Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 122 (2015) 120 – 128

Procedia Engineering

www.elsevier.com/locate/procedia

Operational Research in Sustainable Development and Civil Engineering - EURO working group meeting and 15th German-Lithuanian-Polish colloquium (ORSDCE 2015)

Financial risk estimation in construction contracts

Agnieszka Dziadosz[a], Andrzej Tomczyk[b], Oleg Kapliński[c]

[a] *Institute of Structural Engineering, Poznan Univesity of Technology*
[b] *Commercial enterprise with headquarters in Poznań*
[c] *Facutly of Architecture (IAP), Poznan Univesity of Technology*

Abstract

Risk, as a factor adversely affecting the project, is taken into account as early as at the first stage of the investment process when the tender is won for a contract. The risk level, identified for a particular construction contract, is a serious factor influencing the decision about accepting the contract or not. The key issue is proper identification of contract risk. The risk factors which have a significant impact on the success of the project, and are most common ones, are then analyzed. The method of verification depends on the company's experience in the construction industry. The task of the article is to present the results of studies focused on separating and determining the frequency of financial risk factors in construction projects and their impact on project implementation. We have analyzed 30 construction projects (office buildings, production halls, educational buildings, demolition works, etc.) completed in north-western Poland. The degree of risk (planned and real) for the contract was set as a percentage in relation to the size of contract (costs in million PLN). The aim of the study was to verify the existence of relationship between the kind of structure, the size of contract, and the scope and degree of risk. Statistical approach has been used. This study is a prelude to determining the contract risks identification procedure (i.e., estimating reserves to be used in unforeseen circumstances) so that the company could be competitive, and the price offer to be provided to investors could be advantageous.

Peer-review under responsibility of the organizing committee of the Operational Research in Sustainable Development and Civil Engineering - meeting of EURO working group and 15th German-Lithuanian-Polish colloquium

Keywords: construction contracts, risk management, financial risk, decision-making process in construction project.

* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .
E-mail address: Agnieszka.Dziadosz@put.poznan.pl

Peer-review under responsibility of the organizing committee of the Operational Research in Sustainable Development and Civil Engineering - meeting of EURO working group and 15th German-Lithuanian-Polish colloquium
doi:10.1016/j.proeng.2015.10.015

1. **Introduction**

Project planning, if it is to be efficiently implemented, requires making a number of decisions that have their finale in the smooth running of construction work. This is possible thanks to examining a project from its many aspects and angles, also in terms of likelihood of adverse situations (i.e., risk factors). The risk, as a factor adversely affecting the project, is weighed at the first stage of the investment process, namely at the stage of winning a contract through tender. In view of the situation in the construction industry, where the main aim is to minimize the costs of construction work, as well as to gradually decrease the prices for construction work, procuring an offer for construction work is very difficult. On the one hand, a construction company tries to maximize the profit (in order to secure funds for new investments, and cover possible expenses associated with the occurrence of risk factors during construction). On the other hand, a construction company tries to be competitive and tries give the investor the best price offer. The following question arises – at what level risk should be taken in case of a particular contract in order to win the tender and to secure funding for risks which are very difficult to assess. In the course of project implementation, different situations may occur which, at first glance, may seem unfavourable but, in consequence, may bring financial savings due to the changes of construction techniques, work scope or changes in organization. Construction companies usually analyze most common risk factors, and especially those with potential major impact on construction. The method of verification depends on the company's experience in the industry. The aim of this article is to present the results of research on financial risk factors impacting on construction projects. The second step of the research is to develop a financial risk analysis model which can be used in assessing construction contracts, specifying the size of necessary resources as backup for unforeseen circumstances.

2. **Types of contracts**

In Poland, there are two preferred procedures of winning a contract. The first is public procurement, and the second is a private order. The first procedure is associated with the public procurement law and is strictly codified. Strict rules apply there, which should be adhered to. In the current, competitive situation on the construction services market, most often the only selection criterion is the price. It is the reason why specific items on the price list have to be closely examined. Pricing related to direct costs is relatively easy to calculate, though sound experience is necessary, in addition to good knowledge of detail. There is not much difference between prices of materials and services on the market but a company may be more competitive if it suggests cheaper material and technological solutions, or will organize the work better. The prices offered by suppliers or subcontractors at the tender stage are usually higher than the prices settled after the tender has been concluded. The results of the studies, presented later in the article, suggest that the differences may range from one to even more than ten per cent, which means that additional profit on the project can be significant. This is how the risk, which has not been calculated at the pre-tender stage, can be covered. The fact is that if a company offers a high price, it will lose the tender, while an excessively low price may result in a financial loss at the end of the construction project. Another element is overheads, where there is a certain margin of risk. At that stage we need to determine the costs according to our best experience from the past. Typically, the employee potential and optimal composition of the team are known, so it is easy to calculate how much the team will cost. The last element is markups which are similar in companies of similar potential and size. Markups on company's operations are taken as a percentage of the value of direct costs of the offer. On the other hand, profit and risk are values calculated as a percentage of costs. Profit in large companies is assumed to be at a similar level - between 1% and 5% (depending on the scope and size of contracts, and the company).

Risk is the factor which is relatively difficult to evaluate. In public tenders, in principle, everything needs to be taken into account: every type of risk which in various aspects of activity at the building site. There are risks from the quotation procurement phase, economic risks associated - for example -, with currency exchange rates, if equipment is purchased abroad, technical risks related to the conditions on the site, legal risks associated, for instance, with the provisions in the agreement. Additional costs associated with unexpected risks are in the range from 0% to 5 percent, and even more in extreme cases (the degree of risk in the present study, in the case of an investment project rejected from the set during further analysis, was in excess of 30%).

Public tenders practically exclude the possibility of negotiations and, consequently, restricting contractual liability for unforeseen events is impossible. Tenders for private investors are governed by somewhat different rules.

Here, risk can be regarded as a commodity which has its price. A number of factors which may affect the price can be excluded from the agreement. You can also agree with investors that including risks in the cost is an unnecessary multiplication of costs and an unnecessary burden on the budget of the project. It concerns cases where risks may not occur at all or the occurrence of risks can be reduced in collaboration with the investor.

The most common types of contracts are: a lump sum contract, a quantity survey contract, and GMP (guaranteed maximum price) contract. The first is used quite often by private investors and almost always by the public investors. In principle, the contractor bears all the risks in this type of agreement and, therefore, the contractor should include everything in the offer. It is quite difficult because not everything can be predicted. Firstly, it results in price increase since the contractor must, after all, provide additional financial resources to cover the unexpected costs and, secondly, if this is not done problems with liquidity during the execution of the contract may occur. In theory, such problems do not concern investors, but only apparently. When there are problems with project financing, the contractor seeks a remedy, using different alternative plans. Usually, quality suffers; often the deadline has to be shifted. Despite the use of penalties against the contractor, losses associated with the subsequent completion of investments are difficult to estimate and disproportionate to the penalties imposed, often larger than may seem from the penalties. A court settlement as an option is not always profitable. Court proceedings may be long, and the outcome uncertain.

In a contract based on unit prices, serious risks associated with the quantities of materials and labour are marginal. It greatly facilitates submitting the offer and minimizes the risks. Errors associated with the bill of quantities occur in a half the studied contracts. In 30 analyzed cases, errors occurred in 16 (representing 53.3%, while for 29 contracts, it was 51.52%).

The least risks are associated with a GMP contract. There, working according to an open-book principle, the contractor and the investor collaborate in order to optimize costs and jointly select subcontractors.

3. **Risk in a construction project**

Risk, or measurable part of uncertainty, should be treated as an opportunity to deviate from the desired level. Therefore, positive deviation (a chance) and negative (a loss) must be taken into account. Raftery [22] says: *Risk and uncertainty characterize situations where the actual outcome of a particular event or activity is likely to deviate from the estimate of forecast value* The literature quotes many divisions and classifications of risk factors, such as: according to character, impact, origin, categories of decisions taken to achieve specific objectives, risk measures, etc. [1-32]. A thorough presentation of categories risk was given in [24-26]. The basic classification of random factors includes the following groups: financial risk, technological risk, economic risk, risk of the organization, management risk, time-span risk, and legal risk. Each project may be analyzed according to the so-called check list. However, given the unique nature of the projects, variety of conditions of work execution, a check list should be flexible, allowing for specification of risk factors in relation to the investment. Construction companies usually analyze most common risk factors, and those that have major impact on the implementation of work. Verification methods depend on the experience of companies in the construction industry. The presented studies concern the previously scheduled in-groups and risk factors. The aim of the analysis is to identify the factors with the biggest impact on implementation of the contract. An attempt to demonstrate their dependence on the selected parameters, such as size of the contract has been made. It is worth mentioning that there have been similar thematic studies, carried out on the basis of questionnaire surveys in the US, UK, Hong Kong, China, devoted to the identification and prioritization of risk factors and risk evaluation techniques [7,10,12, 13, 15, 28].

4. **Research methodology**

Thirty (2008-2013) construction projects were analyzed in terms of likelihood of risk (mainly large structures, such as: halls, industrial plants, teaching halls, warehouses, etc.). The aim of the research was to identify main risk factors and classify them into the general groups. The research was based on information from contract managers; the resulting data accounted for both planned and real risk (expressed in percentage units relative to the value of contract). These analyzes are the first step towards developing a risk assessment procedure for contracts in relation to the adopted endogenous variables (e.g. time of execution, contract size, scope and nature of the structure itself, etc.) and having taken into account a defined provision for risk. In the course of data verification, one investment project was rejected, the results of which were radically different from the others (the amount of risk expressed in % in relation to the cost of the contract was at least 10 times higher compared to other results). It could significantly affect conclusions and introduce uncertainty. The study was based largely on a statistical approach and analysis of linear regression, calculations were done using MS Excel data analysis.

5. **Results and discussion**

The study helped verify the previously recognized risk factors in the company which realized all (29) analyzed contracts. The results were analyzed both in terms of planned risk assessment (the level of risk assumed when applying for a contract by tender, based on experience from previous projects), as well as on determination of real risk (percentage of costs in relation to the value of contract) in 6 main groups: cost estimation risk, time-span risk, legal risk, economic risk, technical risk and the risk of necessity of provisional works. An attempt was made to determine the relationship between such variables as the type of structure, duration of the contract, and selected risk factors - as presented in Fig. 1, Fig. 3 and Fig. 4. The size of contract as a variable was assumed to be cost of work, expressed in million PLN, whereas the size of the real risk was defined as the % value of the size of contract (i.e. the expenses incurred due to unforeseen events). 11 categories were established, representing different sizes of contract, and the contracts were qualified accordingly (Fig.1.)

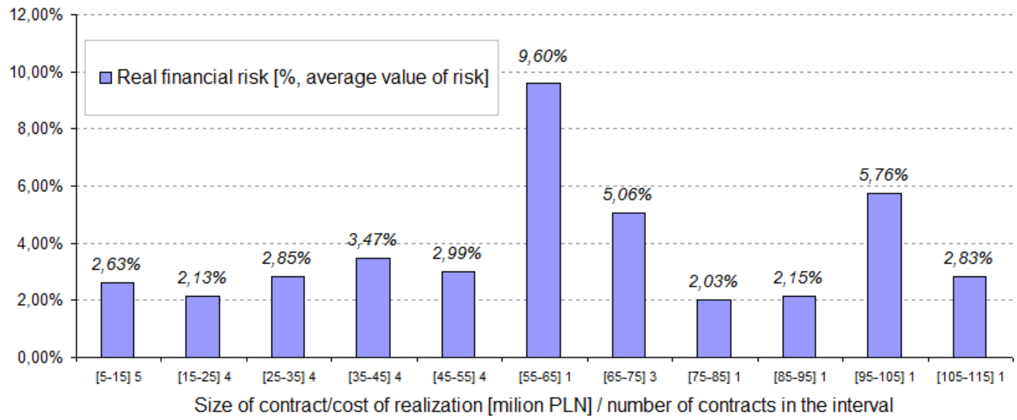

Fig.1. The histogram of magnitude of real risk (%) in relation to the size of contract/cost of realization [Source: own elaboration]

For a wide range of contracts, the average value of real financial risk amounts to 3.77% with relation to the contract value (approx. 72% of contracts were executed - at the amount of 55 million PLN). In this case, there were 3 contacts where the value of the real risk differed significantly from other contracts (9.60%, 5.76%, 5.06%, respectively). Without these contracts, the average value of the risk would have been 2.63%. On the basis of Fig. 1, it can not be concluded that the level of risk depends on the size of contract. It is obvious, even with very costly contracts reaching PLN 100 million, that risk level not exceeding 3% can be achieved.

Statistics regression	
R multiples	29,99%
R-squared	8,99%
Adjusted R-squared	5,62%
Standard error	0,020197762
Observations	29

	Coefficients	*Standard deviation*	*t Stat*	*Value-p*
Intersection	0,023593841	0,006996328	3,37231779	0,0022646
Size of contract/cost of realization	0,000225276	0,000137905	1,63356179	0,1139595

Fig.2. Regression analysis for the following variables: size of the contract/cost of implementation and the size of real risk, [Source: own elaboration]

Based on regression analysis, a weak relationship between the following variables were determined: size of contract and the degree of financial risk, which is evidenced by the value of R-squared, amounting to 8.99%. What is interesting is that R multiple is less than 30%, which undermines the assumption that the relationship between variables is linear (Fig. 2).

Fig. 3 ~~also~~ presents average risk values of planned and actual risk. In some cases, the real risk value definitely exceeds the estimated risk for the contract, assumed at the offer stage. (e.g., structure type: industrial hall, the planed risk is 1.58%, while the real financial risk is 2.51%). The planned risk assessment in relation to real risk was closest in case of for buildings by the highway (perhaps this is due to the requirements of uniform standards and the scope of work for each structure and facility). The largest discrepancies were identified in case of residential buildings and animal passes..

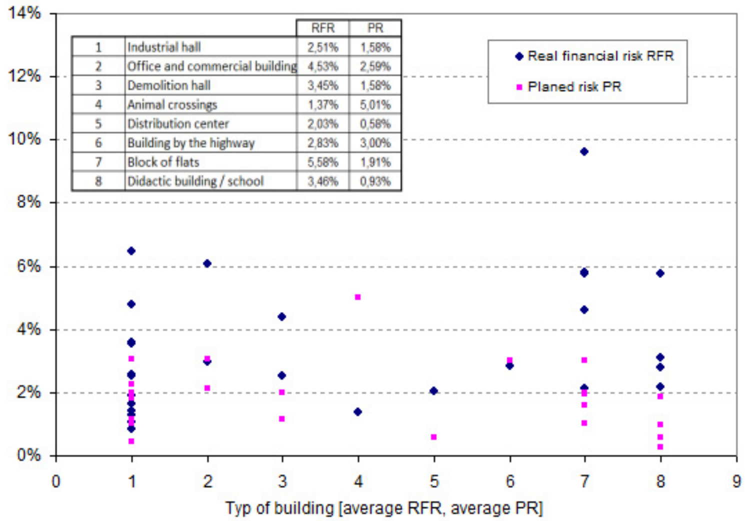

Fig.3. A graph illustrating the relationship between real risk, planned risk, and type of facility or structure [Source: own elaboration]

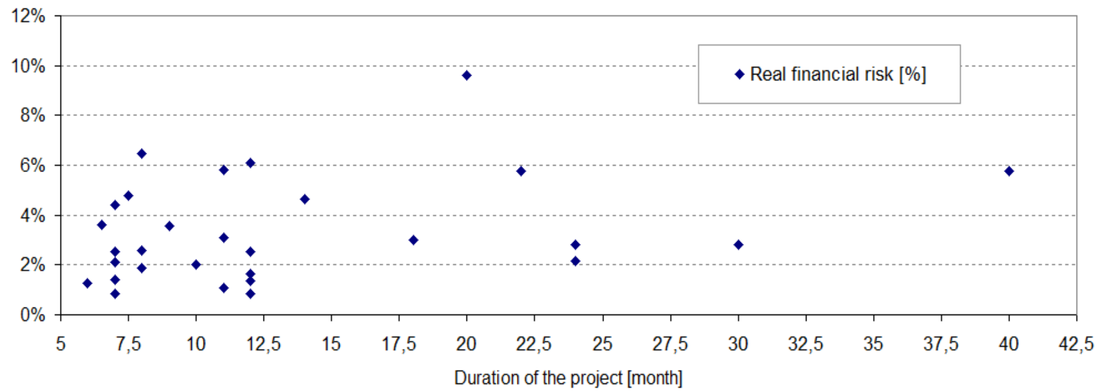

Fig. 4. A histogram illustrating the real risk sizes compared to project implementation time. [Source: own elaboration]

Fig. 4 shows that the majority of contracts (over 70%) have been implemented in a period shorter than 13 months. In case of at least 8 contracts, the real risk has not exceed 2%, in case of 9 contracts, the risk is in the range [2%, 3%], for the [3%, 4%] range, the risk occurred in 3 cases, in the [4% 5%] range - 3 cases, in the [5%, 6%] range - 3 cases. Thus, for the 20 analyzed contracts (representing nearly 70% of all contracts) the actual risk was lower or equal to 4% with relation to the size of the contract.

Statistics regression	
R multiples	30,33%
R-squared	9,20%
Adjusted R-squared	5,84%
Standard error	0,020174919
Observations	29

	Coefficients	*Standard deviation*	*t Stat*	*Value-p*
Intersection	0,022948814	0,007263699	3,159384	0,003874
Duration of the project [month]	0,000779359	0,000471194	1,654009	0,109707

Fig. 5. Regression analysis for delivery time and real risk magnitude variables
[Source: own elaboration]

Both the distribution (Fig. 4) as well as regression analysis (Fig. 5) indicate a weak relationship between implementation time and the magnitude of financial risk. This means that, over a longer time, effective risk management is beneficial.

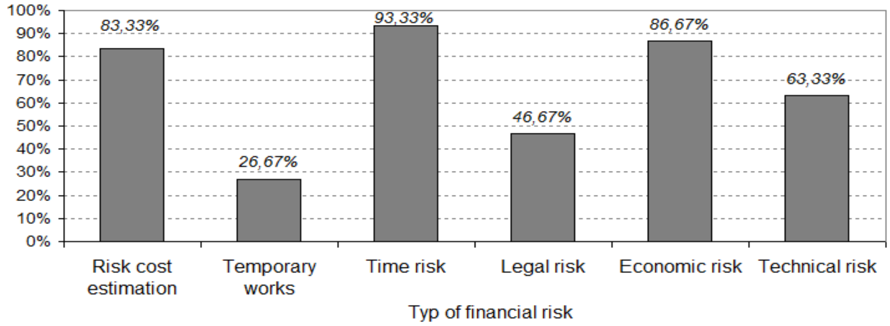

Fig. 6 The histogram of the number of real risks in the analyzed contracts
[Source: own elaboration]

Among all groups of risks, the most common risk is the risk of time (93.33%, occurred in 28 contracts for 29 analyzed), economic risks (26 contracts, accounting for 86.67%) and calculation risk (83.22%, occurred in 25 contracts) (Fig. 6).

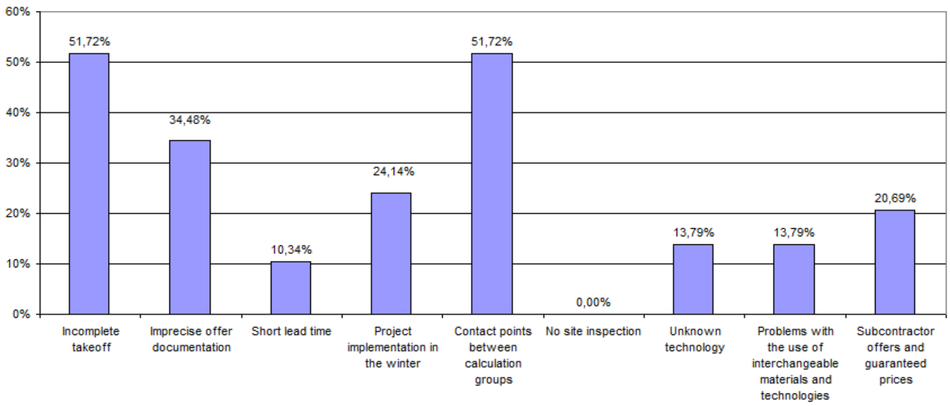

Fig. 7. The histogram of the number of real risks occurring in the cost estimation risk group
[Source: own elaboration]

It is true that time risk occurred in 28 cases, although the size of the average real risk in relation to the value of contract stood at 0.3%. In contrast to the risk associated with estimation of costs, where the average risk value amounted to approx. 1.5%, economic risk was less than 1%. Cost estimation risk group: as to share in cost estimation, the largest is incomplete takeoff (51.72%), errors associated with the contact between industries (occurred in 15 out of 29 cases), and errors associated with inaccurate documentation occurred in 11 cases out of 29 (34,48%) (Figure 7). This is a serious number, making that the line between success and failure relatively thin. In total, the above listed risks account for less than 65% of the costs calculation risk. In the case of quantity survey contracts, it is possible to significantly reduce the risks.

From the viewpoint of sensitivity of results, the differences among most frequent risks were most pronounced. For example, Table 1 is a presentation of distribution of characteristic parameters (average, standard deviation, coefficient of variation). Interestingly, the cost estimation risk factor has relatively high standard deviation. However, with relation to the average, the coefficient of variation does not exceed 1.0. Accordingly, looking at Table 1, standard deviation seems to be more reliable. The spread of results is also noticeable in Fig. 8 which, apart from the cumulative distribution, shows two density functions: cost estimation risk and economic risk. On the other hand, legal risk, time risk, temporary works and technical risk are characterized by smaller spread of results.

Table 1. Sensitivity of results: risk in contracts
[Source: own elaboration]

Risk cost estimation	Risk cost estimation	Temporary works	Time risk	Legal risk	Economic risk	Technical risk
Mean	1,48	0,12	0,30	0,14	0,98	0,29
Variance	2,10	0,13	0,06	0,05	0,82	0,16
Standard deviation	1,45	0,36	0,24	0,22	0,90	0,39
Coefficient of changeability	0,98	3,02	0,80	1,56	0,92	1,34

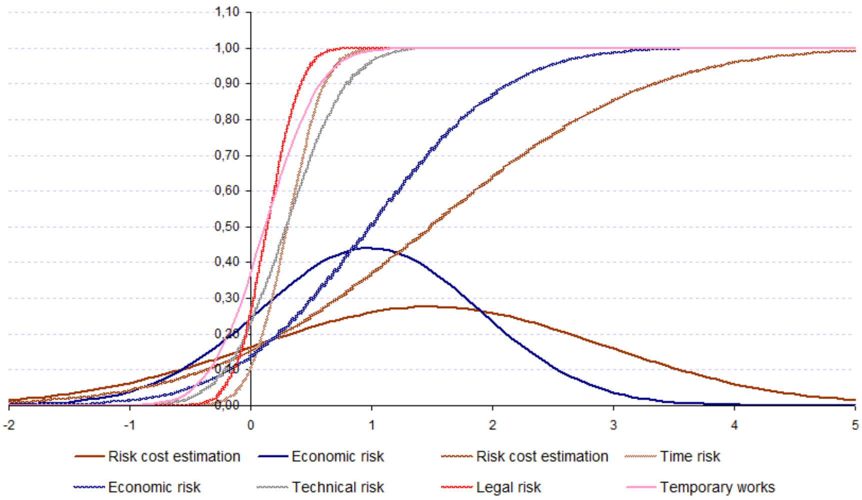

Fig. 8. Probability distribution of real risk in the analyzed contracts,
[Source: own elaboration]

Verification of real and financial risks in approx. 30 contracts shows the dimension of diversity, and the importance of its prior estimate (is related to the instability of building processes). Risk should be assessed individually for each contract. This stems mainly from complexity and unpredictability of risk. A systematic procedure would certainly facilitate a more accurate estimate of the contract with regard to random factors, ensuring accurate planning of financial reserves earmarked for unforeseen events.

6. **Conclusion**

Significant variation of results is noticeable, basing on preliminary analyzes conducted on 30 contracts. It is closely related to the presence of numerous random factors during a construction project implementation. What is characteristic is that the number of occurrences of random factors is not always associated with significant influence of a given factor. Time risk can be an example – this type of risk has occurred in almost all contracts. However, the size of this risk was small (0.3%). That is why it is so important to categorize the factors into groups according to the likelihood of risk occurrence, and the amount of damage. Regression analysis indicated a relationship, albeit only at the level of approx. 30% - between the structure type and the time of implementation. It seems that the wider the time horizon, the better the organization and the more effective risk management is, because the size of real risk was in the range of [4%, 6%]. A systematic procedure would certainly facilitate more accurate contract risk estimates with regard to random factors. Then, there would not be such discrepancies between the planned and real risk (Fig. 3 and Fig. 8). Another aspect is related to changeability or spread of risk in a given category in the contract. Knowing the normal distribution (developed on the basis of actual results), we can determine the probability of a particular magnitude of risk for a particular structure type (contract type) and, consequently, precisely plan the size of financial reserves earmarked for unforeseen events.

References

[1] S. M. Ahmed, R. Ahmed, D. D. Saram, Risk management trends in the Hon Kong construction industry: a comparison of contractors and owners perceptions, Engineering, Construction and Architectural Management 6 (3) (1996) 225-234

[2] A. S., Akintoye, M. J., MacLeod, Risk analysis and management in construction, International Journal of Project Management, 15 (1) (1997), 31-38

[3] A. Aleshin, Risk management of international projects in Russia, International Journal of Project Management, 19 (3) (2001) 207-222

[4] A. Duchaczek, D. Skorupka , Evaluation of probability of bridge damage as a result of terrorist attack, Archives of Civil Engineering. Volume 59, Issue 2, Pages 215–227, ISSN (Print) 1230-2945, DOI: 10.2478/ace-2013-0011, July 2013

[5] A.Dziadosz, Przegląd wybranych metod wspomagających analizę ryzyka przedsięwzięć budowlanych [Overview of selected risk analysis support methods in construction projects], Przegląd Budowlany, 7-8, (2010) 76-77

[6] A. Dziadosz, The influence of solutions adopted at the stage of planning the building investment on the accuracy of cost estimation, Procedia Engineering 54 (2013), 625–635

[7] S. El-Sayegh, M., Risk assessment and allocation in the UAE construction industry, International Journal of Project Management, Vol. 26, 2008, s. 431–438

[8] M. Gajzler, A. Dziadosz, P. Szymański, Problematyka wyboru metody wspomagającej podejmowanie decyzji w budownictwie [Issues of choice of a decision making aiding method the in the construction industry], Czasopismo Techniczne z.1-B/2010, Vol. 2 (ROK 107), 69-84

[9] M. Gajzler, The idea of knowledge supplementation and explanation using neural networks to support decisions in construction engineering, Procedia Engineering 57 (2013), 302-309

[10] D. Fang, M. Li, P. S. Fong, L. Shen, Risk in Chinese construction Market – Contractor's perspective, Journal of Construction Engineering and Management, 130 (6) (2004) 853-861

[11] S. Gruneberg; W. Hughes.; D. Ancell, Risk under performance-based contracting in the UK construction sector, Construction Management and Economics,25, (7) (2007) 691-699

[12] Li, Bing; A. Akintoye; P. J Edwards; C. Hardcastle,, Critical success factors for PPP/PFI projects in the UK construction industry, Construction Management and Economics, 23 (5) (2005) 459-471

[13] T. Lyons, M. Skitmore, Project risk management in the Queensland engineering construction industry: a survey, International Journal of Project Management, 22 (1) (2004) 51-61

[14] B. Kangari, Risk management perceptions and trends of US construction, Journal of Construction Engineering and Management, 121 (4) (1995) 422-429

[15] N.A. Kartman, S. A. Kartman, Risk and its management in the Kuwait construction industry: a contractor's perspective, International Journal of Project Management, 19 (2001) 325-333

[16] O. Kapliński, The Utility Theory in Maintenance and Repair Strategy. Procedia Engineering. 54 (2013) 604-614

[17] O.Kapliński, Risk analysis of construction projects: From risk identification to contingency timetable. SEMC 2010: The Fourth International Conference on Structural Engineering, Mechanics and Computation, Cape Town, South Africa, 6-8 September 2010. [w] A. Zingoni (Ed.), Advances and Trends in Structural Engineering, Mechanics and Computation, CRS Press Balkema, Taylor & Francis Group, London 2010. Abstract: 268, paper CD: 1051-1054 (ISBN 978-0-415-58472-2).
[18] O. Kapliński, Risk Management of Construction Works by Means of the Utility Theory: a Case Study. Procedia Engineering. 57 (2013) 533-539.
[19] O.Kapliński, A. Dziadosz, J.L. Zioberski, An attempt of management process standardisation at the stage of planning and implementation of construction projects, Proc. 57th Annual Scientific Conference: scientific Problems of Civil Engineering, The Faculty of Civil and Environmental Engineering, Rzeszow University of Technology, Rzeszów – Krynica 2011, 18-22 September, 30-31.
[20] D. Kuchta, D. Skorupka, Project risk management taking into consideration the influence of various risk levels based on linguistic approach. World Scientific Proc. Series on Computer Engineering and Information Science 7; Uncertainty Modeling in Knowledge Engineering and Decision Making - Proceedings of the 10th International FLINS Conf 7, (2012) 1093-1098
[21] J. Pasławki, M. Róźdżyńska, Flexible approach in infrastructure design buffer Parking Case Study, Procedia Engineering, 57 (2013) 882-888
[22] J. Raftery, Risk analysis in project management, E& FN Spon, London (1994)
[23] A. V.; Rutkauskas, A. Gineviciu, Integrated management of marketing risk and efficiency, Journal of Business Economics and Management 12 (1) (2011) 5-23.
[24] S. Shevchenko, L. Ustinovichius, A. Andruskevicius, Multi-attribute analysis of investment risk alternatives in construction, Technological end Economic Development of Economy, 14 (3) (2008) 428-443
[25] D. Skorupka, Identification and initial risk assessment of construction projects in Poland, Journal of Management in Engineering, 24 (3) (2008) 120-127.
[26] D. Skorupka., Modeling of risk in the building projects, Operations Research and Decisions, Wroclaw University of Technology, 3 (2006) 133- 143
[27] A. Snarska, Statystyka,Ekonometria, Prognozowanie, Ćwiczenia z Excelem, Placed (2007)
[28] W. Tang, M. Qiang, C. Duffield, D. Young, Y. Lu, Risk Management in the Chinese Construction Industry, Journal of Construction Engineering and Management, 133 (12) (2007), 944-956
[29] P.A. Thompson, J.G. Perry, Engineering construction risks, Wyd. Thomas Thelford, London (1992) 56
[30] Z. Turskis, M. Gajzler, A. Dziadosz, Reliability, Risk Management and contingency of construction processes and projects, Journal of Civil Engineering and Management ,18 (2) (2012) 290–298
[31] E.K Zavadskas, Z. Turskis.; J. Tamošaitiene, Risk assessment of construction projects, Journal of Civil Engineering and Management, 16 (1), (2010) 33-46
[32] Zhi H., Risk management for overseas construction projects, International Journal of Project Management, 13 (4) (1995). 231-237