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METHODOLOGICAL PRINCIPLES OF CALENDAR PLANNING BY PROBABILISTIC CHARACTER OF CONSTRUCTION

It is defined that the tasks of reducing the cost of construction products should not be solved by saving the direct costs, but due to objective reduction of costs by rationality of the production work organization. It is established that construction works are fulfield in prone to changes of the environment conditions, so not only these factors should be taken into account in the process of construction, but also those that may only be predicted with a certain probability. It was developed the dependence of the work duration calculation both with the usage of a set of construction machine and without its usage by applying the coefficient of the construction project sensitivity to the factors of a changing environment. The proposed calculation allows to reduce the failure risk of the commissioning project terms and provides an opportunity to accelerate the construction process in the given specific conditions. It was carried out the estimation of the coefficient of sensitivity in different local conditions depending on the influence of various factors: weather conditions; provision of material resources; number and qualifications of workers.

***Keywords:** scheduling, duration of construction, coefficient of sensitivity, probabilistic nature of construction.*

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МЕТОДИЧНІ ПРИНЦИПИ КАЛЕНДАРНОГО ПЛАНУВАННЯ ПРИ ЙМОВІРНІСНОМУ ХАРАКТЕРІ БУДІВНИЦТВА

Відомо, що завдання зниження вартості будівельної продукції повинні вирішуватися не шляхом економії на прямих витратах, а за рахунок об'єктивного зниження витрат шляхом раціонально організованого виробництва робіт. Установлено, що будівельне виробництво функціонує в умовах схильного до змін середовища, причому на процес будівництва впливають не тільки заздалегідь враховані чинники, але й такі, що можуть бути передбачені лише з певною ймовірністю. Наведено залежності з розрахунку тривалості проведення робіт як при використанні комплекту будівельних машин, так і без нього із застосуванням коефіцієнта сенситивності будівельного проекту до чинників мінливого середовища. Запропонована методика розрахунку дозволяє зменшити ризик зриву термінів здавання об'єкта та надає можливість прискорити процес будівництва в конкретних умовах. Виконано оцінювання коефіцієнта сенситивності в різних місцевих умовах залежно від впливу різноманітних чинників: погодні умови; забезпечення матеріальними ресурсами; кількість і кваліфікація робітників.

***Ключові слова:** календарне планування, тривалість будівництва, коефіцієнт сенситивності, ймовірнісний характер будівництва.*

Introduction. Scientific studies of calendar planning models and methods of control, project management and forecasting of changes in schedules in the course of works are relevant for today and give the significant impact on the results of work of construction organizations [1, 2].

All activities of an organization include risks. Organizations manage risk through its identification, analysis and subsequent evaluation, whether the risk will be changed through processing to accord the risk criteria. Throughout this process they exchange information and consult with stakeholders, carry out risk monitoring and analysis, and fulfill the management actions to counteract risks, to reduce the impact of risks on the construction process.

The main factors that determine the efficiency of construction are the price and quality. The tasks of the costs reducing of the construction products should be solved not by saving the direct costs in the form of buying cheap materials or using «cheap» labor, but by means of the objective costs reduction by optimizing the planning and organizing the construction process [3].

In the field of construction there are numerous problems that should be solved by improving the methods of scheduling. Among these problems are the problems of construction time and costs exaggeration; low productivity; low quality products; downtime of workers and equipment; poor working conditions; the wrong ratio of workers of different professions (adjusters, welders, carpenters, etc.) in each area of work (due to the lack of sufficient numbers of workers of some professions, workers of the other professions will work with low productivity) [4].

So, it is normal that within the equal position the competitive advantage is given to the construction company with higher labor productivity and fewer downtime.

The costs of the construction product depend not only on the costs of used materials, machines/mechanisms, wages of workers, but also depends on how rationally and productively the construction works are organized [3].

Review of the latest research sources and publications. Some of the tasks of the construction production organizing are control, management and optimization of the scheduling in the process of their implementation, taking into account the variability of the working environment and the influence of various groups of factors on the planned actions with the aim to complete the project in the most favorable terms.

In these conditions it is extremely important to ensure the coordination of the work of all construction participants, to subordinate their activities to the general rhythm of construction, to take into account the influence of numerous random factors that cause deviations of the entire system from the planned course of work.

The construction industry operates in conditions prone to environmental changes (supply disruptions, accidental breakdowns of machines and mechanisms, weather changes, etc.), and the construction process is affected not only by factors that can be taken into consideration in advance, but also a number of such influences which can be provided only with a certain probability [5].

The internal risks are such risks that different parties within a company can undertake. Subcontractors, stakeholders, designers etc. fall under internal risks. External risks are those that are out of the project organization range to control, for example weather or introduction of new laws. Project risks represent those risks that could occur during a project and are associated with time scheduling, cost, quality etc.

Risk management does not only involve time and cost factors in a project but it is also the way of understanding the problems that might emerge before it is too late, and by doing so the processes can be more easily controlled. The quantification done in the risk management is good to have as a reference to highlight the different areas that are in need of further investigation, clarification or design [8].

The most frequent causes of project implementation failures are: a lack of resources, insufficiently skilled workforce, misallocation of funds and unrealistic terms, which is a consequence of poor planning quality [1].

It is very important to observe the schedule of construction and installation works, as the disruption of the schedule may introduce disorganization into the production process.

Definition of unsolved aspects of the problem. The creation of resource and time buffers is a typical technique to combat the disruption of the work schedule [2]. The specificity of the construction industry does not allow applying the theory of constraints in its classical form for creating resource and time buffers.

Risk assessments in the organizational and technological models of construction production can be carried out using fuzzy logic [7–9].

Determination of the construction facilities duration by average indicators can be carried out according to normative documents [10], but it should be noted that the schedule is unique for each construction organization.

Problem statement. It is improving the methodological principles of scheduling for the probabilistic nature of construction by calculating the duration of construction and installation work, taking into account their sensitivity to various external and internal factors that cause deviations from the planned schedule of work.

Main material and results. The sequence of work, conditioned by the technology of construction processes, is the first to influence the duration and cost of housing, loading of resources, etc.

Despite the fact that there are general guidelines, they are not intended to provide the risk identical management in all organizations. When creating and applying calendar plans and risk management structures, it is necessary to take into account the different needs of a particular organization, its specification, objectives, context, structure, activities, processes, functions, projects, products, services or assets and specific practical methods used.

It should be noted that the tasks of scheduling are usually considered in the traditional formulation according to the accepted technology of conducting works, starting from technological routes and standards. At the same time, studying of technology options or, at least, using of various technological routes in the analysis will allow to identify the optimal options for loading resources, respectively, to increase productivity and reduce costs.

Moreover, when considering options, it is not necessary to engage in simple search, it will be correctly guided by logical dependencies and experience, which will allow to identify the most promising ways and, having considered them, choose the optimal variant of the schedule.

The chosen schedule will also allow to minimize losses, such as: excess stocks of raw materials and materials; reducing or eliminating the intersection of workspaces with simultaneous carrying out of various works; reducing the probability of spoilage or loss of materials; improving quality (no need to redo the work); eliminating excessive movement of people and equipment through the construction site.

The implantation of risk management and ensuring its continued effectiveness requires the adoption of a strict and permanent commitment on the part of the management of the organization, as well as strategic and detailed planning to fulfill obligations at all levels.

Also, we note that the methods use an imperfect regulatory framework, based, as a rule, on averaged indicators.

The plan of combating risks must be developed throughout the organization, ensuring the application of risk management policies and the inclusion of risk organization in all procedures and processes of the company. The risk management plan can be integrated into other plans of the organization, for example, into a strategic plan.

On Fig. 1 shows the scheme for accounting for the probabilistic nature of construction production in the scheduling (construction and installation work).

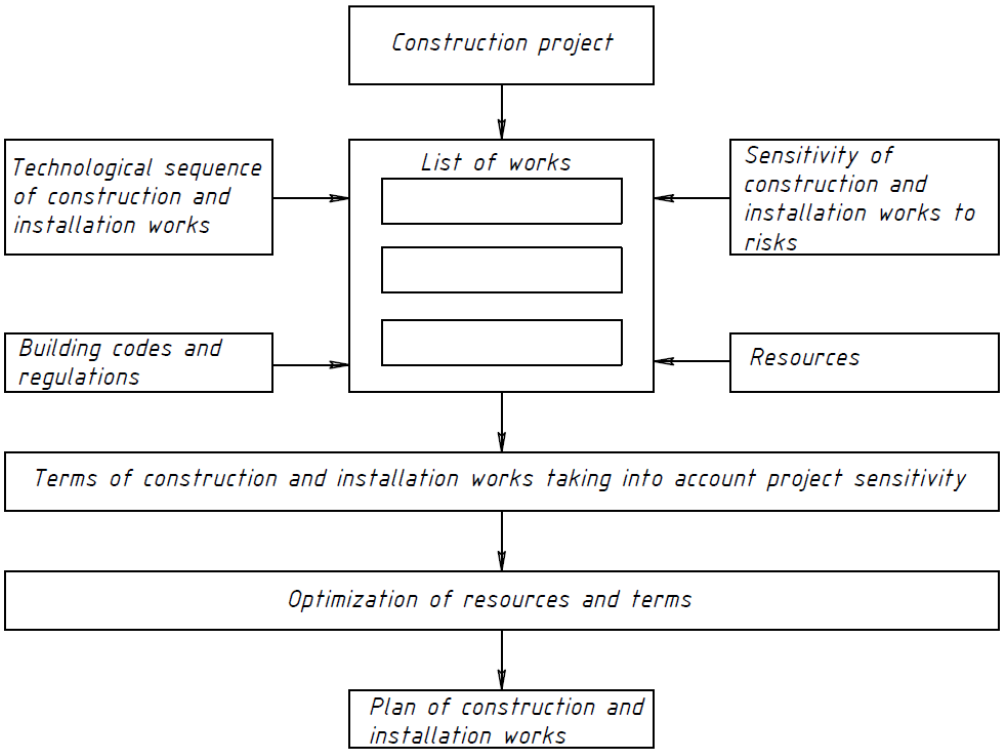

Figure 1 – Scheme of accounting for the probabilistic nature of construction production in the calendar planning

The way expressing the consequences and the probability of their occurrence, and the way they are combined to determine the level of risk, should reflect the type of risk, the available information and the purpose for which the result of the risk assessment should be used. All these principles must comply with the risk criteria. It is also important to consider the interdependence of various risks and their sources.

It is proposed to use the sensitivity coefficient in calculating the duration of construction to take into account the probabilistic nature of the process.

The duration of work (in working days) is determined by the formula (1):

$$T = \frac{Q \cdot K_c}{n \cdot Z}, \quad (1)$$

where Q – labor intensity of work, person-days;

K_C – the sensitivity coefficient;

n – the number of workers who can occupy the front of work;

Z – shifts.

The following formula (2) can be used to estimate the duration of the work performed with the use of a set of machines under the conditions of a probabilistic nature of the construction industry:

$$T_{pð} = \frac{W \cdot K_{CM}}{M_z \cdot Z} + T_P \cdot K_{CP}, \quad (2)$$

where W – scope of the work;

K_{CM} – the sensitivity coefficient for the main work performed;

M_Z – capacity of a set of machines in shift;

Z – shifts;

T_P –duration of preparation of cars for performance of works (installation, sampling);

K_{CP} – the sensitivity coefficient for preparatory work.

Organization and management of processes is always present, but the proposed calculation can reduce the risk of commissioning time disruption and gives the opportunity to speed up the construction process, as in these specific construction conditions, specialists are aware of the strengths and weaknesses of the project. Therefore, during calculating or adjusting the duration of work, a time reserve (insurance) is laid in the form of possible failures (for example, equipment failure, material shortage, theft, staff diseases, etc.). and for the purposes of project acceleration if appropriate conditions are created for it.

As for the impact of risk factors that have little effect on the implementation schedule, such a minor change in the schedule through the management influence of directorate makes it possible to catch up and enter the schedule.

The evaluation of the sensitivity coefficient can be determined in different local conditions, as shown in Table 1 – 4. It is also possible to assess the sensitivity coefficient for other risk factors.

Table 1 – Selecting the sensitivity coefficient to the provision of material resources

№	Assessment of the state of material resources	Coefficient of sensitivity
1	Disruptions in the supply of material resources (unreliable suppliers, logistics violation, other reasons) and / or insufficient quality (many defects)	>1
2	The quantity and quality of material resources do not contribute to effective work (not enough tools and equipment, poor quality of overalls, fuel and lubricants, building materials, etc.)	1
3	The amount of resources is sufficient to carry out the work, their quality is high, which contributes to higher labor productivity and a shorter work execution time	<1

Table 2 – Selecting the sensitivity coefficient taking into account the number of workers

№	Assessment of the number of workers	Coefficient of sensitivity
1	The number of workers is less than required for various reasons (employed at other sites, diseases, absenteeism, etc.)	>1
2	The number of workers is sufficient in quantity, but the wrong ratio between workers of different professions (welders, installers, carpenters, etc.), which does not contribute to effective work	1
3	The number of workers is sufficient in quantity with the correct ratio between workers of different professions (welders, installers, carpenters, etc.), which contributes to higher labor productivity and shorter work execution	<1

Table 3 – Selecting the sensitivity coefficient when taking into account the qualifications of workers and engineers

№	Qualification assessment	Coefficient of sensitivity
1	Workers have insufficient experience in carrying out various jobs, low qualification of engineers and technical workers	>1
2	The qualification of workers and engineers is sufficient to carry out the work, but it is not sufficient to exceed the norms of time	1
3	The qualification of workers and engineers is high, there is a material interest in overfulfilment of norms	<1

Table 4 – Selecting the sensitivity coefficient when taking weather conditions into account

№	Assessment of weather conditions	Coefficient of sensitivity
1	Winter period	>1
2	Autumn and spring periods	1
3	Summer period	<1

If the sensitivity coefficient factor is shown K> 1, this can be, for example, K = 1.1; K = 1.2, if, in the opinion of experts, the scope of work will be performed faster, respectively, by 10%, by 20%. The value of the sensitivity coefficient is K<1, it can be, for example, K = 0,9; K = 0.8, if, according to experts, the scope of work will be executed more slowly, respectively, by 10%, 20%.

Conclusions.

1. Structural chart of accounting for the probabilistic nature of construction production in the calendar planning.

2. There were developed the calculation dependencies of the work duration, both with the use of a set of construction machines, and without their use.

During the research, it was revealed:

The duration of construction is recommended to be determined taking into account the probabilistic nature of the construction process.

Risk is an important factor in the construction industry and its influence and impact only keeps increasing with infrastructure projects becoming ever more complex and therefore more exposed to high risks. Depending on the severity of the problem, the consequences can result in a heavy cost due to a failure or oversight in the risk evaluation. An assessment of the risk rating should provide an understanding of which risks are epymost affected for the particular organization of construction.

It has been analyzed the influence on the sensitivity coefficient of various factors, such as material resources, the number and qualification of workers, weather conditions.

It is planned to consider the determination of the duration for other various works taking into account the probabilistic nature of the construction industry in further studies.

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