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## The influence of historical conditions on time and cost of construction project

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### Abstract

Conducting construction works in a building or in an area entered in the historic register is associated with the contracting authority's risk of incurring higher than planned costs of works, as well as delays in their implementation. In many cases, these deviations are completely independent of contracting authority and contractor. The aim of this article is to indicate the reasons for cost and time changes in the construction project, which is influenced by the historical conditions of the building site's location. In practice, the detailed considerations presented in the article may contribute to increasing the efficiency of spending public funds in the implementation of construction projects of a specific nature.

Based on the selected example - reconstruction of the Old Pharmacy building located in the historic part of the old city of Gdańsk, the authors analyze and classify factors affecting the cost and time of construction works taking into account the historical conditions of the location of the facility.

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### 1. Introduction

The correct determination of the cost and completion date of the construction project is an essential element in making an investment decision and forecasting the economic consequences of a project. This issue is important from the public purchaser point of view, but also the contractor of the construction works preparing the tender. In practice, a given construction investment can be attributed to three basic amount [1-3]:

- the value of construction works estimated by the ordering party in the investor's cost estimate at the stage of project preparation,
- the amount entered into the content of the construction contract, i.e. proposed by the contractor selected on the basis of the analysis of the tenders submitted for the tender procedure,
- the actual value of the investment determined after its completion, including (in the replacement cost estimate, implemented or offer cost estimates for the additional scope of works) the value of supplementary and additional works.

In the case of public procurers, another type of amount may be mentioned, which value is given to the public immediately before opening tenders, and this is the amount the contracting authority intends to spend to finance the contract, most often resulting from a budget statute or financial plan. The amount mentioned above are often

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significantly different from each other. Its change usually entails discrepancies in the planned time of investment implementation.

The analysis of the literature on the subject indicates that investments carried out in the areas of historical cities have so far not been subject to detailed research in the field of factors that give rise to cost and time overruns. For this reason, the purpose of this article is to indicate the reasons and scope of changes in the cost and deadline for the building construction, taking into account the historical conditions of its location. Based on a selected example - reconstruction of the Old Pharmacy building, located in the historic part of the Old City of Gdańsk, the authors analyze and classify factors affecting the cost and time of construction works completion.

## 2. Exceeding the cost and time of construction project implementation – the literature review

The subject addressed by authors in practice is a very important issue - in many countries extensive research is carried out regarding the time and costs of construction completion, including research of the following authors [4-8]. The literature on the subject emphasizes that long-term and large-scale projects are much more likely sensitive in terms of time and increased costs [3,9]. The macroeconomic conditions of the country in which the project is implemented are also significant [10]. Detailed, often individual factors, negatively affecting the time and cost of the project implementation depend primarily on the scale and nature of the investment, its location, environmental conditions, the adopted technology and organization of works, construction management, as well as the specificity and importance of the project [11,10]. In the literature can be found numerous examples of research that concern large public construction projects (including the so-called mega projects, most often concerning infrastructure investments), and smaller ones, constituting a collection of several smaller-scale projects, together forming a large project (e.g. housing construction [7]). Factors giving rise to cost and time discrepancies in the areas of historical cities, which are of authors' interest, according to the literature have so far not been subject to detailed research.

### 2.1. Cost overruns in construction projects

Many construction projects are facing serious cost overruns due to various reasons [12]. According to the research carried out by Moms and Hough, the vast majority (63%) of 1778 building projects financed by the World Bank in 1974-1988 exceeded their budget [9]. This problem is deepened in the case of large infrastructure projects (railway and road investments). The conducted research indicates an increase in costs at the level of 50% - 100% and even higher [13]. The data analyzed in the analysis [9], carried out twenties to nineties, refer to investments carried out in various parts of the world, covering 5 continents and 20 countries. It can be concluded that the increase in the costs of construction investments is a global phenomenon. The situation is even more serious in developing countries, where corruption has a significant impact on the actual costs and accounts for 10-30% of the construction contract value [8,14]. The research also indicates that referring to the possible form of remuneration for the construction project, the largest increase in costs is observed in contracts with a flat-rate settlement, slightly smaller with a monthly settlement, and the smallest in the case of the refund agreements [3].

The classification (ranking) of the factors most frequently mentioned in the subject literature, constituting the reason for the increase in the cost of a construction investment, is presented in Table 1.

Table 1. The ranking of the factors most frequently mentioned in the literature as the reason for cost overrun in construction projects (in order of the most to the least often mentioned factor).

Ranking position	Factor
1.	Poor estimation and financial planning /cost underestimation
2.	Project complexity and duration - changes in requirements
3.	External macroeconomic factors (i.e. the cost increase: labour, materials, equipment)
4.	Poor management, monitoring and financial control
5.	Poor workforce skills and experience affecting quality of construction works
6.	Poor material planning/ change orders
7.	(Short) time to deliver the project / underestimate project duration
8.	Poor design and implementation
9.	Adverse weather conditions
10.	Bureaucratic indecisiveness and the lack of coordination between enterprises

source: own study based on [2,3,7-10,12]

## 2.2. Time overruns in construction projects

As in the case of cost overruns, a delay in the execution of construction works is a frequent phenomenon. According to the literature of the subject [9,11,15], about 35% - 65% of the planned activities, are not carried out according to the schedule [11]. Other studies [9] indicate that about 25% - 30% of planned activities are delayed.

The classification (ranking) of the factors most frequently mentioned in the subject literature, constituting the reason for extending the duration of a construction investment, is presented in Table 2.

Table 2. The ranking of the factors most frequently mentioned in the literature as the reason for time overrun in construction projects (in order of the most to the least often mentioned factor).

Ranking position	Factor
1.	Poor quality of the management and supervision, lack of communication
2.	Mistakes and inconsistencies in the design documentation
3.	Poor workforce skills and experience affecting quality of construction works
4.	Ineffective planning (including the development of schedules)
5.	Poor material planning/ change orders
6.	Adverse weather conditions
7.	Investor's difficulties in obtaining funds to finance the investment
8.	Difficulties in obtaining the necessary permits to implement the works
9.	Unrealistic (too short) period of project implementation
10.	Insufficient necessary equipment at the construction site

source: own study based on [4-6,9-11]

## 2.3. The specificity of construction projects carried out in historical areas

The literature review allowed to identify factors that in the opinion of many researchers, have a significant impact on the increase of costs and duration of construction investments. Most of the mentioned studies refer to the scale of implemented investments, not their specificity [16,17,18].

In the opinion of the authors, there are no examples of smaller projects, which due to their special and unique character, are also exposed to a large increase in costs and extending the time of their implementation. Such undertakings include investments carried out in the areas of historical cities.

It is pointed out that maintenance projects related to renovation, reconstruction, modernization, change of use, additionally carried out in hardly predictable conditions, usually experience the most serious delays and, as a consequence, increase in costs [9]. Investments in historical areas are often located in city centers - this is an additional cause of disruptions. In this case, a reliable development of the construction schedule is a particular difficulty and requires a precise analysis of the conditions under which the works to be carried out [19].

The article attempts to classify and define the scope of impact, on the cost and timing of construction works, the main causes of disturbances. An unusual feature of the presented approach is the inclusion in the factors analysis resulting from the historical conditions of the object location.

## 3. The analysis of time and cost discrepancies - case study

### 3.1. The subject of the analysis

The construction works being the subject of this analysis were carried out from December 2016 to March 2018 as a part of the project entitled "*The improvement of the condition of the historic building of the Old Pharmacy from the 17th century, along with the Gateway Passage and the defensive walls of the Main Town in Gdańsk, by giving new cultural functions*". The project is implemented, among others from the resources of the Regional Operational Program for the Pomorskie Voivodeship under measure 8.3 Material and intangible cultural heritage of the Pomorskie ROP for 2014-2020. The beneficiary of the funds and the implementer of the investment is the local government cultural institution - Wybrzeże Theater. The aim of the investment is to increase the tourist attractiveness of the Main Town in Gdansk by using the potential of historic buildings. The scope of the project includes the revitalization and reconstruction of the historic facilities of the Wybrzeże Theater in Gdańsk, including 17th-century Old Pharmacy and Gateway Passage. The goal is constructing a new stage with a rehearsal room and

an observation deck in the Gateway Passage and a foyer in the Old Pharmacy. The project is part of a wide range of activities including the modernization of the Malarnia scene, the construction of a new Old Pharmacy scene, the modernization of the Large Stage and Teatralna Street, the construction of a glass connector between the buildings. The completion of construction works, with the exception of the stage mechanics in the main building, is planned for 2021. Its scope of activities includes:

- Main building
- Malarnia stage
- Old Pharmacy and Gateway Passage
- Underground technical building
- Modernization of the courtyard
- Teatralna Street
- Theater surroundings (Targ Węglowy, Parking).

In 2015, at the request of the ordering party - Wybrzeże Theatre, the project and cost documentation was prepared for the entire project. In 2017, for some of the objects it was updated. The value of the project was estimated at approx. 90 million PLN. According to the design, all objects are interconnected, including through two ground links and one underground, running under Teatralna St. The implementation of the project depends primarily on the financial resources possessed and acquired by the Ordering Party, and the stage of implementation is to ensure the continuous operation of the unit whose main statutory task is cultural activity.

### 3.2. *Historical conditions of the object location*

The building of the Old Pharmacy and the brick fence of the former courtyard between the Old Pharmacy and the Great Armory, which was adapted as the external wall of the new stage building with the auditorium (the project was planned in the place of the former Gateway Passage), are objects entered into the Monuments Register of the Pomeranian Voivodship. The building of the Old Pharmacy was built in 1636 on a quadrangular plan as a detached building. Historical documents show that it was built on the site of a tower built in the middle of the XIV century and demolished in 1636. In 1952, the Gothic foundations of the tower on the rectangular plan were uncovered, made of brick of the Wendish system. Research shows that the Old Pharmacy building was located on a fragment of one of the towers, located between Słomiana Towel and Szeroka Towel and Szeroka Gate [20].

The reconstruction of the Old Pharmacy building and the construction of a new stage in the former Gate Passage were preceded by conservation works on the front façade of the Old Pharmacy building, high and low wall conservation, demolition works and excavations in the former Gateway Passage (including archaeological research), as well as the construction of an underground technical building.

It is important that works are carried out at historic buildings with cultural values in the city of Gdańsk, with a range of fortifications from the XVII century and a monument of history.

The scope of the contract is divided into 5 stages:

- Stage 1 - Old Pharmacy
- Stage 2 - Gateway Transition, I.1-I.5 axes
- Stage 3 - Gateway Transition, I.5-I.9 axes
- Stage 4 – Connector
- Stage 5 - Subscriber transformer station.

The area where the investment is located is characterized by a compact and sensitive to noise and vibrations building - in the immediate vicinity there is an artistic public university, a hotel and a functioning theater.

### 3.3. *Reasons for cost and deadline discrepancies*

The analyzed case concerns the implementation of the raw state of the new stage and the building of the Old Pharmacy. The estimated value of the implementation of this works scope of the contractual party was set at 3 782 688 net PLN, the completion date was scheduled for June 2017, i.e. after 177 days (26 weeks) from the date of signing the contract. As the part of the demolition works, the demolition of a transformer station was planned after

the transfer of the transformer substation to the underground technical building. The demolition work was planned for March 2017. The demolition works started in August 2017, therefore the transfer of transformers was delayed. During the demolition works, historic foundations were discovered. According to art. 32 para. 1 of the Monuments Protection and Maintenance Act [21], the Ordering Party notified about that fact the Pomeranian Provincial Conservator of Monuments (PWKZ). After the inspection, the PWKZ ordered the suspension of works, protection of relics and archaeological research at the expense of the Ordering Party. A separate PWKZ decision was required to carry out archaeological research, therefore the Ordering Party was obliged to apply to the PWKZ for a permit to conduct research. The application should indicate, the head of the research team, therefore the Ordering Party was obliged to conclude an agreement with an Archaeologist with appropriate qualifications. The task of the Archaeologist was the preparation of the Research Program. From the day of submitting the application for conducting archaeological research, 25 days have passed until the date of obtaining the PWKZ decision. The decision was the basis for the archaeologist to start work. On the basis of the conducted research, in consultation with the author's supervision, technical expertise was drawn up, which showed that the condition of the walls is poor, the foundations have numerous cavities and debris, do not represent historical value, and the low curtain wall between the foundations is contemporary. After completing the archaeological research, the Investor submitted to the PWKZ an application for the issue of a permit for the demolition of the walls, however, PWKZ did not allow the demolition [22]. In the explanatory memorandum to the decision, he pointed out that exposed walls constitute the gothic foundations of the medieval tower, demolished medieval tower in the modern period under the Old Pharmacy, replaced by the building of the Old Pharmacy. PWKZ stated that the condition of the walls allows to read the original function of relicts and reconstruction of the tower's foundation. From the day of the archaeological research to the date of the above decision had passed 27 days. Taking into account the information contained in the PWKZ decision, the discovered relics have a historic value and scientific value (they constitute an original historic substance, whose chronology dates back to the XIV-XV centuries, it is a unique discovery), the investor was forced to adapt discovered relics in the designed space. The contracting authority was also obliged to develop a conservation program and a temporary wall protection project. According to the PWKZ recommendation, in order to protect the relics against possible destruction, the Ordering Party ordered a temporary support of historic foundations in the form of a steel grate. This solution had to be approved by PWKZ. The support of the walls was carried out by the Contractor of basic works for a separate remuneration. After strengthening the walls, the Contractor commenced earthworks in order to obtain the ordinate of the foundation slab. After receiving the construction drawings from the designer, the Contractor resumed work on the construction of the building in I.5-I.9 axes. 125 days had passed since the date of suspending works (4 months and 3 days). This time was devoted to archaeological research, protection and reinforcement of uncovered foundations and introduction of changes to the project documentation. The development of replacement designs was carried out by author's supervision for a separate remuneration. The need to adapt the exposed walls resulted in a number of functional and structural changes in the designed building.

### 3.3.1. Detailed analysis of cost discrepancies

The value of works, in accordance with the contract concluded by the Ordering party and the Contractor selected for the execution of the basic state, amounted to 2 698 640.00 net PLN (i.e. 3 319 327.20 gross PLN). According to the project's budget (set at the stage of submitting the application for co-financing), 3 152 240.00 net PLN was planned for the task (3 877 255,20 gross PLN). Therefore, the value of contracted works was lower by 1 084 048 net PLN than the estimated value of the order (i.e. by approx. 28%). In table 3 is presented the division of the contract into stages, along with the assumed time of their implementation and values.

Table 3. The planned completion time and values of individual work stages.

No.	Work stage	Planned duration of works [number of days]	Planned implementation period	The net value of works according to Contract [PLN]
1	The Old Pharmacy	177	10.12.2016 - 06.06.2017	824 617,63
2	The Gate Passage I.1-I.5	177	10.12.2016 - 06.06.2017	1 041 512,86
3	The Gate Passage I.5-I.9	77	20.03.2017 - 06.06.2017	401 105,64
4	Connector	66	01.04.2017 - 06.06.2017	124 839,87
5	Transformer station	48	10.02.2017 - 31.03.2017	306 564,00
TOTAL:				2 698 640,00

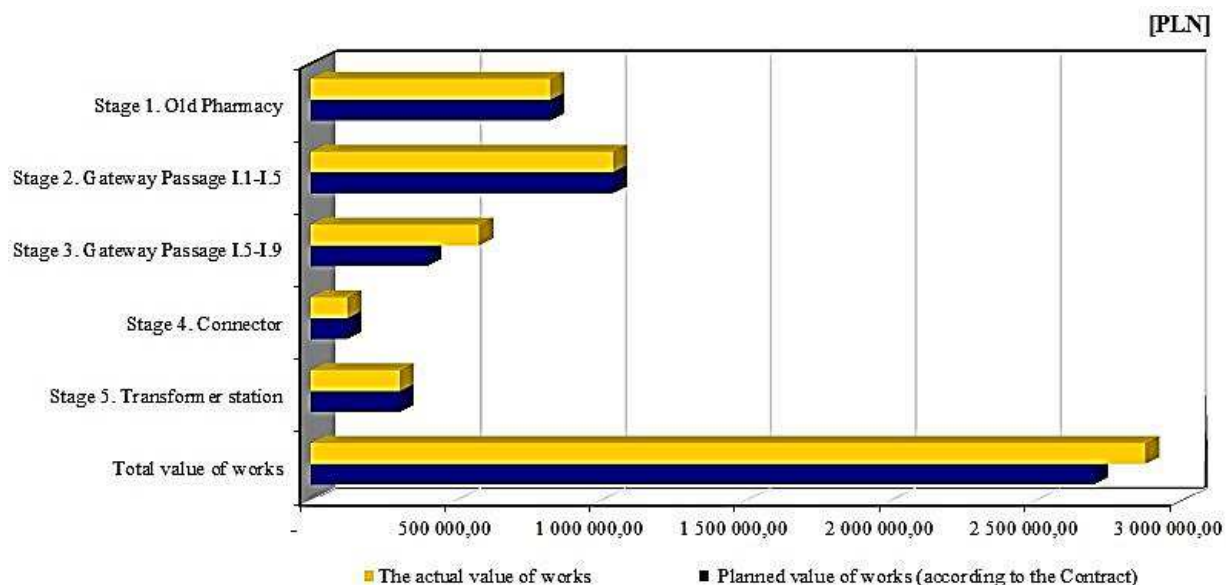


Fig. 1 Planned and actual values of individual work stages.

The scope of work that influenced the increase in the value of Stage 3 is shown in table 4.

Table 4. The list of costs of additional works carried out during the reconstruction of the Old Pharmacy building in Gdańsk.

No.	The scope of additional work	The net value of work [PLN]
1.	The archaeological research	3 724,00
2.	The execution of the replacement project	40 000,00
3.	The implementation of temporary protection of uncovered foundations	92 186,27
4.	The development of the conservation program	5 000,00
5.	The comprehensive restoration of works on foundations	21 500,00
6.	The change of reinforcing steel elements	6 251,67
7.	Change of the location of the heating valves and construction of the technical ceiling	10 199,20
Total:		178 861,14

As shown in Figure 1, The stage 2 covers the most expensive range of activities and constitutes 39% of the value of the entire Contract. Steps 2 and 3 (Gateway Transition) are interrelated and, in accordance with the Material and Financial Timetable, constitute one stage, with a total value of 1 442 618,50 PLN (split into two separate stages: I.1-I.5 and I. 5-I.9, was made for the purposes of this study).

Stage 3 is only 15% of the value of the Contract, however, there was an unplanned increase in costs. The value of Stage 3 was initially 401 105.64 net PLN, and after taking into account additional work: 579,966.78 net PLN. Its value, compared to the contracted price, increased by 31%, and the value of the entire Contract by 6% and amounted to 2 877 501.14 net PLN.

### 3.3.2. Detailed analysis of time discrepancies

Figure 2 presents the planned and actual time of completion of individual stages, taking into account unforeseen circumstances causing delays in the execution of construction works. In the analysis of time deviations, the attention should be paid to the stage of administrative and legal activities, which also generate a delay in the implementation of the contract. In the analyzed case, from the moment of suspension of works (in the scope of Gateway Transition, axis I.5-I.9), for their resumption passed 125 days, and during this time decisions and replacement projects were obtained. As indicated in Figure 2, the implementation of Stage 3 lasted 236 days, and therefore the delay in its implementation was influenced more by administrative and legal activities, which accounted for 53% of the delay of Stage 3.



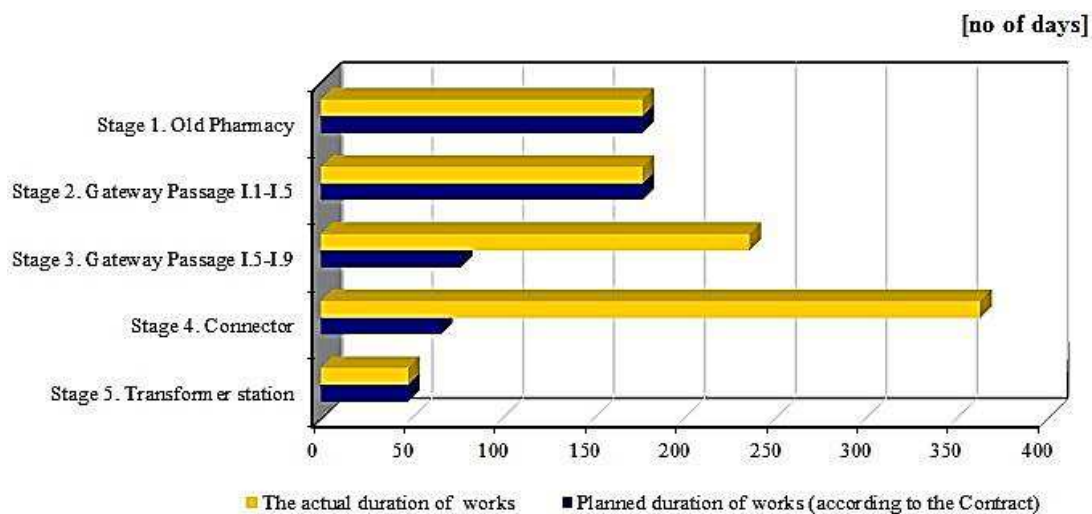


Fig. 2. Planned and actual times for completing particular stages of works.

Table 5. The comparison - planned and actual deadlines for individual stages of works.

No.	Work stage	Planned duration of works (according to the Contract) [number of days]	Planned implementation period	The actual duration of works [number of days]	The actual duration of the performed works
1	The Old Pharmacy	177	10.12.2016 - 06.06.2017	177	10.12.2016 - 06.06.2017
2	The Gate Passage I.1-I.5	177	10.12.2016 - 06.06.2017	177	10.12.2016 - 06.06.2017
3	The Gate Passage I.5-I.9	77	20.03.2017 - 06.06.2017	236	06.08.2017 - 30.03.2018
4	Connector	66	01.04.2017 - 06.06.2017	363	01.04.2017 - 30.03.2018
5	Transformer station	48	10.02.2017 - 31.03.2017	48	10.02.2017 - 31.03.2017

All works, except the Stage 3 (Gateway Passage, I.5-I.9) and Stage 4 (Connector), were completed in accordance with the original Schedule. In Figure 2 are indicated the Steps in where is a delay in implementation. In the case of Stage 3, it was not possible to start the work within the set deadline.

The implementation of Stage 3 lasted 236 days, i.e. 159 days longer than planned, while the implementation of Stage 4 lasted 363 days, thus the delay was 297 days, as shown in Table 5.

Due to the fact that Steps 3 and 4 were connected with each other, the implementation of Stage 4 was delayed and extended from 66 to 363 days, i.e. by 297 days. It should also be noted that certain stages of works were completed in accordance with the Schedule. However, bearing in mind that the conditions of the Contract did not provide for intermediate dates, but only the final date, it should be recognized that the implementation of the entire project was delayed compared to the originally planned date. The initial planned date of the works was 177 days (26 weeks), however, the real time was 474 days (86 weeks). The delay in the entire Contract was 297 days (42 weeks). The stage 3 implementation time was extended three times (over 300%), while the duration of works for the entire Contract was 267.8% longer than originally planned.

#### 4. Conclusion

The extensive analysis of the literature on the subject and the chosen example justifies the formulation of the following conclusions and statements.

1. The initially planned cost of construction works for the case analyzed in the article was 2 698 640.00 net PLN. In practice, due to the increase in the scope of activities and due to delays, the investment cost increased by 6.6%, i.e. 178 861,14 net PLN. It can be considered that the additional expenditure that had to be incurred by the Ordering party is at the same time the value of the time-cost risk associated with the implementation

of the analyzed investment located in the historical part of the city of Gdańsk. It may also be assumed that in the case of the investment being analyzed, the ordering party has a financial reserve for unforeseen expenses (discrepancy between the amount of co-financing and the signed Contract).

2. An attractive tourist element of the project is the combination of a contemporary theater building with a fragment of a historic building from the 17th century. This resulted in a penetrating effect of the usable space of unique character. However, this led to additional expenses and an increase in the duration of the investment.
3. In practice, a frequent reason that hinders the deadline and economical implementation of large construction projects is the existence of numerous factors of various nature: financial, administrative, legal and organizational. The role of these factors increases in the case of projects carried out in the areas of historical cities. In such cases, it should be paid attention to formal and legal obligations such as opinions and administrative decisions, as well as archaeological research, supervision and conservation inspections, expert opinions, protocols of necessity, applications and letters to the institution co-financing the implementation.
4. The inefficient use of funds (including public, EU structural funds, etc.) is an important and very severe effect of delays and increase in investment costs. In practice, the detailed considerations presented in the article may contribute to increasing the efficiency of spending public funds in the implementation of construction projects of a specific nature.
5. In the case of archaeologically rich areas, the most probable reason for suspending works are historical discoveries. Their occurrence after the commencement of construction and assembly works usually results in the suspension of works in the region of discoveries. It is therefore obvious that in the case of such special locations of construction projects, the possibility of extending the duration of works should be taken into account already at the planning stage of the project. Certainly, prior consideration of the risk of discoveries in the form of a reserve in the areas designated for the planned investment (in the form of extending its time and increasing costs) will contribute to improving the implementation of investments. It also means that, in practice, activities related to archaeological research in areas of potential discoveries should be undertaken in advance – i.e. at the initial stage of investment implementation.

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