PREREQUISITES FOR THE CREATION OF LIFTING AND COLLECTING TECHNOLOGICAL MODULE FOR THE INSTALLATION OF STRUCTURAL BLOCKS OF THE COATING

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Abstract: The article considers the approach to the use of lifting and assembly technological module in installing structural blocks of the building. The urgency of this work is the need to develop methods and means of installation and dismantling of long-span buildings, due to the need to build premises (industrial hangars, concert venues, Covid-hospitals, etc.). Modern approaches to the installation of structural blocks of coatings are analyzed. Improvement of constructive decisions of basic units of a covering and directly their supports is offered. Given that the construction of buildings mainly depends on the level of mechanization on the construction site, the main attention is paid to the improvement of existing mechanized technological means. Based on the offered improvements in a design of a covering and its support use of the mechanized technological module for the realization of raising of the block of a covering to a design mark with the simultaneous growth of columns is offered. In the course of comparison of the offered technology of installation of a covering with the basic crane variant, the degree of consolidation of a covering and ways of robotization of the mechanized module are proved.

Keywords: Labor intensity, Lifting and assembling module, Structural block of a covering, Technological process metalwork.

1 Introduction

Formulation of the problem. Experience of installation work during the installation of large-scale coatings shows that their complexity in the total construction of these facilities is 30 – 40%, and in a short time and complex industrial engineering and geological conditions – can reach more than 50% [2]. Today, the improvement of methods of rapid installation of buildings with large coatings is quite relevant due to the need for rapid construction of such buildings, for example, for concert venues, storage hangars, Covid-hospitals, and more. In addition, there is a need to consider the possibility of the rapid dismantling of such a building in the absence of the needs of its operation.

Analysis of recent research. Issues of installation of building elements, large-scale assembly of coating blocks, selection of mechanized technological equipment are considered in detail in the works of Chernenko V. [1, 6], and Shvydenko V. [8], which describes several technological schemes for construction work, mainly based on the use of heavy crane equipment. Such schemes have become widely used in practice, however, in some cases, reduce the efficiency of construction operations, in particular, reduce the accuracy of positioning of building elements, artificially limit the parallel execution of operations, and so on.

2 Materials and Methods

In the work, the approach to the creation of functional technological modules, purpose, structure which form is formed according to necessary technological operations that influence the technological scheme of installation of designs and construction of the building as a whole is considered [7, 11]. The goal of the work is to determine the bases of formation of entrance conditions for the creation of the lifting and collecting technological module intended for the installation of structural blocks of a covering.

3 Results and Discussion

Building's structural blocks of a covering became widespread due to low weight of a design, unification of structure components, big values of steps of supports. However, the process of installation of such structures on the design marks is accompanied by several problems. Namely, the need for large-scale assembly of the structural coating on the construction site, the use of crane equipment with a large boom reach and load capacity, installation of coating supports in the area of assembly of the coating unit. All these operations are usually performed using crane equipment, in which in addition to the high cost of use there is another negative factor – the difficulty of positioning the components of the structures while maintaining the coating unit or its components due to the flexible connection available in crane equipment (Figure 1).

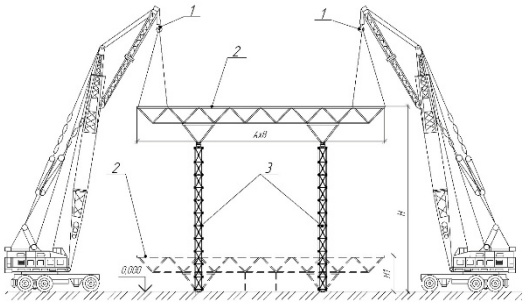

Figure 1 – Installation of the structural block of a covering by the crane way

During the analysis of the methods of installation of the structural block of the coating (SBP), it is proposed to change the design of the columns and support elements of the SBP. On the example of the coating unit with dimensions in terms of AxB and height H1, improvements were made to increase manufacturability, i.e. to redesign a design solution to use effective means of mechanization and technology [2, 3, 4, 9]. The more rational the technological process of assembly, the higher the quality of parts entering the assembly process, the more technological the design of products is and assembly elements, the less labor-intensive assembly process [5, 10, 12]. Taking into account the possible sizes of blocks of a covering 24x24 it is possible to receive variants of the building with the sizes in the plan, according to the number of blocks. In our opinion, the least effective is the number of blocks 2x4 or 3x4 with the arrangement of columns according to the scheme in Figure 2.

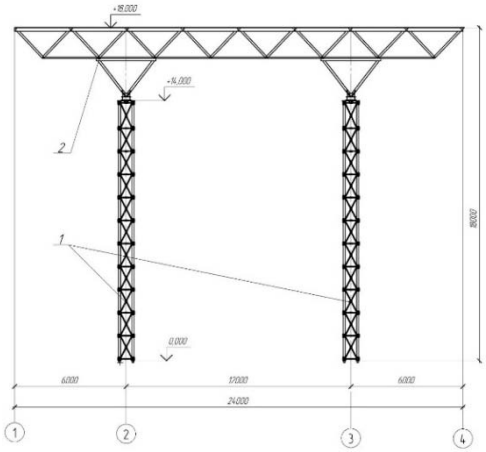

Figure 2 – General view of the block of structural coating on the columns in the axes 2-3:
1 – lattice column (structure);
2 – block of NGN 24x24, 24x18 or 24x15 m.

This arrangement of columns allows obtaining a virtually independent block of the building, in which the elevations may differ from other blocks. The proposed design of the coating unit is based on girders in the form of channels, interconnected by angles of different sizes. The support of the structural unit occurs at a distance of 3 m from the dimensional axes and forms a free zone inside the size of 6x6, 12x12, 12x18, 18x18 m. glass columns (Figure 3).

To increase the manufacturability of the frame, the design solution of the support unit was improved, which is installed and fixed on the lifting and assembly module according to the technology before the SBP unit is enlarged. It is proposed to make the whole element of support a starting mark (Figure 4).

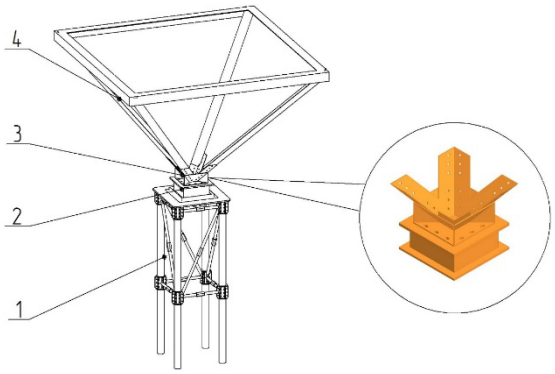

Figure 3 – Support unit of the structural coating unit:
1 – mounted column;
2 – support chair;
3 – support;
4 – support unit of the block.

The next step in improving the manufacturability of structures was to improve the design of the column. The column is a prefabricated structure consisting of 4 tubular elements with a length of 1000 mm, the distance between the axes is 700 mm. The pipe elements are connected by rods with couplings, through which the column is aligned with the help of rods and its components are fixed.

According to the selected parameters of the structural block, we get the following characteristics:

- Weight of a metalwork of the structural block 24x24 – about 12 t;
- Coverage area – 576 m ^{2};
- Coverage height – 2.12 m (with support nodes 4.24 m);
- Column height – 13.8 m;
- Number of tiers – 11 pieces;
- The number of tubular elements of column – 44 pcs.

Installation of the tier of the NGN column is as follows.

For one block of structural coverage, it is necessary to provide such quantity of PfP that will correspond to the constructive scheme of construction and provide stability of NGN. The minimum amount of PfP for lifting the NGN unit is 4 pcs.

It is necessary to ensure a constant power supply for the VPM hydraulic drive system as well as the installation accuracy control system.

The schematic diagram of the PfP and the entire lifting system is as follows:

1. There is a synchronous ejection of all hydraulic cylinders on the 4th point of supports. The extension of the hydraulic cylinders (Figure 3, 4), to a height of $H = l_C + l_M + \Delta$, where l_C is the height of the column section, $l_C =$ 1000 мм, l_M – coupling height, $l_M = 200$ mm, Δ – guaranteed clearance for installation ($\Delta =$ 20 мм).
2. The section of a column with the coupling under constant support of PfP is mounted. The NGN is lowered, the installed section of the column is connected by diagonal ties with the column (Figure 4).
3. The rod of the hydraulic cylinder №1 is retracted. PfP is held in 3 reference points. The section of a column with the coupling is mounted. The hydraulic cylinder №1 rests on the installed section of the column (Figure 4).
4. The hydraulic cylinder rod №2 is retracted. PfP is held in 3 reference points. The section of a column with the coupling is mounted. The hydraulic cylinder №2 is supported on the installed section of the column.
5. The hydraulic cylinder rod №3 is retracted. PfP is held in 3 reference points. The section of a column with the coupling is mounted. The hydraulic cylinder №3 is supported on the installed section of the column.

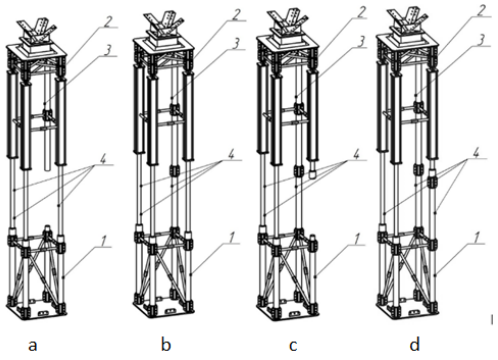

Figure 4 – PfP lifting sequence (grease frame conditionally not shown):
1 – mounted tier of the column;
2 – PfP;
3 – constant support of PfP;
4 – leaning on the column.

The last 10 and 11 tiers of columns are mounted. In this case, the permanent support is unfastened from the PfP and fixed on the column.

The duration of the processes under the new variant is significantly reduced concerning the basic (crane) variant (Figure 5). Reduction of duration occurs by 33-50%, and concerning the basic variant of reduction of terms of construction begins at the transition to the degree of consolidation of 4 blocks on 2 NGN – on 20-40%.

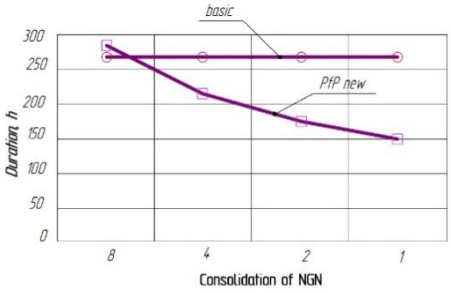

Figure 5 – Graphs of dependence of the duration of the device of a framework with a variant basic and new on the degree of consolidation of NGN

Ultimately, the choice of CTE depends on the determining criterion, if the main criterion is the cost of the process, the main impact is on the cost of renting machinery. The rental cost of the LTM 1090 crane in Ukraine is UAH 24,000 / shift, the rental

cost of 4 PfPs is UAH 500 x 4 = UAH 2,000 / shift. With the degree of consolidation of 8 NGN per unit, the rent for the entire set of PfP (32 pcs) will not exceed UAH 16,000 / shift. If we calculate the cost of rent for the largest degree of consolidation, then for the basic version it will be 34 x 24000 = 816000 UAH. (268.07 / 8 = 33.5 changes). For the new one – 16,000 x 19 = UAH 304,000. (149.48 / 8 = 18.69 changes), which is twice cheaper.

This approach to determining the effectiveness of the new solution is quite approximate, but the advantages of the new option include the proposed feature of the proposed CTE in combination with the design of PfP, which allows you to quickly perform installation/dismantling of the building for the needs.

4 Conclusion

To create the input conditions for the design of the hoisting-and-assembling module intended for mechanization of the assembly process of the coating structural unit, it is determined that it is expedient for mechanization to have cyclic identical operations that can be translated into automated execution mode by PfP synthesis with automation means.

It is also determined that the division of assembly technology into simple operations allows their comprehensive analysis using geometric 3D modeling, modeling of individual technological operations.

Literature:

1. Chernenko, V.K., Osypov, O.F., Tonkacheiev, H.M., Romanushko, Ye.H., et al. (2010). *Technology of installation of building structures: textbook.* In V.K. Chernenko (Eds.) K.: Horobets, H.S., 372.
2. Fedosova, O.V., & Shpakova, H.V. (2010). *Problems of transfer of modern systems of construction technologies - New technologies in construction.* Academy of Civil Engineering of Ukraine, Research Institute of Construction Production, 1, 52-57.
3. Leps'ka, L. (2019). The forming of the tool sets for the compulsory methods of installation of low-rise wireframe buildings. *Ways to Improve Construction Efficiency*, *41*, 12-18.
4. Mishchuk, Ye.O., & Mishchuk, D.O. (2020). IoT-based industrial automation systems. *Mining, construction, road and reclamation machines, 96*, 42-50.
5. Mosakov, B.S., & Kurbatov, V.L. (2006). *Mechanization and automation of construction processes.* M.: Mechanical Engineering-1, 266.
6. Osipov, O.F., & Chernenko, K.V. (2020) Information Model of the Process of Lifting Long Span Roof, *Sci. innov., 16 (4)*, 3-10.
7. Rashkivskyi, V.P., & Chernenko, K.V. (2012). *Technological features of installation of large-block coatings by the method of vertical ejection.* Abstracts of the scientific conference of young scientists, graduate students, and students. Kyiv, November 6 – 8. K.: KNUCA, 76.
8. Shvydenko, V.I. (1973). *Installation of building structures.* Kyiv: Budivelnyk, 310.
9. Sobko, Yu.T, & Novak, Ye.V. (2015). Research of methods of raising large-scale structural coverings of one-story industrial buildings. *Modern technologies and methods of calculations in construction, 3*, 157-162.
10. Tonkacheiev, H.M. (2013). A new system of normalization of time costs for making technological decisions. *Urban Planning and Spatial Planning: Collection of scientific works.* K.: KNUCA, 50, 700-704.
11. Tonkacheiev, H.M. (2013). System of functional modules of construction equipment. *Bulletin of the Donbass National Academy of Civil Engineering and Architecture, 6*, 3-7.
12. Tonkacheiev, H.M., Lepska, L.A., & Sharapa, S.P. (2014). *System of substantiation of technological parameters of mounting equipment for limitation and fixing of mounted structures. Urban planning and spatial planning.* K.: KNUCA, 52, 418-426.

Primary Paper Section: J

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