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METHODOLOGY OF RISK AND UNCERTAINTY MANAGEMENT IN CONSTRUCTION'S TECHNOLOGICAL AND ECONOMICAL PROBLEMS

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ABSTRACT

Uncertainty and risk are close related both as threats associated with indefinite source and consequences during the implementation of construction projects. The article deals with through analysis of possibilities to reduce uncertainty solving technological and economical problems. The methodology is presented as step by step tool for risk and uncertainty management in construction. Theoretical background, practical innovative applications with the clarification of problem source, planning of "what if" solutions in construction site and usage of definite steps of uncertainty management are suggested in this article.

KEYWORDS

Uncertainty, risk, decision making, computer-aided modelling, automation in construction.

1. INTRODUCTION

An uncertainty problem is the main that influence the project's implementation parameters. It can be predicted with some possibility level but it is better to foresee possible optimistic and pessimistic "what if" scenarios with detail solving solutions and "stop threat" means for effective construction project management. Consequently this article is presenting various types risk what are undistinguishable from uncertainty circumstances in construction industry. Article is prepared to describe the reasons of uncertainty and situations during the implementation of construction project.

This article defines uncertainty and risk essentiality [1, 2] and thorough description of steps for construction project risk management as the process of making informed construction project decisions. Thorough description of uncertainty's sources presented with consequences that every project participant can face during the implementation of construction project [3]. When reasons and sources are defined, then the suggestions of reducing the uncertainties in construction technological and economical problems can be given. It is intended to explain the risk management process and related solutions for construction project life cycle management [4] with suggestions how, when and what actions can be taken to support project decision-making [5] under conditions of uncertainty.

2. DEFINITION OF UNCERTAINTY AND RISK

In recent years scientists describe uncertainty as associated with uncertainty management (Smith, 2000), which is the process of integrating risk management and value management approaches of construction process [1]. Theoretically *uncertainty* can be defined as a lack of certainty involving variability and/or ambiguity [2]. Alike *uncertainty management* is concerned as managing perceived threats, opportunities and their risk implications but also managing the various sources of uncertainty which give rise to and shape risk, threat and opportunity (Chapman and Ward, 2002) [3].

In *uncertainty* situations, parameters are uncertain, and furthermore, no information about probabilities is known. Whereas in *risk* situations, there are uncertain parameters controlled by probability distributions are known by the decision maker (Snyder, 2005) [4].

The difference between *risk* and *uncertainty* is usually expressed in terms of whether it is possible to quantify the inexactness with which future values of a particular quantity are known (Brauers, 1986) (Del Caño, Pilar de la Cruz, 2002) [2, 5]. Mathematically stated differences between uncertainty and risk are important, but in this article these the two terms will be used interchangeably because both describes uncertainties in construction project management.

Parts or even entire construction project can be treated as the same to accomplished similar construction projects [6, 7]. However, these assumptions are not always correct and their bias degree is quite high in comparison to actual obtained parameters after the construction project implementation [6, 8]. It is because every construction project is unique [9] and every project includes a high degree of uncertainty.

The uncertainty in undertaking a construction project comes from many sources and often involves many participants in the project [6, 8]. Since each participant tries to minimize its own risk, the conflicts among various participants can be crucial to the project. Failure to recognize this responsibility by the owner or manager often leads to undesirable results. What is why risk management is the means by which uncertainty is systematically managed to increase the likelihood of meeting project objectives [5, 8–10].

Most of scientist emphasize that the key word is systematic [1, 4, 5], because the more disciplined the approach, the more we are able to control and reduce the risks [6].

3. SOURCES OF UNCERTAINTY

Uncertainties and risk cause the range of problems during the implementation of construction project. In this part of article five tables are presented with description of uncertainty sources [5, 10-14] and possible consequences. Sources and consequences are combined in five groups to clarify the type of uncertainty source:

- ununified communication [5, 12] and undefined "Project language" (see Table 1);
- low qualification and professional training [15] of employees (see Table 2);
- unestimated work amounts [16] in project's estimate and unacceptable planning of works [17, 18] (see Table 3);
- the lack of management tools [19–22] and ineffective-irrational organization of works on site [23, 24] (see Table 4);
- unclear responsibility limits [23] and no strict contractual obligations [14] (see Table 5).

Table 1. Sources of uncertainty and consequences due ununified communication and undefined “Project language”

Consequences due ununified communication and undefined "Project language":
a) Using of ununified terms and definitions and project documentation leads to misunderstanding between groups of project participants or even the project team members
b) disordered management of project document leads to chaos in documents (such as unnecessary duplicate of documents and management procedures, unclear current or even final project design and document revisions, frequent .major differences between technical or workshop design documents and documentation of work implementation)
c) unclassificated order of project stages and breach of company procedures or even project implementation with out any procedures leads to waste of time, duplicate of responsibility and procedures, uncoordinated works of team or even project participants;
d) different data formats of project data (drawings prepared with different software), design and document files as different "project language" (waste of time and quality) can lead to communication breakdown and can ruin the project.

Table 2. Sources of uncertainty and consequences due low qualification and professional training of employees

Consequences due low qualification and professional training of employees:
a) unqualified personnel can ruin even very well prepared and organized project with ideally prepared design;
b) waste of time and barriers to effectiveness of project implementation due Stubborn conservative instead of Open minded and innovative attitude;
c) the lack of contractor experience (no experience in similar construction project, lack of professional knowledge, the deficiency of adequate project management) can lead to delay of time for project implementation, grow the expenses.

Table 3. Sources of uncertainty and consequences due unestimated work amounts in project's estimate and unacceptable planning of works

Consequences due unestimated work amounts in project's estimate and unacceptable planning of works:
a) delays due the "enlarged" (unestimated) scope of works and lack of resources (unplanned work force, unordered materials and unrented machinery)
b) low level of quality will be chosen because there won't be enough time to execute works according to technological order and obligatory project's quality requirements (work completed in a rush)
c) rise of prices for fast design and execution of works (connected with changes made by client, delayed problem solutions prepared by designers and delayed implementation on site)
d) unexpected grow of expenses on site (such as site fencing and temporary facility renting, security, salary of site personnel and operational costs)
e) an investment return behind the schedule and grow of unforeseen client's expenses according to contractual obligations to bank other investment source.

Table 4. Sources of uncertainty and consequences due the lack of management tools and ineffective-irrational organization of works on site

Consequences due the lack of management tools and ineffective-irrational organization of works on site:
a) lack of tools for project management can be described as negative effect to design and construction procedures. The professionally prepared documents must be managed with at least the same level of tools (software, hardware and machinery);
b) ineffective organization of works on site due the lack of work schedule, or the unavailable organization work force (links, brigades) routes at work zones, flours and building parts;
c) irrational implementation of different work types (such as superstructure, partitions, finishing and engineering systems) in direct working order instead of working in parallel way or switching to another work type after finishing the whole amount of works (whole flour, whole building part or whole superstructure) instead of dividing the working area in smaller parts.

Table 5. Sources of uncertainty and consequences due unclear responsibility limits and no strict contractual obligations

Consequences due unclear responsibility limits and no strict contractual obligations:
a) Uncertain limits or responsibility can force the investor to pay additional unplanned costs for contractor and vice versa client can force the contractor to do all work even unforeseen due responsibility limits signed contract (such as contractor must foresee and calculate all possible costs and bring the lowest price in tendering),
b) Ambiguous contractual obligations often are the main reason of argue between client and designer, or between client and contractor, or between contractor and subcontractor
c) dearth of work force, materials and machinery due the construction work demand grow both with supply deficit in industry and the factitious rise of prices. It can't be controlled without fixed prices and costs signed in contractual obligations such as long-term contracts with suppliers, manufacturers and subcontractors.

Just after description of uncertainty sources it is possible to understand the real influence of uncertainty to project implementation and prepare methodology for uncertainty management.

4. METHODOLOGY FOR UNCERTAINTY MANAGEMENT

With the growth of information technologies in the field of construction industry over the last years, numerical building information modeling [7, 9, 16] and process simulation [25, 26] has evolved to a fully accepted and widely used tool for project life circle [6, 8] and uncertainty management [19, 27].

The management of risk and uncertainty begins from appraisal phase, first the objectives and demand are defined in feasibility study. After conceptual stage the thorough description of construction decision's and solutions is preceded. It is advisable to take all possible design decisions in the beginning of evaluation phase before obtaining of construction permit, because later the effectiveness of change decrease and the price of changes increase. As we see from Figure 1 (Migilinskas, Ustinovichius, 2006) [28] design decisions made in project initiation are economically rational and have bigger influence than the decisions made later. To solve the project uncertainties and design ambiguities it is recommended to use an expert services, it can ensure the professional opinion with evaluation of alternative solutions [6, 7, 9] at the very beginning of project implementation [27].

In general the project's risk or reserve are in foreseen in cost and included in estimate as percentile expression. This decision is not the best solution, because money spent in project beginning as early problem solving is 5-10 times more effective than the money for actual problem solving in a hurry (this statement is obviously presented in Figure 1).

The development of a construction execution plan preparation is very much analogous to the development of a good facility design. The planner must weigh the costs and reliability of different options while at the same time insuring technical feasibility and make a decision [10, 23, 25, 27]. Construction planning is more difficult in some ways since the building process is dynamic as the site and the physical facility change over time as construction proceeds. In approaching this problem of uncertainty, it is important to recognize that incentives must be provided if any of the participants is expected to take a greater risk. The willingness of a participant to accept risks often reflects the professional competence of that participant to make decisions (can be client consultant-representative or general contractor) as well as its propensity to risk.

In this case the preparation of project's documentation (3D building information model with design parts of architectural, structural, economical, technological-organizational and engineering systems) [3, 6, 16]. This means what it is possible to reduce risk and uncertainty by using automated computer-aided design systems and video simulation of project's implementation. By using this solution one unit of resource spent in beginning will guaranty the reduction of expenses up to 10 times greater compared with ordinary (all possible uncertainties included) implementation of construction project.

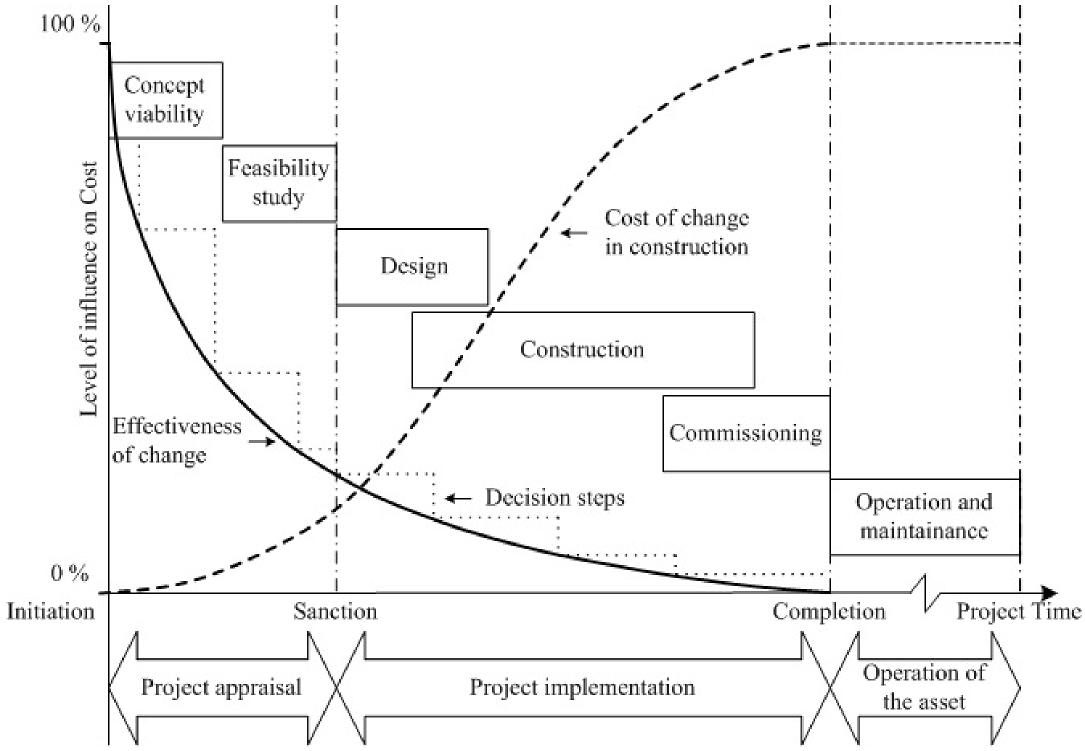

Figure 1 An influence of changes to cost of project

The problem of information exchange between project participants can be solved using defined terminology, descriptions, measure units and constant update of procedures. Disciplined management of project can help to administrate risk and uncertainties, reduce project expenses or time needed for implementation and improve quality of final result (Galway, 2004) [22]. Due the development of construction project the uncertainties are decreasing, the precision of project costs determination is increasing (Tah, Carr, 2001) [23].

However the lack of information is keeping some level of uncertainty and in this case decisions can be made using based on game theory methods (Xu, Wang, Shi, 2001), (Migilinskas, Ustinovichius, 2006). Evaluating of alternatives under uncertainty is fundamentally important in decision-making process [29], especially at the multiple criteria decision-making situations [19, 27]. To compare the construction projects and to select the most economically effective and rational project implementation alternative [20, 25] advisable to use the multiple criteria decision support systems [20].

Description of risk and uncertianties can be used as initial tool for uncertainty management. Continuous management leads to preparation of methodology and solutions to ensure acceptable uncertainty management during whole project life cycle. By summarising all sources of uncertainties mentioned in article it is advisable to use these uncertainty management steps as uncertainty management methodology to reduce and control the uncertainties:

1. All decisions must be based on strictly defined by communication procedures, "Project language" requirements and unified working rules

2. Before the initiation of construction works it is advisable precisely calculate amounts of works (quantities) by using well prepared 3D models, it will help to avoid consequences due unestimated work amounts in proposed tendering price
3. Prepared 3D model of building can be used to simulate construction process before actual start of construction works with possibility to face virtually possible problems and check the proper planning of works. During construction it can help to evaluate any changes of the project and determine possible problems before the consequences occur.
4. Client must choose the contractors with adequate level of knowledge, good experience, enough financial-resource capabilities and effectively working software, hardware and machinery.
5. Limits of responsibility must be defined with strict contractual obligations and common problems with solutions or consequences must be included in construction contract. It is advisable for contractor to have long-term contracts with manufacturers, suppliers and subcontractors.

5. CONCLUSION

Uncertainty management is one of the main problems in construction. Most of solutions are more or less solving this problem but it must meet demands of all project participants. The uncertainty is always evaluated in the beginning of the construction project but it must be continues process with solutions during whole project life cycle.

The sources of uncertainties influence to project and possible consequences are defined in the article. Summarising the research the uncertainty management methodology proposed as general steps and "what if" solutions:

1. Improved communication between project participants and unified terminology;
2. Precise calculation of work amounts (quantities) using 3D building information model;
3. Active planning and virtual project simulation;
4. Chose of qualified personnel and experienced contractors with effective management tools;
5. Defined contractual obligations, responsibility limits and early problem.

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