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MANAGEMENT OF ALTERATIONS TO PROJECT DOCUMENTATION – A CASE STUDY OF WATER SUPPLY AND SEWERAGE WORKS

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Abstract

Background. The implementation of alterations to project documentation is the modification of certain solutions, assumptions or requirements. It mostly involves the verification or the specification of project documentation with regard to the actual conditions of execution or the investor's expectations. The management of alterations in a construction project is aimed at predicting any negative consequences caused by changes in the investment process and their prevention or mitigation. Previous experience indicates that alterations to project documentation introduced during the execution of the work are widespread. They contribute to loss of time and increase in the cost of the project. For this reason, it is necessary to develop and implement an effective model for the management of such alterations.

Research aims. The project manager, before construction, should be aware of any alterations to the project documentation that may have occurred during its execution, and their possible consequences. The aim of the study is to identify the causes, the structure and the consequences of alterations to project documentation with regard to water supply and sewerage construction.

Methodology. The basis of the research and analyses constitute a detailed review of documentation compiled from eight projects in water supply and sewerage. Among the documents concerned, the "Records of Necessity" and "Records of Negotiations" were especially valuable for conducting the analysis.

Key findings. The research conducted indicated the crucial role of the investor in the process of managing alterations to project documentation. The research revealed that proper preparation of the investment process, i.e. recruiting the best designers to prepare the project documentation, tracking changes in the nearer and farther

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surroundings, may significantly contribute to reducing or even eliminating many alterations to project documentation during the execution of the work.

Keywords: project documentation, water supply and sewerage works, management of alterations.

INTRODUCTION AND BACKGROUND

Changes are an integral part of contemporary reality. They occur in all areas of human activity, including the construction process. A change in a construction project is any alteration to the established solutions, assumptions or requirements. Mostly it is a verification or a specification of the project documentation with regard to the actual conditions of execution or the investor's expectations. Obviously, the implementation of an alteration cannot be abandoned because, if so, the structure will not fulfil its functions thoroughly (Adams, 2008; Bonhome-Delprato, 2008; Chan, Scott & Chan, 2004; Chester & Hendrickson, 2005; Czemplik, 2012; Humpries, 2002; Polak, 2011). The management of alterations in a construction project is aimed at predicting the negative consequences of changes in the construction process, and their prevention or mitigation. Therefore, the management of alterations in project documentation is particularly important.

The project documentation of a construction is a set of documents upon which the execution of the work is based. These documents include building design, working plans and specifications, technical specification for the completion and commissioning of the construction work, and the bill of quantities.

The building design is a formal, legal document showing the planned design solutions for the project. It constitutes the basis for obtaining a building permit and other opinions and arrangements (Krupa, 2011). The scope and format of a building design are legally defined (Polish Journal of Laws 1994, Polish Journal of Laws 2004). Working plans and specifications are complementary descriptions, specifying the details of solutions presented in the building design. Requirements regarding the format of the working plans and specifications are the same as for the building design. The bill of quantities provides a list of the works to be carried out, in the order of the processes with their detailed descriptions, calculation and list of the number of work units (Polish Journal of Laws 2004). The technical specifications for completion and commissioning of

the construction include sets of the requirements that are necessary to determine the standard and quality of the work, the properties of the building products, and an assessment of the correctness of execution regarding individual works.

Description of the problem

Alterations to project documentation are initiated by the investor or the contractor. The implemented modifications may concern technical solutions, methods of construction, or corrections to the amount of work as defined in the bill of quantities.

The effect of project alterations is varied and largely depends on the scope and object of these alterations. An alteration may contribute to the execution of an element, or the entire building, in a replacement technology or method, resulting in replacement work. Another case of alterations is additional work, which relates to the extension of the material scope of the agreement or, at least, an increase in the amount of work. A special case of an alteration to project documentation is a correction of the amount of work specified in the bill of quantities. Such an alteration is not a change that is significant according to the construction law. Most often, it results from the underestimation of the quantity of work at the planning stage. The alteration does not involve the introduction of formal changes to the contract, as long as the range of the work is adequate to the work defined in the project documentation, and does not include expansion or reduction of the material scope of the task.

So far, experience shows that alterations to project documentation introduced during the construction phase are a common phenomenon and almost impossible to eliminate completely (Czemplik, 2012; CZP, 2007; Konior, 2007; Leśniak & Plebankiewicz, 2010; Sundram, 2008; Sun & Meng, 2009; Rybka & Bondar-Nowakowska, 2012; 2013). Regardless of the precision and reliability of preparation of the initial data used in the design, and the documentation itself, the specificity of a building project lies in the fact that it is carried out based on particular assumptions and concepts drawn up at the initial stages of the construction process. However, the whole construction process may change in time. Therefore, there is always a risk of alterations to the conditions of its accomplishment at particular stages, and, as a consequence, the need to adapt the project documentation. Accordingly,

it is necessary to evaluate whether the alteration complies with the aim of the project, and how this will affect the scope of the work, its duration and cost. For this reason, it is necessary to draw up and implement an effective management model for alterations to project documentation.

Irrespective of whether the alterations to the project assumptions are made intentionally, or result from unforeseen circumstances, they still generate the necessity of correcting or specifying within the documentation, and drawing up alternative design solutions. Preparation and implementation of new solutions affect the cost, speed and duration of the work (Czemplik, 2012; CZP, 2007; Konior, 2007; Leśniak & Plebankiewicz, 2010; Sun & Meng, 2009; Połoński 2006).

In this report it has been assumed that the process of managing alterations to project documentation runs in a similar way to managing alterations in the building contract. The following stages have been distinguished: identification of the alteration, its approval, notification, implementation and completion/closure of the process (Chen, Tsui, Dzeng & Wang, 2015). A scheme of this process is presented in Figure 1. It includes the specificity of the building works, legal requirements (Polish Journal of Laws 1994), and the contractual conditions of work execution (Fidic, 2008a; 2008b).

The order of activities presented in this scheme indicates that the process of alteration to project documentation is initiated by the contractor or the investor at the moment of reporting the need for its introduction. The project manager analyzes the justification for the alteration and the possibility of its introduction. At this stage, it is essential to obtain the opinions of both the designer and the supervising inspector. The analysis is followed by the stage of negotiations of the alteration costs, the source of financing and the time of its implementation. Consequently, a protocol of negotiations is drawn up. The alteration is sanctioned by a protocol of necessity. After approval of the conditions and rules by the parties, the alteration is implemented. In a case when the alteration refers to a building project, and has been qualified by the designer as important, the investor must allow for additional time and costs resulting from the administrative procedure necessary for obtaining a decision of the change in the building permit.

Currently, there are many computer programs that monitor and register alterations to project documentation. Nevertheless, completion of a building structure within the assumed time and budget requires that

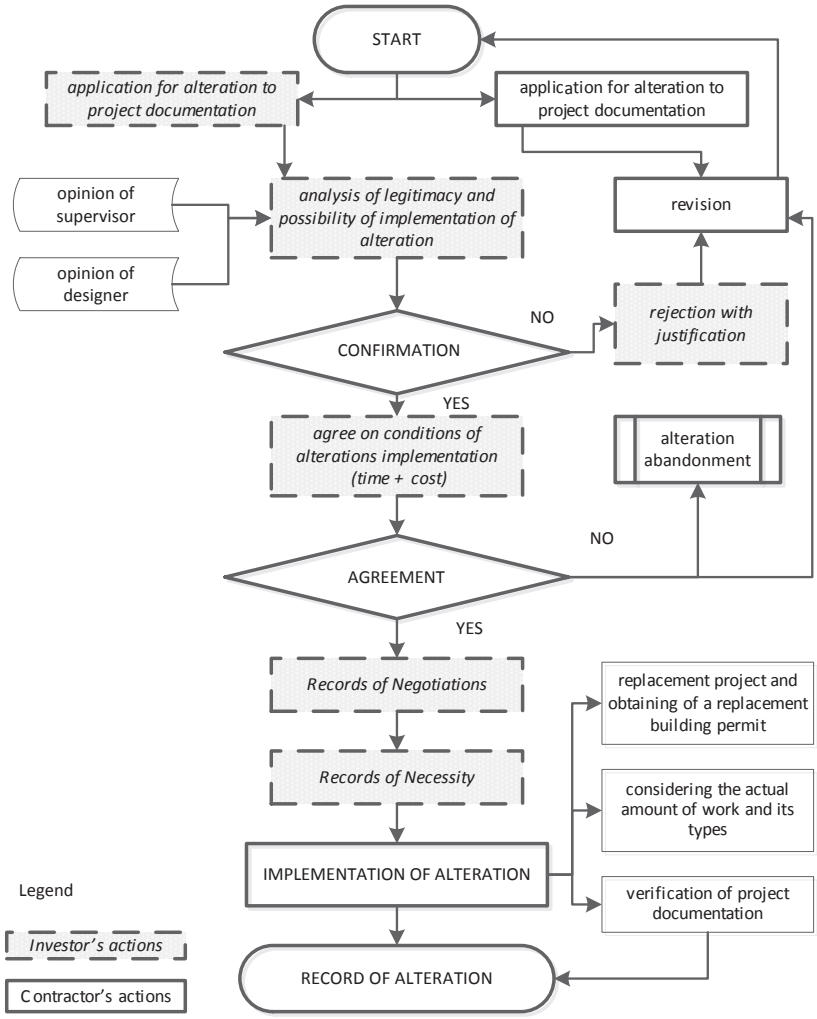

Figure 1. Proposed scheme of alteration to project documentation

Source: individual editing based on: C. Chen, Y. Tsui, R. Dzeng, & W. Wang (2015). Application of project-based change management in construction: A case study. *Journal of Civil Engineering and Management*, *21(1)*, 107–118.

the management of alterations is not limited only to their introduction, analysis and record without an attempt at their early identification. Project managers should be aware, before starting, of what alterations may occur during construction, and what their consequences might be. Their challenge is to coordinate the work of the participants in

the construction process in a context of minimal loss. This problem is the subject of this paper. The aim of this paper is to recognize the causes and the structure of alterations to project documentation in water and sewerage projects.

OBJECTS AND METHODS OF RESEARCH

Research objects

The basis for this research and analysis was a detailed review of project documentation and documentation prepared during the execution of eight water and sewerage projects. The specificity of these projects, unlike other types of buildings e.g. industrial or housing, lies, among other things, in the domination of line works and the associated variability of site conditions, and the necessity for constant movement of the work fronts. Also, the construction of water and sewerage systems is characterized by a predominance of earthworks. This results from the location of many elements of the system (e.g. pipes, pumping stations) in the ground. This effects a considerable dependence on weather and water-soil conditions, terrain and underground infrastructure. All these factors cause the planning and execution of this type of work to be impeded, requiring an individual approach every time. The investments studied were realized in the years 2006–2014, in the area of the Lower Silesia and Opole provinces. The scope of work included the construction of water and sewerage networks together with accompanying infrastructure, a water treatment plant and a sewage treatment plant. All the investments examined were carried out in comparable technical-organizational conditions. The building work was carried out by contractors with a similar level of financial capital, human resources and equipment. The shortest completion time was one year, whereas the longest was four years. The research was performed in the years 2009–2014. During the study, each investment was at a different stage of completion.

Research methods

Review of documentation is a method of research which involves interpreting the content of documents connected with the matter

under study (Pritchard, 2002). The course of the construction process is recorded from the concept of the investment to its final transfer for use. Some of the documents are obligatory for the fulfilment of the construction law requirements. Others, which according to the investor may contribute to efficient and timely investment management, are defined in the contract. The construction documents are, therefore, an important and detailed source of information about the course of the entire investment.

Two groups of documents were chosen for the research. The first group enabled recognizing the research objects. These included: the project documentation, the agreement between the parties, the schedule of the works, and the quality assurance program. Based on them, it was possible to determine the specificity of the object, the scope and conditions of construction, and the planned time and cost of the investment. These documents were prepared prior to the beginning of building work. The other group of documents was prepared during the work. These included: site registers, Records of Necessity, contractor's reports, interim payment certificates, minutes of coordination meetings, and correspondence between the project participants. They were the source of information about the course of the investment realization, including any difficulties and obstacles encountered.

Taking into account the purpose of the study, the documents directly related to alterations to project documentation were isolated from among the project documents. The Records of Necessity and the Records of Negotiations were the most useful. The Records of Necessity included, among other things, justification for the alteration introduced, a description of the alteration, its cause, and the feasibility of its implementation in terms of compliance with formal and legal requirements. The Records of Negotiations contained the contractor's agreed price for the works covered in the Records of Necessity, any additional time needed to carry out the work, the result of negotiations regarding time extensions for carrying out the work, and the investor's commitment to cover these costs.

Results

Based on the review of the documents concerning the investments under study, 243 cases of the introduction of alterations to project documentation were found. These alterations included: refinement,

improvement, and drawing up of new design solutions. The cases identified were classified according to the following categories:

- causes of introduction of alteration to project documentation;
- factors generating the need to introduce the alteration;
- party responsible for the need to introduce the alteration;
- result of the alteration.

The conducted research showed that the largest diversity, in terms of the recorded alterations, occurred in the category of their causes. Based on a detailed analysis of these causes, they were classified in fifteen homogeneous groups. The factors which contributed to the necessity of verifying the adopted design guidelines were sub-divided into external and internal factors. External factors include, among others, lack of the owner's permission to carry out work on the premises, changes to the zoning of the area covered by the investment, technical and technological conditions for work, other than those assumed at the design stage, as well as weather, and soil and water conditions.

Internal conditions resulted mainly from the negligence of the participants in the investment process. In the category 'generating party', the participants in the investment process, i.e. designer, investor and building contractor, were included. The result of each alteration was considered in terms of execution time and investment cost. A detailed register was compiled based on the classified alterations. The structure of this register is shown in Table 1.

Table 1. Register of alterations to project documentation in the research objects

ALTERATION CAUSE	ALTERATION RESULT		external factors	internal factors	designer	investor	contractor	number of records
	ADDITIONAL COST	ADDITIONAL TIME	SOURCE		GENERATING PARTY			
lack of precise definition of requirements regarding technical and operational parameters of the future structure/ system, at the design stage	• preparation of replacement project documentation, or • inclusion of the requirements in existing project documentation			X		X		24
	X	X						

faulty data used in the design – documents do not comply with the terrain, geological, geodetic and urban conditions, etc.	• preparation of replacement project documentation, or • review of the existing project documentation with regard to the actual conditions for realization			X		X		1
	X	X						
lack of required permits, licenses or administrative arrangements, mainly relating to the rights to land for construction purposes	• preparation of replacement project documentation, or • inclusion in the existing documentation of the decision issued during the work			X		X		2
	X	X						
designer error in the calculations, drawings, and in the selection of equipment and materials	• preparation of replacement project documentation, or • correction of an error in the existing project documentation, or • adaptation of new equipment and/or materials to the solutions within the existing project documentation			X	X			26
	X	X						
work conditions different from those assumed in the project documentation due to lack of recognition of existing infrastructure or geological structure	• preparation of replacement project documentation, or • inclusion of the actual conditions in the existing project documentation			X	X			32
	X	X						
incorrect estimate of the amount of work in the bill of quantities	• inclusion of the actual amount of work and type, after execution and quantity survey							92
	X							
application of obsolete or impractical design solutions in the fields of construction and operation of the facility	• preparation of replacement project documentation, or • inclusion of more modern / better solutions in the existing project documentation			X	X			23
	X	X						

non-functional design solution potentially leading to the occurrence of technical and organizational problems during work execution and the operation of the facility	• preparation of replacement project documentation, or • inclusion of objections in the existing project documentation			X	X			11
	X	X						
implementation of design solutions non-compliant with applicable laws, including health and safety	• preparation of replacement project documentation, or • inclusion of the applicable regulations in the existing project documentation							4
	X	X						
changes to the solutions assumed in project documentation for cost-reducing solutions	• preparation of replacement project documentation, or • inclusion of proposed solutions in the existing project documentation			X			X	12
	X	X						
sanctioning the works executed in different manner than in original project documentation, but correctly in technical and functional terms	• preparation of replacement project documentation, or • inclusion of the applied solution in the existing project documentation			X			X	2
	X	X						
lack of owner's permission to carry out work on the premises	• preparation of replacement project documentation, or • inclusion of consequences of changes to the property owner's decisions in the existing documentation		X					2
	X	X						
changes in zoning of the area covered by the project in the period between the end of the design stage and the construction	• preparation of replacement project documentation, or • adjustment of the technical and operational parameters to new conditions		X					7
	X	X						

occurrence of technical and technological difficulties in conducting work, not predictable at the design stage and/or during the contract signing	• preparation of replacement project documentation, or • inclusion of the actual conditions in the existing project documentation		X				4
	X	X					
impact of environmental factors on the construction and operation of the structure	• preparation of replacement project documentation, or • inclusion of the actual conditions in the existing project documentation		X				1
	X	X					

Source: individual analysis.

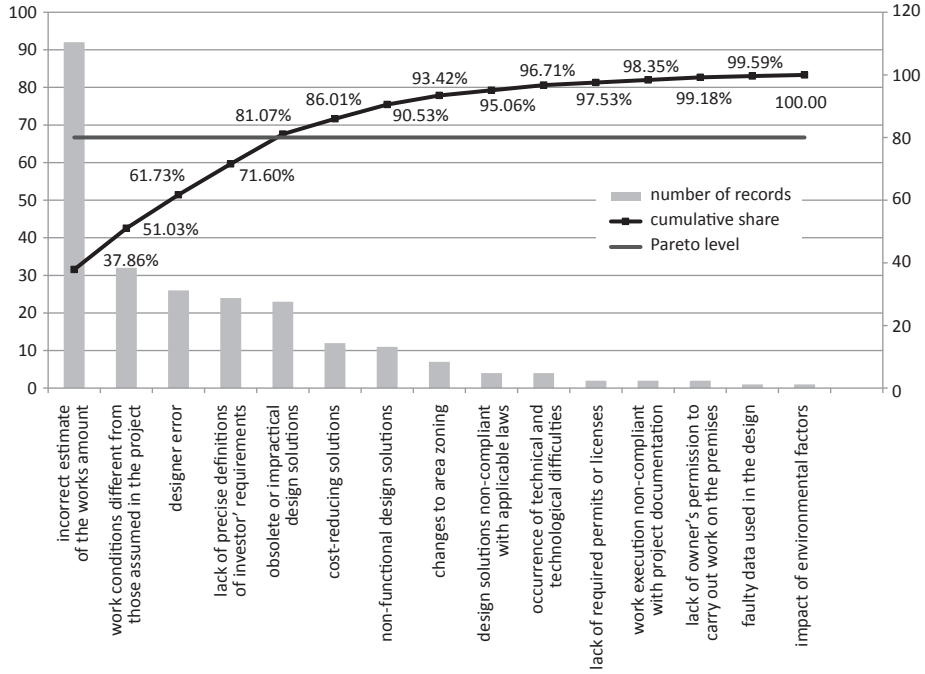

Figure 2. Quantitative analysis of the project alterations based on Pareto diagram

Source: individual editing.

Each alteration to project documentation requires different activities within the process of investment management. According to the Pareto principle, to ensure effective management it is not appropriate

to deal with all problems in equal measure. It is practical to focus on the most likely cases (Brzozowski, 2012). To diagnose such cases, a Pareto diagram was used (Figure 2). Its analysis shows that in the case of the investments under consideration, the most common cause of alterations to project documentation were errors and inaccuracies made by the designer. The most common errors were made in the bill of quantities. This is particularly the case when a quantitative method was the accepted accounting method for the work. Further errors included conditions for the construction of the object other than those assumed in the project, mistakes made by the designer in the calculations and drawings, lack of precise definitions of the investors' requirements and obsolete or impractical design solutions.

RESULTS

Changes are inevitable in the construction process. They result from the unpredictability of conditions for the completion of a building object, resource constraints and environmental variability. The presented research shows that alterations to construction projects of water supply and sewerage systems are common. Flexible reaction and adaptation of the investment process participants to these alterations are important conditions for meeting both the deadline and the cost of the object. Until now, the issue of the quality of project documentation has not received due attention, despite the fact that alterations to documentation, as demonstrated by this analysis, are a complex, time-consuming and costly process.

A condition of successful management of alterations to project documentation, at the stage of work execution, is to have appropriate understanding of the likely causes of alterations, the potential for their occurrence, and their possible consequences. For this purpose, a register of the alterations to project documentation was compiled. This register shows the alterations to the guidelines of the project, which occurred during the completion of eight water and sewerage investments. It shows their origins and the consequences for the investors in these projects. The authors are aware that the results presented refer to only one type of investment, and should be expanded in the course of further research. However, the main advantage of the compilation as presented is that it was created based on direct research conducted on

constructions carried out under current organizational and technical conditions, thereby taking into account the most important elements of the risk of alterations to project documentation. It should be noted, however, that the usefulness of the register will largely depend on how it is implemented by the project manager.

Alteration management should be a permanent element in the construction of water supply and sewerage systems. These changes must be addressed in an organized way. In the case of notification of the need to introduce alterations to project documentation, proceeding should not merely be a reaction to the situation, but the result of an adopted plan. It must, therefore, be assumed that project documentation should be subject to constant verification and must continue to be adapted to the conditions of the work according to external and internal factors. Preparation and modification of the design guidelines should be regarded as an ongoing process, carried out at all stages within the completion of a given object.

The study has pointed to the important role of the investor in the process of alteration management in the project documentation. It shows that proper preparation of the construction process, having the best designers to prepare the documentation, tracking changes in the near and distant environment can contribute significantly to the reduction, or even elimination of many alterations to project documentation during the work. However, due to the occurrence of unpredictable factors, a well-prepared plan of work, taking into account a number of constraints and the dynamic nature of the construction process itself, is essential. While developing such a plan, attention should be paid to, among others, elements such as:

- inclusion in the schedule of the necessary technological and organizational breaks resulting from climate and terrain conditions;
- development of schedules with flexible structures, with a large number of tasks able to be carried out simultaneously, allowing for a possible early start to subsequent tasks and allowing for the use of any time reserve, if such occurs during the execution of the work;
- an analysis of the risk of adverse events with particular emphasis on events that may most likely disturb the planned work, including the risk of alterations to the project;
- inclusion in the work schedule of time and cost buffers that should enable compensation for any delays caused by adverse events;

- introduction of a system for the regular monitoring of work progress, allowing for an early detection of the possible deviations from the plan, and taking effective corrective actions;
- flexible management of the resources available during the work (including reserve means accumulated in the buffers), taking into account the priority of tasks on the critical path and the delayed tasks or those threatening the scheduled completion date of the project.

Information on the alterations regarding project guidelines, experience of the design team and the conclusions and comments of the construction management allow us to improve the quality of the design process during subsequent investments. Therefore, a way of recording these alterations should be proposed. Particular attention should be paid to determining the impact of alterations on investment cost and completion time, and the function of the object. Identification of potential alterations to project documentation prior to the implementation of the contract can help the participants in the investment process in the preparation of management plans for the cost, schedule, and technical risk to the planned investment. This will enable efficient management of the project at the moment when the risk materializes. In addition, it should be remembered that improving the alteration management process is an effective tool for improving an organization, which a construction company in a constantly changing reality ultimately is.

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ZARZĄDZANIE ZMIANAMI W DOKUMENTACJI PROJEKTOWEJ NA ETAPIE ROBÓT BUDOWLANYCH NA PRZYKŁADZIE ROBÓT WODOCIĄGOWYCH I KANALIZACYJNYCH

Abstrakt

Tło badań. Wprowadzanie zmian do projektu budowlanego oznacza zmodyfikowanie przyjętych rozwiązań, założeń lub wymogów. Najczęściej jest to uszczegółowienie dokumentacji projektowej, uwzględniające rzeczywiste warunki realizacji lub oczekiwania inwestora. Zarządzanie zmianami w projekcie budowlanym polega na przewidywaniu negatywnych skutków zmian oraz na zapobieganiu im lub ich łagodzeniu. Z dotychczasowych doświadczeń wynika, że zmiany w dokumentacjach projektowych, wprowadzane w trakcie realizacji budowy, są zjawiskiem powszechnym. Przyczyniają się one do strat czasu oraz wzrostu kosztów inwestycji. Z tego względu konieczne jest opracowanie i wdrożenie skutecznego modelu zarządzania tymi zmianami.

Cel badań. Zarządzający kontraktami, przed ich rozpoczęciem, powinni mieć świadomość, jakie zmiany w dokumentacji projektowej mogą wystąpić podczas realizacji obiektu oraz jakie mogą być ich następstwa. Celem pracy jest rozpoznanie przyczyn, struktury oraz konsekwencji zmian dokonywanych w dokumentacjach projektowych inwestycji wodociągowych i kanalizacyjnych.

Metodyka. Podstawę przeprowadzonych badań i analiz stanowił szczegółowy przegląd dokumentacji projektowych oraz dokumentów prowadzonych na budowach ośmiu inwestycji wodociągowych i kanalizacyjnych. Spośród rozpatrywanych dokumentów najbardziej przydane były protokoły konieczności oraz protokoły negocjacji.

Kluczowe wnioski. Badania wskazały na istotną rolę inwestora w procesie zarządzania zmianami w dokumentacji projektowej. Pokazały one, że właściwe przygotowanie procesu inwestycyjnego, pozyskanie najlepszych projektantów do opracowania dokumentacji, śledzenie zmian zachodzących w bliższym i dalszym otoczeniu w znacznym stopniu mogą się przyczynić do ograniczenia lub nawet wyeliminowania wielu zmian wprowadzanych do dokumentacji projektowej podczas wykonawstwa robót.

Słowa kluczowe: dokumentacja projektowa, roboty wodociągowe i kanalizacyjne, zarządzanie zmianami