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MULTI-CRITERIA DECISION ANALYSIS OF UP-TO-DATE CONSTRUCTION TECHNOLOGY

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At the very moment various construction and projection firms offer to use all kinds of new technologies and its systems, structural decisions, proper materials used as well as work implementation methods, without paying any attention to the factors, effecting the choice of selecting the most effective technology of construction process. Having in mind that funds should be realized rationally, it is the matter of vital importance to measure the practical adaptability of technologies being used either they are new or have been used for many years to achieve the best technological decisions. In order to achieve the efficiency of the funds invested and diminishing construction duration as well as increasing its quality, various construction process technologies are developed and improved by using modern technical and informational tools, which are integrated into the stages of projection and construction. The paper analyzes the methods of multi-criteria alternative technological solution evaluation in construction environment. Methodology, which is used, allows to complex evaluate the efficiency of construction designed decisions at the stage of preparation phase. There has been done a practical technological modeling of installation process of concrete floor as well as there have been determined optimal solutions. In order to achieve the results mentioned, a method of proximity to an ideal point was used.

Keywords: Optimization, Method of proximity to an ideal point, Construction technology, Algorithm.

1 INTRODUCTION

The prospective technological processes' decisions and operations, their efficiency and competitiveness are programmed at the stage of construction objects' projection. In order to achieve the efficiency of construction technology it is advisable to use the achievements of fundamentals and applied science to solve the main tasks in various spheres of construction decision modeling and optimization.

While modeling and projecting construction technologies, it is advisable to perform the multi-criteria analysis of technological processes and decisions on the grounds to fully coordinate the goals of the interested parties (customer, projector and contractor). That is why major principles and methods of construction decision technology multi-criteria optimization as well as questions associated with alternative decision technologies and mathematical modeling are analyzed in this paper. As for example, which provides the practical technological modeling of installation process of concrete floor and determining the optimal decisions based on the method of proximity to an ideal point.

2 MAJOR PRINCIPLES OF CONSTRUCTION TECHNOLOGICAL DECISION OPTIMIZATION

Applicable technological and other project decision optimization methods used in projection and construction processes could be divided into two major groups: applied mathematics and systemic-technical analysis methods. A great deal of construction organization tasks could be solved by using mathematic statistics, theory of chances, mathematic programming, 'gambling' theory, multi-criteria optimization and other methods. The selection of optimization method depends on the task character which is solved, the possessed source information and frequently it requires local interpretation. While solving practical construction optimization tasks, most frequently only one of several economic criteria is chosen. The significance of the criterion selected is very important. It shows that one of the criterions mentioned, which is selected by the interested party, is much more important than the other one, for example, total construction price. So to be concrete it shows the significance of one criterion to the interested party in comparison to the rest, which are left as less significant or insignificant. The significance of the criterion could be determined by employing statistical, expert opinion based methods, even comparison, and entropy methods. These methods help to determine various theoretical, subjective, and complex values of great significance that are further used in the decision optimization counting processes. By counting values it is meant that the interested party could choose the criterion of the greatest significance. So any construction technological decisions could be described and optimized according to the following system of criteria evaluation, where the criteria could be expressed by the indices of technological economy and quality characteristics. For this purpose methods of multi-criteria decisions are used (Zavadskas and Kaklauskas 1996, Janusaitis 1998).

We can definitely state that each of the decision optimization method mentioned has got its own advantages and disadvantages. Moreover, each of them could be used to solve the tasks of specific constructions groups. They help to create various optimization models of theoretical objects, technological or work processes like technological net models, mathematic models, expert level systems, decision support systems and many others models.

Researches of modeling and optimization were founded on the basis of applied mathematics method, economics, system theory, cybernetics, and in the sphere of counting technological science and its integration. While optimizing technological construction processes, it is advisable to apply the theoretical principles of system methodology on the grounds that in nowadays the technological projection methods which are used do not correspond to the requirements of effective decision making. It could be noted that one of the major disadvantages are the decisions accepted synonymous, without any preliminary examination and evaluation of the model of construction process technology and many the like multi-criteria evaluation (Zavadskas *et al.* 1999, Rapceviciene 2010). While solving the any technological decision optimization problem, it is necessary to perform 3 major steps of construction process systemic examination (Figure 1).

While modeling the construction composite process technological decisions, it is advisable to accept these main preconditions (Zavadskas *et al.* 1999, Sarka *et al.* 1999):

(1) All possible variations of complex process technologic decisions have to be constructed. Moreover, technological connections and partial variants of the processes (partial alternative decisions) have to be established;

(2) While forming the net model, consisting of partial process technological variants, it is necessary to take a precondition that only one of many other partial process technological variants will be implemented;

(3) Every partial process has got its individual time duration, which is either technologically based or depends on the work expenditure.

So while creating the mathematical model of alternative technological decision making, it is advisable to define the set of the compared alternative decisions and their evaluation criteria. In that case, the source data matrix P is prepared and most often consists of different units of measurement.

That is why the matrix should be normalized, i.e., it has to be transformed into the anti-dimensioned unit or sizes. Knowing the aims of the solution as well as applying the methods of normalization various normalized values of indices are obtained, which play the key role in other stages of solution multi-criteria optimization.

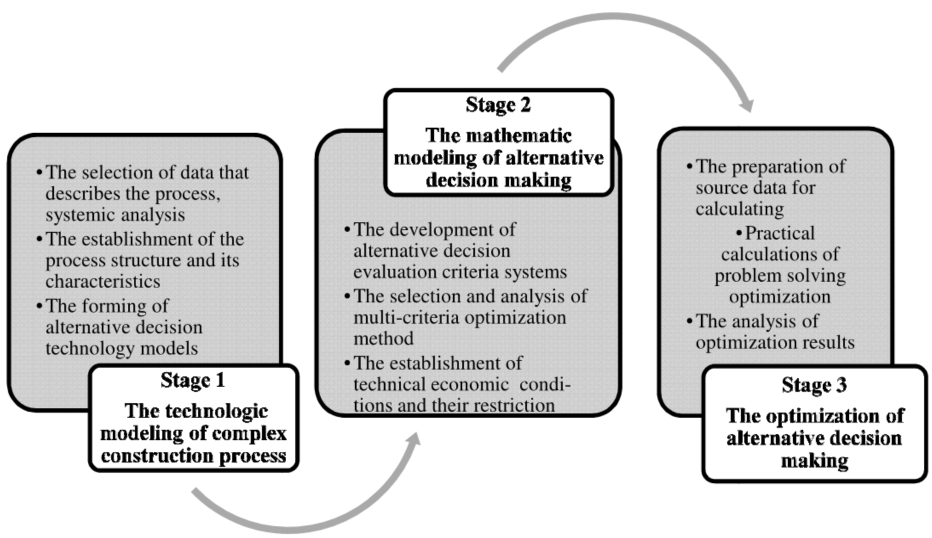

Figure 1. The steps of construction composite process systemic examination.

3 THE MAJOR RUDIMENTS OF APPLYING THE METHOD OF PROXIMITY TO AN IDEAL POINT, USED TO EVALUATE THE TECHNOLOGY

The main essence of the multi-criteria evaluation method is formation of generalized composed criterion. It is based on the comparison deviation of the criteria from so called the ideal criteria, consisting of the best variant criteria being analyzed. By applying the method and K_{bit} criteria, it is advisable to take into account that each variant of the task problem solving utility function has got the tendency to monotonously increase or monotonously decrease, i.e. the larger value of any indices, the better it is or worse for less of the same index value. It depends on the fact whether the utility function increases or decreases. Indices have to be either cardinal or ordinal. If we have got the ordinal indices, they should be quantified. Besides, significance values should be determined, otherwise, they all are accepted as being equals. The application algorithm of the method of proximity to an ideal point, estimating the significance of the criteria, is presented in Figure 2.

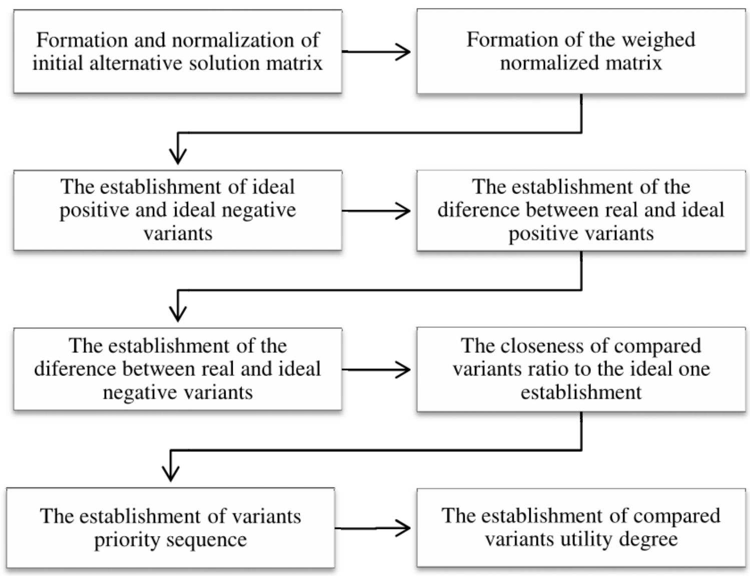

Figure 2. Application algorithm of the method of proximity to an ideal point.

The matrix P of alternative architectural decisions is created. There could also be criteria either grouped or ungrouped. The matrix normalization is being dome according to the formula:

$$\overline{x_{ij}} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \qquad \text{where } i = \overline{1,m};\ j = \overline{1,n} \qquad (1)$$

If the significance of the subjective or theoretical ($\overline{q}$ or q_t) criteria is known, then the vector column multiplied by the normalized matrix corresponding column.

$$\text{We get weighed matrix } \overline{P^*} = \left[\overline{P}\right] \cdot [q] \qquad (2)$$

If there are no values of significance, then $\overline{P} = \overline{P^*}$ ($\overline{P}$ matrix is compared to the weighed matrix), i.e. we take the precondition that entire alternative solution criteria are equally important. The ideal positive variant is being established:

$$a^{+} = \left\{ \left[\left(\max_{i} f_{ij} / j \in I \right), \left(\min_{j} f_{ij} / j \in I' \right) \right] / i = \overline{1,m} \right\} = \left\{ f_1^{+}, f_2^{+}, ..., f_n^{+} \right\} \tag{3}$$

where I – indices of ratio (maximizing), which possess the highest values.

The ideal negative variant is being established:

$$a^{-} = \left\{ \left[\left(\min_{i} f_{ij} / j \in I \right), \left(\max_{j} f_{ij} / j \in I' \right) \right] / i = \overline{1,m} \right\} = \left\{ f_1^{-}, f_2^{-}, ..., f_n^{-} \right\} \tag{4}$$

The difference (distance) between real and ideal positive variant is being found:

$$L_i^{+} = \sqrt{\sum_{j=1}^{n} \left(f_{ij} - f_j^{+} \right)^2} \tag{5}$$

where a_i – real variant; a^+ - ideal positive variant; L_i^+ - positive distance.

The difference between real and ideal negative variant is being found:

$$L_i^{-} = \sqrt{\sum_{j=1}^{n} \left(f_{ij} - f_j^{-} \right)^2} \tag{6}$$

$K_{bit,\,i}$ calculation of values (each alternative value is found):

$$K_{bit,i} = \frac{L_i^{-}}{L_i^{+} + L_i^{-}} \text{, when } \forall_i ; i = \overline{1,m} \tag{7}$$

$0 \le K_{bit} \le 1$, besides,

$$K_{bit,i} = \left\{ \begin{matrix} 1, \; jei \quad a_i = a^{+} \\ 0, \; jei \quad a_i = a^{-} \end{matrix} \right\} \tag{8}$$

The best (the most rational) architectural solution will become the one, which K_{bit} value will be max ($K_{bit,i}$=max). Using the values we form the priority sequence utility degree establishment. We compare the value of the variants: examined with the ideal.

$$N_i = \frac{K_{bit,i}}{K_{bit,\max}} \cdot 100\% \tag{9}$$

4 THE ESTABLISHMENT OF THE OPTIMAL FLOOR COVER EQUIPMENT TECHNOLOGY, APPLYING THE METHOD OF PROXIMITY TO AN IDEAL POINT

The change appeared in technological systems affect not only the rest systems parts or elements, but also the expected final result. This is why it is of vital importance to deliver systemic structuralization of the construction technological processes.

The installation of the floor cover is only a partial installation process, which could be analyzed in the complex manner. The complex process of the floor cover equipment maximally can form 7 partial processes. Each partial process possesses the original structure, which is distinctive from the rest.

While establishing the combinations of partial processes, the technological combination sequence of partial processes is found. It is important to establish the combinations of technological connections among the separate partial processes, because it could happen so that the variant of the partial process does not possess the connectivity with the other variant of the partial process, i.e. one of them could have no technological connection with another.

Evaluation criteria system: *K1* – the price of floor installation variant; *K2* – work costs; *K3* – the level of work mechanization in percentage, %; *K4* – the floors' resistance to wear and tear; *K5* – the chemical resistance of the floor cover, in points; *K6* – the beginning of using the floor cover, in days; *K7* – comfortability, in points; *K8* – ecology conditions, in points; *K9* – aesthetic view, in points; *K10* – hygiene, in points.

Subjective criteria significance are determined by the even comparison method. While performing the calculation of criteria significance on the basis of even comparison method, we received the significance of subjective criteria. The source matrix is formed in the following stage.

While performing the normalization of the matrix, and evaluating the significance of the criteria, as well as forming weighed normalized matrix, we received calculation results.

5 CONCLUSIONS

At the very moment various construction and projection firms offer to use all kinds of new technological projecting systems as well as work execution technologies, without paying any attention to the circumstances, affecting the choice of selecting the most effective technology of construction process. In order to rationally employ the technological process of the funds, it is advisable to perform the modeling and multi-criteria evaluation of the alternative solution technology.

To perform the selection of the most suitable floor cover installation variant, the algorithm of solution optimization was formed a well as the criteria evaluation system, which describes the goals of interested parties striking for the aim in projection, work execution and exploitation processes.

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