COMPLEX
CONTROL
SYSTEMS
ISSN 2603-4697 **Proceedings of the International Scientific Conference "Robotics and Mechatronics 2024"**

Electrical Hoist Load Lift Up System

Lubomir Lahtchev

Institute of robotics, Bulgarian Academy of Sciences, Sofia, Bulgaria

Abstract. The activities for rising of multi-floor buildings are usually attended to jibe-cranes, lifts, and spread plane constructions. These means are expensive and with economy important expenses for low floor buildings. On the other hand, the handmade raising of loads is risking and tiring. The building of electric hoist load lift up system is a task, which is not solved till now, because of absence of suitable ladders and bearing constructive elements. The fixture pole can be base for simple and cheap electric hoist load lift up system, which serves for promising and fast load lifting up at rising of low floor buildings. The paper contains the method of robust verification and exploration of an example electrical hoist load lift up system.

I. INTRODUCTION

The lift up, carry and drop down the large, heavy building materials are among the base operations in the building edifice and special attention is given to that activity. The jibe-cranes, lifts, and spread plane constructions are traditionally heavy and large constructions with low air resistance high power, and energy important force, providing access to any point inside their range. Correspondingly, their costs are comparatively high and they are rarely applied in the building of low floor family houses. A small building crane is shown in fig. 1 and it is a construction of limited access [1] with special positioning.

The building lift [1] is a stationary lift up driver which carry load in height only and requires floor frames.

Fig. 1. Small low floor building crane

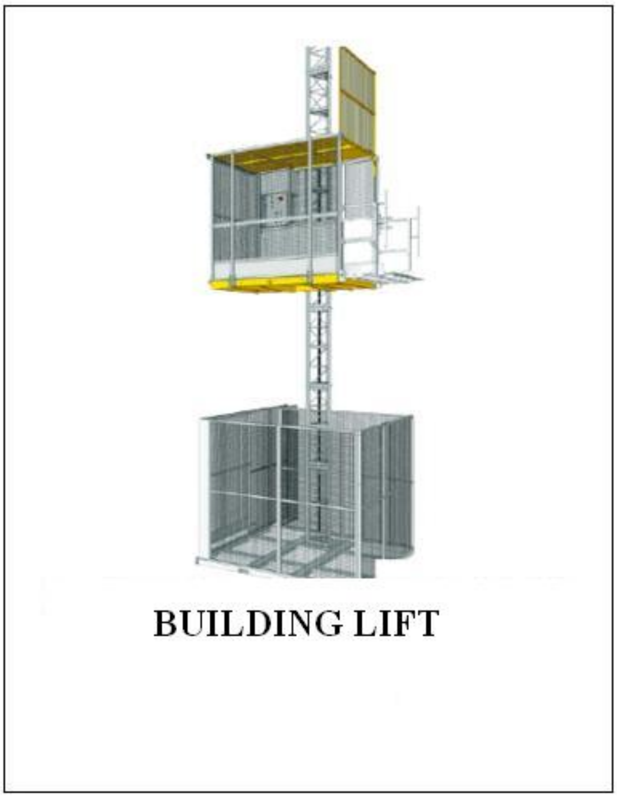

Fig. 2. Building lift

The assemblies of those equipments are a complex task executed with special means. The market does not suggest acceptable load lift up systems, because of their complex and responsible specifics and important weight. The aluminum constructions of similar kind could not meet the important force requirements and they are not projected. Consequently, the task for development of acceptable load lift up engine of low floor houses remains opened for solution.

Despite of arisen prices of building fixture poles in some shops, they remain acceptable alternative for low floor buildings, especially when they are purchased in building warehouse with lower prices. In these cases, the force verification of the system construction is a preliminary condition for its application.

The technical books give detail descriptions of the force verification with equations of resistance and load torques. The comparison of the higher resistance torque to the lower load torque gives positive answer to the requirement of force wearing. The distributed force load on the construction is on across bend and on length bend. The small air resistance is a worth, which cannot be neglected. The task consists of providing normal access to the range of the load lift up system, non conflict lift up of the load drop down before end top position of the electrical hoist, and exit of load from the upper range.

Usually, such a construction is built near to the house wall. Thus, its connection to the house wall in a random number of points provides high resistance – a warranty for high security. The connection of removed from the wall vertical poles becomes with horizontal supports and steel ropes.

Additional vertical fixture poles can be arose by hand with help of tin ring, in which they creep from down to up, when the palm gives freedom of the pole at time of movement. At the moment of final contact between lower and upper poles the other hand tighten up the screw of the ring or make welding point.

The skill of weld is individual and especially responsible. The weld ranges have to be saturated with welding metal. The important lengths of fixture poles require horizontal support by short fixture pole rectangular rings and they can be vertically easily corrected. Right montage means right vertical of fixture poles and less tiredness for the worker. The different loads have different sizes, which influence to the system construction. This is connected to their sizes and their force bear.

The exit of materials imposes use of movable bridge plane between the wall of the house and the load lift up system. The size of the load defines important free range in the middle of the load lift up system and absence of closed rectangular or ropes along with the vertical construction inside middle zone.

II. METHOD OF FORCE BEARS VERIFICATION

The scheme of load lift up system is given in fig. 3 and represents four pole vertical construction with minimally two closed steel rectangular rings (top and bottom), stable girders in the middle and connections to the wall, where it is possible. Additional connections with steel ropes of the removed vertical poles can only improve its force bear. The method of force bears verification computes the resistance and load torques of across bend of horizontal beams, and resistance of vertical force at given distance between the top and the point of support the construction, applied to the vertical poles. The distances are defined by arose loads.

The scheme images the wall with thick lines. The construction is connected with it in two points as minimum through vertical bear fixture poles 1, 2, 3, and 4, as the removed are poles 2 and 3. The top beam with a special square cross profile bears the electrical

ISSN 2603-4697 **Proceedings of the International Scientific Conference "Robotics and Mechatronics 2024"**

hoist and lies on two bear beams, which are double poles. The other part of construction has single poles.

The movable bridge plane is on distance **m** from the hoist hook. The hook hangs on distance **n** from the top beam and this distance is different for each electrical hoist. The fixture poles are fixed in points shown by triangles of fixing.

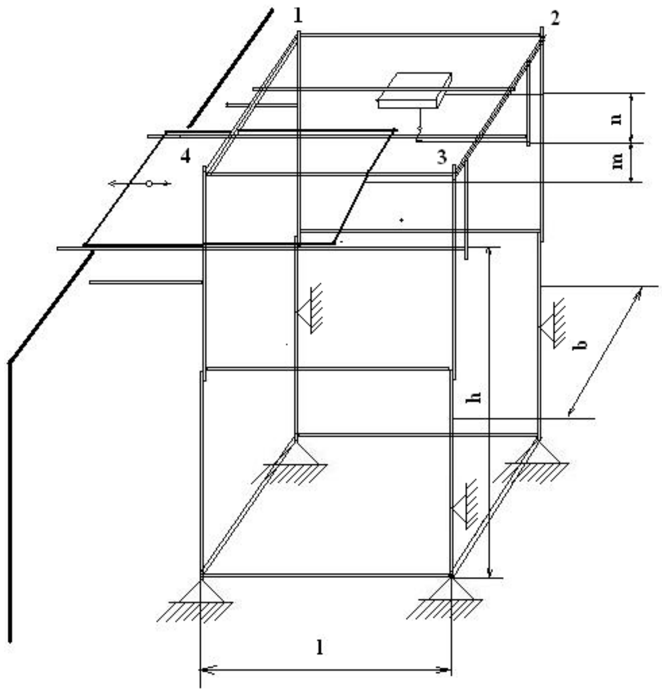

Fig. 3. Scheme of electrical hoist load lift up system

The point of across bend is crossing between the rope of hook and the middle of top beam. The poles, which are forced of length bend, are the four bearing points of the load lift up system. The connections with the base are immovable and fixing the vertical poles – bearings. The closed steel rings at the bottom and the top of the construction make it single and with one centre of the weight.

The verification of force bearing at across bend is based on the equations for tensions on stretch of the low beam layer and bend pressing of the up beam layer, as follows [2]:

$$\sigma_1 = (M_{max} / J) * e_1 < \sigma_{as} \quad (1)$$

$$\sigma_2 = (M_{max} / J) * e_2 < \sigma_{ap} \quad (2)$$

In these equations the torque M_{max} is in kg.cm, the tensions are in kg/cm^2, the inertia moment J is in cm^4, and distances e_1 и e_2 are in cm, as the symbols before and after the signs for equality and inequality are the tensions on bend force and on length bend force of bearing.

In these equations the relations $W_1 = J/e_1$ and $W_2 = J/e_2$ are extracted as resistance moments on stretch and pressing after substitution in eq. 1 and eq. 2, which define the equations of force bearing at stretch and pressing at bend of beam:

$$(M_{max} / W_1) \leq \sigma_{as} \quad (3)$$

$$(M_{max} / W_2) \leq \sigma_{ap} \quad (4)$$

It is accepted that permissible tensions on stretch and pressing are equal, from which the equation on force bearing at bend is:

$$(M_{max} / W_2) \leq \sigma_{ab} \quad (5)$$

In this equation the σ_{ab} is permissible tension at length force bend. Usually, the electrical hoists are with bearing square cramps for hollow square beams to them. The inertia moment of such a beam is defined by the next equation:

$$J_g = (B*H^3 - b*h^3) / 12 \quad (6)$$

In this equation B – outside width of rectangular across profile of the beam, H - outside height of rectangular across profile of the beam, b - inside width of rectangular across profile of the beam, h - inside height of rectangular across profile of the beam.

Similar is the equation for the resistance moment of the profile of beam in cm^3:

$$W_g = (B*H^3 - b*h^3) / 6*H \quad (7)$$

On the other hand, the moment over the beam, which lies over two bearing points in the common case is defined from the vertical force and the distance between bearing points, as follows:

$$M_{max} = F * (l/4) \quad (8)$$

and the bearing reactions are equal to the half of the applied force F.

If the distances are different, the moments are computed for each shoulder and the larger is taken. The reactions in the bearing points are proportional to the force and the relation of the distance from the point of force application to common distance of the beam.

In parallel, the permissible load F in kg is defined from the resistance moment and the length of the beam with account of the permissible tension of bend.

$$F = 4 * \sigma_{ab} * W / l \quad (9)$$

Correspondingly, the resistance moment in cm^3 is:

$$W = F * l / (4 * \sigma_{ab}) \quad (10)$$

The comparison of resistance moment, which is computed by eq. 7, and resistance moment of the load, which is computed by eq. 10 and it is a load moment, gives the solution of the verification of the resistance force on bend. The higher resistance moment of the profile is the obligatory condition for resistance of across force bend of the beam.

The force of permissible load, operating on vertical bearing fixture poles is on length bend, when the poles are fixed in the fundament, and it is defined as follows:

$$F = \pi^2 * E * J_{min} / (4 * \nu * l^2) \quad (11)$$

In this equation E is a module of elasticity kg/cm^2 and J_{min} - the lowest inertia moment of the across profile in cm^4, l – length of the pole in cm, ν – coefficient of the security, which is minimally 5. Usually, the constructor computes the load moments and looks for across profiles of the bearing beams, which would provide higher resistance moments.

It is important to know the length **l** of a part of the bearing pole, which will bear it rigid vertically after the load is applied. In the current case, the bearing poles are four numbers and they are mutually supporting. The additional resistance force is the massive weld zone in the points of connection of the fixture poles. Each pole is differently loaded, as the vulnerable are the removed vertical poles from the wall. But we have a force equally distributed on all four fixture poles and it is computed individually, as the length till the point of the load is manipulated. If each pole is secured enough, then the whole system construction has proved bearing capability. The case of important distances from the point of load application till the point of the bearing has a more complex character. The put intermediate connections at the system construction are of prime interest for the bearing force. Here are the connections with steel ropes between top and the bottom of removed fixing poles, and connections to the wall. These are well observed in the constructions of system antenna of operators of wireless communication.

III. EXPLORATION OF ELECTRICAL HOIST LOAD LIFT UP SYSTEM

The construction of electrical hoist load lift up system is not character for the building practice. It can be attacked and seems to be comparatively unstable from the constructive point of view. The load distribution among the bearing fixture poles is the main argument with its use. The axis of the centre of the weight of the load coincides with the axis of the centre of the weight of electrical hoist system. Other redundant deviations absent and the single care is the load orientation toward bearing poles, horizontal supporting beams and receiving bridge at time of arising.

The risk of worker with such a system is minimal because he/she never goes inside danger zone under the electrical hoist, but draw up the load from the outside, when is stepping in the beginning point of the bridge.

The main additional task is the impact with steel pole over the load, when it arises in a way, its conflict with the pole construction in the middle of the system and with the bridge will be avoided.

Let accept the load represents single wheel wheelbarrow for building purposes. It has length 140 cm, height – 65 cm, width – 55 cm. The start orientation of the wheelbarrow is with the wheel ahead to removed fixture poles. The close vertical poles influence to it in a way it is always in such a position or close to it. The conflict is possible with the horizontal supporting beams in the middle of the construction. When such a conflict is obvious, the worker stops the wheelbarrow, orients it in parallel to the horizontal pole, and brings it up with the electrical hoist. Now the wheelbarrow achieves the bridge, which is constructed in way to have conflict with the handles. The worker stops the load, press on it pushing ahead and moves it up, when the handles are outside the bridge. Now the worker slides the bridge ahead. The bridge remains outside the wheel of wheelbarrow. Because of that circumstance he/she pulls his/her self the wheelbarrow for handles giving the electrical hoist down and the load steps on the bridge. The wheelbarrow is removed from the hook and it is ready for transportation on the upper floor.

The task of arise is solved. With account the sizes of the wheelbarrow the sizes of the load lift up system are width – 135 cm, length – 165 cm, height to the bridge – 160 cm. They provide enough freedom for the wheelbarrow for arising and movement.

The arising of building nets (2m x 4m) and building planes (1.2m x 2.4m) are also possible. They are with less weight and easier extracted.

The system works thanks to the large window, in which the wheelbarrow is accepted. The vertical size is around 110 cm and only 45 cm is the empty zone around the load. That looks to be good distance, but 17 cm under and over the wheelbarrow is not comfortable for pull out it, especially when it can be inclined at lifting up.

The hanging up of the wheelbarrow to the hook of electrical hoist becomes with the help of steel ropes, which envelop it from the bottom, pass in parallel inside to the wearing pipes of the basin and they arise over it on 10 cm. Now we have only 35 cm free zone around the wheelbarrow or 17 cm under and 18 cm over it. The steel ropes are fixed to the wheelbarrow and it becomes more controllable. They are so much long that after hanging down from the hook they go outside the basin and do not affect the concrete flow. The steel ropes are used also for orientation of wheelbarrow at time of lifting up.

It is accepted that the weight of wheelbarrow achieves 80 kg together with the concrete load. The worker is of 100 kg weight. The beam of electrical hoist and its weight are 40 kg. The other bearing elements weigh 52 kg. The weight of vertical fixing poles is neglected because they provide the bearing of whole construction. Thus, we have 272 kg over the bearing fixing poles and a part of the bridge, which is 20 kg weight.

The verification of electrical hoist lift up system on across bend force consists of computation of the resistance moment of the cross square profile. Its size is 5 cm and thickness 0.4 cm. They are included in eq. 7. The beam is fixed on one end, but this circumstance is not accounted in eq. 7.

$$W_{g1} = (5^4 – 4.2^4)/ (6*5) = 10.46 \text{ cm}^3$$

The impact of force of the weight from the wheelbarrow and the electrical hoist block together with the beam is accepted 120 kg. This means reactions in the bearing points of beam, which is long

135 cm, to be 60 kg each one. The moment of bend from this force, in accordance to the eq. 10, at permissible moment of bend 900 kg/cm^2 is:

$$W = (120 * 165) / (4 * 900) = 5.5 \text{ cm}^3$$

From these computations is seen that resistance moment of the square profile exceeds the load moment of bend and the verification on bear force of across bend is satisfied.

It is required the verification of bearing poles, which are doubled fixture poles with diameter of 1.8 cm and they are fixed in points of connection.

$$W_{g2} = 2 * \pi * d^3 / 32 \quad (12)$$

$$W_{g2} = 2 * 3.14 * 1.8^3 / 32 = 1.145 \text{ cm}^3$$

The load moment from reactions in the bearing points of the bearing fixed beams is defined as follows:

$$W_R = F * l / (12 * \sigma_{ab}) \quad (13)$$

After substitution of the data the result is computed:

$$W_R = (60 * 135) / (12 * 900) = 0.75 \text{cm}^3$$

The double fixture poles, which are fixed in points of bearing, provide resistance moment exceeding the load moment from reactions in points of bearing and the verification of the force of across bend is satisfying.

It follows to be noted that the increasing the weight of the useful load around 100 kg is not wished because then it can exceed the resistance moment of the fixed bearing poles. The limit value for weight of the load is 80 kg. It is not achieved because the concrete liquid will overflow at time of lifting up. The normal weight of the load is 60 – 65 kg.

The verification of electrical hoist load lift up system on force of length bend is connected to the distance between it and the nearest bearing point for fixing of the pole. These beams bear the useful load, the worker, and the other bearing elements. Thus, the common weight achieves 272 kg or 68 kg on each vertical fixture pole. From eq. 11 the equation for distance is extracted, as follows:

$$l = SQRT(\pi^2 * E * J_{min} / (4 * \nu * F)) \quad (14)$$

The module of linear deformations E for welding steel is accepted $E = 1.6 * 10^6$ kg/cm^2. After substitution of data at coefficient of security 5 the minimal distance between the bearing point of the load at the top of the electrical hoist and the bearing point at the pole is not larger than 388 cm. This distance is satisfying for the near to the wall vertical poles, where it is around 220 cm toward the wall and 380 cm toward the lateral side bearing point. For the removed fixture poles 2 and 3 on fig. 3 these distances are larger and they curve at lifting up of the load. The fixture of the removed vertical poles at the base and partially in the lateral bearing points is a good prerequisite for their bearing capability at lifting up the load of 60 – 65 kg.

In conclusion the issues for verification of bearing force on across bend and on length bend are satisfying. The real functioning of such system proves the capability for possible its application in the building practice of low floor family houses.

REFERENCE

1. Internet site: www.haspel.bg , visited 26.09.2024.
2. M. Klisarov, G. Klisarov Handbook of the electrician. Sofia, Publ. House "Technics", 1969, 1046 p. (In Bulgarian)