Analysis of risks arising at the stages of production, transportation, installation of large-sized modules in the design position

Sergey Ambartsumyan, Dmitry Mochalin, Robert Avetisyan*, and Julia Siebeva
Moscow State University of Civil Engineering, Yaroslavskoye shosse, 26, 129337, Moscow, Russia

Abstract. The paper considers the prospects for the development of large-sized modular housing construction in the face of industrial and managerial risks. The authors consider the risks identified at the time of production of a large-sized module, transportation and installation in the design position. The risk planning management algorithm is considered. The article identifies the factors that arise at the stage of production, transportation, installation of a large-sized module in the design position. A literary analysis was carried out on the topic of large-sized volume-block housing construction. The technical and economic prerequisites for the construction of buildings from large-sized modules and obtaining an economic effect are considered, in comparison with the construction of similar buildings in a large-panel or monolithic design. An algorithm for studying potentially significant factors is considered. Practical experiments were carried out, which made it possible to determine the risks affecting the quality of large-sized modules. The task of this work is to identify risks that affect the quality of large-sized modules at various stages: production, transportation, installation of a large-sized module in the design position. As a result, risks were identified by three groups for further qualitative and quantitative analysis, response planning, monitoring, and risk management. The relevance of the considered topic lies in the implementation of investment projects, in their implementation in the field of management.

Keywords: large-sized modular housing construction, modular construction, quality of modular products, risks of large-sized modular construction.

1 Introduction

According to the strategy approved by the Government of the Russian Federation dated October 31, 2022 No. 3268-r, on the development of the construction industry and housing and communal services of the Russian Federation for the period up to 2030 with a forecast until 2035, it is necessary to ensure the development of industrial housing construction, including block housing construction [1]. Large-sized space-block housing construction allows you to provide the population by today's standards with inexpensive and comfortable housing. During the production of large modules, due to the production line at the house-
building plant, the accuracy of manufactured reinforced concrete products is increased, less process waste is generated, and high quality of finished products is ensured under the rooftop. Large modules with high degree of prefabrication up to 95% are transported to the construction site - comprehensively equipped with engineering systems, facade systems, windows and with completed interior decoration. At the stages of production of large modules, transportation and installation into the design position, risks arise that have a significant impact on the quality of modular products [2-4].

The authors assessed the inevitably emerging of risks situations at the house-building plant, during transportation and at the construction site, which must be worked out in order to implement similar methods of prevention, identification and response in order to minimize or eliminate risks affecting the quality of the finished large module [5-7]. This article discusses the risks identified during the manufacture of the large module, transportation and installation into the design position.

2 Materials and methods

During the study, the following methods of scientific research were used: analysis, synthesis and deduction, in order to systematize and analyze information within the framework of the current study. This work is aimed at studying the impact of production and management risks on the quality of a large module. For the analysis were used initial data, regulatory documents, research studies, internal documents of LLC "Combine of Innovative Technologies - Monarch," including technological documentation and reports on the achieved results of the experiment in the field.

Within the framework of construction organizations, special attention is paid to the risk management and assessment process, on the basis that they help supervisors to rationally identify possible losses, develop a system of measures to eliminate them, and of course, during risk management, these measures allow companies to predict their economic effect.

It is impossible to fully prevent risks in the company, meanwhile, it will be possible to investigate and implement preventive methods for identifying, preventing and eliminating them as soon as possible in order to avoid or at least reduce the level of losses.

The basis of effective enterprise risk management is as follows: identification, qualitative risk analysis, quantitative risk analysis, response planning, monitoring and risk management (Fig. 1).

Fig. 1. Risk Management Planning.
Below will be considered the risk tree, the primary importance of which is the classification of groups by the operation of the enterprise [8-11]. Next, the list of key risks of the enterprise, which describe the structure of construction organizations, is systematized:

1. Risks of a production nature - determined by the implementation of construction and installation works on the basis of a contract agreement between the customer, the general contractor and the contractor.

2. Financial risks - determined by unscheduled excess costs or budget losses in the financial activities of a construction organization.

3. Commercial Risks - Critical to this listing of risks due to unsustainable sales and advertising policies. In such situations, auxiliary unplanned expenses, a shortage of income or losses due to an incorrect course of sale of goods arise.

4. Managerial risks - determined by the loss of the vector of strategy development due to conflict situations between the administration on different levels.

5. Marketing risks - This is characterized by an incorrect definition of the development strategy of the construction enterprise in the market, resulting in additional unforeseen costs.

6. Risks of a social nature - determined by the low level engagement of the construction organization in development of social infrastructure for the safe operation of working personnel.

This study will identify production and management risks arising during the production, transportation and installation of large modules in the design position (Figure 2). To determine potential risks, were analyzed implemented projects, current projects and possible future conditions during the construction of buildings from large modules (Fig. 2).

**Fig. 2.** Algorithm for investigating potentially significant risks.
The authors study a large-sized dimensional module, which is produced at the "Combine of Innovative Technologies - MonArch." The plant plans to produce large modules with the following maximum dimensions: length - 15.5; width 6.5; height 3.55 [12-14].

It is planned to implement projects for various purposes from large modules: public buildings, residential and administrative. The plant produces a large-sized module equipped with all engineering systems, facade systems and finishing equipment. Complete factory readiness is 95%. There are various options for a space-planning solution within a large module.

This method of erecting buildings has a number of advantages compared to the construction of buildings made of cast reinforced concrete or large-panel housing construction in terms of obtaining an economic effect [15-17]. The main advantages are:
- enhanced receiving quality control of components and materials.
- increased quality and accuracy of products, reduction of adverse factors that may affect the products at the construction site;
- increased labor productivity;
- rational integration of all types of construction works and standardized working processes;
- energy efficiency of factory production;
- the most labor-intensive processes are carried out with the use of mechanization and robotization due to the transfer of the main production processes to the plant, reducing the labor intensity of work at the construction site.
- reduction of the total environmental load on the construction area, taking into account the fact that the construction site turns into an assembly site;
- reduction of the cost of work;
- acceleration of the project payback period due to reduction of the building construction period;

Research was carried out on the basis of the Combine of Innovative Technologies - MonArch to identify potentially significant risks. The risks were determined at the stage of production, transportation and installation of the large module into the design position. At production site were revealed risks arising at all stages of making of a large module in production conditions. During the study, were considered works on formation of products, assembly of modules, internal facing works, facade works. On the stage of transportation of the large module to the construction site, the factors that significantly affect the quality of the transported large module were analyzed. At the stage of installation of the large module into the design position, risks were identified, the impact of which reduces the quality of finished products, reduces operational properties, and increases the time for commissioning the facility.

3 Results

The authors took part in all production stages of the large module based on the Combine of Innovative Technologies - MonArch. As a result of the analytical and practical study, factors were identified that have a significant impact on the quality of construction products.

One of the main tasks is to identify risks that can have a significant impact on the quality of construction products made. During the study, the most significant risks were divided into three groups: production, transportation, installation of a large module in the design position. Identified risks are shown in Table 1.
Table 1. Risk groups affecting the quality of the large module.

<table>
<thead>
<tr>
<th>Large module production</th>
<th>Large module transportation</th>
<th>Installation of the large module into the design position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor quality of supplied products, components and materials.</td>
<td>Preliminary transportation of large dimensional block when concrete strength is less than 100%</td>
<td>No Job instruction for Installation of large modules</td>
</tr>
<tr>
<td>Lack of technological documentation.</td>
<td>Uneven load distribution relative to the longitudinal axis of symmetry and relative to the axes of the wheels of the cargo platforms of vehicles during transportation of a large module</td>
<td>No geodetic monitoring at the time of installation</td>
</tr>
<tr>
<td>No operational control of all phases of works at the plant by the Quality control department (QCD)</td>
<td>Transportation of large size modules without specially equipped fastening and supporting devices ensuring product safety and traffic safety</td>
<td>Absence of operational control of erection by the construction and installation contractor, technical and designer supervision</td>
</tr>
<tr>
<td>Low-quality board equipment and molds for making flat products</td>
<td>Absence of auxiliary retainers of the large module on the vehicle, minimizing longitudinal and transverse displacement</td>
<td>Collisions when connecting utility systems between large modules</td>
</tr>
<tr>
<td>Low qualification of working personnel</td>
<td>Absence or poor-quality methods of module fastening specified in the construction documents, taking into account the rules in force for specific vehicles</td>
<td>No incoming inspection at construction site</td>
</tr>
<tr>
<td>Poor quality of concrete structures and lack of concrete care</td>
<td>Transportation of large size module without covering material</td>
<td>Absence or incompleteness of certificates, manufacturer’s data reports, test reports and other documents certifying the quality, safety and properties of materials, structures and products used during the work performance</td>
</tr>
<tr>
<td>Violation of technological stages during finishing works</td>
<td>Damage to the road surface in the form of hollow spots, breaks</td>
<td>Absence or incompleteness of technical devices test reports, utilities systems,</td>
</tr>
<tr>
<td>Large module production</td>
<td>Large module transportation</td>
<td>Installation of the large module into the design position</td>
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<td>results of examinations, expert assessments, laboratory and other tests of the work performed during construction control</td>
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<tr>
<td>Low-quality assembly of a large module</td>
<td>Low visibility of the road when transporting a large module, snow-covered roads</td>
<td>Lack of confirmation of compliance of the facility with the requirements of energy efficiency and its equipment with devices for measuring energy resources used</td>
</tr>
<tr>
<td>Removal of the wall panel from the vibration table for assembly with concrete strength of less than 50%</td>
<td>Low qualification of a cargo transport vehicle driver</td>
<td>Missing or poorly executed documentation confirming the fact of work performance in accordance with the approved design documentation</td>
</tr>
<tr>
<td>Dismantling and transportation of the large module from the assembly stand when the concrete strength of the tile floor is less than 50%</td>
<td>Narrow sections of driveways and lanes on the way to the facility under construction</td>
<td>Poor connection of utilities between sections</td>
</tr>
<tr>
<td>Sloppy transportation of the large module from the molding shop to the finishing shop</td>
<td>Radii of turns of road passages</td>
<td>Absence of WMS for large modules installation</td>
</tr>
<tr>
<td>Low-quality concrete surface of flat products</td>
<td>Side rake or top rake of a roadway</td>
<td>Poor primary sealing of joints after installation of large modules</td>
</tr>
<tr>
<td>Low quality performance of finishing works</td>
<td>Gusty and squally wind at the time of transportation of the large module</td>
<td>No temporary roof during the construction of high-rise residential buildings to prevent flooding in the rainy period</td>
</tr>
<tr>
<td>Violation of the technology during facade works</td>
<td>Ice on the road surface in the form of a smooth film or rough crust. Compacted snow, snow roll</td>
<td>Absence of permanent external utilities for timely commissioning</td>
</tr>
</tbody>
</table>
As a result of the study, it is necessary to describe the following provision: at all stages of production of large modules, risks arise that significantly affect the quality of finished products. The risks are identified in three groups for further qualitative and quantitative analysis, response planning, monitoring and risk management.

4 Conclusion

The risk management system is part of a comprehensive project management model. Only based on a well-functioning project management system enterprises can implement a strategy for developing large-scale projects. For a long time, the construction sector lagged behind other sectors of the economy in productivity. In modern conditions of economic development and technological progress, there is an opportunity to transform the construction industry, the development of industrial methods of building construction. According to the results of the study, the identified risks are divided into three groups. In further studies, a questionnaire will be compiled and an expert survey will be conducted to identify the most affecting group of risks.

References


