

RISK OF ALTERATIONS TO PROJECT DOCUMENTATION ON AN EXAMPLE OF ENVIRONMENTAL ENGINEERING CONSTRUCTION

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Investor bears responsibility for proper preparation of the investment process. One of his tasks is to prepare the project documentation and obtain a building permit. Frequently, during his work, there are situations and events whose impact interferes with the design solutions. Regardless of reasons, alterations to a project constitute a source of cost risk. In each case, the Investor should be prepared for this type of a risk. Exposure to risk should be taken into account in the planning stage of the investment. Also, a model of investment execution should be chosen at this stage. The type of model is associated with the distribution of risk throughout the project. The aim of this paper is to identify events that generate risk related to alterations to Project Documentation in the context of the selection of the investment execution model.

Keywords: alterations to Project Documentation, cost, schedule, risk.

1. INTRODUCTION

The aim of each structural design is to complete a building object at the scheduled time and in accordance with the assumed budget. This is not an easy target because in the course of construction there are events compelling the project participants to change the agreed decisions and seek new solutions [19]. The source of these events include, e.g. modification of the investment process environment [7]. Given the works are conducted usually under conditions of risk or uncertainty [11], [19] it is difficult to predict all the events that may hinder their course at the planning stage of the project.

The Investor bears responsibility for the proper preparation of the investment process. According to the Building Code [1], it is the investor's duty to draw up the construction design and, if appropriate, other designs. Prior to the start of construction, a sequence of essential decisions should be taken by the Investor, related to the budget [10] and the system of its execution. In the case of the implementation of contract conditions based on FIDIC, there is the possibility of applying for at least two ways of

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project execution: according to the so-called “Red Book” or “Yellow Book” system. In the first instance, the Contractor executes the work in accordance with the design provided by the Investor. For this type of contract, the Investor bears responsibility for the risk of loss resulting from flawed designs prepared by his personnel. The Designer should be considered as a member of the investor’s personnel [4]. The second type of contract consists of the contractor’s duty to both design and execute the object, based on the requirements specified by the Investor [5], [12].

Both systems have advantages and disadvantages. The main advantage of the first one is that the Investor is directly involved in the preparation of the documentation. However, commissioning the design and the execution of work to a contractor eliminates disputes among the participants in the investment process, which generally have costly consequences for both parties to the contract [18].

Regardless of who is responsible for the proper preparation of the project, the solutions adopted have a significant impact on the execution time, as well as the budget [16], [17]. In 2011, an expert survey aimed at identifying risk events during constructions within the range of environmental engineering was conducted [3]. The survey was directed at the people with long-term professional experience, working on the side of the Contractor, Investor, or Contract Engineer. The results of the survey showed that, in the case of investments within the range of environmental engineering, the occurrence of flawed solutions in the Project Documentation is high. As many as 96% of respondents confirmed this. Additionally, 71% of respondents found that design flaws resulted in an increased investment costs. The research conducted by Czemplik confirms these results [6]. They indicate that the Investor and the Contractor must be prepared for the time and financial risks stemming from flawed design solutions.

The purpose of this paper is to:

- identify the reasons of alterations to Project Documentation of investments within the range of environmental engineering,
- evaluate the alterations’ impact,
- examine the investments executed on the basis of the conditions of a contract, as defined in the “Red” and “Yellow” Books, from the aspect of alterations to Project Documentation.

2. SUBJECTS AND METHODS OF RESEARCH STUDY

The research conducted was based on two constructions located in Lower Silesia (Poland). They are comparable with respect to the range of work, duration, and budget. Both contracts were executed by the same Investor, and coordinated by the same team of staff members.

The documentation review was done in order to gain the data necessary to conduct the analysis. Documents compiled at the planning stage, as well as during execution of building work, were the subject of the study. These included: design documentation,

specifications, the Records of Necessity, the Records of Negotiations, the building diary, all Contractor's reports and programmes, as well as the correspondence within the contract.

The Records of Necessity were especially valuable for conducting the analysis. These documents substantiate all additional or replacement work as a result of alterations to the Project Documentation. 93 of such documents were analysed as part the study.

2.1. INVESTMENT NO.1

The examined investment involved the construction of:

- 161 km of sewage,
- *64 sewage pumping stations.*

The Project Documentation was prepared in the period 2000 to 2003. The work began much later, that is in October 2005. The Accepted Contract Amount came to 10,162,715.51 EUR [14]. The investment was conducted on the basis of conditions of contract as defined in the "Red Book". According to this system of investment, the Investor first entrusted the Project Documentation to the Designer, then the construction work was put out to tender.

2.2. INVESTMENT NO.2

The second analysed investment was conducted under the terms of the "Yellow Book". The Contractor was obligated both to design and execute the work under the assigned contract. The object of construction was the following:

- 90 km of sewage,
- 27 sewage pumping stations,
- *control and monitoring network of sewage systems.*

The Accepted Contract Amount was 9,939,788.00 EUR. The work began on 31st March 2006, the date for completion was assumed for 30th June 2008 [15].

3. THE RESULTS

93 events resulting in alterations to Projects Documentation were identified on the basis of the documentation review as described above.

Nearly all of them (92) related to investment no.1. The analysis of the sources of their occurrence enabled the classification into 4 groups, viz:

- I – underestimation of the amount of work,
- II – long period between the planning stage and the execution of work,
- III – flawed design solutions,
- IV – faults in data output for designing.

Table 1

The classification of events which generated alterations to Project Documentation during Investment no.1.

Reason for alterations to Project Documentation		Effect
I	Underestimation of the amount of work.	Modifications to the Bill of Quantities. Differences between the amount of work specified in Bill of Quantities and actually measured.
II	Long period between the planning stage and the execution of work.	Withdrawal of consent by certain property owners to conduct works on their plots. Changes in sewerage route aiming to bypass the disputable plots.
		New Urban Zoning Plan of the area covered by investment. The need to adjust the technical and operating parameters of the designed sewage systems to a larger number of users.
		New objects in the infrastructure of the area covered by investment. Changes in sewage route aiming to avoid collision between designed sewage systems and new technical infrastructure facilities.
		Technical and technological progress. Replacement of the designed pipes by the pipes made of material more resistant to adverse environmental conditions.
III	Flawed design solutions.	Errors in the design. <ul style="list-style-type: none"> • The need to unify much too different types and sizes of fittings assumed in the project. • The elimination of devices serving the same function in designed system. • The change of the laying level of certain sections of the systems, designed too shallow or too deep.
		No inventory of area covered by investment prior designing. Changing the location of the pumping station, which was designed on the traffic lane.
IV	Faults in data output for designing.	Errors in the maps and geodetic base. A redesign of the pumping stations' and sewage systems' parameters as a consequence of faultily assumed size of area catchment.
		No normalization of land ownership. Changing the location of objects designed on disputed land.

The alterations presented in the table were made at the stage of works execution. However, the cause of these changes resulted from events and actions taken in the earlier stages of the investment. From the table it appears that the correction of the measured quantity of the work determined in the Bill of Quantities resulted from an underestimation of their amount in the planning stage. In addition, a source of changes

was the long period between the design and construction. During that period, a new Urban Zoning Plan of the area covered by investment was produced. The plan included new areas for housing which had not been assumed in the previous design solution.

The effect of alterations in Project Documentation to the investments in question was modifications to the following factors:

- technical and technological parameters of the systems,
- duration of activities assumed in the construction schedule and the dates of their completion,
- the cost of works.

The conducted analysis showed that the impact of the identified events on the factors indicated above, were varied – from irrelevant to significant. A four-grade scale was utilised to assess this diversity. On this scale, 1 means that the event did not affect the considered factor, while 4 – the impact was significant. A detailed description of the various grades of the scale is shown in table no. 2. The number of events contributing to alterations was assigned to the identified factors and the grades of the adopted scale.

Table 2

The impact of identified events on technical solutions, time and costs of works

The scale of the impact assessment:	<u>Impact on:</u> technical and technological parameters of the systems	Number of events	<u>Impact on:</u> the duration of the works	Number of events	<u>Impact on:</u> the cost of works	Number of events
1	No changes	43	No impact	43	Reduction of the Contract Price	32
2	Irrelevant changes	32	Prolongation of a single activity, without affecting the subsequent activities.	32	No impact on the Contract Price	2
3	Relevant changes	11	Prolongation of sequences of activity without affecting the time for completion	16	Increase in the Contract Price less than 100,000 EUR	53
4	Significant changes	6	Prolongation of the time for completion	1	Increase in Contract Price more than 100,000 EUR	5

From table no. 2, it appears that 17 events caused relevant and significant changes in technical and technological parameters. The same number contributed to changes in the duration of work. The majority, as much as 58, affected the cost of the investment. In 5 cases, the consequence of this impact was an increase in the Contract Price by more than 100,000 EUR.

Previous experience indicates that the impact of adverse events on the investment process is frequently of a synergistic character [3], [9]. In the case of the examined investments, this means that the same events can simultaneously affect changes in the designed solutions, the course of construction, as well as their cost. These impacts, similar to the case of individual factors, were considered in a four-grade scale, ranging from minor to which “1” is assigned, to substantial which is assigned by “4”. The results of the analysis are shown in the form of a matrix diagram, in Figure no.1.

The number of events that simultaneously affected the two factors in a significant way are placed in shaded fields. In relation to their total number, there are few of them. For instance, there were no such events which would significantly affect both the

				4	The change in technical and technological solutions	4			5	1
				3		3	5		5	1
				2		2	21	2	9	
				1		1	6		34	3
						1	2	3	4	
						The cost of works				
						1	2	3	4	
			43	1	The duration of the works	1	6		34	3
		32		2		2	21	2	9	
		12	4	3		3			2	14
			1	4		4				1

Fig. 1. The simultaneous impact of identified events on technical solutions, time and costs of work

technical solutions and the course of work. However, 12 events were recorded which contribute to significant changes in the technical solutions and increase the cost at the same time. In the diagram, 17 events are shown, causing simultaneously relevant changes in the schedule of works and the budget of the project.

The data presented show that alterations to Project Documentation mainly affect the cost of the investment. The events included in group I relating to changes to the Bill of Quantities mainly impact on increases to the Contract Price in the case of the examined investments. Next in line, there are events belonging to group II – those caused by the long period between the planning stage and the execution of work, as well as events from group III – flawed design solutions. However, the events qualified as group IV contribute to a reduction of investment cost. Nevertheless, the final balance demonstrate that additional expenses caused by alterations to Project Documentation are higher than the savings obtained. This is shown in detail in Figure no.2.

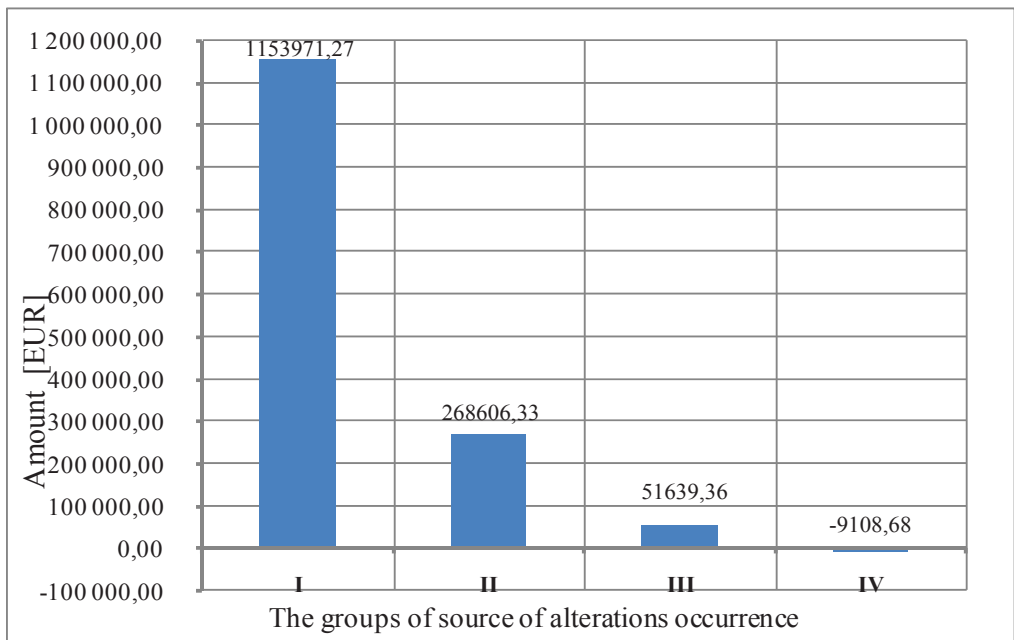


Fig. 2. The financial results related to source of alterations

In the instance of investment no.2, the range of alterations to Project Documentation and their impact on time and cost was significantly lower than in the investment no.1. There was only one change to project documentation compared to the solutions originally assumed. The dynamic development of the community required that an additional section of sewage be designed and constructed. This was necessary to collect sewage from newly established industrial and residential areas. Responsibility

for the project and its execution was transferred to the Contractor. Many events which hindered the completion of investment no.1, were eliminated in the investment no.2 thanks to such a contract solution. The events caused by the interval between design and construction were avoided. Work began at once after the completion of the design, which is a characteristic of the “Yellow Book” system. The final balance of alterations to Project Documentation of both the investment and the financial implications are presented in table no. 3.

Table 3

Financial effect of alterations to Project Documentation

Analysed element	Investment no.1	Investment no.2
The Conditions of contract.	The “RedBook”	The “Yellow Book”
The number of alterations to project documentation.	92	1
The Accepted Contract Amount [EUR].	10,162,715.51	9,939,788.00
The cost of alterations to project documentation [EUR].	1,465,108.28	696 697,35
The percentage of the cost of alterations to project documentation in relation to The Accepted Contract Amount.	14,42%	7,01%

On the basis of data contained in table no. 3 it can be concluded that the combination of designing and executing work by the same subject is a better solution than commissioning it to different units in the case of linear works which include sewage works. It depends largely on the specification of such investments, which generally include a large area, with a fast process of transformations in land use. These qualities are cumbersome for all participants of the investment process. Therefore it is recommended to always employ highly qualified designers, irrespective of the contract system.

4. CONCLUSION

The carried on analysis demonstrates the large number of alterations made during construction. Some of these changes contributed to a reduction in investment costs, but in most cases they impact on cost increase. Alterations to Project Documentation therefore should be regarded as risk factors, mainly related to cost [13].

Both the cases of investment dealt with the increase of the assessed budget. Incomparably more changes were made to the Project Documentation in the investment executed based on the conditions of contract as defined in the “Red Book”. The

consequence of this was a rise in the Contract Price of nearly 14%. The main reasons for this change were incorrect calculations of the amount of work assigned in the Bill of Quantities, as well as the long time between the design and construction. The “Yellow Book” system proves more preferable. In this system the responsibility for the project and its completion is transferred to the Contractor. This contributed to the elimination of flaws in the Bill of Quantities and of those arising from a lack of recognition of topography and land use.

However, based only on this particular analysis, it is impossible to state explicitly that the system for contract “design-build” is in all circumstances more beneficial for the Investor, nor that it prevents the Investor from incurring additional costs. Before choosing a system, it is always necessary for the Investor to assess the competence of personnel, consider the nature, complexity and duration of the investment, as well as consider to whom the increased amount of work will be transferred. The possibility of providing a contingency amount (the amount of money that the Investor should set aside aiming to secure the completion of the project) should also be considered [8].

At the same time, the risk assessment should be a helpful tool for the investor when choosing the best investment system. This assessment should include technical, cost and scheduling aspects, because those fields are most strongly affected by alterations to the Project Documentation, as demonstrated by the analysis question.

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