UDK 621.876.113
DOI https://doi.org/10.15673/

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DEVELOPMENT OF THE SCHEME OF THE RIGGING AND ASSEMBLY INSTALLATION

Abstrakt

In the conditions of reconstruction or technical re-equipment of grain storage and processing enterprises, there are cases of absence or impossibility of using the necessary universal lifting and transport means, in particular, construction tower or self-propelled jib cranes at the installation sites. In such situations, they resort to the construction of specialized rigging and installation installations, which are based on the use of rigging and installation mechanisms, rigging devices and rigging equipment. The given sequence of actions, definitions and calculations at the same time practically excludes the adoption of unfounded and erroneous decisions. Most often, such installations are located near the facade walls of buildings, equipped with installation slots and loading and receiving platforms, hoists and cargo winches. Choose the design, location and means of fastening the mounting beam or boom. The load capacity of the winch, from among those in the distribution, is specified and accepted. Determine the required multiplicity of the hoist, its efficiency, the amount of tensile and breaking forces in the load rope. Choose the type and diameter of the rope, as well as its length. Determine the rope capacity of the cargo winch drum and specify its technical characteristics. Choose the location and method of securing the winch. If necessary, calculate the mass of the ballast counterweight. Choose the location and method of attachment of the diverter block, determine the amount of force exerted by this block on the building structure or anchor. Choose the type of anchor and, if necessary, calculate its stability. If it is necessary to pull the load from the front wall of the building or structure, calculate the pulling force and choose the necessary winch or hoist for this. The effort to pull the cargo from the receiving platform into the premises and the technical means required for this are determined.

Keywords: installation; rigging; arrow; polyspast; load rope; winch.

Introduction

In the conditions of reconstruction or technical re-equipment of enterprises of the industry, there are cases of absence at the installation sites of universal lifting vehicles, in particular, construction tower cranes with a load capacity of 1.5 ... 50 t and a hook lifting height of up to 45 m.

The limited size of the installation site at such facilities sometimes also makes it impossible to use self-propelled jib cranes - automobile, crawler or pneumatic wheel cranes [1].

In similar situations, they resort to the construction of specialized rigging and installation installations, which are based on the use of rigging and installation mechanisms, rigging devices and rigging equipment [2,3].

Research results and their discussion

A generalized diagram of such an installation is shown in Fig. 1. The sequence of scheme development should be as follows.

1. Determine the maximum height H_{MAX}, m to which, according to the project or technical task, lifting of equipment and metal structures is provided.

2. Specify the cargo and dimensional characteristics of the equipment and metal structures that will be lifted by the installation under development: determine the load of maximum mass - M_{MAX}, kg and weight - Q_{MAX} (it is obvious that $Q_{MAX} = g\ M_{MAX}$, H), as well as maximum dimensions - length, width and height; taking into account the maximum width and height of the goods that must be delivered to each floor, determine the dimensions of the mounting slots necessary for this in the structural elements of buildings and structures, and the length is taken into account during the development of load slinging schemes and the selection of the necessary load-holding devices (slings, grabs or traverses).

3. Depending on this, as well as taking into account the features of the location and design of the neighboring buildings and structures closest to the installation object, choose the design, location and means of fixing the mounting beam or mounting boom (Fig. 2).

If necessary, perform a calculated check of the strength of the selected elements under the expected operating conditions.

The strength condition of a two-support beam (Fig. 2, a) or a fixed cantilever beam (Fig. 2, b) is written as follows

$$\sigma_3 \leq [\sigma_3], \qquad (1)$$

where σ_3 and [σ_3] are valid and permissible bending stress in the beam or beam material, Pa.

In turn, the actual bending stress is equal to

$$\sigma_3 = \frac{M_3}{W}, \quad \text{Pa} \qquad (2)$$

where M_3 is the bending moment acting on the beam or beam, N m; W is the moment of resistance of the cross section of the beam or beam, m^3.

The bending moment acting on the two-support beam is equal to

$$M_{3Б} = \frac{1}{4}\,(Q_{MAX}\,L_Б) + \frac{1}{8}\,(q_1\ L_Б^2),\ N\cdot m \qquad (3)$$

where $L_Б$ is the distance between supports (length of the beam), m;

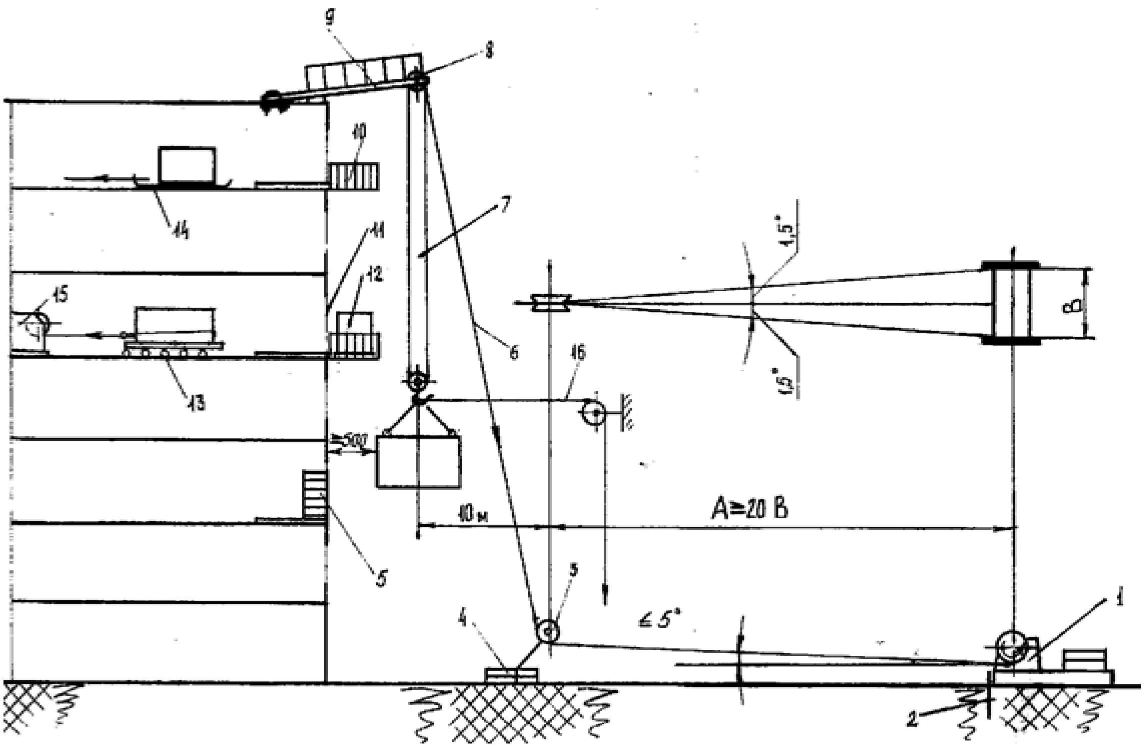

Fig. 1 – Scheme of the rigging installation: 1 – cargo winch; 2 – fuel-type anchor; 3 – outlet block; 4 – ground (ballast) type anchor; 5 – cargo receiving platform in a raised (non-working) state; 6 – descending branch of cargo rope; 7 – freight hoist; 8 – fixed block; 9 – cantilever boom; 10 – loading platform in lowered (working) condition; 11 – mounting slot; 12 – wattage at the cargo receiving platform; 13 – skating rinks; 14 – steel sheet; 15 – manual winch; 16 - brace.

For example, formulas (1), (2) and (4) are given for cantilever beams, which, after transformations, provide the determination of the required cross-section height

I-beams h_d

$$h_d \geq \sqrt[3]{\frac{51 Q_{MAX} L_C}{[\sigma_з]}} -0{,}02,\ m \qquad (5)$$

or $h_Ш$ channels: as single $h_{ш(од)}$

$$h_{ш(од)} \geq \sqrt[3]{\frac{81 Q_{MAX} L_C}{[\sigma_3]}} - 0.05\ ,\ m \qquad (6)$$

and double $h_{ш(здв)}$

q_1 is the force of the weight of one meter of the beam, N/m (it is obvious that q_1 = 9.81 m_1, where m_1 is the mass of one meter of the beam, kg).

The bending moment acting at the end of the cantilever boom is equal to

$$M_{3C} = Q_{MAX}\, L_C\ ,\ \ N \cdot m \qquad (4)$$

where L_C is the departure of the arrow, m

The moment of resistance - W - depends on the shape and dimensions of the cross-section of the beam or beam and is subject to calculation by conventional methods. Since I-beams and channels (single or double) are often used for the manufacture of beams and beams, below are empirical formulas for calculating the approximate values of moments of resistance of these sections

$$W_d \approx \frac{1}{51}(h + 0{,}02)^3\ m^3 \text{ and } W_ш \approx \frac{1}{81}(h + 0{,}05)^3,\ m^3$$

where h is the height of the corresponding section, m.

It is obvious that the design determination of h dimensions is also possible if the permissible stress - [σ₃] - in the material of the beams or beams is taken as known.

$$h_{Ш(ЗДВ)} \geq \sqrt[3]{\frac{81 Q_{MAX} L_C}{2[\sigma_3]}} - 0.05\ ,\ m \qquad (7)$$

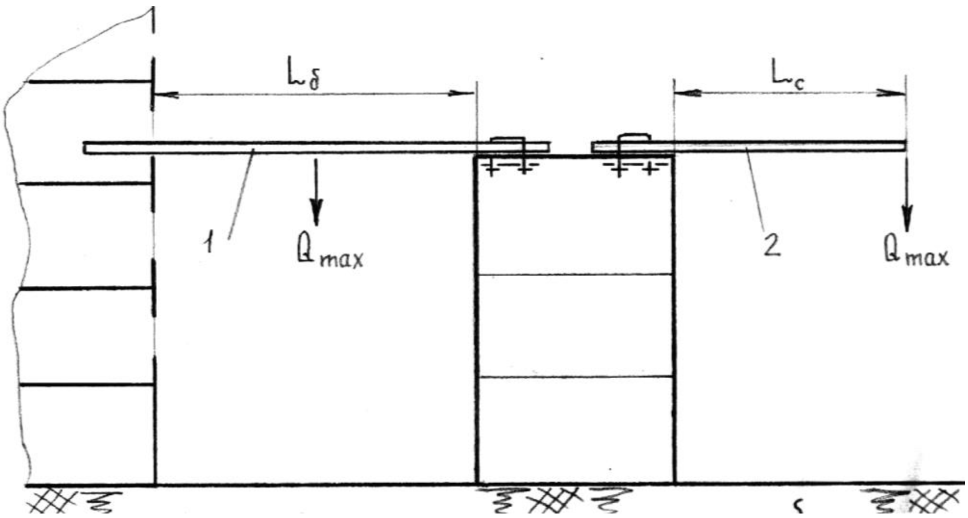

Fig. 2 – Layout of the mounting beam (a) and cantilever fixed boom (b): 1 – two-support beam; 2 – cantilever fixed boom.

4. Specify the load capacity of winches – P_W, which are available (in the conditions of real construction) or provided for in the technical task, and accept P_W, N.

5. If $Q_{MAX} > P_W$, then the required polyspast multiplicity is roughly determined by the expression

$$n = \frac{Q_{MAX}}{P_{ТП}}, \quad (8)$$

where $P_{ТП}$ is the pre-accepted effort in the descending branch of the cargo rope, H (take $P_{ТП} \le P_W$). The found value of n should be rounded to the nearest whole number, which should not go beyond the interval 2 ... 10.

After that, the efficiency coefficient of polyspast is determined, which is equal to

$$\eta = \frac{1}{nk^n}\frac{k^n - 1}{k - 1}, \quad (9)$$

where k is the resistance coefficient of the roller bearing support (for a block with rolling bearings k = 1.03, and with sliding bearings k=1.04).

The specified value of the traction force - P_T - is determined after the appropriate transformations of the expression (8)

$$P_T = \frac{Q_{max}}{n \cdot \eta \cdot \eta_{вб}^m}, N \quad (10)$$

where η and $\eta_{вб}^m$ are the efficiency coefficients of the cargo hoist and diverter unit (at k = 1.03 η or $\eta_{вб}^m$ = 0.97, and at k=1.04 η or $\eta_{вб}^m$ = 0.96);

m is the number of lead-off blocks (under the conditions provided in Fig.1, m = 1).

6. According to the values of the found traction force - P_T - and the safety factor - ε = 5 ... 6, determine the breaking force of the cargo rope

$$P_K \ge P_T \varepsilon, \ N. \quad (11)$$

7. After that, the type and diameter - d - of the steel wire rope with the calculated breaking force is selected from the standard

$$P_{Кр} \ge P_К . \quad (12)$$

8. Determine the diameter of the rollers of polyspast blocks - D, focusing on the ratio

$$\frac{Д}{d} \ge (e - 1), \quad (13)$$

where $Д$ is the block roller diameter, measured along the bottom of the groove, mm;

d – rope diameter, mm;

e is a coefficient, the value of which depends on the type of lifting machine and its mode of operation (for cargo winches with machine drive and mode of operation: light - e = 20, medium - e = 25 and heavy - e = 30).

Note: The easy mode is characterized by the operation of the rope at low speeds, without jerks, with the number of bends on the rollers no more than four; heavy - by the work of the rope at high speeds with jerks and the number of bends on the rollers is more than four [4].

9. Determine the length of the cargo rope - L - for equipping the rigging installation (together with the hoist)

$$L = n\,(H + 0{,}5\,\pi Д) + \ell + m_Б \pi Д_Б, \ m \quad (14)$$

where H is the distance from the axis of the upper, stationary block of the hoist to the axis of the lower, mobile one, when it is in the lowest position, that is, it touches the ground, m;

ℓ - the length of the descending branch of the cargo rope from the upper block of the hoist to the cargo winch, m, which is taken on the basis of the dimensions indicated on the diagram of the installation being developed;

$m_Б$ - the minimum allowable number of turns of the rope, which remains on the rope receiving drum with a diameter of $Д_Б$, when the movable block of the hoist touches the ground ($m_Б \ge 1.5$).

It is clear that $H = H_{MAX} + H_П$,

where $H_П$ is the length of the polyspast in the tightened state, which depends on its carrying capacity (for example, with a carrying capacity of 10 t $H_П$ = 2.6 m, with a carrying capacity of 25 t $H_П$ = 3.7 m). The carrying capacity of the polyspast is $10^{-3} \cdot \frac{Q_{max}}{g}$, tons.

10. Determine the rope capacity of the drum of the cargo winch - L_K, which is equal to the length of the rope that must be wound on the drum during the lifting of the moving block to a height of H_{MAX}, i.e.

$$L_K = n\,H_{MAX}, \ m. \quad (15)$$

Taking into account the found value of L_K, specify the technical characteristics of the selected winch, in particular, the length of the drum - B, m (Fig. 1).

11. Determine the effort on the part of the diverter block - SBB - on the building structure or anchor by the expression

$$S_{ВБ} = 2P_T \cos\frac{\psi}{2}, \ N \quad (16)$$

where ψ is the angle between the directions of the sections of the descending branch of the cargo rope before and after it wraps around the lead-off block, degrees.

The location of the lead-off block is shown in fig. 1. The distance of the axis of the block from the front wall of the building is taken as close10 m.

12. Taking into account the value of $S_{ВБ}$, solve the issue of the means of fixing the lead-off block, choose the type of anchor and, if necessary, calculate its parameters according to the known method. At the same time, they are guided by the data in Table 1.

13. Choose the location of the cargo winch. The distance between the axes of the take-off block and the

Table 1 – Stability of anchors buried in the ground [1]

Constructive implementation of the anchor		Resistance, or the maximum force perceived by the anchor, kN
In the form of one wooden pile		to 20
In the form of two successively located wooden piles, connected to each other		up to 50
-“- -“- three -“- -“-		up to 100
Inventory anchor rod type		up to 120
Pit anchors type	Horizontal	up to 150
	Fuel-shield	up to 220

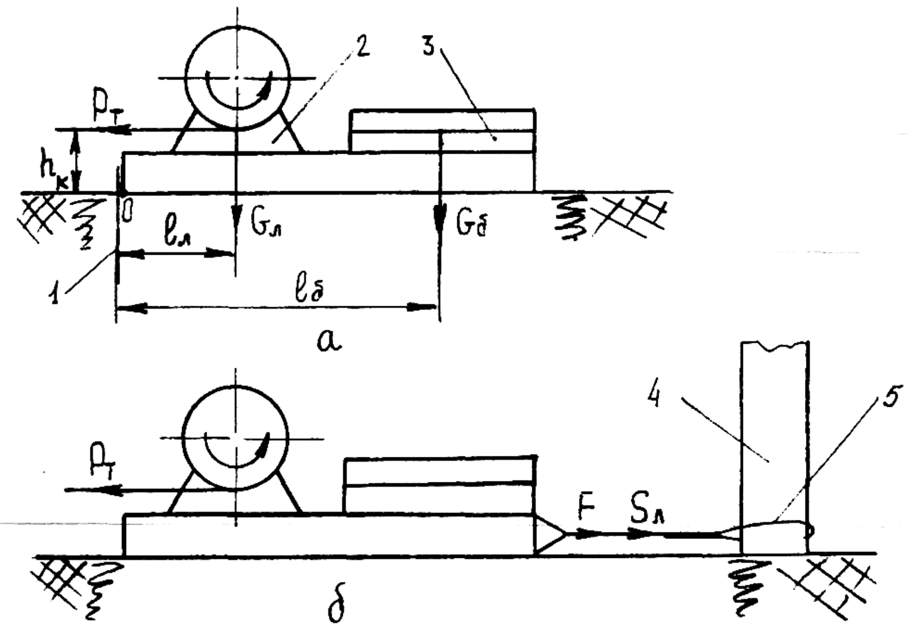

Fig. 3 – Schemes of securing the winch: 1 – emphasis; 2 – winch; 3 – ballast; 4 – column; 5 - strut.

rope receiving drum of the cargo winch - A - is determined by the expression

$$A \geq 20\,B\,,\ m. \tag{17}$$

The longitudinal axis of the drum should be perpendicular to the direction of the rope, which crosses the drum in the middle of its length (see Fig. 1).

14. Choose the method of fastening the winch and perform the necessary calculations. If the fastening corresponds to fig. 3, and, then the shift of the winch 2 is prevented by the stop 1, and the overturning is prevented by the ballast 3. The mass of the ballast - $M_Б$ - is found by the expression

$$M_Б = \kappa_C \frac{P_T h_K - G_Л \ell_Л}{g \ell_Б}\ кг, \tag{18}$$

where P_T is the traction force calculated according to (10);

h_K - the distance between the supporting surface of the winch frame and the axis of the load rope, m;

$G_Л$ - winch weight force, H;

$\ell_Л$ - shoulder on which the weight of the winch acts, m;

$\ell_Б$ - the shoulder on which the weight of the ballast acts, m;

g - acceleration of gravity, m/s2;

k_C - coefficient of stability (take $\kappa_C = 2$).

In the case when it is impossible to drive the abutment into the ground, the winch is tied to the nearest building according to the scheme of fig. 3, b. The effort acting on this structure from the side of the winch - $S_Л$ is calculated as follows:

$$S_Л = \kappa_C (P_T - F),\quad N \tag{19}$$

where F is the force of friction between the winch frame and the surface of the mounting platform, N.

The force of friction is equal to

$$F = f\,(G_Л + G_Б)\quad N\,, \tag{20}$$

where f is the coefficient of friction of the winch frame sliding on the support surface, the value of which depends on the frictional properties of the contacting surfaces (steel on steel f = 0.15; steel on dry soil or concrete f = 0.45; dry wood on concrete f = 0.50; steel on wood f = 0.60).

15. If it is necessary to pull the load from the front wall of the building or structure, the pulling force is determined as follows.

If the brace is directed horizontally, apply the formula

$$S_B = Q_{MAX}\, tg\, \alpha,\ N \tag{21}$$

where S_B is the pulling force, N;

Q_{MAX} – weight force of the load, N;

α is the angle by which the longitudinal axis of the hoist deviates from the vertical due to the pulling of the load, degrees.

- If the brace is directed upwards from the horizontal plane, then

$$S_B = Q_{MAX} \frac{\sin\alpha}{\sin(\alpha+\beta)},\ N \tag{22}$$

where β is the angle between the vertical and the direction of the tension, degrees.

If the guy is deflected from the horizontal plane down and creates an angle β relative to the vertical, there is a danger of overloading the hoist.

The effort on the pulley P in a similar situation is equal

$$P = Q_{MAX} \frac{\sin\beta}{\sin(\alpha+\beta)}.\quad N \tag{23}$$

16. Determine the effort of pulling the cargo from the cargo receiving platform into the premises - S_{BT} - under the condition

$$S_{BT} \geq F, \tag{24}$$

where F is the force of friction (sliding - F_{KOB}, or rolling - $F_{KOЧ}$, depending on the conditions of retraction).

If retraction takes place by pulling on a wooden pallet or on a supporting steel sheet in the direction against the inclination of the supporting surface (at an angle α_B , degrees to the horizon), then the retraction condition has the form

$$S_{BT} \geq F_{KOB} + Q_{MAX} \sin\alpha_B \tag{25}$$

and the retraction force is equal to

$$S_{BT} \geq Q_{MAX}\,(f \cos\alpha_B + \sin\alpha_B),\ N \tag{26}$$

where f is the coefficient of friction of the load sliding on the support surface (see the explanation of expression (20)).

If $\alpha B < \alpha_B < 15^0$, it is accepted

$$S_{BT} \geq Q_{MAX}\,(f + \sin\alpha_B),\ N. \tag{27}$$

The pull-in effort can be significantly reduced by using backing rollers.

If $\alpha_B < 15^0$, then the retraction force is equal to

$$S_{BT} \geq Q_{MAX}\,(\sin\alpha_B + \frac{f_K' + f_K''}{d_K} \cos\alpha_B),\ N \tag{28}$$

where f_K' and f_K'' are the coefficient of rolling friction between the support surface and the rollers, as well as between the rollers and the retracted load;

d_K - roller diameter, m.

If $\alpha_B < 15^0$, then $\cos \alpha_B \approx 1$. Then the retraction force is

$$S_{BT} \geq Q_{MAX} (\sin \alpha_B + \frac{f_K' + f_K''}{d_K}), \ N \qquad (29)$$

In the case of retraction along the horizontal plane, that is, when $\alpha_B = 0$,

$$S_{BT} \geq Q_{MAX} \frac{f_K' + f_K''}{d_K}, \ N \qquad (30)$$

It should be noted that the coefficient of rolling friction has the dimension of length and, in particular, is equal to

steel by steel - $0.05 \cdot 10^{-2}$ m;

steel on wood - $(0.04 ... 0.07) \cdot 10^{-2}$ m;

steel on concrete - $0.06 \cdot 10^{-2}$m;

wood by wood - $(0.05 ... 0.08) \cdot 10^{-2}$m;

steel on soil - $0.22 \cdot 10^{-2}$m.

Finally, according to the project, the nomenclature of technical means for pulling cargo into the premises, their locations and fastening methods are determined.

Conclusions

The need for the construction of rigging and assembly installations, which accommodate rigging and assembly mechanisms, rigging devices and equipment, often arises at the objects of reconstruction or technical rearmament of enterprises of the industry. For the most part, this work is based on the practical experience of foremen of assembly organizations or rigging foremen. The desire to avoid cases of destruction of structural elements under load leads to the establishment of excessive safety margins, which causes unreasonable consumption of materials in their manufacture and creates unnecessary difficulties in application.

The technology of construction of rigging and assembly installations proposed in the article involves the preliminary development of their schemes, during which, in an appropriate sequence, their normatively justified components are calculated or selected, which excludes the adoption of voluntary decisions when creating such responsible structures.

REFERENCES

1. Marshev V. Z. Installation of technological equipment. Builder's directory. - M.: Stroyizdat, 1983.
2. SNiP 3.05.05-84. Technological equipment and technological pipelines. - M.: 1985.
3. Vainberg A.A., Grosul L.I. Fundamentals of repair and installation of equipment for grain storage and processing enterprises. M.: Kolos, 1992.
4. Tarasov V.P. Technological equipment of grain processing enterprises. – Barnaul: Izd-vo Alt GTU, 2010.

УДК 621.876.113

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РОЗРОБКА СХЕМИ ТАКЕЛАЖНО-МОНТАЖНОЇ УСТАНОВКИ

Анотація

В умовах реконструкції або технічного переозброєння підприємств по зберіганню і переробці зерна бувають випадки відсутності або неможливості застосування на об'єктах монтажу необхідних універсальних підйомно-транспортних засобів, зокрема, будівельних баштових або самохідних стрілових кранів. У подібних ситуаціях вдаються до спорудження спеціалізованих такелажно-монтажних установок, які базуються на застосуванні такелажно-монтажних механізмів, такелажних пристроїв і такелажної оснастки. Наведена послідовність дій, визначень і розрахунків при цьому практично виключає прийняття необґрунтованих і помилкових рішень. Найчастіше такі установки розташовують біля фасадних стін будівель, облаштованих монтажними прорізами і вантажно-прийомними площадками, поліспастами і вантажними лебідками. Обирають конструкцію, місце розташування і засоби кріплення монтажної балки або стріли. Уточнюють і приймають вантажопідйомність лебідки, з числа тих, що є у розпрядженні. Визначають потрібну кратність поліспаста, його коефіцієнт корисної дії, величину тягового і розривного зусиль у вантажному канаті. Обирають тип і діаметр каната, а також його довжину. Визначають канатоємність барабана вантажної лебідки і уточнюють її технічні характеристики. Обирають місце розташування і метод закріплення лебідки. У разі необхідності, розраховують величину маси баластного контрвантажу. Обирають місце розташування і спосіб кріплення відвідного блока, визначають величину зусилля з боку цього блока на будівельну конструкцію або якір. Обирають тип якоря і у разі потреби розраховують його стійкість. У разі необхідності відтягування вантажу від фасадної стіни будівлі чи споруди, розраховують величину зусилля відтягування і обирають потрібну для цього лебідку або таль. Визначають зусилля втягування вантажу з приймальної площадки у приміщення і потрібні для цього технічні засоби.

Ключові слова: монтаж; такелаж; стріла; поліспаст; вантажний канат; лебідка.

Received 19.02.2022
Reviewed 05.03.2022
Revised 20.03.2022
Approved 04.10.2022

Cite as Vancouver Citation Style
Soldatenko L., Shipko A., Shipko I. Development of the scheme of the rigging and assembly installation. Grain Products and Mixed Fodder's, 2022; 22 (3, 87): 46-50. DOI https://doi.org/10.15673/

Cite as State Standard of Ukraine 8302:2015
Development of the scheme of the rigging and assembly installation. / Soldatenko L. et al. // Grain Products and Mixed Fodder's. 2022. Vol. 22, Issue 3 (87). P. 46-50. DOI https://doi.org/10.15673/