Study of factors influencing organizational and technical solutions in the construction of monolithic reinforced concrete buildings

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Abstract. Having identified the relationship between the influencing factors of organizational and technical solutions and the effectiveness of the organization of the process of erecting structural elements of multi-storey buildings, it is possible to reasonably predict the probability of achieving the desired result at any stage of the construction process. The effectiveness of the method of assessing the factors of organizational and technical solutions is determined by a large-scale approach to the selection of factors that determine the organization of the process of erecting structural elements of monolithic buildings.

Keywords: organizational and technical solutions, factors, production methods, structural elements of monolithic buildings.

1. Introduction

The field of study was determined based on current trends in the active use of concrete as a building material. According to information agencies, the annual volume of global concrete production has exceeded 2 billion m³ and continues to increase. The annual volume of concrete production in Russia is about 30 million m³, while about 26-30% falls on housing and civil construction [1].

Most experts in the field of construction speak in favor of continuing the observed trend of growth in the volume of monolithic construction in the real estate market. The obvious advantages of this technology are the ability to implement a variety of architectural and space-planning plans, there are no areas of elements joining (unlike panel housing construction), there is the possibility of erecting a large number of floors [2].

It is with the industrial method of production of critical structures that special quality control and optimized organization of processes are required. Water, aggregates, additives, reinforcement frame – all these components must have the appropriate regulatory documents and design documentation characteristics. The organization of the design and

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construction process of structural elements of monolithic buildings should be aimed at making optimal and effective organizational and technical decisions at all stages of capital construction of the facility [3].

One of the most important aspects of the construction of monolithic buildings is to ensure the safety and operational reliability of building structures [4; 5]. Requirements for the mechanical safety of buildings are listed in Federal Law No. 384-FZ dated December 30, 2009 "Technical Regulations on the safety of buildings and structures". Mechanical safety is the most important condition for the construction of structural elements of monolithic buildings [6, 7].

Based on the results of the review of the industry as a whole, the main types and types of building structures, it was decided to designate the structural elements of multi-storey monolithic buildings as an object of research. The subject of the dissertation research is organizational and technical solutions for the construction of structural elements of multi-storey monolithic buildings [8].

2. Methods
Organizational and technical solutions (OTP) is a set of structured solutions for the organization, equipment and technology of construction production, adopted in organizational and technological and organizational and technical documentation. Organizational and technical solutions should contain a detailed description of the composition of the work performed, a description of the organization of processes, methods and production technologies [9].

The organization of construction production includes:
1) planning of construction production,
2) the choice of methods of construction organization,
3) design of the organization of construction and production of works,
4) preparation of construction production,
5) organization of labor,
6) operational dispatch management,
7) organization of logistics,
8) mechanization of works and organization of transport work,
9) quality management in construction organizations.

The result of long-term observations of the state of structural elements of buildings was a list of factors that clearly affect the quality of load-bearing structures. The grouping of factors was carried out according to the principles of the sequence of construction production, where group 1 – factors at the stage of design and survey work, and group 2 - at the stage of construction and installation work. The full list of factors is presented below [10]. In turn, the parameters of the factor are understood as characteristics determined by unambiguously definable elements. The division into groups is based on the following principles: at the stage of design and survey work, it is possible to obtain predictive data (taking into account the database of previously implemented objects, as well as the expected values of parameters); at the stage of construction and installation work, it is possible to obtain data confirmed by practical execution with the prediction of subsequent events [11].

As a result of the experiment, a list of influencing factors was formed. The first group – design and survey work - includes 5 factors determined by 14 parameters.

The quality of engineering and geological surveys includes the following parameters:
- The work program has been approved by the General designer;
- The actual work performed meets the requirements and the approved work program;
- Availability of scientific and technical support.
The quality of engineering and geodetic surveys contains the following parameters:
- The work program has been approved by the General designer;
- Availability of scientific and technical support.

The quality of engineering and environmental surveys is determined by the parameters:
- The work program has been approved by the General designer;
- Availability of scientific and technical support.

The quality of the project documentation contains parameters:
- Application of BIM technologies (TIM);
- Availability of subcontracting design organizations;
- The average experience of the project team employees is more than 5 years;
- Availability of scientific and technical support for design.

The quality of the working documentation contains parameters:
- Availability of scientific and technical support for design;
- Detailing and individualization of working documentation;
- Compliance of the working documentation with the requirements of the approved project documentation.

The second group of factors relates to the stage of construction and installation works and includes 14 factors, 41 parameters.

The quality factor of conducting construction control is determined by the parameters:
- Permanent presence of construction control at the construction site;
- Equipped with high-tech devices and equipment;
- Timely input quality control of construction materials, products and equipment;
- Timely operational quality control of individual construction processes or production operations;
- Timely acceptance control of completed works.

The quality of author supervision contains the following parameters:
- Maintenance of author supervision by the developer of project documentation;
- Permanent presence of the staff of the author's supervision service in the work area.

The quality of the technical customer's service is determined based on the parameters:
- Availability of an occupational health and safety engineer on staff;
- Availability of a process engineer in the staff;
- The presence of an engineer in the staff of the production and technical department (PTO);
- The presence of a load-bearing structural engineer on the staff;
- High degree of communication and management of production processes.

The quality of scientific and technical support of construction is determined by one parameter:
- Availability of scientific and technical support service.

The quality of the general contracting organization is determined using the parameters:
- Availability of internal quality control service, availability of enterprise standards and internal regulations of the organization;
- The percentage of work performed based on their total volume is more than 50%.

The level of automation and mechanization of production contains the following parameters:
- Availability of modern high-performance equipment for lifting and moving goods;
- Availability of modern high-performance means of small mechanization.

The qualification factor of engineering and technical workers (IT) teams is determined by the following parameters:
- Work experience of at least 5 years in the field of activity;
- Higher education in the field of activity;
• Professional development in the field of activity;
• The category of concrete engineers is not lower than the 3rd;
• The category of reinforcement engineers is not lower than the 3rd.

The quality of shuttering systems consists of two parameters:
• Availability of mobile unified shuttering systems;
• Application of an individual project for the selection of formwork systems.

The quality of the organizational and technological scheme for the construction of monolithic structures consists of the parameters:
• Packaging and pre-packing of small-piece elements;
• Timely provision of concrete care measures;
• Availability of technological maps adapted to the construction object;
• Detailing and individualization of working documentation.

The quality of executive documentation is divided into such parameters as:
• Completeness of executive documentation;
• Compliance with the requirements of execution of executive documentation;
• Timeliness of registration;
• Availability of an electronic form of executive documentation.

The quality factor of engineering and household preparation of production is determined by the following:
• The location of the household town corresponds to the approved project documentation;
• The presence of supply disruptions (electricity, water, heat, etc.).

The natural-climatic factor contains the following parameters:
• Construction in the high temperature zone;
• Construction in the low temperature zone;
• Construction in the zone of active seismic processes.

The quality factor of the supplied materials, products and equipment contains the following parameters:
• The supplied materials, elements and equipment comply with the approved design and working documentation;
• There are no significant defects and defects.

The "other" factor takes into account the individual characteristics of the construction object and contains two parameters:
• The uniqueness of the building;
• Dense urban development.

To identify the necessary and sufficient list of factors influencing the organization of the construction of structural elements of monolithic buildings, as well as the assignment of synaptic weights of factors, the method of individual expert survey was used.

3. Results

To determine the required number of experts, we use an inequality containing the Kendall concordance coefficient \( W \), the number of experts \( m \) and the number of ranked objects \( n \):

\[
W \times m \times (n - 1) > x^2_{\gamma}.
\]

Taking the minimum value of the concordance coefficient equal to 0.5 and substituting the values of \( n \) and \( x^2_{\gamma} \) (the tabular value of the Pearson criterion), we present the inequality in the following form:
\[ m > \frac{2 \times 21.7}{(10-1)} > 4.8. \]

Thus, when ranking 10 objects, the participation of at least 5 experts is required.

<table>
<thead>
<tr>
<th>Number of ranked objects</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5–6</th>
<th>7–9</th>
<th>10–16</th>
<th>17–31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum number of experts</td>
<td>14</td>
<td>10</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

In total, the accepted number of experts was 4 people.

To unambiguously solve the tasks of the expert survey, 8 experts were involved (twice the tabular value to prevent possible deviations in the consistency of expert opinions), which avoids the need for additional expert surveys.

Experts with higher technical education, experience in the field of design and construction were involved as experts.

A number of issues related to their work experience and membership in the national register of specialists were put forward for the experts to decide. Further, questions were proposed about the sufficiency of the list of factors, after which each expert ranked the factors according to the significance of each factor, thereby assigning a synaptic weight from 0 to 1.

4. Discussion

During the first survey, the actual concordance coefficient was 0.68. After re-discussing the factors with experts and conducting the second stage of the survey, the concordance coefficient was 0.87, which indicates a high degree of consistency of experts' opinions regarding the sufficiency of factors.

Based on the results of the expert survey, a final list of influencing factors with assigned synaptic weights was formed, which looks like this:

Group 1 – design and survey work:
1. The quality of engineering and geological surveys – 0.4;
2. The quality of engineering and geodetic surveys - 0.3;
3. The quality of engineering and environmental surveys - 0.2;
4. Quality of project documentation – 0.6;
5. The quality of working documentation is 0.8.

Group 2 – construction and installation works:
1. Quality of construction control – 0.9;
2. The quality of author supervision – 0.2;
3. The quality of the technical customer's service is 0.5;
4. The quality of scientific and technical support of construction – 0.1;
5. The quality of the general contracting organization – 0.5;
6. The level of automation and mechanization of production – 0.7;
7. Qualification of ITR teams – 0.8;
8. The quality of formwork systems – 0.8;
9. The quality of the organizational and technological scheme for the construction of monolithic structures - 0.7;
10. Quality of executive documentation – 0.1;
11. The quality of engineering and household preparation of production - 0.6;
12. Natural and climatic factors – 0.7;
13. Quality of supplied materials, products and equipment – 0.9;
14. Other – 0.2.

Thus, using the method of individual expert survey, a list of factors influencing the organization of the construction of structural elements of monolithic buildings has been formed. The factors are assigned synaptic weights in the range of values from 0 to 1.

5. Conclusions

Statistical data of monolithic construction are considered. The stages of the organization of the construction of structural elements of monolithic buildings are studied. The main production methods and organizational and technical solutions are described. The problems in the implementation of organizational and technical solutions are determined. The solution to the problem is to control the main influencing factors.

List of literature