Development of the methodology of calendar planning in the system of organizational and technological preparation of capital repair of multi-apartment residential houses

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Abstract. The features of the repair and construction work during the overhaul of buildings are reflected in the development of organizational and technological design documents, which include calendar plans. Organizational and technological models represent the basis for the development and calculation of calendar plans, as well as for determining resource requirements. They for prevention works, the order of their implementation, the nature of the relationship between individual works, reflecting the specifics of the selected technology for the production of work and the features of the simulated object. The scheduling of overhaul works is carried out on the basis of the developed methodology, which allows obtaining rational organizational and technological solutions with a low level of certainty of the initial information. To evaluate the final set of alternative options for calendar plans and choose the best option in accordance with the described methodology, it is recommended to use quasi-metric methods. This allows us to lay the foundation for the rhythmic and coordinated work of all units involved in overhaul at the stage of scheduling, as well as to keep track of the possibility of ensuring timely completion of the planned work.

1. Introduction
For prevention of emergency and dilapidated condition during the operation of buildings and structures associated with the laws of the physical and moral deterioration processes, planned measures are taken to overhaul the common property of multi-unit residential buildings, aimed at improvement of the state of the housing stock.

Repair and construction production has a variety of the specific features, which significantly distinguished it from construction. Repair and construction work, as a rule, is carried out in extremely cramped conditions, which determines the specific technology and organization of their implementation, the use of special equipment, mechanisms, tools, devices.

One of the important directions for improving the forms and methods of organizing the overhaul of residential buildings is the creation of an integrated production preparation system based on the wide practical use of modern methods for solving organizational and technological problems.
2. Materials and Methods

One of the main stages in the preparation of repair and construction production is the development of a project for the organization of repair and construction works, calendar plans are one of the most important components of these works.

The development of calendar plans is an important task of organizational and technological design, the optimal solution determines the choice of the technological sequence of work and spatial development of flows, the degree of their combination, as well as the calculation of the parameters of calendar plans.

In theoretical terms, scheduling is one of the areas of operations research, in which the theory and methods of solving optimal ordering are developed in time of a finite set of work performed under given conditions using given resources.

Using modern methods of organizational and technological design, the basis for the development and calculation of calendar plans, as well as for determining resource requirements, become organizational and technological models, which describe the entire complex of works, the order of their implementation, the nature of the relationship between individual works, reflecting the specifics of the selected technology for the production of works and the features of the simulated object.

The method of automated formation of organizational and technological models is based on the logical and mathematical representation of the model elements and their interaction, which allows one to take into account the multi-variability of the parameters characterizing the models and form many alternative options on their basis, by analysis there is choice of the best organizational and technological solution.

For the practical implementation of the method of automated formation of organizational and technological models, the following parameters are required:

- nomenclature of works;
- technological dependencies between works;
- spatial parameters of overhaul facility;
- volume of works;
- characteristics of the resources needed to carry out the works.

When solving the problems of optimal scheduling based on organizational and technological models produce:

- determination of the topology of the model, corresponding to the rational technology of work;
- mutual coordination of work with the determination of the estimated duration of repair (modernization, reconstruction) of an object or group of objects;
- calculation of time parameters for certain types and for the whole complex of repair and construction works;
- the formation of many options for organizational and technological models with different technological sequence of works, with various schemes of spatial development of works and with different conditions for the repair and construction works at the facility [1].

The compilation task of the rational calendar plan for the overhaul of buildings (or their complexes) in mathematical form can be written as follows:

\[
\begin{align*}
\max_y y_j & \rightarrow \min_j \\
y_j &= \max_i \left( y_i, x_{ij} \right) + a_j, \ j \in J; \\
\sum_{i \in I} b_i \Theta \left( y_j - y_i \right) \times \delta \left( y_i - y_j + a_j \right) &= C, \ i \in J; \\
y_j &\leq d_j, \ j \in J; \quad y_j \geq G_i, i \in I;
\end{align*}
\]

where \( y_j \) is the moment of completion of the \( j \)-th work;
\( a_j \) is the duration of the \( j \)-th work;
\( J \) is a lot of works;
\( b_j \) is the intensity of consumption of non-stored resources of the \( j \)-th work;
\( C \) is maximum allowable consumption intensity of resources being simultaneously performed by the work, corresponding to the capacities of construction industry enterprises;
\( d_j \) is directive (estimated) deadline for the \( j \)-th work;
\( G_{ij} \) is accepted technological sequence of works;
\( \Theta (x), \delta (x) \) - indicators (characteristic functions), uniquely determining the probability distribution: \( x \in X_{ij} \), where \( X_{ij} \) is the desired rational technological sequence of works [2].

\[
\begin{align*}
\Theta (x) &= \begin{cases} 1 & \text{for } x \geq 0; \\
0 & \text{for } x < 0
\end{cases} \\
\delta (x) &= \begin{cases} 1 & \text{for } x > 0 \\
0 & \text{for } x \leq 0
\end{cases}
\end{align*}
\]

\( X_{ij}G_{ij} = \begin{cases} 1 & \text{at the beginning of the } j \text{-th work after the end of the } i \text{-th work;} \\
0 & \text{at the beginning of the } j \text{-th work until the end of the } i \text{-th work.}
\end{cases} \)

The second important stage after preparation of repair and construction production is an assessment of quality of the project of the organization of repair and construction works. The main methods of qualimetry reveal the nature and content of methods for measuring and quantifying the quality of the organization of repair and construction works, according to its various characteristics (functional and operational capabilities, technological and cost characteristics, etc.) (Fig. 1), i.e. product evaluation at the horizontal level, on the one hand. On the other hand, the main methods of qualimetry reveal ways of combining measurements and estimates of individual characteristics of the organization of repair and construction works into ever wider groups and categories, ending with a single integral assessment - this is the assessment of products at vertical levels.
Figure 1. Classification of qualimetric estimates of the organization of repair and construction works at the horizontal level (developed by the author)

In qualimetry, quality is considered as a hierarchical aggregate (Fig. 2) such properties that are of interest to consumers of this product of labor. At the initial (zero) level of the hierarchical set of properties, quality is accepted as some of the most generalized, complex property of the organization of repair and construction works, and its constituent less generalized properties - at a higher (first) level of the hierarchy, etc.

Thus, it can be formulated as follows: the property of the \( i \)-th level of product quality is determined by the corresponding properties of the \( (i + 1) \)-th level \( (i = 0, 1, 2, ..., t) \).
Figure 2. Quality as a hierarchical set of properties of the organization of repair and construction works
(developed by the author)

3. Results and discussion
The methods developed by well-known scientists make it possible to carry out scheduling with varying degrees of detail of the schedules at various levels of certainty of the initial information [1,3]. Innovative and technical solutions for environmental sustainability in the construction and management of urban housing and communal services developed by scientists [4-7]. The most promising method for scheduling repair and construction production seems to be a technique that allows you to obtain rational organizational and technological solutions with a low level of certainty of the initial information, which consists of:
- directive predetermined duration works;
- information on the composition and technological sequence of the implementation of certain types of repair and construction works;
• data on the breakdown of the common front into private fronts.

This technique allows to determine the duration of types of repair and construction works at facilities, the duration of certain types of work on private work fronts, the start and end dates of types of work on objects and private work fronts, as well as to form, calculate and optimize on the basis of the results obtained. Schedules according to the selected criterion (usually temporary) by changing the order of input into complex streams of object streams. Schedules are drawn up for the following varieties of stream management:

• with continuous performance of critical works identified taking into account resource and frontal ties;
• with continuous use of resources;
• with the continuous development of private fronts at facilities;
• with the continuous implementation of critical works identified taking into account resource, frontal, rank and special ties.

With the stream-organization of work at facilities with continuous performance of critical work, the minimum duration of the entire complex of work is ensured, which increases the efficiency of repair and construction production. Many studies of construction works based on the researching in the sphere of housing and communal services [8-11,15-21]. Some studies of complex of construction works, their parameters are devoted to the technical solutions in the ecodesign [12-14].

Stream organization of work with continuous use of resources makes it possible to reduce the duration of the types of work, which allows the most efficient use of specialized stream s in time.

With the stream organization of work with the continuous development of private fronts, the minimum duration of the complex of works at each object is guaranteed.

To assess the final set of alternative options for calendar plans and select the best option in accordance with the described methodology, it is recommended to use 12 evaluation indicators, called differential criteria for evaluating calendar plans [3]. These include:

• timeliness of a complex of works;
• correspondence between need and availability of resources;
• resource efficiency over time;
• combination of work;
• continuous use of resources over time;
• uniform use of resources over time;
• criticality of work;
• continuity of development of work fronts;
• optimality of resource saturation of the fronts of work;
• the effectiveness of the use of resources over time along with the efficiency of the development of the fronts of work;
• distribution efficiency of financing;
• minimum duration of the work package.

The assessment is carried out by qualimetry methods based on the analysis of the results of expert surveys.

4. Conclusion

The task that has to be most often solved in the process of designing the organization of repair and construction production is the formation and calculation of irregular streams with unequal sizes of private work fronts. This is due to the heterogeneity of residential buildings undergoing repairs, as well as different volumes of work on the same grips, due to different technical conditions of the same structures, elements, systems in different parts of the buildings being repaired.

The spatial parameters of the stream during the overhaul of buildings almost always determine its irregularity.

This analysis allows us to argue that in the repair and construction industry the main method of organizing work will be a specialized stream, the products of which are the same type of structural elements, or the same types of work. At the same time, the more buildings are simultaneously under
repair, the more efficient and long-term private streams will be, which once again confirms the advisability of overhauling multi-apartment residential buildings by the group method.

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