Main principles of choice of multi-purpose design solutions for construction operations when conducting judicial construction and technical expertise (JCTE)

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Abstract. The article contains the discussion of materials on the principles of selection of multi-purpose design solutions for the construction industry when conducting a judicial construction and technical expertise, as well as the presentation and an algorithm for solving problems of this type. Based on the interpretation of results of theoretical works and analysis of judicial practice, a method was obtained that can be used when conducting a judicial construction and technical expertise in order to solve the issues of selecting design solutions and materials. When using this method, all rearrangements of variants are checked by their preference and compared with each other. The considered method has been continually applied in solving practical issues of judicial construction and technical expertise. Actually, this type of tasks is often found in the framework of arbitration processes when solving issues on the effectiveness of the use of budgetary funds. The use of the proposed algorithm is the most optimal for the preparation of conclusions of a forensic construction expert for cases of this category.

Introduction

Observance of law and order is one of the top state goals in a democratic society of any country. The solution of this issue largely depends on the effectiveness of functioning of the institute of judicial expertise, which is one of the most important means of proof when conducting investigations of crimes and the judicial examination of cases.

The judicial construction and technical expertise (JCTE) plays a significant, and sometimes a crucial role in judicial proceedings and investigations of accidents and incidents in construction; when adjudicating civil disputes regarding the real estate ownership, the quality and value of construction work performed, administrative offense cases related to the determination of the construction legality, operation of construction facilities in courts of general jurisdiction and arbitration courts [1].

The need of legal procedure in the use of special construction and technical knowledge is constantly increasing, and with an increase in the scale and pace of construction taking place in recent years, this trend will continue. Nevertheless, with all the importance of proof which is a feature of special construction and technical knowledge in all types of legal proceedings (criminal, administrative, civil and arbitration ones), the practice demonstrates the lack of uniform legal, organizational and methodological approaches to solving issues, as well as deviations from procedural norms and the presence of legislatively and organizationally unregulated relations.
Facilities and materials studied by a construction expert have significant differences both in their natural and technical features and the functional purpose, and in terms of adopted technical solutions or organizational and technological solutions in the design, construction, operation or management of construction processes and works. The taken solutions are not a dogma, and any of them can be timely adjusted or replaced by another ones if it is required by changed conditions, that determines the specificity of JCTE and distinguishes it from other types of forensic examinations. In the process of research, a construction expert should consider the possibility of selecting a solution based on a comparison and assessment of possible variants while taking into account the multi-purpose nature of technical solutions and organizational and technological solutions.

Thus, the current state of the issue is characterized by its real significance for legal proceedings, but at the same time by the insufficient scientific elaboration. In this regard, there are many problems of procedural, methodical and organizational nature that are directly related to the expertise, as well as the formalization of results of expert research and their effective protection against the criticism of opponents during the court proceedings.

The main objective of the research is to consider the principles for selecting multi-purpose design solutions for building production when conducting JCTE expert studies and to develop an algorithm for solving issues of this type.

**Research materials and methods**

In the problem of selecting design solutions from the standpoint of JCTE, two main aspects can be traced: informative and methodological one.

During the design process, in particular, if significant errors were revealed at the final stage, a construction expert may set out questions related to the assessment of one of the two cases:

- to determine the likelihood of possible results (consequences) that may occur when selecting one or another solution;
- to set preferences for different possible results.

These questions are formally included into the classical decision making theory (DMT), and in order to take them into account, it is necessary to present figures in the form of judgments about possible consequences and statements about preferences. For the first case, methods of probability theory are applied, and for the second one, there are methods of utility theory.

Errors in the design may occur when using incorrect source data, incorrect methods, etc. When computerizing the design, the problems associated with errors made in the computational process have appeared. The process of assessment of selection of design solutions for construction production by a construction expert is influenced by many factors that can be divided into the following groups [2]:

- the purpose of legal proceedings;
- the content of the questions raised;
- the initial documentation (research of case papers);
- grounds for solutions selection (performance indicators and solution methods taken into account);
- assessment situations (results of a field study);
- the level of professional training of a construction expert.

At present, within the framework of JCTE, issues related to the assessment of the computer component of the process of selecting design solutions for building production are not being resolved. In addition, there are still no major developments aimed at solving the scientific, methodological and organizational foundations of this problem.

The need to select design solutions is usually based on the need to determine the costs of financial, labor, material and energy resources at violation of the requirements of regulatory documents; the established procedure for the construction of facilities, their acceptance and commissioning; the rules of use of the premises, as well as of the maintenance and repair of premises, buildings, structures, etc. The proper costs determination is a complex task which requires considerable theoretical knowledge and practical experience. Alternative design solutions are considered when there is more than one
variant, and therefore more than one result. The results are the end consequence of certain solutions which is characterized by different value. At that, the concepts of practicality, advantages, fines, losses, etc. are used to justify the value [3].

The most important stage in the selection of design solutions is the formation of the initial data for a construction expert, i.e. the information support of the research process. Sources of information in the research of the construction process are the production object and process, the environment, the relationship between elements of the production process and the environment as well as between individual participants in the construction process. When analyzing the construction process, a construction expert performs field studies, measurements, comparisons and some calculations.

The activity of a construction expert includes performing observations, surveys and assessments. The surveys and assessments can be carried out either using questionnaires or the Delphi method. The calculations carried out in order to analyze the results of expert research are conducted by applying the methods of regression and correlation analyzes, performing interpolation and extrapolation calculations, using the methods of mathematical statistics and ones of researching operations.

Many basic data for a construction expert can be obtained through mathematical modeling. In this case, a real or idealized object is taken as the basis of modeling. As a real object, an experiment can be accepted which is performed in laboratory or production conditions with subsequent modeling on a PC. An idealized object is a mathematical model of functioning of the object under study. At mathematical modeling of a real or idealized object, listed or standard indicators specified in various reference materials or data obtained as a result of experimental or field studies can be used as technical and economic indicators. The activity of a construction expert when conducting mathematical modeling includes performing the required experiments, observations, measurements, modeling, analysis of the results obtained, comparison with existing similar research results.

The formation and development of JCTE, along with the arrangement of the methodological support of this kind of activity, implies the creation of algorithms for solving typical expert issues.

The specificity of the tasks considered in the framework of JCTE is if an expert is only asked questions when assigning examinations of other types, then at assigning of JCTE, in addition to solving issues, the expert is invited to develop variants and select the most preferred one.

On the basis of the local interpretation of some results of theoretical works [2] and analysis of judicial practice, a method was obtained that can be used at JCTE in order to solve the issues of a design solution selection. When using this method, all rearrangements of variants are checked by their preference and compared with each other. The method allows determination of the best adjustment of variants. It was developed by I.Paellnk [4] for use in case if the cardinal (numerical) values of the importance of efficiency indicators are known.

As part of this paper, an adaptation was made for the use of an existing methodology, which was developed and practically implemented in the non-judicial sphere of variant design. A significant difference is the use of both cardinal and ordinal performance indicators as the indicators of effectiveness. The method algorithm is shown in Figure 1.

The decision making matrix is compiled as:

\[
P = \begin{bmatrix}
x_1 & x_2 & \cdots & x_n \\
a_1 & x_{11} & x_{12} & \cdots & x_{1n} \\
\vdots & \vdots & \ddots & \vdots & \vdots \\
a_2 & x_{21} & x_{22} & \cdots & x_{2n} \\
\vdots & \vdots & \ddots & \vdots & \vdots \\
a_m & x_{m1} & x_{m2} & \cdots & x_{mn}
\end{bmatrix}
\]

(1)

In order to solve the issue, a set of factors of importance for performance indicators is required: \( q_j \), \( \sum q_j = 1; j=1, n \)

From these n variants, selection of the best one is needed — setting the preference relation for the multitude of variants, or, equivalently, finding a rearrangement of variants that agrees with the value
system “in the best way”. Let us suppose that there are only three variants: \(a_1, a_2, a_3\); then there are
only six rearrangements (\(3! = 6\)):

\[
\begin{align*}
\pi_1 &= \{a_1, a_2, a_3\} & \pi_2 &= \{a_1, a_3, a_2\} \\
\pi_3 &= \{a_2, a_1, a_3\} & \pi_4 &= \{a_2, a_3, a_1\} \\
\pi_5 &= \{a_3, a_1, a_2\} & \pi_6 &= \{a_3, a_2, a_1\}
\end{align*}
\]

Let us suppose that the checked order of variants is \(\pi_5 = \{a_3, a_1, a_2\}\), then the multitude of the consistent partial
order is \(\{a_3 > a_1, a_3 > a_2, a_31 > a_2\}\), and the multitude of the inconsistent partial order is
\(\{a_3 < a_1, a_3 < a_2, a_1 < a_2\}\).

If at the adjustment (rearrangement) of variants, there is partial order \(a_k > a_e\), the fact that
\(x_{kj} \geq x_{ej}\) is estimated using \(q_j\), and the fact that \(x_{kn} < x_{en}\) – using \(q_n\).

The assessment of the adjustment of the \(\beta_g\) (\(g = 1, 2, ..., m!\)) variants is performed as follows: let
there be the \(g\)-th rearrangement \(\pi_g = \{..., a_k, ..., a_e\}\), \(g, g = 1, m!\), where \(a_k\) is more preferable than \(a_e\;\); then this rearrangement is assigned the following assessment of \(\beta_g\):

\[
\beta = \sum \sum g - \sum \sum g; g = 1, m!
\]

where \(C_{k,e} = \{j/x_{kj} \geq x_{ej}\}; k, e = 1, m; k \neq e; H_{k,e} = \{j/x_{kj} < x_{ej}\}; k, e = 1, m; k \neq e.\)

The best (most consistent) adjustment is the one at which \(\beta_g\) is the largest value.

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**Figure 1.** Logical diagram of the adjustment of possible variants by preference

The considered method has been repeatedly applied in solving practical issues of JCTE. Some
examples of the application of this method were previously discussed in scientific papers [5,6,7].
Actually, this type of tasks is often found in the framework of arbitration processes when solving issues on the effectiveness of the use of budgetary funds. The standard issue for the research of JCTE is: whether it was possible to perform construction and installation work using a smaller amount of funds, or whether it was possible to achieve a better result using a certain amount of funds.

The use of the proposed algorithm seems to be the most appropriate for preparing conclusions of the forensic construction expert in this category of cases.

Summary
In order the research performed by a forensic construction expert to meet modern requirements at its level, and its development to be progressive, the paper includes the consideration of principles of selection of multi-purpose design solutions for construction production and the development of an algorithm for solving problems related to the determination of the efficiency of using budgetary funds. The availability of such information in the arsenal of construction experts largely determines the effectiveness of their work.

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