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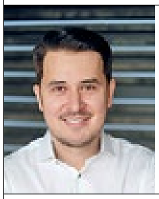
Methodology for calculating the production cycle in industrial real estate construction taking into account ecological aspects

Ecology is a science that encompasses the existing connections between humans and the environment. Ecological relationships are distinguished not only by their diversity but also by their complexity. Their characteristic feature is that many of them cannot be studied using traditional methods. As a result, many types of natural resources suffer irreparable damage.
Construction most actively interferes with established natural processes.
The most important disruptions to the natural environment during the construction process include: loss of vegetation layer due to large volumes of earthworks; deforestation and clearing of greenery, disturbance of fauna and flora development conditions, as well as the upper soil cover; changes in groundwater levels causing flooding of agricultural land and populated areas.
Currently, there is a reduction in landscape disruption, water and wind regimes, damage to soil and vegetation cover, pollution of water and air basins, atmosphere and soil cover, and noise and light effects are being mitigated. During the construction process, violations in the natural environment are restored through reclamation of disturbed lands, preservation and reuse of the humus layer; necessary treatment facilities and air purification installations; creation of protective dams, use of unsuitable and swampy areas for construction development; preservation of the natural regime of rivers and landscape; maintaining proper order in the territory used by construction organizations, construction industry enterprises, and building materials industry; prevention of contamination of the territory with by-products and production waste.
Keywords: *ecological connections, reserve territories, indicators of construction production of the developer-builder, subcontracting plans, industrial complex backlog norm*



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I. The GENERAL PART

The construction system, from the perspective of social division of labour, develops in accordance with the nature of the functioning of national economy sectors. Hence, the organization of environmental protection is carried out in two directions: *first*, construction objects of the main industries are equipped with modern technical means ensuring environmental protection; *second*, territorial concentration of construction is implemented, contributing to the widespread use of special large facilities for the protection of the natural environment and the economic use of its components [1].

Increasing complexity in the development of construction leads to more efficient use of local resources and protection of the natural environment. It is necessary to implement progressive forms of organizing associated productions and to rationally locate them, taking into account production and economic connections.

The most significant factor limiting the formation of new construction is land use. The size of the territory for development is strictly limited. In the near future, the possibility of alienating land from agricultural circulation for industrial development will be completely excluded. In connection with this, extensive work is being carried out to identify reserve territories in cities, urban-type settlements, and villages by analyzing the density of residential and industrial development. Inventory data are taken into account in the process of construction preparation. The task of construction is the timely and complete implementation of all special technical means of environmental protection at facilities [2, 3].

II. LAND RESOURCES AND EFFICIENCY OF THEIR USE FOR DEVELOPMENT

The territorial orientation of construction infrastructure determines the need for rational land use.

In order to increase the achieved level of territory use within the boundaries of cities and enterprises, sands, land plots overgrown with shrubs, peatlands, ravine areas, and marshes should be used. Reserve land plots are located in areas inconvenient for construction on uneven terrain, marshes, etc. Construction polygons, bases, warehouses, etc. can be located on these sites in the process of preparing them for development [4].

It is advisable to identify and study reserve territories for construction according to the following methodology. Data on free territories in cities and other settlements that can be used for construction are accumulated in the form of reference catalogs (passports) of reserve sites. The passport of each construction site is developed based on data from schemes and projects of district planning, master plans of settlements, materials from municipal land authorities, state supervision bodies (water, sanitary, etc.), as well as on the basis of schemes of master plans for industrial enterprises and their complexes [5].

Each construction site has specific placement conditions, so the correct choice of construction points significantly affects the efficiency of capital investments.

The compilation of the list of sites is carried out in two stages. At the first stage, construction sites are identified based on the general labour and other resources of the area under consideration, as well as the existing placement of industry and transport. Sites with an area of over 10 hectares and located no more than 10–15 km from railways, settlements, and water supply sources are considered promising. The area of the certification site should be at least 5 hectares.

For each site, indicators of economic efficiency for development are determined for all possible levels of need for multipurpose resources [6].

The following constraint must be observed:

$$M_{ik} < R_{ik}, \tag{1}$$

where M_{ik} is the set of possible needs for the i-th resource; R_{ik} is the availability of the i-th resource for the k-th site in natural measurements (t, m^3).

Based on the above calculations, the list of sites is ranked by the minimum amount of reduced costs for their preparation and transfer for development.

III. ECONOMICS OF CONSTRUCTION PRODUCTION

The production program is the main part of the work plan for each development company [7].

At the same time, the nomenclature of construction production in development activities is very extensive. The quantitative characteristic of objects being built simultaneously according to several projects is given in units of measurement of their main features: area, capacity, etc. Their natural measurers are: m^2, t, pcs., etc. The capacity of the created production facilities, for example, a cement plant, is measured in thousands of tons of cement output per year.

The entire volume of construction products can be combined only in monetary terms (in rubles). Estimated prices are used to account for construction products.

The indicator of readiness of construction objects K_{pi}, %, characterizes the level of readiness of the object for commissioning and is determined by the formula:

$$K_{pi} = O_{ki}/O_{mi} \cdot 100 \cdot 100. \tag{2}$$

where O_{ki} is the volume of contract works submitted to the customer from the beginning of construction of the object until the beginning or end of the planned year, thousand rubles; O_{mi} is the estimated cost of construction and installation works of the object, thousand rubles [8].

The indicator of contract work volumes submitted to the customer B_{pi}, %, characterizing the volume of construction and installation works performed for the stage, start-up complex, object and submitted at the beginning or to be submitted at the end of the planned year, in the total estimated cost of construction and installation works of the object, stage, or start-up complex, is determined by the formula:

$$B_{pi} = O_{Bi}/O_{mi} \cdot 100 \cdot 100. \tag{3}$$

where O_{Bi} is the volume of contract works submitted to the customer from the beginning of construction to the beginning of the planned year and to be submitted at the end of the planned year, thousand rubles [9].

The indicator of incomplete construction production Z_{pi} is defined as the difference between the indicators of construction readiness of the object K_{pi} and the indicator of contract work volumes submitted to the customer B_{pi}:

$$Z_{pi} = K_{pi} - B_{pi}. \tag{4}$$

IV. DEVELOPMENT OF The CONTRACTOR'S WORK PLAN BY The DEVELOPER-BUILDER

In accordance with the standards of construction duration, the plan for commissioning production capacities and facilities is broken down by quarters, and title lists are reviewed. Backlog standards serve as the initial basis for planning the volumes of construction and installation works for delivered and transitional construction objects, planning incomplete construction production, and distributing the plan by quarters [10].

When developing the plan for co ntract construction and installation works, the standards of construction duration, backlog standards for the construction of objects in various industries, and estimated standards are used.

The indicator of the volume of construction and installation works for the construction organization is calculated. This indicator serves as the basis for determining: the consolidated need of this organization for material and technical resources, the size of the wage fund, working capital, and loans. Commissioning and work volumes are established for each object by quarters. A statement of work volumes in natural measurers by objects is attached to the construction production plan [11].

When drawing up the annual production program of a contracting organization, special attention must be paid to creating an optimal construction backlog. In construction, which is characterized by a long production cycle, there is a natural need to create backlogs that ensure the normal functioning of technological processes. Construction backlog is a specific concept that characterizes the degree of preparation of construction conditions and ensuring the continuity of the construction backlog process; it is measured by physical and cost indicators, which are standardized in relation to the natural and sectoral features of construction [12].

In industrial construction, the backlog is determined for individual enterprises, their stages, and start-up complexes.

The main indicators of the regulatory backlog are: readiness of the construction object for commissioning; intermediate commissioning of technological stages and work packages; remainder of the regulatory backlog at the end of the quarter.

The readiness of the object (U_g, %), is determined by the ratio of the volume of capital investments realized from the beginning of construction to the end of the quarter, K_a to its estimated cost:

$$U_g = K_a/S_s \cdot 100. \tag{5}$$

The intermediate commissioning of technological stages and work complexes at the end of the quarter M_k, %, is determined by the ratio of the estimated cost of their part to be commissioned for the period from the beginning of construction to the end of the given quarter M, to their total estimated cost S_e:

$$M_k = M/S_s \cdot 100. \tag{6}$$

The remainder of the regulatory backlog is the difference between the readiness of the object U_g and the intermediate commissioning of fixed assets for this object M_k. The absolute value of the backlog at the end of the quarter is expressed by the difference between the volume of capital investments realized since the beginning of construction and the cost of fixed assets put into operation during this period.

When compiling operational, tactical, and strategic planning of capital investments for industrial construction and non- production facilities, the backlog can be determined using the following methodology: the backlog is calculated by the capacity of the enterprise or facility, the commissioning of which will ensure the implementation of the normative duration of their construction; the norm of backlog readiness; the relative size of incomplete construction. The value of the backlog by the capacity of enterprises or construction objects, the completion of which will allow putting them into operation in accordance with the normative terms of construction duration. The norm of the backlog by capacity is equal to the product of its average annual size, envisaged for commissioning over a number of years, by the average normative duration of construction of enterprises in the backlog. The ratio of the difference between the total design capacity of enterprises under construction and their commissioned capacity to the capacity planned for commissioning in the upcoming period by industry [13]. The indicator of the readiness of the construction backlog reflects the volumes of capital investments that should be realized in the normative terms for backlog construction sites. It is defined as the ratio of capital investments that should be mastered on backlog objects to the estimated cost of these objects without the cost of previously commissioned main stages. The norm of object readiness N_g is equal to:

$$N_g = \frac{K_o - K_f - K_p}{S_o - S_f - S_p} \cdot 100, \qquad (7)$$

where K_o, K_f and K_p are capital investments, respectively total at the date of determining the backlog, realized on commissioned funds from the composition of backlog construction, on auxiliary and service objects from backlog construction; S_o, S_f, S_p are the estimated cost, respectively full at the date of determining the backlog, of commissioned funds from the backlog and other objects [14].

The backlog for capital investments is expressed by the following relationship:

$$Z_k = (B_1G_1 + B_2G_2 + B_3G_3 + B_4G_4)/100, \qquad (8)$$

where Z_k is the backlog according to the estimated cost of residential buildings planned for delivery next year, %; B_1, B_2, B_3 and B_4 are the distribution of the total area of housing commissioned respectively by quarters of the year, %; G_1, G_2, G_3 and G_4 are the readiness of houses by the end of the year, ensuring their commissioning in the corresponding quarters, %.

The backlog for the total area of houses Z_p, %, is determined by the formula:

$$Z_p = \sum(B_1 + B_2 + \ldots + B_{i-1})/S, \qquad (9)$$

where B_1, B_2, ..., B_{i-1} are the total area of houses put into operation during 1, 2, ..., months, starting from the first month, ml; $(i-1)$ is the duration of construction of one house, months; S is the total area of houses put into operation in the calculated period, ml.

The volume of incomplete construction production for works performed by own forces at the end of the planning period, $Q_{own.e.p.p.}$ is determined by the formula:

$$Q_{own.e.p.p} = Q_{own.b.p.p} + Q_{own.c.w} - Q_{own.c.p}, \qquad (10)$$

where $Q_{own.b.p.p}$ is the volume of incomplete construction production for works performed by own forces at the beginning of the planning period; $Q_{own.c.w}$ is the volume of contract works performed at the construction of an enterprise or object in the planning period by own forces; $Q_{own.c.p}$ is the volume of commercial construction products for the enterprise or object, performed by own forces, to be delivered to the customer in the planning period.

The total volume of incomplete construction production for the enterprise under construction, the start-up complex, or the object at the end of the planning period $Q_{total.e.p.p}$ is determined by the formula:

$$Q_{total.e.p.p} = Q_{total.b.p.p} + Q_{own.c.w} + Q_{sub} - Q_{total.c.p}, \qquad (11)$$

where $Q_{total.b.p.p}$ is the total volume of incomplete construction production at the beginning of the planning period; $Q_{own.c.w}$ is the volume of contract works performed at the construction of an enterprise or object in the planning period by own forces; Q_{sub} is the volume of commercial construction products accepted in the planning period $Q_{total.c.p}$ of construction products planned to be delivered to the customer in the planning period.

The total volume of incomplete construction production recorded on the balance sheet of the contracting organization at the end of the planning period $Q_{total.b.e.p}$ is determined by the formula:

$$Q_{total.b.e.p} = Q_{total.e.p.p} - Q_{w.p}, \qquad (12)$$

where $Q_{w.p}$ is the estimated cost of construction and installation works performed at the beginning of the planning period under general and direct contracts (including the volumes of work performed by subcontracting organizations) and delivered to the customer.

V. SYSTEM OF INDICATORS OF The VOLUME OF CONSTRUCTION PRODUCTION PRODUCTS

The system of cost indicators of the volume of construction products used in the planning and accounting of construction production is formed based on economic, organizational, and other features of capital construction. These primarily include the structure of construction activities, the measure of participation in production, forms of specialization, the system of contractual relations, sources of financing, forms of subordination, territorial placement, features of the technology of construction production, etc. [15].

Taking into account the features of the organization and functioning of capital construction noted above, the system of indicators of the volume of construction production products is formed according to the following main characteristics:

1. By stages of construction activity:
   - produced construction products;
   - commercial construction products.
2. By the nature of contractual relations:
   - construction products under general contracts;
   - construction products under direct contracts;
   - construction products under subcontracts.
3. By sources of financing at the expense of:
   - state capital investments;
   - public-private partnership funds;
   - specialized funds;
   - population funds;

- funds from authorized regional and territorial sources of financing.

4. By the nature of participation in cooperative construction production:
   - construction products produced by the contractor's own forces;
   - construction products of involved organizations;
   - construction products produced economically.
5. By subordination and territorial placement of products produced by own forces (under subcontracting agreements), for organizations subordinate to:
   - their association, construction groups;
   - other construction groups.
6. By subordination to the territorial placement of products of involved organizations, subordinate to:
   - their association, construction groups;
   - other construction groups.

The results of the work of the developer-builder, as well as construction production as a whole, are characterized by a system of product indicators, in which construction activities are considered as a single process of production and implementation (delivery to customers) of construction products. In accordance with this economic content, two subsystems of indicators are formed — the volume of produced products and the volume of commercial construction products (delivered to customers), having different economic meanings and purposes. Indicators of the volume of produced products characterize the volume of construction production (gross volume of construction and installation works) regardless of the sale of products. Indicators of the volume of commercial construction products are used to assess the final result of the production activities of construction companies.

When building large industrial, transport, and other complexes, dozens of subcontracting organizations participate in the order of production cooperation. At the same time, subcontractors are responsible only for the works entrusted to them, while general contractors are responsible for all works at the facility and the construction site as a whole, i.e., for works performed both by their own forces and by subcontracting organizations. The peculiarities of production relations between construction organizations, the nature of the functions they perform in joint construction find expression in the system of construction product indicators.

When determining the value of the total volume of commercial construction products, the finished products of the developer-builder are taken as a basis.

The stage and complex of works in the composition of this indicator are accounted for:

- the cost of works on start-up complexes and objects delivered to customers under direct contracts;
- the cost of completed complexes of works (on site improvement; works not included in the start-up complex) on previously delivered special objects to the customer;
- the cost of completed construction and installation works delivered to the general contractor at enterprises and objects under construction under subcontracting agreements;
- the cost of completed technical stages delivered to the general contractor at objects under construction;
- the cost of works on completed capital repairs of buildings and structures;
- the cost of other contract works.

VI. FINAL PART

When calculating construction organizations for a finished object, the estimated cost for the object is included in the commercial construction products after the complete completion of its construction in the volume and composition of works provided for by the project and estimate, and its delivery to the customer. The cost of works on technological stages and complexes of works is included in the commercial construction products of the organization after their complete completion in the volume and composition provided for by the estimate.

The composition of realized construction products differs from the composition of commercial construction products for the corresponding period in that the realized construction products do not include: the volume of works on unfinished objects and completed but not delivered to the customer objects, volumes of works delivered to the customer, the construction of which was not provided for by the plan; the estimated cost of sold products, the proceeds from which did not arrive at the settlement account by the end of the planning period.

When determining the volume of realization of construction products, the full cost of works on completed objects is taken into account, regardless of when they were started, and not just the cost of works performed in the reporting period. For example, if some works on the object were not completed in the preceding period, then the estimated cost of works on them will not be accounted for in the organization for this period in the realized products. In the next reporting period, after the completion of all works on the object and its acceptance by the customer, the estimated cost of works of this object (including the result of the previous year) will be credited to the realized construction products. For example, the total volume of works delivered to customers for the reporting period amounted to 16,707 million rubles. The volume of works on completed and delivered to the customer objects approved for this reporting year will amount to: 12,500 + 1,134 + 915 + 1,120 = 15,792 million rubles. The realized products did not include: the volume of completed but not delivered to the customer works on the boiler house — 440 million rubles, the volume of works delivered to the customer on a residential house, the construction of which was not provided for by the plan of the given year — 915 million rubles.

The fulfillment of the plan for the realization of construction products in the reporting year was: 15,792/16,232 = 97.3 %.

When calculating the volume of these works, double counting of individual and accepted types of works should be avoided.

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Методика расчета производственного цикла при строительстве промышленной недвижимости с учетом экологических аспектов

Экология — это наука, охватывающая существующие связи между человеком и окружающей средой. Экологические связи отличаются не только разнообразием, но и сложностью. Их характерная особенность заключается в том, что многие из них не поддаются изучению традиционными методами. В связи с этим многим видам природных богатств наносится непоправимый ущерб.

Строительство наиболее активно вмешивается в сложившиеся природные процессы.

К важнейшим нарушениям природной среды в процессе строительства относятся: потери растительного слоя в связи с выполнением больших объемов земляных работ; вырубка зеленых насаждений и леса, нарушения условий развития фауны и флоры, а также верхнего покрова почвы; изменение уровня грунтовых вод, вызывающее подтапливание сельскохозяйственных угодий и населенных мест.

В настоящее время уменьшаются нарушения ландшафта, водного и ветрового режима, повреждение почвенного и растительного покрова, загрязнение водного и воздушного бассейнов, атмосферы и почвенного покрова, погашаются шумовые и световые эффекты. В процессе строительства восстанавливаются допущенные нарушения в природной среде путем рекультивации нарушенных земель, сохранения и повторного использования гумусового слоя; необходимых очистных сооружений и воздухоочищающих установок; создания защитных дамб, использования под строительную застройку негодных и болотистых местностей; сохранения природного режима рек и ландшафта; наведения надлежащего порядка на территории, используемой строительными организациями, предприятиями строительной индустрии и промышленности строительных материалов; предотвращения загрязнения территории попутными продуктами и отходами производства.

Ключевые слова: *экологические связи, резервные территории, показатели строительного производства девелопера-застройщика, планы подрядных работ, норма задела промышленных комплексов*

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