Organizational and technological decisions in the construction of transport infrastructure facilities

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Abstract. In recent years, the technology of design and construction of buildings has changed significantly both in terms of applied structural solutions, and in terms of the use of construction machines, mechanisms, equipment. The recent significant qualitative leap in the development of methods and ways of organizing the implementation of individual technological processes and their complexes requires an improvement in the methodological approach to the adoption of organizational and technological decisions as part of the documentation developed during the design and construction of facilities.

1. Factors affecting the development and adoption of organizational and technological solutions
Organizational and technological solutions (OTS) are complexes of engineering measures developed for a specific object and the conditions of a particular construction site, ensuring technical feasibility, manufacturability, acceptable deadlines, resource consumption of the construction of the whole or its parts, subject to safety and environmental protection requirements.

They establish the rationale, methods and rules by which the requirements of the design documentation, production technology and safety, the conditions of the construction site and the environment are carried out during the construction of specific structures of the facility or its parts in specific conditions.

This coordination is carried out by the method of formulating a specific organizational and technological problem and a detailed justification of how to solve it that meets the specified requirements. The results of the development of organizational and technological solutions are organizational and technological schemes. [1]

Factors affecting the development and adoption of organizational and technological decisions are very numerous and diverse. They are determined by various aspects of construction in general and the conditions for the production of specific types of work: legal, administrative, hydrogeological, climatic, technological and installation, as well as the negative impact of construction work on the surrounding buildings. For each object of capital construction, various combinations of these factors determine the limitations in the implementation of technological processes.

Legal and administrative restrictions include land use rules, rules for the operation of buildings and structures (in the case of work on operated facilities), requirements for the preservation of certain elements of structures during reconstruction, maintaining public order, balance delineations, activities of a contractor listed in the SRO permit, the presence of certified specialists and several others.

The regulatory restrictions include the requirements for the development period, the content and execution of organizational and technological documentation.
Climatic restrictions begin to operate in the period of time during which it is necessary to provide the temperature and humidity regime required by the technology to complete the process. Climatic restrictions are overcome with the help of the following engineering works: construction of additional insulation layers that protect against freezing (for example, the bottom of the pit), heaters (for example, for facade or roofing work in an unfavorable season), temporary roofing, as well as cutting off cold traffic air (drafts when drying the plaster layer), or preventing local intense heating (to avoid uneven shrinkage and cracks when drying), or heating (hardening bet of the mixture and during the period of strength gain), or additional heating of the premises, etc. [2]

Hydrogeological limitations of the implementation of technological processes for the construction of the underground part of the structure are the influence of the intensity, aggressiveness and groundwater level with a connected or free surface on the selection of the necessary supporting engineering work, to prevent flooding of the foundation pit and corrosion of the mounted elements during earthwork, as well as the influence of static and dynamic properties of the soil mass of the foundation of the structure on the stability of slopes and the transmission of vibrations to foundations located near the construction construction sites with various methods of soil development, or strengthening the walls of the pit.

The technological and installation restrictions include compliance with the conditions of the construction site, space-planning and design decisions, the current construction readiness of the building to the technological requirements of the organization and technical equipment of workplaces for performing work operations, the rules for performing work operations as part of the manufacturing process, and safety requirements for specific work operations [3-9].

2. Application of a systematic approach to the development of organizational and technological solutions

As mentioned earlier, the development of OTS involves a multivariate complex analysis:
- space-planning, structural solutions and construction readiness of the structure at specific design elevations;
- geodetic, geotechnical, infrastructural town-planning features of the construction site, adjacent territory;
- the composition of the workflow of technological processes carried out at specific design elevations;
- technical characteristics of typical building mechanisms and technological equipment.

A comprehensive (system) analysis is performed according to the criterion of safety and rationality of the ways of performing work operations. At the same time, rationality should be understood as the balance (approximate equality) of the ratios of some parameters of the technological process while minimizing the mechanical work performed. The rationality criterion includes a balance of 4 ratios:

1 – the ratio of the required labor intensity, taking into account the performance of work with specialized equipment and providing engineering work ($Q_{\text{spec. eq.}} + Q_{\text{eng. work}}$), to the normative labor input of the technical process ($Q_{\text{norm}}$);
2 – the ratio of the mass of special equipment ($M_{\text{spec. eq.}}$) to the mass of standard equipment ($M_{\text{type eq.}}$);
3 – the ratio of volume (in meters of erected structures) ($V_{\text{spec. manual}}$) of the result of manual labor to volume ($V_{\text{spec. mech.}}$) of the result of mechanized labor by using special equipment and performing supporting engineering work;
4 – the ratio of the duration of the implementation of the engineering work ($T_{\text{eng. work}}$ and (de) installation of the special equipment ($T_{\text{spec. eq.}}$) to the duration of the normative work.

In the case of rational OTS, these ratios should be equal to each other and strive to a minimum, i.e. to regulatory methods for performing operations (1).

$$\frac{Q_{\text{spec. eq.}} + Q_{\text{eng. work}}}{Q_{\text{norm}}} = \frac{M_{\text{spec. eq.}}}{M_{\text{type eq.}}} = \frac{V_{\text{spec. manual}}}{V_{\text{spec. mech.}}} = \frac{T_{\text{spec. eq.}} + T_{\text{eng. work}}}{T_{\text{norm}}} \rightarrow \min$$ (1)
work is written as follows (2)

$$\sum_{i=1}^{N} b_i \int F_i dl \rightarrow \min$$

(2)

$N$ – the number of performed; $i$ – numbers of work operations; $F_i$ – the resultant force applied to the (de)mounted structure when performing the $i$-operation; $l$ – the mass trajectory of the (de)mounted structures during the $i$-operation; $a, b$ are the coordinates of the feed start point and the design position point of the mounted element.

The above criterion (1) and (2) serves primarily to analyze the initial data and to verify the OTS received by the method of a qualitative approximate estimate of the spread in the values of relations (1), but it also allows the quantitative assessment of rationality, the implementation of the relevant scientific rationale. [3]

According to the systematic approach, the formation of the system begins with the formalization. Of its purpose, or, what is the same, with the establishment of pre-set desired values of the parameters of the result of the interaction of elements (so far unknown) of the system with each other and with the external environment. The most general formalization of the system is performed by the method of composing a predicative expression starting from the set of parameters of the desired result (the right side).

For instance: In the case of construction and management of the system “technology of building production” (TSP), the $S_{TSP}$ system can be formalized as follows:

$$\exists S_{TSP} \subseteq \{(Ob_{TSP}) U (T_c) U (T_{ch}) U \{M\} \times \{K\},$$

$$S_{TSP} \equiv \{El_{te}\} U {Org(Kmp_{proc})}: \{(Ob_{TSP}) U (T_c) U (T_{ch}) U \{M\}) \rightarrow \{K\}$$

(3)

$\{Ob_{TSP}\}$ – the set of parameters of the part of the structure being erected within the capture; $\{T_c\}$ – many labor parameters: the number of jobs, work operations performed; $\{T_{ch}\}$ – a set of installation parameters for equipping workplaces (technological process) with construction machines and mechanisms: weight, size, number, drive; $\{M\}$ – a lot of installation parameters of material resources: weight, size, ductility, physical and chemical activity with the environment and with other structures; $\{K\}$ – many technical parameters (quality) of the finished structure; $\{El_{te}\}$ – many parameters of standard technological equipment; $Org\{Kmp_{proc}\}$ – operator (rules, order) for organizing the components of the $S_{TSP}$ TSP system: performing work operations at workplaces in the process mode using technological equipment, inventory and means of conditioning).

In the case of construction and management of the system “organization of construction production” (OSP), the $S_{OrgSP}$ system is formalized as follows:

$$\exists S_{OrgSP} \subseteq \{(KP) U \{SGP\} \times \{Ob_{OrgSP}\},$$

$$S_{OrgSP} \equiv \{El_{tp}\} U (TR) \times \{KP\} U \{SGP\} \rightarrow \{Ob_{OrgSP}\}$$

(4)

$\{KP\}$ – the set of schedule parameters; $\{SGP\}$ – many parameters of the construction plan; $\{Ob_{OrgSP}\}$ – many parameters of the constructed structure; $Org\{El_{tp}\} U (TR) \}$ – operator (rules, order) of the organization component of the OSP system “construction economy”; $Org$ – operator (rules, order) of the organization component of the “technological processes and their complexes” OSP system.

The normatively accepted criterion for managing such a system for the organization of construction production is known, this is ensuring the estimated duration of the construction $- T_{plan}$. Formalization of the $S_{OrgSP}$ system managed by this criterion can be performed as follows:

$$\exists \{T_{plan}\} \subseteq \{(KP) \cap \{SGP\} \times \{Ob_{OrgSP}\}.$$  

(5)

Where the main parameters of the construction time $T_{plan}$ are:
- methods of organizing construction work;
- normative estimated durations of technical processes and their complexes at the construction fronts;
- spatial parameters of fronts;
- \( N_{\text{max}}, N_{\text{aver}} \) – the maximum and average number of workers at the construction site;
- the number and performance of leading mounting mechanisms;
- stock standards.

Depending on the task and the chosen control criterion, other formalizations of various systems for the organization of construction production. More over, as practice shows, the systems of organization of construction production can replace each other and be activated at different periods of the construction of the structure. [4]

In the case of the construction and management of the system "organizational and technological solutions for the implementation of the technical process at specific project marks", the \( S_{\text{OTS}} \) system is formulated as follows:

\[
\exists S_{\text{OTS}} \subseteq \left\{ \{Ob_{\text{OTS}}\} \cup \{T_p\} \right\} \times \{K_{pp}\}, \\
S_{\text{OTS}} \equiv \{E\{\text{spec}\}\} \cup \text{Org}\{Kmp_{\text{OTS}}\} : \left\{ \{Ob_{\text{OTS}}\} \cup \{T_p\} \right\} \rightarrow \{K_{pp}\}
\]  

\( \{Ob_{\text{OTS}}\} \) – the set of parameters of the OTS object; \( \{T_p\} \) – many technical process parameters: the number of jobs, work operations performed and their technical equipment; \( \{K_{pp}\} \) – many design parameters in the design position; \( \{E\{\text{spec}\}\} \) – many parameters of special equipment and providing engineering work; \( \text{Org}\{Kmp_{\text{OTS}}\} \) – operator (rules, order) for organizing the components of the \( S_{\text{OTS}} \) of OTS: labor and workplaces for performing technological operations using special equipment, as well as for specialized workplaces for performing engineering work.

3. The order of development of organizational and technological solutions

After the adoption of any development logic OTS perform:
- the establishment of factors affecting the methods and safety of the performance of work operations of the process;
- restoration of the design scheme for the joint work of the (de) mounted structure and existing building readiness, points of application, occurrence and direction of efforts in the structures during (de) installation;
- the rationale for the implementation of work operations;
- establishment of the nomenclature (projected) of specialized technological equipment, as well as the nomenclature of supporting engineering work;
- determination of the procedure for performing work operations of the technical process and supporting engineering work;
- performing calculations and designing special technological equipment and its testing. [5]

### Table 1. General procedure for the development of OTS.

| OTS development procedure | Intermediate result for the formation of the source data | Intermediate result for the adoption of OTS |
|--------------------------|--------------------------------------------------------|------------------------------------------|
| 1. The statement of the organizational and technological task (OTK) of the implementation (complex) of the technical process in specific project marks. | Table of conditions, as well as restrictions on the construction of parts of the structure, the performance of the process (es), or work operations | 1. The established logical connections of the parameters of the technical process (es) and the parameters of the structure |
| 2. Restoring the scheme of | Initial data for the | 2. Initial data for the development of OTS. |
|                          |                          | 3. The rationale for the adoption of OTS. |

4
maximum redistribution of efforts in (de)mounted elements and structures of building readiness arising from a specific work operation

development of special technological solutions

special technological solutions (equipment).

2. Substantiation of private organizational schemes for the implementation of work operations and supporting engineering work

2. The rationale for supporting engineering work.

3. Design / selection:
   - technical means of performing engineering work;
   - means of mechanization of those processes;
   - special equipment

Initial data for the development of private organizational schemes for the implementation of work operations and supporting engineering work

1. The source data for the development of private organizational schemes for the implementation of work operations, or process technology.

2. The initial data for the development of a general organizational scheme for the implementation of the process

4 The choice of methods, or the formation of the sequence of execution (complex) of technological processes, or the choice of methods for performing work operations and providing engineering work that meets the requirements of OTK.

5. Development of private organizational schemes for performing work operations

Initial data for the development of a general organizational scheme for the technical process

1. Correspondence of the mounting assemblies of equipment to design design solutions and construction readiness.

2. The rationale for the implementation of work operations

2. Preliminary textual description and graphic representation of the technical process execution order, or work operation, providing engineering work, notes and instructions.

3. Justification of the general scheme of the technical process.

1. Substantiation of private schemes for performing work operations and providing engineering work.

5. Development of private organizational schemes for performing work operations and supporting engineering work

Initial data for the development of a general organizational scheme for the technical process

In the more rare case of the organizational and technological task “the formation of the spatial structure of the technological flow from the complexes of technological processes” at specific design elevations, the development of OTS is reduced to determining the boundaries and the order of development of the grips, plots and assembly tiers by various technological processes, with their permissible spatial approximation on the plots and assembly tiers and combining on grips. The boundaries of the grips, plots and assembly tiers of technological processes are determined by the selection and determination of parking points (service areas) of the leading mechanisms of the technological processes based on an analysis of the relationships between the parameters of technological processes, space-planning and design decisions, and compliance with the technological sequence. As a rule, this kind of organizational and technological problems arise when attaching new buildings to existing ones while reconstructing existing buildings, while conducting work on closely
located (parts) of structures, different assembly tiers or grips, with unfavorable ratios of space-planning and design decisions and urban development characteristics of the site. [6]

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