danger area must place the forbidden sign. According to [4][6] fences are usually made of steel piles with wooden cross bars, or steel piles with steel bars. Figure 6 is the structure of these two barriers.



(a)



(b)

a) Barriers made of steel piles and wooden crossbar **b)** Steel crossbar and steel barriers

Fig 6. Barrier structure

CONCLUSIONS

Calculated content shows that, when the crane mounted cargo on the cable, the danger area of the crane is the circle of radius L equal to the maximum range of the crane, with the increase of the distance of the tilt the largest and most distant of the goods in the radius, plus the longest dimension of the goods. Increasing the distance due to cable tilt, and the distances from falling air depend on the height of the hang, the height of the load, the speed of rotation, the start-up time or the damping mechanism, and the wind load acting on the cargo. The calculations here may apply to rotary crane types but it should be aware of their working characteristics. The article also outlines two types of accident prevention structures commonly used around the working area of the crane. Determining the correct safe distance and taking good precautions will help prevent dangerous accidents. The paper has important economic and technical significance, and contributes to the improvement of safety knowledge using lifting equipment.

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