The monolithic buildings complex renovation’s organizational and technological model creation

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Abstract. Reliability and quality of monolithic construction works are determined by analyzing the system of preparing certain technological operations for implementation, establishing and ensuring the order, sequence and time schedule of works, and all types of resources supply. Periodic inspections of compliance with construction norms and regulations are held in the course of construction and erection works. As a follow-up on such inspections, the prescriptive orders on the detected nonconformities rectification and the violations within a specified time limit are issued. There is no provision for the time consumed by the corrective action in the calendar plan, and consequently the actual duration of construction as often as not exceeds the scheduled term to a great extent. In this connection, there is a task of assessing the level of the violations’ impact on the functioning efficiency and the production processes organizational quality. This paper explains how to create a proper database model to account for the defects and irregularities in monolithic construction and the details specifications of the technical failures impacting the organizational and technological construction reliability. The information technology use enables to calculate the various performance indicators quickly so as to streamline the defect and failure detection procedures adhered to by a contractor. The specialists in the field of risk analysis and assessment, experts and insurance companies, as well as the organizations conducting the assessment can use the methods described herein.

1. Introduction
Monolithic construction is a complex probabilistic system where all the circumstances affecting the technological process are impossible to foresee. The practical experience findings analysis reveals a number of unsolved problems reducing the monolithic construction efficiency. Today, many scientists study the problems of improving technology and organization in monolithic construction aiming to enhance quality and reliability [1-5]. According to the reliability theory, it is technological failures that mostly affect the efficiency of a construction system [6-7]. A failure is defined as an event that has caused a malfunction in an object fully functional prior to such a failure. The production system failures are defined as the events occurring under the influence of many random factors. The quantitative indicators of random events are constructed from a probabilistic measure and are determined statistically. The defects and irregularities identified in the production process are often an essential component of a production system failure, and, therefore, they serve as the main factor affecting construction duration and the quality of on-site operations. Accordingly, it is deemed possible to evaluate the efficiency of a construction object with due account for the impact of
violations and defects by applying the organizational and technological reliability (OTR) index and using the mathematical statistics [8-9].

Organizational and technological reliability (OTR) is defined as the ability of technological, organizational and managerial decisions to ensure the achievement of a given result of construction production taking into account random influences inherent in such complex stochastic system as construction [6-7]. A large number of studies and scientific papers on this topic are dedicated to the development, analysis and adoption of organizational, technological and managerial construction solutions [1-2, 6]. At the same time, the organizational and technological solutions within the project greatly affect construction duration, since production costs constitute a significant part of a construction project’s budget. The analysis has shown that currently there is a clear trend towards construction of buildings and structures from monolithic reinforced concrete structures. So, improving the reliability and validity of options for the functioning of monolithic construction objects is becoming a very relevant scientific and practical problem.

2. Materials and methods
In order to develop a methodology for improving the OTR we show a general description of the object, as well as its purpose and functions. The object quality indicators and the parameters affecting it are compiled into an information database. Next, we define the factor values and the object’s normal functioning range within which these values can change. More detailed analysis of causal relationships between the possible defects and their causes was done in the previous papers [9] using the Ishikawa diagram and the expert survey. An analysis of the factors per the Ishikawa diagram makes it possible to identify the key parameters of production processes and reveal the causes for problems.

A failure may occur as a result of one or several structural defects, but presence of defects does not necessarily mean there is a failure, i.e. inoperability of a structure or an object as a whole. To do this, it is necessary to assess the degree of influence of each detected violation or defect on the work quality and the construction duration.

Thus, at the stage of analysis and assessment of risks of violations identified during the quality control and organization of work in monolithic construction, we determine the factors affecting the organizational and technological reliability indicators, as well as the degree and type of their influence. This analysis enables one to establish the most important factors affecting the duration of construction and production quality without conducting trial experiments or using regression analysis.

3. Results and discussions
The developed methodology includes the following documents for risk assessment and analysis, and determination of conformity assessment:
- form of questionnaire;
- form of summary table for risk analysis and assessment;
- table of inconsistencies frequency;
- tabulated scales detailing value deviations and influence thereof on construction duration.

It is suggested that analysis of the object’s production stages and monitoring its performance and characteristics be assessed from the technological process model studying. The research deals with the monolithic construction production organizing process and especially the certain technological stages at which the defects are most likely to appear (design non-compliance to the defined parameters, regulatory requirements or project requirements), as well as deviations (any deviations between the actual value of any construction parameters and the design requirements and technological parameters) [8]. These inconsistencies are hereinafter referred to as violations. The violation significance can be determined by analyzing the representative number of orders issued by the supervisors at monolithic construction sites. The research further describes the production stages and controlled parameters during the execution course and considers a block diagram of the production technological process, the entire construction process or the technological workflow to control factors leading to a violation.
A description is also given of one of the control stages in the production process and probable parameters under control.

Thus, the criticality of an identified violation (critical defect, CD) is calculated as follows: CD = D1*D2*D3, where D1, D2, D3 are the frequency, significance and probability of discrepancy (violation) scores is determined according to the Tables 1 to 3.

**Table 1. The violation probability estimation.**

| Violation frequency | Violation probability     | D1 score, points |
|---------------------|---------------------------|------------------|
| Very rare           | less than 0.001           | 1 to 2           |
| Rare                | 0.001 to 0.01             | 3 to 4           |
| Probable            | 0.01 to 0.1               | 5 to 6           |
| Frequent            | 0.1 to 0.3                | 7 to 8           |
| Very frequent       | more than 0.3             | 9 to 10          |

**Table 2. Assessment of violation consequences.**

| The violation consequences description | Significance category | D2 score, points |
|----------------------------------------|-----------------------|------------------|
| Insignificant                          | V                     | 1 to 2           |
| Fairly insignificant                    | IV                    | 3 to 4           |
| Significant                            | III                   | 5 to 6           |
| Critical                               | II                    | 7 to 8           |
| Catastrophic                           | I                     | 9 to 10          |

**Table 3. The violation detection probability assessment.**

| The violation detection probability description | The violation detection probability | D3 score |
|-------------------------------------------------|-------------------------------------|----------|
| Very high probability of detecting inconsistencies in the course of operational control | more than 0.90                  | 1 to 2   |
| High probability of inconsistencies detection. Some defects may not be detected in the course of operational control. | from 0.9 to 0.75                  | 3 to 4   |
| Moderate probability of inconsistencies detection. A significant portion of defects will not be detected during operational control, but most of them will be revealed as a result of acceptance control. | from 0.75 to 0.50                | 5 to 6   |
| Low probability of inconsistencies detection. Acceptance inspection does not guarantee the defects or deviations’ detection | from 0.50 to 0.10                 | 7 to 8   |
| Very low probability of violation detection. The defect is hidden, detection is most unlikely. | lower than 0.10 | 9 to 10 |

An integrated assessment of a violation in terms of its significance by consequence, occurrence and detection probabilities is referred to as the violation integrated risk. The quantitative indicator of such a CD’s integrated risk is a priority risk number.

The analysis results are presented in the explanatory note in the form of the object’s description, its functions, indicators and factors. The analytical review of the information on the object under study makes it possible to determine their completeness and reliability degree. Microsoft Office Excel, Access, MathCad, and other software products are used to process the data. Information support involves the data generation to be used in the database form. The database is a register of defects, violations and inconsistencies identified by the supervising bodies in the course of the monolithic technology projects large number monitoring quality.

To construct a database, its goals and objectives need to be defined. In our case, the database is designed for rapid collection, storage and analysis of information on technological process of constructing the monolithic structures and organizing production, including the prescriptions issued by the construction control department, which enables planning remedy activities and controlling timeline thereof. All types of information are presented (source, reference, operational information from measuring tools or after processing in measuring systems, deliverables, etc.).

The subject area for which the database is being developed, in particular, the organization of production and quality control on site, is shown using a conceptual model. The diagram below defines the semantic structure of the subject area, shows multiple components, concepts and their causal relationships within the subject area. To build it, one needs to define the objects, relationships and attributes (Figure 1). Afterwards, this conceptual model is transformed into a relational database model shown in Figure 2. This model represents relationships between tables using key fields that uniquely identify each entry in the table. Inter-table links allow one to simultaneously call up related data from within several tables.
Figure 1. Conceptual database model
Figure 2. Relational database model
4. Summary

Thus, the developed criterion-based database enables analysis of probabilities with regard to the certain undesirable events (failures) occurring and influence thereof on achieving project objectives (time, cost and quality). Using the method of expert assessments, the influence of these factors on the organizational and technological reliability (OTR) of a monolithic construction project was quantified. The analysis results enable one to quickly assess the criticality degree for the detected violations, rank them and streamline production processes accordingly. The information presented in the database suggests an optimal technological solution that helps one to save time. In order to properly address the reliability issue in monolithic construction, the author has set the following task: to develop a technique for improving the OTR in monolithic construction through a timely adjustment of a construction calendar plan. The developed technique will enable to quickly determine the reliability level for a construction site and to adopt the rational solutions that will cut the timeline in the most labor-intensive work areas when constructing monolithic buildings and structures in cases where failures occur in the production process.

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