Quality of Organizational Processes Assessing in Modeling a Low-Rise Construction System Development

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Abstract. Main difficulties, arising in the selection of a workers link, as well as changes in the parameters of the model, depending on the composition of the link in organizational and technological planning are discussed in this article. The results, obtained in the course of the study, are summarized in graphs. Variant modeling of the technological process complexes implementation consists in finding a variant of teams’ composition, taking into account their intra-team plans and combining them at the work fronts, where the indicators of production program (construction plan) will be the best one, according to a given criterion and restrictions on resources and conditions of the customer. Otherwise, construction period of the first option was 22.46 months: the duration of each subsequent house construction was 19.5 days longer than the previous one. In variants 2 and 3, this difference decreased to 14.5 days, and the total duration decreased by 4.88 months and amounted to 17.58 months.

1. Introduction
Currently, a fairly large number of options for low-rise buildings construction are implemented due to a fairly large number of constructive and technological solutions. The number of options for individual fragments (walls, roofs, partitions, etc.) in some cases reaches many tens, and each of these options has its own specific advantages and disadvantages. Therefore, the choice of an appropriate option for each object is a rather difficult task.

The composition of the workers link performing this or that work is necessary for a clearer planning of workers at the facilities. The definition of the link normative composition allows you to build a graph of the need for human resources at the facility. Also, it is possible to determine the normative duration of each work and comparing it with the actual one, to eliminate deviations and thereby increase labor productivity with the knowledge of the workers normative number. All this will lead to an increase in the organization's income per unit of time, to savings on wages.

As a goal, one can consider the issues of assessing the quality of organizational processes, modeling the development of a low-rise construction.

Formulation of the problem

1. Determine the range of quality assessment in modeling.
2. Conduct a model experiment and track changes in the main parameters of the organizational model, depending on the link composition on the basis of the experiment.
1.1. Theoretical research

Modeling of intra-team technological processes is aimed at finding such rational parameters of intra-team plans, which tie into a single system the team size, the number of technological links, the degree of processes combination, as well as saturation of the work fronts. As a result, there is such a distribution of technological processes, where the performance indicators of a particular brigade would be (in conjunction with the work of all teams combined with it) close to optimal (rational).

The total size of the crew is variable in design. Finding the optimal number and its qualification composition of the brigade is one of the tasks of modeling intra-brigade technological processes.

For typical construction projects, modeling and linking of technological processes does not differ from the method of designing the work flow organization with the exception that the initial information should be the results of in-team modeling and taking into account the customer's requirements for the dates of facilities commissioning.

Low-rise building projects are able to flexibly respond to market conditions, which is a good way to save money, given the low prices for used building materials [3].

The deployment of the system proceeds in three directions - the system fragmentation, complication of one system level (inclusion of additional elements, differentiation of elements), transition to a super system.

1. Crushing the system. Workers number (the number of links) for performing a specific work, entrusted to the brigade, can fluctuate in a fairly wide range and it is mainly limited to two values - the minimum and maximum. The minimum value (the number of links) is regulated by the cart of the labor process and the maximum - by the work front, which can accommodate the largest number of workers (links).

2. Complication of one system level (inclusion of additional elements that perform auxiliary functions or expand its functionality, differentiation of elements). Deployment occurs from the functional center to the periphery. In construction, work is being consolidated: earthworks, installation of the building box, finishing work, etc.

3. Transition to a super system that is to build one complex of objects, the construction organization moves on to the next.

The selection of comparison criteria is made on the basis of the most characteristic features of low-rise apartment buildings construction, as well as the peculiarities of work in teams’ organization of various types, to determine the parameters of assessment in the study course.

The following were selected as organizational and technological criteria: complex technological processes, degree of combining work, level of workers qualifications, level of engineers qualifications, work front organization, workload uniformity of performers, defects occurrence in the process of performing work. At present, the issue of information modeling in construction is considered in sufficient detail, including at the legislative level [6].

2. Materials and methods

2.1. Experimental research

Modeling was carried out on the example of the cottage village "Nightingale Grove", which was located in the Novosibirsk region. There were 228 building plots in this village. The facilities were divided into 10 phases. The beginning of the preparatory period was in April, 2020, the beginning of the main period was on June, 2020, taking into account holidays and weekends. In the first phase, 22 houses would be built. In order to start the modeling, a typical house was selected and the estimate for its construction was calculated. Based on the estimate, the primary production unit was determined, which was presented in table. 1.
Modeling was carried out using MS Project 2016. Microsoft Project creates critical path schedules. Schedules could be created based on the resources used. The chain was visualized in a Gantt chart. All changes were tracked by means of graphs and diagrams built by this program.

In order to trace how the parameters of the model change depending on the workers number, it was decided to consider 3 options for building a queue, namely, add additional links of masons, since the critical path of the queue went through the process of building a box. The transition scheme of bricklayers links from object to object for each option is shown in Figure 1.

In the first version, the critical path went through the process of erecting the box (Figure 2). However, in the second and third variants, the critical path changed and began to go through another, most lengthy process - finishing work (Figure 3).

The construction period of the first option was 22.46 months. At the same time, the duration of each subsequent house construction was 19.5 days longer than the previous one. In variants 2 and 3, this difference decreased to 14.5 days, and the total duration decreased by 4.88 months and amounted to 17.58 months.

The next monitored parameter was labor intensity. The graph (Figure 4) shows that the fewer links in the process of box erecting, the more evenly labor intensity is distributed.

**Table 1.** Primary production unit.

| №  | Tasks                        | Links | Lina.ikonnikova@sibstrin.ru compa.ikonnikova@sibstrin.ruosition | Mechanisms |
|----|------------------------------|-------|-----------------------------------------------------------------|------------|
| 1  | Pit construction Site breakdown | link 0 | Handyman 2p-1 | Excavator |
| 2  | Site breakdown Foundation device | link 1 | Handyman 3p-1,2p-1 | - |
| 3  | Foundation device | link 2 | Concrete reinforcement worker 3p1, 4p-1 | Concrete pump |
| 4  | Erection of the box | link 3 | Bricklayer 3p-1,4r-1,5r-1 | Crane |
| 5  | Floor device | link 4 | Concrete reinforcement worker 3p1, 4p-1 | Concrete pump |
| 6  | Roof device | link 5 | Carpenter - Roofer 2p-1,3r-2,4r-1,5r-1 | Crane |
| 7  | Arrangement of windows and doors Ladder construction | link 6 | Carpenter 4p-1,2p-1 | - |
| 8  | Gas equipment | link 7 | Carpenter 5p-1,3r-1 | - |
| 9  | Plumbing equipment | link 8 | Gas | Subcontracting |
| 10 | Electric installation work | link 9 | Installer, int. sanitary-technical systems and equipment 4p-1,3r-1 | - |
| 11 | Landscaping | link 10 | Electrician | Subcontracting |
| 12 | Facing-concrete worker | link 11 | Facing-concrete worker 4p-1 3p-1 | - |
| 13 | Plasterer 3 r-1 | link 12 | Plasterer 3 r-1 | - |
| 14 | Green construction worker | link 13 | Green construction worker 3p-1, 2p-1 | - |
Coefficient of the labor costs distribution uniformity was calculated to estimate the parameter. The calculation results are summarized in table. 2.

An assessment was also made of cash flows during construction. The cost of building one house was 5,215.47 thousand rubles. The assessment was carried out, using the coefficient of the labor costs distribution uniformity.

![Figure 1. Scheme of links transition from object to object.](image1)

![Figure 2. Critical path of option 1.](image2)
Figure 4. Comparison of labor distribution.

Also, in addition to the workers’ link in the process of box erecting, a self-propelled jib crane is busy for supplying and transporting materials. Therefore, the crane operation duration at the construction site and the percentage of its work were calculated for each option. The graph (Figure 6) shows that the crane operation increases by 10%, and the duration of its work on the construction site decreases with the addition of additional links.

Figure 5. Cash Flow.
Figure 6. Comparison of crane employment at facilities.

Table 2. Summary table of estimated parameters.

| Indicates                        | Variant 1 | Variant 2 | Variant 3 |
|----------------------------------|-----------|-----------|-----------|
| Duration of construction         | 22.46     | 17.58     | 17.58     |
| Uniform distribution of labor    | 0.68      | 0.51      | 0.36      |
| costs                            |           |           |           |
| Uniform distribution of funds    | 0.56      | 0.50      | 0.35      |
| Maximum crane load               | 15.00%    | 25.00%    | 35.00%    |

3. Results
As we see, very strong changes can be observed in a number of indicators during the construction of 22 houses with the introduction of one or two links, which consist of 3 people. The choice of a specific option depends on the required results, but the essence remains unchanged, the rationally selected composition of the link and their number plays a very important role in organizational and technological modeling.

Modeling allows you to carry out experiments in order to design, analyze and assess the functioning of the facility, to implement new systemic approaches and organization of low-rise construction, but only while ensuring quality at all stages of modeling.

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