Identification and risk assessment of historic and listed buildings

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Abstract. The article deals with the identification and evaluation of risks of publicly funded construction projects. The study presents a risk analysis, incl. draft measures to eliminate some of the most serious risks that may affect the completion date and contractual budget. Risks are qualified as the product of the probability of the occurrence of an adverse event and the potential damage caused by the event. Risk identification was based on a list of 30 publicly funded national heritage constructions. The most serious risks from the contractor's point of view were identified as a poor-quality preparation and formulation of the contract agreement, climatic effects and shortcomings in the project documentation. Possible implementation of the proposed solutions to these risks in the construction process can eliminate the contractor's failure to meet the deadline for completion of the construction and exceeding the contractual budget.

1. Introduction

By awarding public contracts, the state provides significant opportunities for the public to use public funds in the economy. In the Czech Republic (CR), 31,428 public contracts were awarded in 2018, with a total volume of CZK 495.50 billion (excluding VAT). Of this amount, roughly 2/5 of the construction is allocated. The value of public contracts increased by 43.50% and the number of contracts by 15.60% compared to 2017 [1]. Given the amount of public funding provided to construction, the use of funds should be considered and directed towards meeting the needs of the general public. In spite of all the efforts of the state to check compliance with the agreed procedures during the construction of the work, serious deficiencies are repeatedly identified in some projects leading to failure to meet the deadline for completion or failure to comply with the contractual budget of the construction. E.g. in the Czech Republic (CR) four construction projects out of ten have not been met and six out of ten construction projects have not been respected [2]. Problems such as budget failures and building cost increases occur both in developing and developed countries. Bent Flyvbjerg, a professor and scientist at Oxford's Said Business School, specializing in the management and financing of world construction projects, said that nine out of ten major construction projects will be more expensive in the world. The planned costs for the analysed buildings are exceeded in the range of 50-100% [3]. Another study states that construction projects have an average cost increase of around 33% [4]. Risk analysis is an irreplaceable tool for decision-making and legislative activities in the construction industry and is important for the success of the project. In developed countries, very high amounts are spent on safety, risk reduction and health protection and their volume is constantly increasing [5]. Project risk management is recognized as a major contributor to the success of a project, but its implementation in practice is far from easy as the process requires a thorough understanding of the 'components' that influence project development [6]. The aim of the risk identification phase is to identify as many potential project risks as possible, to understand them and then to describe them correctly, thus increasing the project's preparedness for possible threats. Risk is a factor that is relatively difficult to assess. In principle, public procurement must take into account all possible risks: political, economic (e.g. market risk, exchange rate risk, credit
risk), security, environmental, etc., since public procurement is linked to the Public Procurement Act and they are strictly codified [7]. Many domestic and foreign publications have addressed the subject of risk identification and risk analysis / management, where researchers analysed various aspects of risk management through the implementation of different research methodologies [5], [8]. Considerable less attention has been paid to the remaining risk management processes such as risk response and risk monitoring and control over the last few years. Many of these studies dealt with risk management at the construction project level, while research into the impact of risks on the construction company and the construction sector as such has been neglected. The most common way to obtain data for carrying out risk assessments was to use a questionnaire or a case study, with output in the form of statistical data [8]. Expert publications are being published and updated to provide a generalized approach to risk management based on modern knowledge [6]. This article aims to identify and qualify the severity of risks that may adversely affect the work of the contractor, thereby leading to a failure to meet the deadline for completion of the construction or to fail to meet the contractual budget of the project. Analysis of construction risks in the Czech Republic is needed to improve the process of implementation of public buildings that will be economically advantageous for the state, as defined by the Public Procurement Act, No. 134/2016 Coll.

2. Methods
The risk assessment process includes risk identification, risk analysis and risk assessment. Risks can be identified using various methods, which are largely universal [9]. In this risk analysis, the world-renowned risk management approach of the US Project Management Institute, specified by the PMBOK Guide (2004), was chosen. The risk identification is based on the definition of risk (R) given by prof. M. Tichý as the product of the probability of realizing an adverse event (P) and the potential damage / impact caused by the event (D) according to the formula: \( R = P \times D \) [9]. The components of risk identification were: 1) study of the project, tender documentation, consideration of circumstances, 2) identification of all hazards and possible hazard scenarios, and 3) list of possible hazards, hazard scenarios, trigger mechanisms. One of the possible methods [10] was chosen for risk identification: brainstorming and consultation with three construction professionals from 10 to 30 years, from the position of site manager to construction company management. Furthermore, historical data and previous experience with own projects were used. Risks were identified and analysed on the basis of an author-created list of 30 public construction projects implemented in the Czech Republic between 2008 and 2019, in the financial range from CZK 700,000 to CZK 30 million. These were listed buildings (churches, historic facades, etc.). The database of implemented projects was compiled from in-house data sources and from publicly available data sources, i.e. portals that publish information on public procurement. The period from the takeover of the construction site to the handover of the completed construction work was included in the risk analysis. Individual risks were classified according to the subject matter into: construction - technical - technological; manufacturing; economic and financial; market; credit; legislative; political; environmental; force majeure; strategic; information and risk with human factor. The second stage of risk assessment is risk analysis, a concept whose interpretation is understood and interpreted differently within risk management. Risk analysis can be quantitative and qualitative [5]. The aim of risk analysis is to make a sound estimate or to directly calculate the probability of occurrence of a certain hazard and the amount of expected adverse impact. In practice, the most frequently encountered are methods of expert estimation, which is the case of this study, ie evaluation by description and scale. Therefore, for the purposes of this study, the probability of risk occurrence and the risk impact rate were defined by the experts as follows (table 1):

| Probability of risk - scale | Numerically | Impact of risk on the construction process | Numerically |
|-----------------------------|------------|------------------------------------------|------------|
| Almost excluded             | 1          | Unimportant                              | 1          |
| Unlikely                    | 2          | Low                                      | 2          |
| Possible                    | 3          | Medium                                   | 3          |
| Very likely                 | 4          | High                                     | 4          |
| Almost certain              | 5          | Catastrophic                             | 5          |
A risk matrix is designed to give a likelihood of occurrence and a measure of impact to each identified risk that graphically assesses the significance of the risks. Quantitative risk analysis, using a mathematical logical risk model and software to simulate risk impact, was not used in this study because of the lack of necessary numerical data on the risks examined, as a result of human error or sociological linkage and uncertainty for which theoretical models are lacking. The third stage was risk assessment and selection of those that could have the most serious negative impact on the project, and subsequently possible measures to minimize the impact of risks from the contractor's point of view were proposed.

3. Results
As part of the risk analysis, a list of risks to the construction process in its various phases was created (table 2). Only high and very high risks are included in the list of risks, i.e. there are no acceptable and increased risks, therefore the market and environmental risks are missing from the list of risks.

Table 2. List of the most serious risks of the construction process.

| Risk area (code) | Risk scenario | Consequences of risk implementation | Likelihood of risk | Risk impact | Product |
|------------------|---------------|-------------------------------------|-------------------|------------|---------|
| 1. CONSTRUCTION TECHNICAL AND TECHNOLOGICAL RISKS | Project documentation (1.1) | Incompleteness and non-fulfillment of claims on PD. | Changes in PD. Financial loss and failure to meet the deadline. | 4 | 3 | 12 |
| | Cultural and archeological heritage (1.2) | Insufficient archaeological survey. Possible damage to cultural and archaeological monuments located near the implemented project. | PD change required. Performing archaeological research. Possible financial loss and completion date. | 3 | 4 | 12 |
| | Building budget (3.1) | Incorrectly processed BOQ. Underestimation of work in the budget according to PD. | Failure to meet the deadline for completion of the construction. Possible financial loss. | 3 | 4 | 12 |
| 2. PRODUCTION RISKS | | | | |
| 3. LEGISLATIVE RISKS | Additional authorizations (5.1) | Necessity to obtain additional permits related to the realization of the work (restoration plans; binding opinions; etc.). | Possible financial loss and failure to meet the deadline. | 3 | 3 | 9 |
| 4. INFORMATION RISKS AND HUMAN ERRORS | Qualification of workers and subcontractors (6.1) | Untrained and unskilled workers / subcontractors carrying out professional construction work. | Additional costs related to removal of defects. Failure to meet the deadline. | 3 | 5 | 15 |
| 5. FORCE MAJEURE | | | | |
Climatic effects (7.1)  
Negative influence of the building process by climatic influences (floods, landslides, heavy rains, earthquakes, etc.).  
Suspension of construction.

Failure to comply with the contract price of the construction and the date of completion of the construction.

3 4 12

6. STRATEGIC

Contracts (8.1)  
Poorly compiled contracts. Contract changes caused by any party involved in the construction process.

Failure to comply with the contract price of the construction and the date of completion of the construction.

4 5 20

A risk matrix (table 3) was drawn up for expert graphical assessments of the significance of risks, where the intensity of risk impact intensity is plotted on the vertical axis and the risk probability value is plotted on the horizontal axis. The risk assessed is the more significant the higher the probability of its occurrence in combination with the intensity of its possible impact on the project.

Table 3. Risk matrix.

| RISK IMPACT | LIKELIHOOD OF RISK |
|-------------|-------------------|
| 5           | 1                 |
| 4           | 2                 |
| 3           | 1.2               |
| 2           | 3.1               |
| 1           | 7.1               |

The following paragraphs present options for managing selected risks, with the highest probability of occurrence:

- **Risk CONTRACTS (Risk Severity Rate: 20)**
  The contract for work implies to the contractor obligations that must be fulfilled. The draft contract must be properly studied and commented before it is signed. Where possible, it is good to quantify the contractor’s obligations, such as the extent of the salinity survey (number of probes), the extent of the mycological survey (description of the structures and / or location where it is to be carried out) elements of the building, etc.

- **Risk: QUALIFICATION OF WORKERS AND SUB-CONTRACTORS (Risk Severity Rate: 15)**
  It is advisable that the contractor invests time and money to train the staff and not to select subcontractors only at the lowest bid price, but also on the basis of past experience (e.g. reference buildings, client satisfaction, financial analysis, etc.). Consequently, the Contractor may eliminate the aforementioned risk of financial loss and failure to comply with the contractual completion of the works.

- **Risk: PROJECT DOCUMENTATION (Risk Severity Rate: 12)**
  The contractor confirms the accuracy and completeness of PD by signing the Contract for Work. It may be the case that the client does not have to acknowledge to the contractor future work resulting from the discovered new facts during construction, which were not mentioned in the original PD. The transferred
risk from the PD processor to the contractor must be properly contracted in advance. One way is, for example, to ensure that the processor of the PD will be obliged to submit to the contractor a new technical solution by a certain date, on the basis of which the contractor shall prepare a change sheet. Should this not be the case, the contractor shall not be obliged to commence the aforementioned works and shall not be responsible for any failure to meet the deadline for completion of the construction.

- **Risk: CULTURAL AND ARCHEOLOGICAL HERITAGE (Risk Severity Rate: 12)**
The contract for work implies to the contractor obligations that must be fulfilled by the contractor. The draft contract must be properly studied and commented before it is signed. It is necessary to pay attention, for example, to the delegated responsibility from the client to the contractor in the framework of archaeological research in case of positive findings. Furthermore, it is necessary to ensure that if a positive finding of archaeological elements is found, the contractor is not responsible for any failure to meet the deadline for completion of the construction.

- **Risk: BUILDING BUDGET (Risk Severity Rate: 12)**
The Contractor confirms within the conclusion of the Contract for Work that the budget together with the PD has been studied and it is correct and complete. It may be the case that the client does not have to accept the contractor’s future works resulting from a poorly prepared budget (BOQ). A risk delegated from the designer of project to the contractor must be properly contracted. One way is to ensure that the designer will be obliged to submit to the contractor a properly processed BOQ by a certain date, on the basis of which the contractor prepares a change sheet, which the client is obliged to confirm and accept. Should this not be the case, the Contractor shall not be obliged to commence the aforementioned work and shall not be responsible for any failure to meet the deadline for completion of the construction.

- **Risk: CLIMATIC EFFECTS (Risk Severity Rate: 12)**
The contractor draws up a construction schedule, which is usually a necessary annex to the contract for work. It is advisable for the contractor, when drawing up the construction schedule, to include a time reserve to cover suspended construction work due to adverse climatic effects (long-term frosts, heavy rains, floods, etc.). If the construction schedule is correctly designed so that the individual construction phases and professions are smoothly connected, the late completion date due to adverse climatic effects is eliminated. Furthermore, the contractor may be insured against adverse weather conditions.

4. Conclusion
Today, public procurement authorities have a number of tools and procedures at their disposal to increase the success of the project. An example would be a way to at least mitigate the effect of a decrease in the number of contractors’ bids per contract from the contracting authority (i.e. competition), which has a negative impact on rising prices, declining quality and sometimes the need to cancel orders for lack of interest. Public procurement competition, which is a key tool for achieving maximum price / quality in public procurement, is experiencing the weakest period in the construction sector (and other sectors) from 2006 to 2018, with an average of 6 bids (2016) falling below 4 bids (2018). This leads to more expensive public contracts. Competition for public procurement therefore appears to be one of the most important indicators of good practice in public procurement. From the point of view of the contracting authority, the precise preparation of the tender documentation and proper market research can increase the chance of success of the contract. In addition, other important factors are: the time of the contract (between April and June); type of procedure (open procedure); receiving electronic offers (not paying so far; paid only in the long run); contracting authorities’ profiles (e.g. EZAK and e-contracts show better competition compared to NEN and Tender arena, especially in the small-scale segment); size of the contract (division of a large contract into smaller units, under the law). For each construction project it is necessary to identify the required risks, determine their importance, size, evaluate them and take steps to eliminate them. The most serious risks are the omission of essential moments for the successful start of the work, such as failure to estimate the archaeological and geological conditions (within the project documentation), poorly compiled contract with the client or subcontractors, use of bad materials or neglect of safety measures in individual intermediate construction works. Sometimes there are shortcomings in the provision of a sufficient number of qualified experts who are able and willing to participate in the project and with their professional profile to guarantee the quality and
credible result of the project. Risks can be eliminated to some extent, managed. However, there may be risks that cannot be predicted and eliminated, such as terrorism. From the perspective of the contractor, 11 possible causes of deviations from the construction work schedule and cost overruns were defined in this study. If sufficient time is not foreseen in the schedule, the whole project may be delayed in addition to the delay of one activity. Each project is unique and during the implementation of the project there may be a situation where an unexpected cause or a combination of causes that will delay the project may arise, especially if the performance of the public contract covers a longer period of time. The main reasons for not respecting the budget of the public contract in the Czech Republic are: changes and errors in project documentation (32%), insufficient geological survey (14%), non-compliance or change in construction technology (12%), climatic effects (9%) (6%), unprofessional project management (4%), and archaeological exploration (4%) [2]. According to the above analysis, the greatest risks for contractors are unclear contracts, insufficient project documentation and insufficient qualification of workers and subcontractors. The last is closely related to poor quality of work, e.g. failure to follow the technological procedure, failure to observe the material specified in the project documentation, speed of construction (time pressure usually reduces the quality of work). Therefore, it is necessary to pay maximum attention to these areas before the start of the project and also to regularly inspect the riskiest areas during construction. Of course, the magnitude of the financial impact on a building depends directly on the type and extent of the cause. Late contracting of subcontractors, poor technological continuity of work in the schedule and poor timing of the duration of activities are significant risks that can affect the work schedule. The prolongation of the works can be very likely, and is often caused by either the contractor or additional investor requirements. Therefore, it is important that extra work is adequately treated in the contract of work. Thanks to the qualitative analysis carried out, it is possible to identify the risks to be further focused and the risks to which particular attention should be paid. The weakness of qualitative risk analysis, where the scale defined by the expert team is used to assess the risk, is the risk of subjective assessment of the problem. The uncertainty of expert estimates can be reduced, for example, by breaking down the unfavourable situation into smaller, sub-parts, where it is easier to estimate the probability and the amount of negative impact.

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