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INVESTIGATION OF LABOUR INTENSITY AND DURATION OF THE ASSEMBLY PROCESSES OF STRUCTURAL COVERING BLOCKS

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The article considers an approach to determining the labour intensity and duration of the processes of enlargement and installation of the structural blocks of the coating, which is due to atypical design and technological solutions. The relevance of this work is the need for a qualitative analysis of methods for calculating the labour intensity and duration of technological processes in the justification and decision-making on the organization and mechanization of installation processes.

Modern technologies of installation of structural blocks of coatings are analyzed. The analysis of labour intensity was carried out for the option of using lifting assembly modules to reduce the specific share of the use of heavy crane equipment at a construction site. In comparison with the way of installation of a structural coating using heavy crane equipment, load-lifting assembly modules occupy a smaller area of the construction site, which is important for a limited space.

To determine the labour intensity of the process, the installation of columns, installation of stands, enlargement of blocks, installation of blocks and installation and movement of assembly lifting and harvesting modules are included in the consideration. All calculations were made in tabular form in accordance with the formula of the integer normalization technique. Based on the results of the study, all components of the labour intensity and duration of the processes were determined, on the basis of which schedules for the implementation of the processes of enlargement and installation of structural pavement blocks (SBP) of a one-story spatial planning building were built.

Keywords: labor intensity of the process, integer rationing,time rationing, coating structural block,enlargement,assembly, installation,lift assembly module.

1. Problem statement

In recent years, the problem of designing and building spatial structures such as hangars, warehouses, as well as structures for other purposes with a short service life (1-2 years) has become urgent. To do this, it is necessary to revise the approaches to the technology of their construction and dismantling of structures. The main requirements for technologies are the speed of construction while maintaining a high level of reliability and the speed of disassembly with maximum safety of materials and structures for reuse. The most relevant for this are technologies with a forced method of lifting and installing structures, as well as structural covering blocks [1].

Most often, for spatial structures, design solutions are used from light metal structures with spans of 18 ... 36 m. Depending on the technological process, they have a variety of planning and design solutions that determine their assembly methods and mechanisms [1].

The process of enlargement of the structural covering blocks(SCB) of buildings can take place on special sites (enlargement sites), on mobile stands or on assembly lines. For the assembly technology using cranes, the zones for enlargement of the SCB are located near the installation sites. These zones must be in the area of action of cranes. To lift the SCB without the use of heavy cranes, enlargement, as a rule, is performed on the ground in terms of the axes of the bearing structures.

2. Analysis of recent research

In [1], the issues of assembly of building elements, enlarged assembly of roof blocks, selection of mechanized technological equipment are considered, a number of technological schemes for performing construction work are described, mainly based on the use of heavy crane equipment.

In works [2], methods and methods of installation of structural coatings are considered.

In [3], an approach to the creation of mechanized technological modules is considered, the use of new methods for determining the technological indicators of construction operations when using new solutions for the mechanization of construction processes is proposed.

In [4-5], approaches to the synthesis of technical solutions for ensuring the mechanization of technological processes are proposed, the efficiency of various types of drives is analyzed.

In [6, 12], the design of a lifting module for the installation of structural covering blocks is proposed, which makes it possible to reduce the specific share of the use of heavy crane equipment at the construction site.

The purpose of the work is to identify the labour intensity and duration of the processes, to analyze the features of the assembly of the structural blocks of the coating, to justify the effectiveness of the use of technology with lift assembly module.

3. Research results

As we know, the labour intensity of the construction process is determined by the methods of technical regulation of processes according to the methods of chronometric observation [7-9]. Based on these observations, standards are developed [7]. The labor intensity is measured in man-hours, and the rate of labour intensity is derived from the standard time, taking into account the number of performers.

Options for the enlargement and assembly of the SCB are not typical. Timing studies are not known for them, so it was decided to use the well-known integer rationing technique [8]. The basis of the method, as in the method of microelement rationing, is the actions corresponding to the structure of operations. Therefore, at the first stage of the study, a list of actions by operations and actions is determined.

The use of lift assembly module (LAM) replaces cranes in the processes of lifting and installing SCB blocks, which allows you to enlarge the SCB blocks directly in the axes of the columns. The dimensions of the construction site are reduced, as the columns are installed as the blocks rise, which become larger in the axes of the installation.

Before enlargement of SCB blocks, monolithic reinforced concrete foundations are installed under the columns. Foundations are installed with anchor bolts.

Further processes, in contrast to the process of assembling the frame of a structure, with the option of using heavy lifting cranes, are different in terms of content and execution sequence.

First, the first sections (tiers) of the columns are installed and fixed on the base plates of the foundations with a light crane. The height of the section is about 1.0 m, the weight of each section does not exceed 150 kg. For this, a truck crane with a lifting capacity of 10 tons is sufficient. The structure of the process of installing the supporting sections of columns on foundations is as follows [6, 10]:

$W_{1.1}$ – moving workers to a new work area;
$W_{1.2}$ – workplace preparation;
$W_{1.3}$ – installation of gasket and support nuts;
$W_{1.4}$ – preparation of the structure for assembly;
$W_{1.5}$ – crane hook delivery and structure slinging;
$W_{1.6}$ – lifting and delivery of the structure to the installation site;
$W_{1.7}$ – guiding the structure upon delivery to the installation area;
$W_{1.8}$ – orientation and installation of the column on the anchor bolts;
$W_{1.9}$ – installation of nuts and rough fixation of the post;
$W_{1.10}$ – alignment and final fixation of the column;
$W_{1.11}$ – removal of sling hooks;
$W_{1.12}$ –pouring joints with concrete;
$W_{1.13}$ – acceptance quality control.

The labour intensity and duration of the enlargement of the SBC blocks were found using the integer normalization technique (Table 1).

Determination of the standard time of all processes using the formula [9]:

$$T_h = 0,01667 \cdot \sum_{j=1}^{m} \sum_{i=1}^{n} r_j \cdot W_{ij},$$

where T_h – standard time for the process of the third level, hour; r_j – the coefficient of complexity and responsibility of actions, expressed as integers from 1 to 5 minutes; W_{ij} - the number of i-th actions (elements) of the j-th complexity and responsibility.

Labor intensity will be $\Theta_h = 0,01667 \cdot 72 = 4,534$ man-hours, duration of the process with a combination of actions is T_h = 0,01667·116·1,12 = 2,17 hours.

Table 1

Rationing matrix of the process
of mounting the supporting sections of columns

Actions, W_i	Number of actions by degree of responsibility, r_j					T_h, min.	Number of workers N_p, pers.	Labour intensity Θ, man.-min.
	1	2	3	4	5			
$W_{1.1}$	**4**					4	2	8
$W_{1.2}$	**4**					4	2	8
$W_{1.3}$				**4**		16	2	32
$W_{1.4}$	**4**					4	2	8
$W_{1.5}$		**4**				8	2	16
$W_{1.6}$		**4**				8	2	16
$W_{1.7}$		**4**				8	2	16
$W_{1.8}$		**4**				8	3	24
$W_{1.9}$				**4**		16	2	32
$W_{1.10}$					**4**	20	3	60
$W_{1.11}$	**4**					4	1	4
$W_{1.12}$		**4**				8	2	16
$W_{1.13}$				**4**		16	2	32
Results:						44		154

The next process is the installation of the LAM on the mounted support sections of the columns, using the same crane. The module is lowered onto special couplings of the supporting section and enters inside by the rods of hydraulic cylinders.

Структура процесу наступна:

$W_{2.1}$ – moving workers to a new work area;

$W_{2.2}$ – workplace preparation;

$W_{2.3}$ – preparation of the load-lifting module (LLM) for assembly;

$W_{2.4}$ –supply of the crane hook and slinging of the LLM;

$W_{2.5}$ – lifting and delivery of the LLM to the installation area;

$W_{2.6}$ – guiding LLM upon delivery to the installation area;

$W_{2.7}$ – orientation and installation of theLLMin the couplings;

$W_{2.8}$ – removal of sling hooks;

$W_{2.9}$ – acceptance quality control.

The labor intensity of the mounting process of 4LAMis: $\Theta_h = 1{,}867$ man-hours and the duration is T_h= 0,90 hours.

The third process is the installation of the LAM power drive [4, 11], its performance and the operation of control systems are checked. According to the experience of arranging such systems for sliding formwork, this takes one work shift [9]. For 4 performers, respectively, the complexity of the installation of the LAM system will be $\Theta_h = 32$ man-hours and the duration will be T_h = 8 hours.

The next fourth process is to perform enlargement of the SCB into blocks. For the method using LAM, the enlargement is performed at the level of +2.500

m, which requires a different solution for the design of the assembly stands. First, the supporting elements of the SCB block are installed in the form of inverted pyramids on the head of the columns (Fig. 1). The elements are fixed on the heads of the columns, which are temporary components of the LAM, and after the installation of the SCB, they pass into the construct of the columns.

Table 2

Rationing matrix of the LAM mounting process

Actions, W_i	Number of actions by degree of responsibility, r_j					T_h, min.	Number of workers N_p, pers.	Labour intensity Θ, man.-min.
	1	2	3	4	5			
$W_{2.1}$	**4**					4	2	8
$W_{2.2}$	**4**					4	2	8
$W_{2.3}$	**4**					4	2	8
$W_{2.4}$	**4**					4	2	8
$W_{2.5}$	**4**					4	2	8
$W_{2.6}$		**4**				8	2	16
$W_{2.7}$		**4**				8	2	16
$W_{2.8}$	**4**					4	2	8
$W_{2.9}$				**4**		16	2	32
Results:						48		112

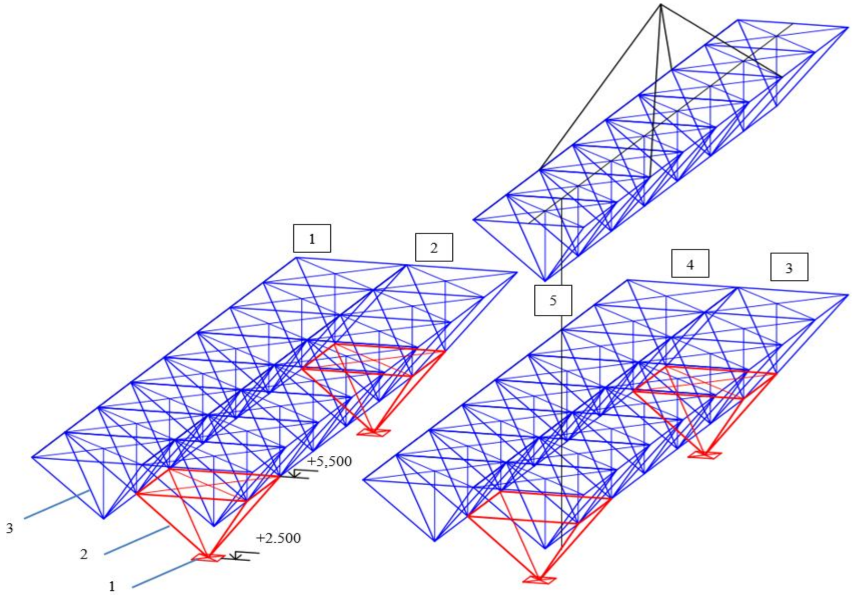

Fig. 1. Scheme of enlargement of the block of the structural block of the coating (SBC) with dimensions of 24 x 15 m: 1 – column head; 2 – supporting element of the SBC block; 3 – SBC shipping mark 24 x 3 m. The assembly sequence is indicated by numbers in squares

To install the fifth shipping mark and small elements, ordinary scaffolding in the form of a tour is used. The functions of the assembly stands are performed by the supporting element of the SBC block, therefore the structure of the process of enlargement of the SBC blocks is represented by the following set of actions:

$W_{4.1}$ – moving workers to a new work area;
$W_{4.2}$ – workplace preparation;
$W_{4.3}$ – supply of the crane hook and slinging of the structure;
$W_{4.4}$ – lifting and feeding the structure into the enlargement zone;
$W_{4.5}$ – guiding the structure when entering the installation area and installation;
$W_{4.6}$ – temporary fixing of the shipping mark;
$W_{4.7}$ – reconciliation and final fixation of shipping marks;
$W_{4.8}$ – removal of sling hooks;
$W_{4.9}$ – installation and fixing of individual SBC rods;
$W_{5.10}$ – acceptance quality control.

Table3

Matrix for calculating the parameters of the process of enlargement SBC

Actions, W_i	Number of actions by degree of responsibility, r_j					T_h, min.	Number of workers N_p, pers.	Labour intensity Θ, man.-min.
	1	2	3	4	5			
$W_{4.1}$	**2**					2	4	8
$W_{4.2}$	**2**					2	4	8
$W_{4.3}$			**9**			27	4	108
$W_{4.4}$			**9**			27	3	81
$W_{4.5}$			**9**			27	3	81
$W_{4.6}$		**9**				18	4	72
$W_{4.7}$				**9**		36	3	108
$W_{4.8}$			**32**			96	4	384
$W_{4.10}$					5	25	2	50
Results:						256		900

Actions $W_{4.1}$, $W_{4.2}$, $W_{4.3}$ can be combined. Labour intensityof the process of enlargement of one block of the SCB is: $\Theta_h = 15,003$ man-hours and the duration of the process with the combination of actions is T_h = 4,78 hours.

After the enlargement of the SBC block, the ascent begins in steps of 1.0 m with the installation and fixing of the elements of the column sections (Fig. 2). There are 11 such steps in the given example. One section of columns requires 16 assembly elements with the responsibility of the second stage [9].

The structure of the process of lifting SBC blocks with the help of LAM is as follows:

$W_{5.1}$ – squeezing out three cylinders of the LLM at once;
$W_{5.2}$ – installation of the support column of the column in a free place;

$W_{5.3}$ – the next rise of the rods of three cylinders;
$W_{5.4}$ – sequential installation of three columns of the column section;
$W_{5.5}$ – installation, fixing and adjustment of the grating;
$W_{5.6}$ – acceptance quality control.

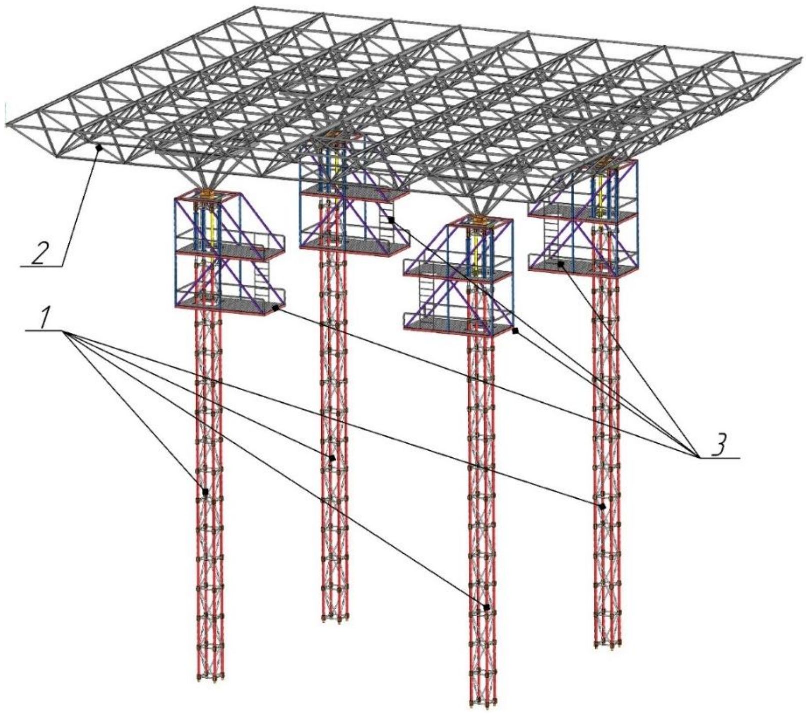

Fig. 2. Scheme of organizing the installation of the structural block of the coating using a lifting module: 1 – column; 2 –structural block of the coating; 3 –lifting module

Table 4

Rationing matrix for the lifting process of SBC blocks

Actions, W_i	Number of actions by degree of responsibility, r_j					T_h, min.	Number of workers N_p, pers.	Labour intensity Θ, man.-min.
	1	2	3	4	5			
$W_{5.1}$	**1**					1	1	1
$W_{5.2}$		**1**				2	2	4
$W_{5.3}$		**3**				6	1	6
$W_{5.4}$		**3**				6	2	12
$W_{5.5}$		**12**				24	2	48
$W_{5.6}$					**1**	5	2	10
Results:						44		81

The labor intensity of the process of lifting SBC blocks using LAM is: $\Theta_h = 1,35$ man-hours and the duration of the process with a combination of actions is T_h = 0,81 hours. Accordingly, to perform 11 lifting cycles with four modules, the labor cost is 59,400 man-hours and the duration is 9,80 hours.

The dismantling and relocation of the LAM to the next parking lots will be one work shift in duration, and 32 people in terms of labor costs.

The general structure of the processes, respectively matrices (Tables 1-4), is as follows:

TC1 - installation of supporting sections of columns on foundations; TC2 - installation of LAM; TC3 – hydraulic system installation; TC4 - enlargement of the SBC; TC5 - lifting of the SBC block; TC6 - dismantling of the LAM; TC7 - other processes not taken into account (5%).

Table 5 shows general technological calculations of the process of enlargement and installation of SBC.

Table 5

Technological calculations of the process of enlargement and installation of SBC

Process cipher	Product volume		Labor cost rate, man-hour	Time consumption rate, hours	Labor intensity of the process, man-hours	Duration of the process, hours
	Unit of measurement	Quantity				
TC1	1 block	1	4,534	2,17	4,534	2,17
TC2	1 block	1	1,867	0,9	1,867	0,9
TC3	1 block	1	32,000	8	32,000	8
TC4	1 block	1	15,003	4,78	15,003	4,78
TC5	1 block	1	59,400	9,8	59,400	9,8
TC6	1 block	1	32,000	8	32,000	8
TC7	%	5			7,24	1,07
					152	34,72

4. Conclusions

The existing normative database for standardizing new processes does not allow determining the labor intensity and duration of processes, as is clearly shown in the example in which the LAM lifting and harvesting module is used in the technology. The use of a modified microelement method of (holistic) rationing makes it possible to calculate the labor intensity and duration of any processes, to justify various options, which significantly increases the efficiency of design and technological solutions.

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ДОСЛІДЖЕННЯ ТРУДОМІСТКОСТІ І ТРИВАЛОСТІ ПРОЦЕСІВ МОНТАЖУ СТРУКТУРНИХ БЛОКІВ ПОКРИТТЯ

У статті розглянуто підхід до визначення трудомісткості та тривалості процесів укрупнення та монтажу структурних блоків покриття, що зумовлено нетиповими конструкційними та технологічними рішеннями. Актуальністю даної роботи є потреба у якісному аналізі методів розрахунку трудомісткості та тривалості технологічних процесів при обґрунтуванні і прийнятті рішень щодо організації та механізації монтажних процесів.

Проаналізовано сучасні технології монтажу структурних блоків покриттів. Аналіз витрат праці проводився для варіанту з використання вантажопідйомних монтажних модулів для зменшення питомої частки використання важкої кранової техніки на будівельному об’єкті. У порівнянні зі способом монтажу структурного покриття із застосуванням важкої кранової техніки вантажопідйомні монтажні модулі займають меншу територію будівельного майданчику, що актуально для обмеженого простору.

Для визначення трудомісткості процесу до розгляду включені монтаж колон, монтаж стендів, укрупнення блоків, монтаж блоків та встановлення і переміщення монтажних підйомно-збиральних модулів. Всі розрахунки виконувалися у табличній формі відповідно до формули методики цілочислового нормування. За результатами дослідження визначені всі складові трудомісткості та тривалості процесів, на підставі яких побудовано графіки виконання процесів укрупнення і монтажу структурних блоків покриття (СБП) одноповерхової будівлі просторового планування.

Ключові слова:трудомісткість процесу, нормування часу, структурний блок покриття, укрупнення, монтаж, підйомно-збиральний модуль.

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INVESTIGATION OF LABOUR INTENSITY AND DURATION OF THE ASSEMBLY PROCESSES OF STRUCTURAL COVERING BLOCKS

The article considers an approach to determining the labor-intensiveness and duration of consolidation processes during the installation of structural blocks of the covering, which is caused by atypical structural and technological solutions. The relevance of this work is the need for a qualitative analysis of methods for calculating the labor intensity and duration of technological processes when justifying and making decisions regarding the organization and mechanization of assembly processes.

Modern technologies of installation of structural blocks of coatings are analyzed. The analysis of labor costs was carried out for the option of using load-lifting assembly modules to reduce the specific share of the use of heavy crane equipment at the construction site. In comparison, the method of installing a structural coating using heavy crane equipment and load-lifting assembly modules is considered.

To ensure the principle of comparison of options, the processes of column installation, stand installation, block consolidation, block installation, and installation and movement of a crane or assembly lifting and gathering modules are included in the consideration. All calculations were performed in tabular form according to the formula of the integer normalization method. Based on the results of the study, all the components of the labor intensity and duration of the processes were determined, on the basis of which the schedules of the consolidation and installation of the SBP blocks were built.

Keywords: labour intensity of the process, time rationing, standard time,structural block of the coating, technological process, lifting and collecting module.

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Табл. 5. Іл. 2. Бібліогр. 15 назв.

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Tabl. 5. Fig. 2. Ref. 15.

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