Choice of the Rational Option of the Organizational and Technological Decision, Taking into Account the Exposure of Random Factors

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Abstract. Nowadays with investment lack and degradation of the traditional contracting form of construction the use of project-based management allows to implement investment and construction projects under the fixed time and cost constraints using the development of rational management decisions. The use of method of limited resources distribution based on priority of works and costs to compensate the negative impact of random factors during scheduling and feasibility studies of investment projects contributes to a more efficient use of allocated resources for the construction of units and more accurate planning of expenses. The authors give necessity evaluation of the implementation of comprehensive engineering support of investment and construction projects throughout the life cycle with maximum responsibility of the construction company to the customer under the highest concentration of managerial authority.

1. Introduction

Construction is one of the few economy sectors, which unites a great number of independent economic entities, having their own economic interests, that confirms the necessity of presence of an organizer, who coordinates the activity of all the participants of the investment-construction activities.

Concentrating the management authority in places of occurrence of disturbances, which have negative impact on the construction course, the construction organizer makes feasible decision efficiently and delegates them to contractor organizations, fulfilling works and building construction, special works and logistic technical support as well.

In domestic practice of organization of the investment-construction activities feasibility study of construction, in general, is expensive in nature and does not consider the effect of changing external environment, subjective reasons and other random factors properly, which negative impact prevents implementing the project in frames of originally specified limits [1].

2. Methodology

For solving the problem of choosing the best option for the organizational and technological solution taking into account the priority of the works performed and costs for compensation of the negative impact of random factors it is offered iterative modelling of various uncertainties by means of introducing corrective indexes which form database statistic sampling distributions, expert assessment, mathematical expectation and dispersion [2].
3. Main part
Identification of the probability of deviation of indicators timing facility construction cost from the specified options if implemented according to the following scheme:

1) to identify the maximum likelihood of the implementation of all kinds of works with observance of the time constraints;

2) to determine the greatest probability value of execution of certain types of works within limited cost parameters;

3) the received results are compared with each other as well with the other criteria after that the probability of the project realization is determined.

The main rules of the priorities identifications of the work performed can be the following:

1. The work which is on the critical way of the calendar plan (network) and is in completion stage has the priority.

2. Priority corresponds the expected useful effect in general scope of work.

So all the works to be performed are offered to be divided into three parts according to their importance:

1) High importance - these works implementation provides mechanical, fire, and for especially dangerous, technically difficult and unique objects: industrial, nuclear, radiation safety, which supposes priority funding in full at this stage.

2) Medium importance - this works execution allows to complete the construction of the object in sufficient to start operation provided: safe to human health, living conditions and stay in buildings and constructions, safety of users of the building and constructions, access of these buildings and constructions for disabled and other population groups with limited possibility of movement, energy efficiency of buildings and constructions, safe level of environmental impact of buildings and constructions etc. In this case resourcing and funding is implemented according to the residual principle after satisfaction the requirements of the first group.

3) Low importance - works, which determine aesthetic perception and don’t influence the safety of the object. These works cannot be financed during the main period of the construction, and their implementation, if necessary, can be moved to the initial stage of facility operation after start profit.

In case of even and sufficient funding all works of medium and low priority are implemented in full according to construction schedule. Object implementation in frames of engineering management scheme is focused on maximum contractor responsibility to the customer, including the functions of linking procedures of choices work implementation, their estimation and resource allocation among them.

The conception of project management enables to create new instruments of regulation of investment activity, which, in their turn, enable to plan construction costs of objects taking into consideration their erection in deadlines and to determine the probability of deadlines.

In this regard the construction organizer and contractor companies interact in view of great number of the original settings: time and cost of construction, the range of material-technical and labor force range, production capacity indicators of the contractors, construction terms, intensity and uniformity of resource consumption, etc.

On the stage of construction preparation during the development of technical documentation different variants of solutions are compared, the sequence of works is determined taking into consideration their achievement of the highest total efficiency. The proposed system of averaged priority coefficients on works, which is used in calculation scheduling and technical-economical justification (TEJ) of investment projects, especially when funding is limited can become an effective instrument of improving the efficiency on account of rational distribution in time and space of allocated construction resources.

Problem statement of alternative variants choose of technical decisions and formalized description of its decision is offered to carry out based on method of nested scalar convolutions proposed by A.N. Voronin [3, 4], based on N. Bohr principle of complementarity and K. Gödel incompleteness theorem.

In general, the solution to the problem is represented by the formula:
\{ \{N\},\{Y\}\} \rightarrow \mathcal{N}^*, \quad (1)

where \{N\} is multitude of construction works; \(Y\) - selection function (rule of priority determination); \(\mathcal{N}^*\) - selected priority kinds of construction works.

Multitude \{N\} - list of construction works, from which is necessary to choose priority ones according to the category.

In determining function \(Y\) specification and vector estimation of work options are determined (for example: resources, duration, complexity, machine capacity, time reserves, etc.) after it the decision is made by results of their comparison. The system of vector approach is implemented by means of decomposition \(Y\)-function on the set, which leads to priority determination in the structure of its indicators. Properties of all the works to be performed preliminarily divided to priority categories from the first to the third one, at this they are considered to such level at which they are convenient to compare. The problem of setting standards of alternative variants can be expressed by hierarchical system, when on the low level estimation of separate works is carried out on indicators, determined by means of priority vector, and on the high level the importance level is determined from the point of view of the entire object construction. For this purpose, it’s necessary to set the list of estimation standards preliminarily and distribute them on hierarchical level.

Quality characteristics (alternatives) of executed works are determined by prior vector system.

\[
y^{(i-1)} = \left\{ y^{(i-1)}_i \right\}_{i=1}^{m^{(i-1)}} \text{ for } i \in [2,q], \quad (2)
\]

where \(y^{(i-1)}_i\) - is priority vector on \((i-1)\) hierarchical level, on its standards quality characteristics of variants on \(i\)-level; \(q\) - number of levels in hierarchy; \(m^{(i-1)}\) - number of estimated parameters \((i-1)\) level. Numbers of \(m\) standards \(y^{(i)}\), first category standards for the considered variant of the performed work are given. It follows therefore, that \(m^{(1)}=m\) and \(m^{(q)}=1\).

The same indicator \((i-1)\) level can be involved in estimation of some properties \(i\)-level at the same time.

The important of every \((i-1)\) level component criteria at estimating \(p\)-quality \(i\)-level is characterized by priority coefficient aggregation of which makes priority vectors system.

\[
K^{(i-1)}_{ip} = \left\{ K^{(i-1)}_{ip} \right\}_{p=1}^{m^{(i-1)}} \text{ for } i \in [2,q], \quad (3)
\]

where \(K\) - priority coefficient.

Based on system method, at solving the problem of choosing alternative variants the search of analytical estimation of priority vector \(y^*\) and quality estimation of the effectiveness of this method is made, and from the determined alternative variants the best one is chosen. At this, every alternative should be considered in aggregation of all correlation components with different characteristics, which differ from common object parameters.

The decision of the problem by the method of nested scalar convolution ex expressed by iterative sequence of operations of measured scalar convolution of vector settings of separate hierarchy levels from low to the high one taking into consideration priority vectors based on selected compromises scheme:

\[
\{y^{(i-1)}, K^{(i-1)}\} \rightarrow y^{(i)} \text{ for } i \in [2,q], \quad (4)
\]

and the search of efficiency estimation of all the hierarchical system (alternative) in general is presented as a problem of definition scalar convolution at the high hierarchy level:

\[
y^* = y^{(i)}, \quad (5)
\]

Possibility of using of recurrent formula (4) is determined by term of rational choice of compromise scheme. Using the method of nested scalar convolution, it is preferable to use nonlinear compromise
scheme, provided that all private settings are non-negative, are subjected to minimization and are limited but at this the unity of hierarchical system is maintained in general:

\[ 0 \leq y_i \leq B_i, \quad B_i = \{B_i\}_{i=1}^{n}, \quad \text{where } B - \text{is limited settings vector of considered hierarchy level; } n - \text{is their number.} \]

Estimation of P alternative quality on \(i\) hierarchy level on the basis of the positions (4) and using nonlinear compromise scheme if determined by the following formula:

\[ Y_{p(i)} = \sum_{i=1}^{n(p-1)} k_{ip}^{(i-1)} \left[ 1 - y_{0p}^{(i-1)} \right], \quad P \in [1,n]. \]

where the normalized parameters of the (i-1) level are reduced to unity. At this, \(y_{0p}^{(i-1)}\) - are components of normalized vector \(y_0^{(i-1)}\), participating in estimation P-alternative quality on \(i\)-hierarchy level; \(n_{p}^{(i-1)}\) - is number of components; \(n^{(i)}\) - is number of estimated settings on \(i\) level.

K priority coefficient, being formal parameters, have double physical meaning. Firstly, they are (construction organizer). Secondly, they are coefficients of meaningful regression model, which is based on the concept of nonlinear compromise scheme. K coefficients are formed at each hierarchical level by means of optimization on simplex and using dual approach or by means of expert estimations according to normalized drawn scale (Table 1)

| Importance category | Intervals of normalized scale estimations \(Y_0\) |
|---------------------|-----------------------------|
| Low                 | 1.0...0.6                   |
| Medium              | 0.6...0.2                   |
| High                | 0.20...0.0                  |

The maximum allowable multitude of priority \(K \in G_k\) coefficient is determined by simplex method:

\[ G_k = \{k|k_i \geq 0, \sum_{i=1}^{n} k_i = 1\}. \]

Such sphere of determination is formed provided calculation priority coefficients by formula:

\[ K_{ip}^{(i-1)} = \frac{J_{ip}}{J_{ip}^{(i-1)}}, \quad p \in [1,m^{(i)}], \quad i \in [2,n]. \]

where \(K_{ip}^{(i-1)}\) - \(i\)- component vector priority criterion on (i-1) hierarchy level at definition of effectiveness evaluation of \(p\)-quality of \(i\)-level; \(j_{ip}\)-evaluation effectiveness of \(i\)-quality (i-1) level for \(p\)-quality of \(j\)-level (appointed by the construction organizer according to scale score) (Table 1).

The received expression should be normalized, it means to take relative criterion \(Y_{0p}^{(i)} \in [0; 1]\) so that it should be minimized and its limited value should be equal to 1. At this formula (7) shows the idea of nested scalar convolution method according to recurrent formula (4).

The structure of nonlinear compromise scheme enables to norm nesting (10) not to maximum (in this case it is problematic), and to minimum value criterion nesting. Total recognized than zero values are ideal for minimized criterions. Putting in formula (10):

\[ Y_{0p}^{(i)} = 0, \quad \forall i \in [1,n_{p}^{(i-1)}]. \]

and taking into consideration normalization (8), we get \(y_{pmin}^{(i)} = 1\). Final expression for recurrent formula calculation of analytical estimations alternative properties on all hierarchy levels get the look:
A_{39}^{(1)} = 5 - H \sum_{j=1}^{19} (15)^{9 (15)} (15) \sum_{i \in \{?,\leq,\geq\}} (11).

Based on concepts of ordinal fundamental scale and variants estimation method at choosing alternatives by interval normalized drawn scale for analytical data translation, received by calculation way to appropriate linguistic criterions description, scale score for assessment of importance of work performed is introduced (Table 1).

4. Conclusions

More exact forecasting of the results of investment construction projects in conditions of engineering scheme of management in presence of construction organizer enables to make rational management decision, increasing not only planning efficiency, but implementation of project solutions [5]. Modern communication media and appropriate software, which is the basis of BIM-technology contribute improving the quality of decisions, efficiency of development and feasibility of probability of their implementation. Changing of given parameters of investment-construction projects under the influence of random factors can be corrected by introducing appropriate priority coefficients, which enables to state time and cost of the construction which are close to real. Together with it kinds of construction works are determined which implementation as a matter of priority will enable to get maximum efficiency; stages of development of technical decisions of erecting the object are stated in accordance with selection criterion hierarchy. Otherwise, ignoring of negative impact of random factors can cause to essential distortion of data at development of forecast indicators duration and cost of object exaggerated simplification of chosen scheme of implementation of investment-construction object [6].

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