# Analysis of Parallel Execution Of Construction Works

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**Abstract**. The construction of buildings and structures is a complex process, in which a large number of performers of various types of work take part. In order to shorten construction time, the front of the work is divided into seizures, the work on which is entrusted to various executors for the parallel performance of work. This feature of the construction underlies the concept of specialization and the streamlined organization of construction production. Determination of the rational size and number of seizures is one of the most important tasks in the design of the work plan for the work on the site. At the same time, the more the number of seizures, the shorter the duration of construction. However, the number of captures can not be increased arbitrarily. For a comfortable work, the brigade at the seizure requires the minimum necessary space for organizing workplaces. In addition, it is necessary to take into account the number of brigades available to the performer. When designing the flow organization of construction, it is necessary to determine the design parameters of the flows, and then perform their mutual coordination. The main design flow parameters are temporal (flow step, flow rhythm) and spatial (number of captures, processes, brigades) parameters. Calculation of these parameters must be performed in a complex for all flows: private, specialized, object and complex. Calculating parameters and designing flows allows you to develop a calendar plan in a concise and convenient form. With this organization of work, favorable conditions are created both for the work of contract organizations, and for the work of manufacturers of building materials, suppliers and other related organizations, as well as for storing materials at the construction site.

## 1. Introduction

It is known that productivity increases dramatically if the contractor performs the same work for a long time. The increase in productivity is occurs due to the acquisition and improvement of labor skills using special devices, equipment and tools. This pattern is the basis of specialization. Specialization involves the maximum division of any work into separate technological parts with the assignment of each of these parts to an individual contractor. No less important for productive work are such organizational factors as a complete and uniform production supply, uniform distribution of machines. Hence, there is a definition of the parallel execution method of construction. The parallel execution method is called such a method of construction organization, which provides a systematic and rhythmic production of finished construction products on the basis of continuous work of labor collectives of constant composition evenly supplied with material and technical resources. The use of the parallel execution method is caused due to the tasks and requirements of construction organizations to ensure the continuous production of works. The composition and number of teams for a fairly long period of time should remain constant on average, even in the construction of heterogeneous objects. This condition provides both a sustainable increase in productivity and the creation of a favorable socio-psychological climate in the team [1].

The parallel execution method ensures the uniformity of resource consumption and the rhythm of output of finished products. Parallel execution organization creates favorable conditions for the work of organizations of subcontractors: contractors, suppliers, transport and procurement organizations.

The task of the parallel execution design is to determine such parameters that, taking into account the rational technology and organization of work, provide the total duration of the construction of the complex within the regulatory limits.

Organization of the parallel execution method in construction involves:

1) identification of objects close to each other by space-planning and design solutions and technology of their construction;
2) the division of the construction into separate work equal to or a multiple of labor;
3) Fixing of certain types of work for certain teams of workers, establishing the sequence of inclusion in the parallel execution;
4) the Calculation of basic parallel execution parameters to ensure the simultaneity in the Association perform most of the work;
5) determining the sequence of the transition teams on the division.

The main issue of parallel execution calculation is to determine the possible reduction in the duration of construction, which would ensure the most efficient use of workers by saturating the front of work with available resources [1].

Classification of construction parallel executions can be carried out on the following grounds:

1) by product type: private, specialized, object and complex parallel execution.

Private and specialized parallel executions can have different directions, which depend on the volume-planning solution of the building, types of work performed. They can be horizontal, vertical, inclined and mixed. The horizontal direction of the parallel execution is carried out at the device of foundations, installation of structures of a one-storey building. The vertical scheme is used in the installation of multi-storey buildings.

2) by nature of rhythm (temporal development): a rhythmic, multi-bit and irregular.

The time parameters of the parallel execution are: the total duration of work on the parallel execution as a whole; the total duration of the parallel execution of all work by the teams on one division; the period of the parallel execution deployment; the total duration of each individual team's work on all divisions; the rhythm of the work of the brigade; the parallel execution step. The parallel execution step is calculated or set for each pair of adjacent process activities. For the construction parallel execution, the work of all processes which have the same rhythms, the steps are equal to the rhythms. Step and rhythm may differ in the presence of technological or organizational breaks.

From this it follows that the breaks can be 2 types: structural due to the volume (complexity and duration), established by calculation; organizational, due to technology and organization of work (defined and mandatory). Technological breaks between the works of related processes on the divisions are usually considered as reserves of time and corresponds to downtime. Breaks related to the technology of the work and related to the spatial constraint between the works. In physical sense, the first corresponds to the expectation in the network graph.

## 2. The integration and optimization aliquot (differently) rhythmic parallel executions

In differently rhythmic parallel executions (aliquot is a kind of multi-bit) to perform some processes can be taken the same rhythm of the teams, and for other processes several times larger. The integration of the work teams in this stream is produced graphically.

If the rhythm of the 1st brigade is higher than the rhythm of the 2nd brigade, the flows are link on the first division, and if less than the latter.

1) in the functioning of different-rhythmic parallel executions, in order to division not idle, seek to increase the number of workers in the teams with the highest rhythm and thus to equalize the rhythm of the least private parallel execution. However, this is not always possible, for various reasons: small scope of work, limited productivity of the crane, etc.
2) to Avoid these disadvantages may desire to ensure that processes commit to multiple teams (see Fig.). In this case, the number of teams is equal to the ratio of the greatest rhythm of the private parallel execution to the smallest.

The figure shows only one of the possible options, it may differ depending on the number of teams.

## 3. Calculation of parameters of non-rhythmic parallel executions

The mutual linkage of non-rhythmic parallel executions has some features due to the different duration of their operation on private fronts.

## 4. Linking of non-rhythmic parallel executions with non-uniform rhythm change

Mutual linking of non-rhythmic parallel executions with non-uniform rhythm changes is performed analytically (using a matrix). Of particular importance among the methods of optimization of construction parallel executions is the change in the order of inclusion of division in the parallel execution. This is because the positive effect is achieved without increasing the need for resources. This method of optimization is applicable in the design of a complex type of parallel execution; for the object parallel execution, its use is possible only in the case of structurally and functionally separate divisions (for example, the construction of a building consisting of various modules connected by transitions).

$$T=T_1+T_2+T_3+T_4+T_5 \quad (1),$$

where T1 - the duration of the preparatory period; T2 – the duration of the zero cycle; T3 – the duration of the construction of the above – ground part of the building; T4 – the duration of special works (electrical and plumbing); T5-the production of finishing cycle.

When the parallel execution (parallel-combined) scheme of organization of work (Figure 1) each subsequent stage of construction begins after the implementation of the previous stage. Thus, the continuity of construction production is achieved.

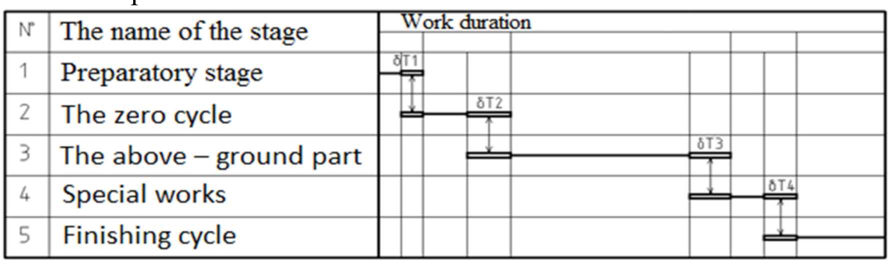


**Figure 1.** Scheme of organization of work.

This scheme provides a significant reduction in the duration of construction of the entire facility. And the higher the level of work combination, the shorter the duration (2).

$$T_{опт.}=K_1 \cdot T_1+K_2 . T_2+K_3 . T_3+K_4 T_4+K_5 \cdot T_5 \quad (2),$$

where K1, K2, K3, K4 and K5, respectively, the coefficients of the overlapping of operations between the stages of construction.

The construction object is divided into horizontal or vertical planes. Depending on the type of object and the scope of work, the direction of development of the streams is established. In this case, the number of seizures is determined depending on the number of sections, span of the building, and the number of tiers depending on the number of floors of the building. Combination of construction works can be carried out in two ways: internally aligned (for various types of work of the preparatory period) (Table 1), external (produced by splitting the construction site into seizures) (Table 2).

**Table 1.** The internally aligned.

| Catch number | Brigade No. | | | | $T_{ct}$ | $T_{rest}$ | $T_{o1}$ |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | j | | | |
| 1 | $t_1$ | $t_1$ | $t_3$ | $t_{1j}$ | $T_{ct1}$ | $T_{ct.1}$ | $T_{o1.1}$ |
| i | $t_4$ | $t_5$ | $t_6$ | $t_{ij}$ | $T_{ct.1}$ | $T_{ct.1}$ | $T_{o1.2}$ |
| $T_{brig}$ | $T_{brig1}$ | $T_{brig2}$ | $T_{brig3}$ | $T_{brig.j}$ | $\sum T_{захв}$ | $\sum T_{пер}$ | $\sum T_o$ |

Coefficient of overlap can be determined by the following formula (3)

$$K = \frac{t_{ij}}{t_{ij} + \sum T_{rest}}$$

:

The maximum degree of alignment of construction works is determined by the number of divisions, their size and type of work performed. The minimum size of the division is determined by the size of the plot, i.e. the amount of work performed by one crew during one shift. However, the principle of minimum division is not always applicable in practice. In fact, in the performance of construction work, for workers need a comfortable area that separates the production of one type of work from another. Therefore, when designing the schedule to lay the time interval that is parallel to and safe comfort to perform the work.

**Table 2.** The options for combining work.

| № | The name of the stage | The options for combining work | | Coeff. |
|---|---|---|---|---|
| | | Internal combination | External | |
| 1 | Preparatory | Combining when performing various types of work of the preparatory period | It is made by division of the territory of construction on captures (tiers) | $K_1$ |
| 2 | Zero cycle | | | $K_2$ |
| 3 | Above – ground part | | | $K_3$ |
| 4 | Special works | | | $K_4$ |
| 5 | Finishing cycle | | | $K_5$ |

## Conclusion

Thus, the degree of combination of construction works determines the number depending on the number of seizures. At each individual stage of construction, the coefficient can be very different. Most of the work can be combined during the erection of the above-ground part of the building.

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