Construction project organizational and technological parameters analysis

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Abstract. The article deals with the organizational and technological features of construction. Methods of optimization of values to the required level are considered. Recommendations are given on making changes to organizational and technological solutions and achieving the required indicators. Reducing the timing of work while maintaining the cost of the final product is the main condition for the organization of construction production. This can be achieved by developing network and calendar schedules with the correct sequence of work, the composition of teams, and optimal technological solutions. Adjustment of graphs is possible when determining the parameters of resource graphs and comparing them with normal values. The effectiveness of the applied optimization methods in terms of time and resources depends on the technological and organizational parameters of the designed building or structure. The calculation of the parameters of construction production is carried out on the basis of the conditions that each work is provided with all the necessary resources. In reality, all resources are always limited. All planning work comes down to a constant analysis of the use of resources and their redistribution. When scheduling work, it is necessary to link the objectives of the plan in as much detail as possible with the possibilities of their implementation, that is, with available resources. Adjustment of graphs is called work to improve certain parameters of the graph. Since as a result of changing the schedules, the calculated parameters are brought into line with the task, and some optimal option is not achieved.

1. Introduction

The calculation of the parameters of construction project is carried out on the basis of the conditions that each work is provided with all the necessary resources. In reality, all resources are always limited. The lack of certain resources leads to a change in the sequence of work. In essence, all planning work comes down to a constant analysis of the use of resources and their redistribution. When scheduling work, it is necessary to link the objectives of the plan in as much detail as possible with the possibilities of their implementation, that is, with available resources. Adjustment of graphs is called work to improve certain parameters of the graph. In other words, adjustment is the allocation and redistribution of chart resources to complete a task. This process is often referred to as optimization. The use of the term “optimization” is not entirely justified, since as a result of changing the schedules, the calculated parameters are brought into line with the task, and some optimal option is not achieved.
The main parameters of construction production are the duration and estimated cost of construction. Optimization of these planning elements can be done using resource design. The construction of the facility includes many diverse works. Their implementation requires a certain set of various resources: building materials, means of mechanization and workers. In most cases, it is the level of organization in the distribution of these resources that determines the duration and, as a consequence, the cost of construction.

2. Materials and methods
The study of the issue was carried out on the basis of the analysis of theoretical data adopted in the organizational and technological documentation. During the study, a comparison of optimization methods was performed. Criteria assessment or application of a generalized indicator depends on the goals of the project and the tasks to be solved.

3. Results
In scheduling, there are three main stages: structural planning, scheduling and operational management. At the stage of structural planning, the production process is divided into clear operations. A network diagram is compiled, which clearly shows the relationship of technological processes with each other. The critical path, time reserves are determined, thanks to which in the future it will be possible to optimize the schedule. The second stage involves the construction of a calendar schedule that determines the start and end dates of all work. The final product of the second stage is a work schedule. The schedule helps to track the time reserves of non-critical operations that can be managed during process optimization. The third stage is operational management, where the schedule and network schedule are used to provide reports on the progress of work. To date, the most effective method of organizing construction production is the in-line method. It forms the basis for building work schedules. In order to achieve stable dynamics of construction, it is necessary to take into account the uniform distribution of resources when designing. Restrictions on building materials, labor, and mechanization can significantly reduce the efficiency of the inline method. It is necessary to foresee the distribution of resources over time at the facility. Resource schedules are designed to solve this problem. With the help of the full time reserves of non-critical works, shifting them within the reserve time, it is possible to achieve a decrease in the maximum resource requirements. In the absence of resource constraints, they can be aligned during construction. The graphs are evaluated by finding the coefficients, comparing them with standard indicators or their specified values.

Resource demand schedules task:
1) Presentation of information on the uniform distribution of resources;
2) A visual representation of the shortcomings or surpluses of resources;
3) Adjustment of the distribution of resources depending on the conditions of construction;
4) Evaluation of the effectiveness of the selected technological design methods by finding the coefficients of the parametric data of resource schedules.

Resource design is part of organizational and technological design. The aim of the article is to analyze resource schedules, parametric analysis of their indicators and on this basis to highlight the optimal method for adjusting schedules, taking into account the in-line method of organizing construction and installation works.

According to the schedule, the needs for machines and mechanisms, human resources, the delivery time of building materials and structures, the schedule for financing construction in units are determined: volume - time (days, weeks, months) (table 1).
Table 1. Resource allocation during construction

| Resource type          | Duration | Total amount of resource |
|------------------------|----------|--------------------------|
|                        | Period 1 | Period 2 | Period 3 | Period 4 |                      |
| Labor resources        | L1       | L2       | L3       | L4       | SL                    |
| Construction machinery | M1       | M2       | M3       | M4       | SM                    |
| Technological equipment| T1       | T2       | T3       | T4       | ST                    |
| Construction materials | R1       | R2       | R3       | R4       | SR                    |
| Financial resources    | F1       | F2       | F3       | F4       | SF                    |
| Congestion             | CG1      | CG1      | CG1      | CG1      | -                     |

*Note: L - labor resources; M - construction machinery; T - technological equipment; R - construction materials; F - financial resources; CG - congestion; SL - total amount of labor resources, etc.

Optimization of labor productivity allows you to adjust the workload of labor resources, the use of working time, responsibilities in accordance with qualifications, motivation, communication between departments and hierarchical communication, as well as the general internal situation at the enterprise to maximize productivity.

The optimization of labor costs is aimed at directly reducing the costs of the enterprise. This procedure involves reducing the number of staff to a minimum, provided that the implementation of the entire production program is maintained. Also, as part of this procedure, all staff costs and tax deductions are analyzed, and a decision is made to reduce them.

The goal of reducing the cost of the project implies the maximum possible cost reduction without loss in productivity, and at the minimum cost of the optimization project. Therefore, optimization should be carried out by the enterprise itself, although the involvement of an external consultant for such a project is more preferable. In addition, each optimization component should solve specific problems aimed specifically at reducing the cost of the project.

Types of parameters of construction production and methods for their adjustment:

1) Parameter type: duration of work calculated (actual).
   Normative (recommended) value / possible deviation: minimum duration regulated by the norms for the duration. Correction methods: redistribution labor resources within the framework of one specialization in various areas of work; combination of technological processes in time; attraction of additional resources; consideration of destabilizing factors in the scheduling of construction production.

2) Parameter type: estimated cost of construction work.
   Normative (recommended) value / possible deviation: calculated according to local and object estimates. Correction methods: reducing the duration of construction work; change in design decisions;

3) Parameter type: uniform distribution of labor resources.
   Normative (recommended) value / possible deviation: estimated by the coefficient of uneven distribution, the coefficient of flux density, the coefficient of stability. Correction methods: movement of work to a later date; increase the duration of work;

4) Parameter type: the complexity of construction and installation works;
Normative (recommended) value / possible deviation: the basic complexity is taken according to the regulatory and technical documentation. Correction methods: inadequate analysis of all conditions for the implementation of construction work;

5) Parameter type: specific labor costs per unit of final product.
Normative (recommended) value / possible deviation: regulated by the specific indicators of construction products. Correction methods: change in design decisions

6) Parameter type: intensity of construction production.
Normative (recommended) value / possible deviation: defined by the technical customer of construction. May deviate from agreed values depending on the terms of the contract. Correction methods: the increase in output.
Consider the methods of adjustment in the examples.

1. Adjustment of the duration of the work.
1) Redistribution of labor resources within the framework of one specialization in various areas of work. Transfer of teams from non-critical to critical sections of the network
2) The combination of technological processes in time. Dividing the work area into small grips.
3) Attraction of additional resources. Increase shift with additional labor and other resources.
4) Consideration of destabilizing factors in the scheduling of construction production.
An example of reducing the duration of construction work is shown in Figure 1.

![Figure 1](image_url)

Figure 1. Representation and comparison of parameters in various embodiments.

If the estimated cost of construction work is unacceptable, a situation arises when it is necessary to reduce this indicator. As you know, the cost of construction work in general consists of the following indicators (1): estimated profit, overhead costs, direct costs determined by the cost of materials and salaries - the wages of workers. Reducing the estimated cost of work can be made by reducing the cost of renting construction vehicles and mechanisms.
Uniform distribution of labor resources. It is estimated by the coefficient of uneven distribution, the coefficient of flux density, the coefficient of stability, as well as the amount of downtime of the teams.
Moving the work to a later date. The use of time reserves for non-critical work; Increase the duration of work. Within the time reserves while reducing the number of workers.

The complexity of construction works. Involvement of measures that increase the level of industrialization. When designing the construction industry in the calculations of construction work, they lay down the machines and mechanisms listed in the normative and technical documentation. But as you know, construction equipment is being modernized very quickly and new models surpass previous ones in operational indicators. Therefore, when designing, one should take into account the latest models of technology with high performance. Another reason for the increase in the complexity of construction works is an insufficient analysis of all the conditions for performing construction work. Also, the complexity of construction work can be reduced by changing the design decisions of the object, for example, the enlargement of the mounted elements.

Specific labor costs per unit of final product. Unit labor costs per unit of final product are regulated by specific indicators of construction products. Deviation should not exceed 10%. This indicator is a derivative of the complexity of construction work. To reduce costs for this indicator should also change design decisions and reduce the duration of work.

The intensity of construction production. The intensity of construction production is set by the technical customer of the construction. May deviate from agreed values depending on the terms of the contract. The intensity can be increased by increasing the volume of output. As a result of comparing the options, the matrix of parameters of construction production (Table 2).

| Parameters | P1 | P2 | P3 | P4 | P5 | P6 |
|------------|----|----|----|----|----|----|
| V1         | A1 | B1 | C1 | D1 | E1 | F1 |
| V2         | A2 | B2 | C2 | D2 | E2 | F2 |
| V3         | A3 | B3 | C3 | D3 | E3 | F3 |
| V4         | A4 | B4 | C4 | D4 | E4 | F4 |

*Note: Colored: green–acceptable, brown – average, yellow - unacceptable

From the compiled matrix, you can see a clear picture of the parameters of construction production, evaluate critical (minimum and maximum) values. As a result, accept the best option or carry out the adjustment of the relevant parameters.

After compiling a matrix of parameters, it is necessary to assess their impact on the subject of deviations from standard values and the impact on the main indicators of the project (table 3).

| №  | Parameters                  | Deviation from | The degree of influence on the overall project performance |
|----|-----------------------------|----------------|----------------------------------------------------------|
|    |                             | Standard values | Capabilities | Guideline values | Cost of construction | The timing | Variability |
| 1  | Group of parameters-1       | DS1            | DC1          | DG1             | K1.1                  | K1.2        | K1.3        |
| 2  | Group of parameters-2       | DS2            | DC2          | DG2             | K2.1                  | K2.2        | K2.3        |
| 3  | Group of parameters-3       | DS3            | DC3          | DG3             | K3.1                  | K3.2        | K3.3        |
| 4  | Group of parameters-4       | DS4            | DC4          | DG4             | K4.1                  | K4.2        | K4.3        |
5. Group of parameters-5
   DS5  DC5  DG5  K5.1  K5.2  K5.3
6. Group of parameters-6
   DS6  DC6  DG6  K6.1  K6.2  K6.3

*Note: DS - deviation from standard values, %; DC - deviation from capabilities of building company; DG - deviation from guideline values, defined by customer; K1.1 - the degree of influence on the overall project performance, cost of construction; K1.2 - the degree of influence on the overall project performance, the timing; K1.3 - the degree of influence on the overall project performance, variability;

4. Conclusion
   Thus, the task of adjustment is reduced to the compilation of an optimal work schedule, ensuring the greatest uniformity of resource schedules. The correct adjustment of the schedules is based on the calculation of the coefficients and parametric indicators of the resource schedules. Comparing them with normal indicators, we can conclude that the optimization was successful.

References
[1] Lapidus A., Abramov I. Implementing large-scale construction projects through application of the systematic and integrated method XXIst International Scientific Conference on Advanced in Civil Engineering: Construction - The Formation of Living Environment, FORM 2018. "IOP Conference Series: Materials Science and Engineering" 2018. P. 062002.
[2] Lapidus A.A., Yves N. Integrated quality index of organizational and technological solutions for implementation of burundian capital master plan Materials Science Forum. 2018. T. 931 MSF. P. 1295-1300.
[3] Lapidus A., Makarov A. Automation of roof construction management by means artificial neural network Advances in Intelligent Systems and Computing. 2017. V. 692. P. 1168.
[4] Topchy D.V., Lapidus A.A. Construction supervision at the facilities renovation Topical Problems of Architecture, Civil Engineering and Environmental Economics (TPACEE 2018) electronic edition. Ser. "E3S Web of Conferences" 2019. P. 08044.
[5] Lapidus A., Dmitry T. Formation of methods for assessing the effectiveness of industrial areas' renovation projects IOP Conference Series: Materials Science and Engineering 3. Ser. "3rd World Multidisciplinary Civil Engineering, Architecture, Urban Planning Symposium, WMCAUS 2018 - Session 1" 2019. P. 022034.
[6] Lapidus A., Shesterikova Y. Mathematical model for assessing the high-rise apartment buildings complex quality E3S Web of Conferences 2019. P. 02025.
[7] Lapidus A., Abramov I. Systemic integrated approach to evaluating the resource potential of a construction company as a bidder IOP Conference Series: Materials Science and Engineering 3rd World Multidisciplinary Civil Engineering, Architecture, Urban Planning Symposium (WMCAUS 2018). 2019. P. 052079.
[8] Sinenko S.A., Ginzburg V.M., Sapozhnikov V.N., Kagan P.B., Ginzburg A.V. Automation of organizational and technological design in construction: Textbook.- Saratov: Higher education, 2019. -235p.
[9] Lapidus A., Abramov I. A system-integrated approach to the study of the problem of ensuring the sustainability of complex production and dynamic systems in construction / In the collection: Construction system engineering. Cyberphysical building systems A collection of materials from a seminar held as part of the VI International Scientific Conference. 2018.S. 159-162.
[10] Abramov I, Lapidus A. Systemic integrated method for assessing factors affecting construction timelines Collected at: International Scientific Conference Environmental Science for Construction Industry - ESCI 2018 Ser. "MATEC Web of Conferences" 2018.S. 05033.
[11] Oleinik P.P. The choice of the rational relationship of the method and form of organization of construction Industrial and civil construction. 2019.No 6.P. 46-50.
[12] Pakhomova L.A., Oleinik P.P. Selection and assessment of parameters for certification of work places sout (special assessment of working conditions) Technology and organization of construction production. 2019. No 1. S. 49-52.

[13] Oleinik P., Yurgaytis A., Voronina G., Makarenko A. Methods for the formation and optimization of calendar plans for construction companies Collected: MATEC Web of Conferences 2018. S. 05037.

[14] Zhadanovsky B.V., Erzhokova E.S., Gorshkova E.A. Stream method as a way of organizing the construction of System Technologies. 2018. No. 3 (28). S. 136-140.

[15] Zelentsov A.A., Tokarsky A.Ya. Modeling the consequences of the risks of manifestation of negative factors during the construction of capital construction projects. In the collection: Days of student science. Collection of reports of a scientific and technical conference based on the results of research work by students of the Institute of Construction and Architecture. 2019. S. 1361-1363.

[16] Lapidus A.A., Tolstova K.S., Topchiy D.V. Formation of groups of parameters affecting the criterion of admissibility of combining processes in the production of finishing works Science and business: development paths. 2018. No 6 (84). S. 18-22.

[17] Solomatina M.I. Study of the influence of destabilizing factors on the reliability of production processes. In the collection: Days of student science. Collection of reports of a scientific and technical conference based on the results of research work by students of the Institute of Construction and Architecture. 2019. S. 1299-1301.

[18] Liu, J., & Lu, M. (2020). Synchronized optimization of various management-function schedules in a multiproject environment: Case study of planning steel girder fabrication projects in bridge construction. Journal of Construction Engineering and Management, 146(5). doi:10.1061/(ASCE)CO.1943-7862.0001813.

[19] Arashpour, M., Kamat, V., Bai, Y., Wakefield, R., & Abbasi, B. (2018). Optimization modeling of multi-skilled resources in prefabrication: Theorizing cost analysis of process integration in off-site construction. Automation in Construction, 95, 1-9. doi:10.1016/j.autcon.2018.07.027.

[20] Sun, Q., Li, D., & Ren, Y. (2018). Study of redundancy and variance based P-cycle construction algorithm. Tiedao Xuebao/Journal of the China Railway Society, 40(12), 101-107. doi:10.3969/j.issn.1001-8360.2018.12.013