Abstract
The system of construction design completion most frequently used in Poland is the traditional one. In this system, the client describes the subject of the order by means of design documentation and technical specifications of construction and commissioning of building works. The article analyses the most frequent errors that appear in design documentation, discusses the reasons for their occurrence and specifies their possible consequences.

Keywords: design documentation, public procurement, construction

1. Introduction
The basis of an appropriate bidding procedure concerning construction works is the correct preparation of documents describing the subject of the order. In the case of orders involving public funds, the client must obey the relevant regulations, especially ones specified in the Public Procurement Law. Although the regulations came into force years ago and even though there exist numerous master documents, clients continue having problems with an appropriate preparation of design documentation describing the subject of the order. As a result, a number of issues ensue on both the bid preparation and project completion stage. In many countries extensive researches on problems with an appropriate preparation of design documentation were carried out (Love, Lopez & Kim, 2014; Lopez & Love, 2012; Dosumu & Adenuga, 2013).

The aim of the article is to analyse the errors that occur most often in describing the subject of the construction order when the client separates the design contract from the construction works contract.

2. The scope of design documentation
Construction works consist of two stages. The first involves designing the building, while the second embraces works execution on the basis of design documentation.

In the traditional form of construction works completion, the design stage is separated from the construction one. In this case, the investor first orders designing a project and then, when the design is ready, execution of works. In the other form, one contractor is entrusted with both design preparation and construction completion (Design & Build). Both systems are described in the Polish law (Act on Public Procurement Law of 29th January 2004, as amended), as the possible ways of contracting construction designs in the public sector.

The traditional system of completing construction works designs is the most popular and most commonly implemented one (Harris, McCaffer & Edum-Fotwe, 2006). In Poland as many as 99% of public investments are done within this system. Here the client describes the subject of the order by means of design documentation and technical specification of construction and commissioning of building works.

The scope of design documentation differs depending on whether or not it is necessary to obtain a building permit. In the case of the necessity of a building permit, design documentation consists of a construction design which includes the specificity of construction works, detailed designs, bill of quantities of the works, as well as the information about safety and health protection, when its compilation is required by separate regulations.

3. Errors in construction and detailed design projects

The content of a construction design, as it is required in Poland, was defined by the Act on the Construction Law. The Act mentions only the construction design, which is necessary to prepare when one needs to obtain a building permit. The construction design should contain the following: land or plot development plan, architectural and construction plan, specifying the function, form and construction of works in question, their energy and ecology performance, also including suggested technical and material solutions.

In accordance with the needs, the design may also contain declarations about ensuring a supply of energy, water, heating and gas, sewerage; statements about the conditions of connecting the building object to systems of water supply, sewerage, heating, gas, electroenergetic, telecommunication and roads; a declaration about the possibility to connect the plot to a public road; a geology engineering report and geotechnical conditions of foundation of a building object.

The aim of the detailed design is to complement and provide details to the construction design to the degree necessary to formulate the bill of quantities of the construction works, an investment cost estimate, to prepare a bid by the contractor (in the form of a tender cost estimate) and to facilitate the subsequent execution of the construction works. In sum, the detailed design is prepared in order to complete the works.

Errors in the preparation of designs, in both the construction design and the detailed design, are an inseparable part of preparing a construction investment and, unfortunately, they tend to occur frequently. A simple definition of a design error is “a deviation from the plans and specifications” (Suther, 1998).

An analysis of errors committed in designs reveals a possibility of dividing them into categories according to the place of their occurrence: technical description, engineering drawings, calculations. Another categorisation is one according to the person: investor, architect, discipline-specific designer. Categorisation according to the type of error includes: discrepancy in the design, discrepancy within design documentation, lack of information, incorrect or incomplete information, errors in designing. The most frequent errors in construction and detailed designs in public procurement in Poland were included in Table 1. All the errors were categorised in accordance with the type of error, its place of occurrence and the person responsible for the appearance of the error.

Table 1. The most frequent errors in designs.

<table>
<thead>
<tr>
<th>Error groups</th>
<th>Person responsible</th>
<th>Place of error in a design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discrepancy in the design</td>
<td>Investor</td>
<td>Discrepancy between technical description with drawings</td>
</tr>
<tr>
<td></td>
<td>Architect</td>
<td>Discrepancy between technical description with drawings</td>
</tr>
<tr>
<td></td>
<td>Discipline-specific designer</td>
<td>Discrepancy between technical description with drawings</td>
</tr>
<tr>
<td>Discrepancy within design documentation</td>
<td>Discrepancy between the design’s bill of quantities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Investor</td>
<td>Technical description</td>
</tr>
<tr>
<td></td>
<td>Architect</td>
<td>Technical description</td>
</tr>
<tr>
<td></td>
<td>Discipline-specific designer</td>
<td>Technical description</td>
</tr>
<tr>
<td>No information</td>
<td>No information required</td>
<td>Technical description</td>
</tr>
<tr>
<td></td>
<td>No dimensions in drawings</td>
<td>Technical description</td>
</tr>
<tr>
<td></td>
<td>No detailed information about technology or materials</td>
<td>Technical description, drawings</td>
</tr>
<tr>
<td>No design assumptions</td>
<td>Excluding data, i.e. load, ground conditions</td>
<td>Drawings, Calculations</td>
</tr>
<tr>
<td>Incorrect or incomplete information</td>
<td>Incorrect or incomplete description of elements</td>
<td>Technical description</td>
</tr>
<tr>
<td></td>
<td>No design assumptions</td>
<td>Drawings</td>
</tr>
<tr>
<td></td>
<td>Incorrect dimensions in drawings</td>
<td>Drawings, Calculations</td>
</tr>
<tr>
<td>Errors in designing</td>
<td>Incorrect assumptions design</td>
<td>Drawings, Calculations</td>
</tr>
<tr>
<td></td>
<td>Incorrect description of materials</td>
<td>Technical description, drawings</td>
</tr>
<tr>
<td></td>
<td>Discrepancy between elements designed and law</td>
<td>Drawings, Calculations</td>
</tr>
</tbody>
</table>
There exist a few main factors which cause errors to occur in designs. They include the following: designers’ lack of construction knowledge or experience, lack of time to prepare a high-quality design documentation, working on two-dimensional documentation which hinders design verification, lack of coordination between subjects, wrongly defined or imprecise scope of duties, human errors.

4. Errors in bill of quantities

The requirements concerning the bill of quantities, which constitutes the description of the subject of a public procurement on construction works, are specified in the Regulation of the Minister of Infrastructure of 2nd September 2004 on the detailed scope and form of design documentation, technical specifications of construction and commissioning of building works and the functional-utility program (Journal of Laws No. 202, pos. 2072 as amended). According to article 6, section 1, “A bill of quantities of construction works should contain a list of basic works predicted to be completed in the technical order of their completion together with their detailed description or indication of the basis establishing a detailed description and indication of appropriate technical specifications of construction and commissioning of building works, with the calculated and listed bill of quantities items of basic works”. As the article states, the bill of quantities of construction works should include the following: the title page, an index of the sections of the bill of quantities and a table of the bill of quantities. The information that should be included in the individual sections of such a compilation is listed in Table 2.

Table 2. The contents of the bill of quantities (BOQ) of construction works

<table>
<thead>
<tr>
<th>elements of BOQ</th>
<th>Information required in the given element of the bill of quantities (BOQ)</th>
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</thead>
<tbody>
<tr>
<td>Title page of BOQ</td>
<td>1) name of the order given by the client; 2) depending on the scope of construction works specified by the subject of the order – names and codes: a) works groups, b) works classes, c) works categories; 3) address of the construction object; 4) name and address of the client; 5) date of the BOQ completion.</td>
</tr>
<tr>
<td>List of BOQ sections</td>
<td>1) division of all works in a given construction object into work groups according to CPV; 2) further division of the BOQ according to the taxonomy established individually or taxonomy employed in publications concerning standard cost-estimates of non-cash outlays; 3) in the case of works involving multiple construction objects, the list of sections should additionally include the division of the whole investment into construction objects – the work group concerning ground preparation should constitute a separate section of the BOQ for all of the objects.</td>
</tr>
<tr>
<td>Table of BOQ</td>
<td>1) BOQ items related to basic works; 2) numbers of the BOQ items; 3) codes of BOQ items, specified according to the taxonomy of works established individually or on the basis of publications concerning standard cost-estimates of non-cash outlays; 4) numbers of technical specifications of construction and commissioning of building works including the requirements for individual BOQ items; 5) names and descriptions of BOQ items, and calculations of the number of units of measure for BOQ items; 6) units of measure concerning the particular BOQ items; 7) number of units of measure for the particular BOQ items.</td>
</tr>
</tbody>
</table>

Errors committed in the bill of quantities can be classified as follows: formal errors and calculation errors. Formal errors – relating to the discrepancy between the bill of quantities as part of the design documentation describing the subject of the public procurement for construction works and the requirements of the Regulation mentioned above. A synthetic compilation of formal errors that occur in the bill of quantities are presented in Table 3.

When considering the reasons for which formal errors occur, one needs to take into account such aspects as: lack of knowledge or experience of the people preparing the bill of quantities documentation, especially their poor knowledge of public procurement laws and regulations concerning the bill of quantities of construction works; incoherency of construction designs, detailed designs and technical specifications of construction and commissioning of building works.

Table 3. The content of the bill of quantities (BOQ) of construction works
Calculation errors occur in the discrepancy between the number of works calculated and included in the bill of quantities and the actual numbers that result from the technical documentation. When considering the reasons for which calculation errors occur, one may distinguish the following factors: the quality of construction designs and detailed designs – design errors are transferred to the bill of quantities; human errors – resulting from a large number of necessary calculations, the complexity of the calculation formulas and their laboriousness.

The bill of quantities should be in the form of a document that, to a large extent, facilitates the preparation of a bid compatible with the Regulation article 4 section 3, if the order for construction works “is granted as a single source procurement or, in the essential decisions of the contract, a lump-sum remuneration was agreed on, design documentation may not include the bill of quantities of the construction works”. As a result, the risk involved in the preparation of the bill of quantities and the possibility of errors which may occur in the calculation of the number of works is taken by the potential contractors, not the client.

5. Errors in the information about safety and health protection

The duties of the designer involve, according to the Act of 7th July 1994, Art. 20, sec. 1, pt. 1b of the Construction Law, Journal of Laws of 2003 No. 80, pos. 718, preparation of the information concerning safety and health protection (referred to as “information”) related to the specificity of the building object’s design which will be included in the safety and health protection plan. Thus the information in question is essential to prepare such a plan by the construction manager, whose duty is to prepare it himself or to have it prepared in such a way that the plan contains the specificity of the building object and the conditions of conducting the construction works, including the planned simultaneous construction works and industrial production.

The designer’s duty also includes the preparation of information for each investment for which a construction design is done. The safety and health protection plan is indispensable to be granted a building permit or a separate decision approving a construction design (Art. of 35 sec. 1 pt. 3 of the Construction Law). In addition, information concerning safety and health protection must be prepared in the case of the need to obtain the final decision about a demolition plan when the application includes a plan of the building object demolition.

The relevant authority that issues building permits, before granting permission or approving on a construction design, has to verify the completeness of the design, the required opinions, agreements, permits, verifications and the information about safety and health protection.

To preparation of the information is based on the construction design. The scope of the information is specified by article 2 of the Regulation of the Minister of Infrastructure of 23rd June 2003 on the information about safety and health protection, as well as the safety and health protection plan (Journal of Laws of 2003 No. 120, pos. 1126). The information about safety and health protection consists of the above-mentioned Regulation, a title page and a descriptive section.

The descriptive section, contains the following.

• the scope of the works for the whole construction project and the order of completing individual objects;
• a list of the existing building objects;
• indication of the elements of land or plot development that may pose a danger to people’s safety and health;
• indication of possible danger existing during works completion, specifying the degree and types of danger, its place and time of occurrence;
• indication of the way employees are instructed before the beginning of particularly dangerous works.
• Indication of technical and organizational means preventing the risks that result from the conduction of construction works in places posing particular danger or in their neighbourhood, including those that ensure safe and efficient communication facilitating quick evacuation in case of fire, breakdown or other dangers.
The lack of knowledge of the health and safety regulations, lack of experience and inaccuracy may be the source of errors in the prepared safety and health protection information. The particular errors that may occur include the following:

- failure to indicate all the elements of land development which may endanger people’s health and safety;
- incomplete specification of possible risks which may arise during construction works;
- incorrect specification of the degree and types of danger, or the place and time of its occurrence;
- incomplete specification of technical and organizational means preventing risks that result from the construction works in places posing particular danger or in their neighbourhood.

6. Consequences of errors in the subject of the order

The consequences of errors in the description of the subject of the order are taken by the client as early as at the bidding procedure stage. Contractors willing to prepare their bid correctly ask many of questions. Therefore, in order to receive an insight into the problems associated with the preparation of the bid, the results of construction works contracts announced by the authorities of chosen cities in 2010-2011 were analysed (Kozik & Plebankiewicz, 2013). The analysis involved the structure of questions based on the proceedings conducted in Krakow and Szczecin (in total 270 questions). Figure 1 presents the structure of the questions.

Figure 1. The structure of the questions (proceedings conducted by the Municipality of Krakow and the Municipality of Szczecin)

A significant number of questions involved project designs (41% of questions). Many of them asked about the building materials to be used. They included requests for more precise statements about the client’s requirements concerning materials and questions about possibilities of using substitutes, which may be seen as the consequence of imprecise descriptions of these elements in the documentation.

Since the majority of questions were connected with design documentation, Figure 2 presents the scope of bidders’ most frequent doubts associated with the design.

The greatest number of doubts found in questions concerning design documentation occurred in relation to the differences between the design and the bill of quantities of construction works. Bidders also noticed differences between technical specifications and the design. In some cases, the lack of dimensions in the design documentation hindered appropriate pricing and caused bidders’ doubts whether the pricing should include those elements. Moreover, bidders indicated the lack of a particular item in the bill of quantities or the lack technical specifications, as well as incomplete information in the detailed design.

It must be emphasised, though, that questions do not necessarily mean gaps or improperly prepared documentation. Questions may just as well result from contractor’s ignorance or the willingness to enforce the postponement of tender submission. What indicates that contractors’ questions are valid and that the proceedings have been correctly prepared is, to a large extent, the necessity to introduce changes to the documentation. On the other hand, the need to introduce numerous changes to the documentation may cause tender submission postponement or, in extreme situations, cancelling the proceedings.
Changing or complementation of documents took place in about 31% of all proceedings and in about 90% of those in which questions were asked. This indicates that contractors’ questions almost always lead to the introduction of changes. Changes in tender documentation involved completing the bill of quantities, adding drawings, changing and completing technical specifications, changing and completing significant terms and conditions of the tender, and changes in contractual provisions.

The most frequent and the most serious consequences of mistakes in design documentation at the stage of completion of the investment include the following:

• suspension of works until design changes are ready or discrepancies in technical documentation are clarified;
• increase in the contract value due to additional and complementary works when the scope and type of works have changed;
• a threat to workers’ health and life.

7. Summary

A correctly prepared documentation that bidders receive in tender proceedings is a condition of the contractor’s submission of a tender that fulfills the client’s requirements.

The article indicates the errors that appear most frequently in design documentation and technical specifications of construction and commissioning of building works. An attempt has been made to evaluate the reasons of error occurrence and enumerate their possible consequences. When more attention is paid to the preparation of the documents by reliable designers, the client may avoid spending time and resources on the introduction of necessary corrections.

References

Regulation of the Minister of Infrastructure from 2nd September 2004, concerning the detailed scope and form of design documentation, technical specifications of construction and commissioning of building works and the functional-utility program.