

SELECTED ISSUES OF BILLS OF QUANTITIES IN CONSTRUCTION WORKS IN POLAND

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Abstract:

A bill of quantities (BOQ) is an important link in the cost estimation process and construction work planning. The correctness of determining the amount of work in a bill of quantities affects the accuracy of costing of construction works in budget estimates, as well as the quality of work implementation schedules. In the paper the authors point out some problems related to the issue of performing a bill of quantities in Poland. They refer to the applicable ways of taking off under the applicable legal framework and in the light of environmental methods. They draw attention to possible taking off methods. The paper also raises problems of inconsistency of definitions, discrepancies in the available principles of a bill of quantities, including temporary and accompanying works while performing BOQs.

Keywords:

BOQ, bill of quantities principles, digital taking off

INTRODUCTION

The BOQ is an important development falling within the scope of project and cost documentation in the investment and construction process [9]. This is due to the following reasons:

- in public procurement a bill of quantities is a requirement of project documentation and is to detail the description of subject-matter of a construction work contract;



- a bill of quantities defines the material and quantitative scope of works planned to be implemented;
- a bill of quantities is the basis for determining the estimated value, price or remuneration for building works; its scope and form in public procurement is defined in two Regulations under which the BOQ is included in project documentation constituting the basis for investor's cost estimate.

The accuracy and correctness of determining the amount of works largely influences the quality of cost estimate or valuation of costs of particular stages of work, elements of works and an entire facility, the calculation for which is carried out in accordance with [7]. The quality of BOQ is also important for scheduling construction work. The flow and change in the scope of information about a construction object from technical documentation to a work schedule with a bill of quantities taken into consideration is shown in figure 1.

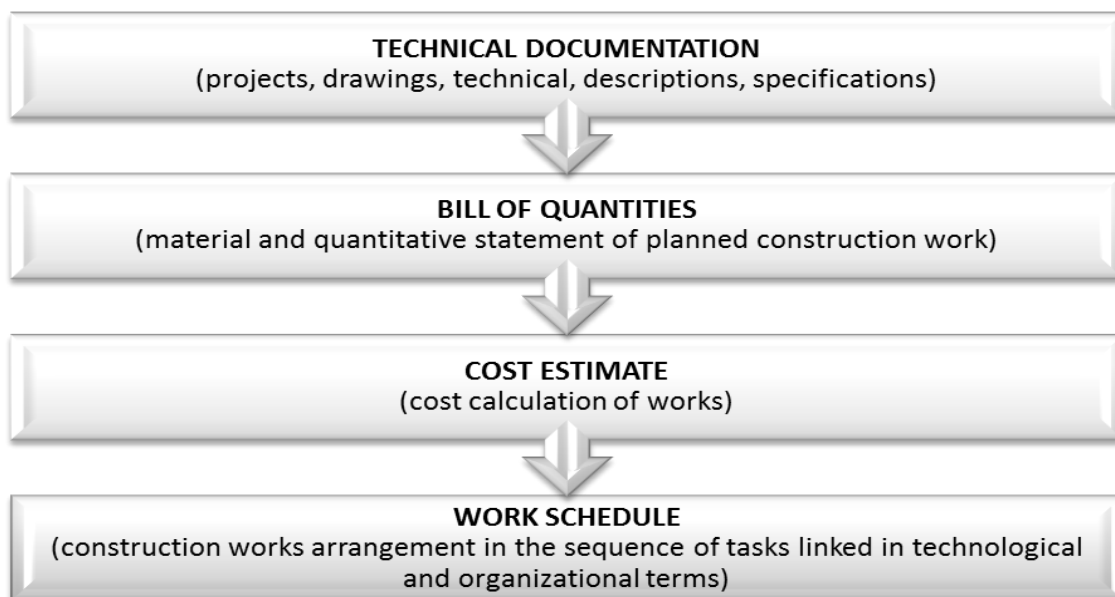


Fig. 1. The place of a bill of quantities in the flow of information about a construction object

Source: Own study

Currently, the issue of BOQ is regulated only in the area of public procurement in respect of:

- a bill of quantities constituting a component of project documentation describing the object of a contract for construction works (the Regulation of the Minister of Infrastructure of 2 September 2004; Journal of Laws No 202, item. 2072 on the detailed scope and form of project documentation, technical specifications of execution and acceptance of works and the functional and utility program, hereinafter referred to as the Regulation of 2 September 2004);
- a bill of quantities constituting the basis for developing an investor's cost estimate (the Regulation of the Minister of Infrastructure of 18 May 2004;



Journal of Laws of 2004. No. 130, item. 1389 on determining methods and bases for preparation of an investment cost estimate, calculating planned costs of design works and planned costs of construction works specified in the functional and utility program, hereinafter referred to as the Regulation of 18 May 2004).

Apart from public procurement the definition and principles of preparing bills of quantities are defined by the so-called environmental methods included e.g. in the Polish Cost Estimating Standards [5], the application of which is optional. There are no legal regulations covering the preparation of BOQ in contracts of the private sector.

1. DEFINITIONS AND FUNCTIONS OF BOQ

A bill of quantities as part of project documentation (according to the Regulation of 2 September 2004) [3] should include a statement of projected fundamental works in the order of their technological performance together with their detailed description or indication of the basis for detailed description development, and indication of relevant technical specifications for execution and acceptance of construction works, with the calculation and the summary of the number of BOQ units of basic works.

While a bill of quantities as part of an investor's cost estimate (in accordance with the Regulation of 18 May 2004) [4] is an itemized list of works to be implemented in the order of their technological performance, together with their detailed description, the place of performance or the grounds for detailed description development, with the calculation and statement of units of measurement of basic works and the indication of the grounds for pricing of individual works or individual physical inputs.

As follows from the above definitions, differences in prepared studies come down to provide the basis for calculating the unit price for a bill of quantity as the basis of an investment cost estimate or a number of technical specification and a standard code for BOQ as part of project documentation. In the assessment of the authors the provision on the use of a standard code, that is the acceptance of construction work taxonomy in BOQ, deserves particular attention. In Poland, a universally applicable classification of construction works has not been developed yet (such classifications have functioned successfully in other countries for many years) [10], which requires the use of individually adopted classifications of works. In practice it is usually prepared each time by a cost estimator and serves no other purpose in addition to complying with the requirements of the Regulation of 2 September 2004 [3]. The absence of a link between a classification used in BOQ and technical documentation, technical specifications and cost estimates puts the purpose of its application in the current form into serious doubt.

In addition, both presented definitions of a bill of quantities contain the formulated requirement for the statement of works to be carried out in the technological sequence of their execution. This provision is in practice often overlooked. While taking off, the systems are adopted, where BOQ positions are grouped in accordance with the same types of work (e.g. earth, masonry and reinforcement works) or buildings or



parts of buildings (e.g. floors). Situations when a bill of quantities has no discernible order are also common.

According to the Polish Standards of Cost Estimating of Construction Works [5] a bill of quantities is defined as a summary prepared before execution of a contract, containing works to be performed in technological order, their detailed description or an indication of the basis for a detailed description thereof, an indication of relevant technical specifications of performance and acceptance of work (the obligatory requirement in public procurement), with the calculation and statement of the amount of work provided in fixed BOQ units. The definition has been referred to with the aim to regulate the issue of a bill of quantities in the field of cost estimating (sometimes called the general system) beyond public procurement.

Differences related to a bill of quantities depending on the accepted definitions are summarized in Table 1.

Table 1. Differences related to the purpose, the basis, the obligation to prepare and law regulations for BOQ

	Bill of quantities as part of project documentation	Bill of quantities as the basis for the development of the investment cost estimate	Bill of quantities according to the Polish Cost Estimating Standards
Purpose of development	– determination of the material and quantitative scope of works for the description of a subject-matter of a public procurement contract for construction works.	– determination of the material and quantitative scope of works for the establishment of the value of a public procurement contract for construction works.	– determination of the material and quantitative scope of works for the cost calculation of construction works.
Basis for development	– technical documentation of a building structure; – Technical Specifications for Work Accomplishment and Acceptance (<i>Polish abbrev. STWiORB</i>); – BOQ principles described in STWiORB or sources indicated in STWiORB where these principles are described.		– technical documentation of a building structure; – BOQ principles applied on a voluntary basis.
Obligation to prepare the development and law regulations	– obligatory in public procurement; – rules for preparation regulated by law; – in special cases the rules of using BOQ by contractors as the basis for preparing a tender for a public contract for construction works are governed by the provisions of the Important Order Specifications.		– not obligatory beyond public procurement, – beyond public procurement the rules of using the BOQ (alternatively rules for preparation) for tendering purposes or settling accounts specified in the contract for construction works.

Source: Own study



2. PRINCIPLES FOR BOQ

The principles of performing BOQ applied in Poland (here understood as the rules for calculating the amount of work on the basis of project documentation) are not unified and coherent.

In public contracts for construction works those rules should be formulated in the Technical Specifications for Work Accomplishment and Acceptance (*Polish abbrev. STWiORB*) in section 7 (the issue of technical specifications is regulated by the Regulation of 2 September 2004 [3]). A common situation is a laconic record in STWiORB relating only to the units of measurement in which the amount of work must be calculated. Another frequently encountered practice is reference to the detailed BOQ principles contained in catalogs, which summarizes standard of physical inputs.

Apart from public procurements the rules adopted in these catalogs are commonly used.

The inconsistency in BOQ principles manifests itself most often in the case of the analysis of different catalogs, which summarize standards of physical inputs for the same work. The differences may relate to both BOQ units as well as detailed methods for calculating the amount of these units. Examples include provisions concerning BOQ of masonry works in the Ytong or Porotherm technologies in KNNR 2 and respectively KNR 16 and KNR 27 catalogs, where the BOQ unit is either m^2 or m^3 .

3. TEMPORARY AND ACCOMPANYING WORKS

According to the Regulation of 18 May 2004 [4] a bill of quantities is a development summarizing works to be carried out (...) with the calculation and statement of the amount of units of measurement of basic works, that is the minimum scope of works which when performed are possible to be accepted in terms of quantitative and quality requirements and take into account the adopted level of aggregation of works. It follows from the above that in a bill of quantities constituting part of an investor's cost estimate should recognize only basic works. Additionally, the need for taking the adopted degree of aggregation of works into account might suggest the necessity of including temporary works in the price for basic work. Hence, it allows the interpretation that BOQ should cover only basic works, shifting the task of accounting for temporary works only in the price for basic elements execution.

In contrast, in accordance with the Regulation of 2 September 2004 [3] a bill of quantities is a summary of basic works to be carried out (...) with a calculation and statement of units of measurement of basic works. Under § 9 point 1 BOQ Tables must contain BOQ items corresponding to basic works. In § 9 point 2 reads that BOQ Tables do not take into account temporary works, which are designed and performed as required to perform basic works, but they are not forwarded to a contracting authority and are removed after basic works are completed, with the exception of cases when there are reasonable grounds for accounting them separately. Hence, when treating a bill of quantities as part of project documentation posing the basis for tenders for building contractors only basic works should (but do not have to) be summarized in BOQ. Temporary works can be recognized in a bill of quantities in the event of reasonable grounds. However, the Regulation does not specify the grounds, thus it may be as-



sumed that these are temporary works which significantly affect the cost of an investment (although it is also open to debate). The Regulation does not mention accompanying works, so they are excluded from BOQ statements. The problem, however, is the lack of publications or lists of works that can be regarded as temporary and accompanying works [2].

4. METHODS OF BOQ PERFORMANCE

4.1. TRADITIONAL BOQ – BASED ON PRINTED DOCUMENTATION

The traditional method is based on the manual calculation of BOQ amounts according to the principles enshrined in the Catalogues of Physical Inputs. An estimator reads all necessary dimensions from design drawings. Dimensions can be written on a sheet of paper and BOQ calculations may be made on a sheet of paper using a calculator figure 2 or entered into a cost estimate program and calculated by the program figure 3.

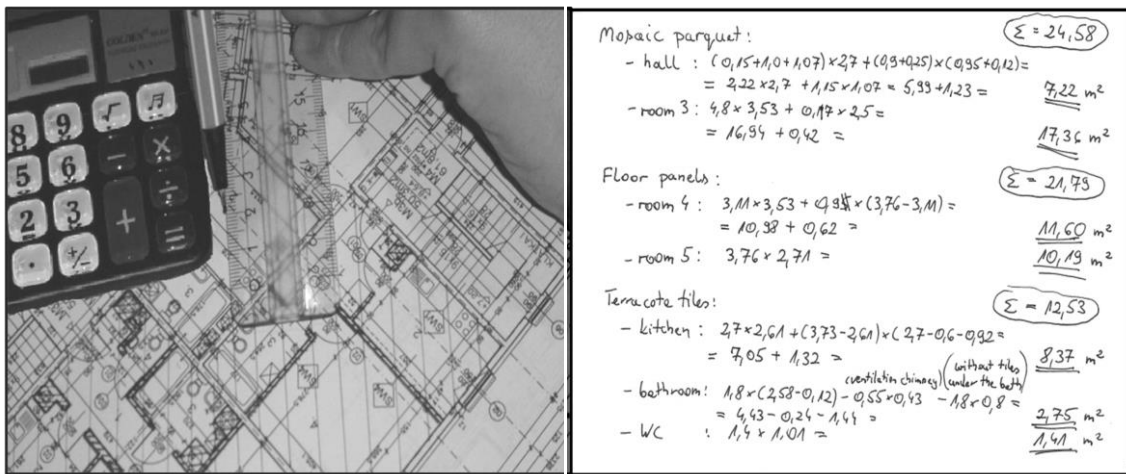


Fig.2. The manual bill of quantities based on paper documentation

Source: Own study

Nr	Podstawa	Opis robót	J.m.	Ilość	Info
	Kosztorys	Cost Estimation			
1	Rozdział	Finishing			
1.1	Element	Floors			
1.1.1	KONR BC 2/416/7	Self leveling floor screed Soloplan 30, screed thickness - 20 mm, ground smooth, cement	m2	Σ 58,91	
1.1.2	KONR 2/1205/6	Mosaic parquet	m2	Σ 24,59	
1.1.3	KONR 2/1205/9	Floor panels	m2	Σ 21,79	
1.1.4	NNRINB 202/1118/10	Floor 1- and 2-color with terracotta tiles on adhesive mortar "Atlas", plates 30x30 cm	m2	Σ 12,53	
				543,16	
Obiekt	Opis	Obliczenia	Zmienna	Część	Ilość
Room 4		$(3,11 \times 3,53) + 0,95 \times (3,76 - 3,11)$			11,595800
Room 5		$3,76 \times 2,71$			10,189600

Fig.2. The view of calculations in the cost estimate program ZUZIA 11

Source: Own study



The analysis of the current method of a bill of quantities calculation points to the following types of errors associated with manual calculation and compilation of units of measurement of basic works:

- errors in the graphic designs (projections, sections);
- errors in reading or copying dimensions from drawings, errors in calculating missing dimensions;
- omission or multiple inclusion of certain items in drawings;
- calculation errors;
- too many elements included in a drawing, which hampers the estimator’s work.

4.2. DIGITAL BOQ - BASED ON 2D DIGITAL DOCUMENTATION

Using electronic documentation may effectively eliminate a considerable proportion of errors. The graphical environment that produces the documentation becomes the medium of information necessary for BOQ performance and at the same time the natural environment for cost estimators who not only read electronic documentation, but often make additional elements of drawings by themselves (e.g. while performing a bill of quantities of earthworks).

The basis for the work are drawings in*. DWG format, which is the most popular one for drawings that make up design documentation. Selecting any area automatically calculates the floor surface and assigns a bill of quantities to the appropriate layer. Furthermore, the program calculates lengths, surfaces and volumes of elements. There are also other options such as counting components of bills of quantities of network works, computing roof surfaces of a given slope.

Figure 4 shows the calculated BOQ of flooring surfaces for a sample apartment. The “Bill of quantities” tab together with descriptions and calculations can then be imported into any cost-estimating program.

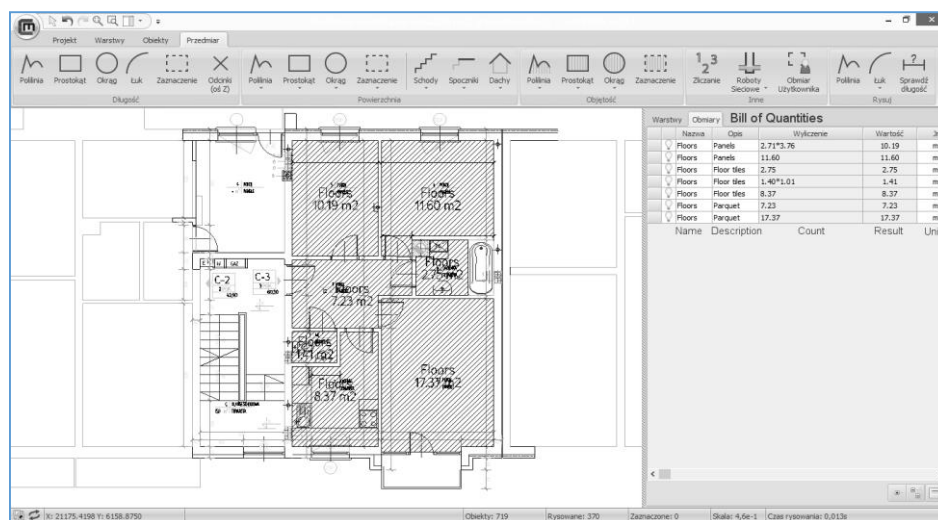


Fig. 4. The BOQ of a floor surface calculated in the program METRICAD

Source: Own study

4.3. BIM-BASED BILL OF QUANTITIES

Applications allowing for semi-automatic bill of quantities performance use the IFC (Industry Foundation Classes) format and transfer data to the cost estimate program. The IFC is the data model for saving a building model that file storage formats are based on, which, in turn, can be used in a variety of BIM-class programs, regardless of a producer. This term was created by the NIBS Association (National Institute of Building Sciences) and provides a common data scheme enabling the exchange of programs between different BIM-class programs. It contains information covering many disciplines that make up a complete picture of an investment process: from an idea, through design, construction and operation to the renovation or demolition.

The IFC model contains the following information:

- a building hierarchy (a phase, a stage, e.g. a floor);
- a type of an element (walls, slabs, columns, beams, stairs, etc.);
- geometry (dimensions, the coordinates of an element, volume);
- a relation between individual elements;
- standard and non-standard characteristics assigned to elements (material, color, sections, fire protection, weight, etc.).

Thus, the IFC allows not only for the exchange of information between the software, for example for planning and cost estimating of construction works, but also automating BOQ calculations by automatic export of data from CAD programs [11]. Figure 5 shows an example of information carried in the IFC file.

Lp.	Nr	Ifc typ	Nazwa / opis	Wart.	Gr.
497	9816	IfcQuantityArea	GrossFootprintArea	0,152884	
498	666340	IfcWallType	błoczek z betonu komórkowego gr. 24 cm + izolacja styropian gr. 5 cm + cegła pełna gr. 12 cm, wykończenie wewnątrz: tynk i farba olejna biała, na zewnątrz: tynk cienkowarstwowy mineralny		
499	9840	IfcWallStandardCase	SCIANA ZEW		
500	5258	DC_MaterialNode	Tynk		0,01
501	5291	DC_MaterialNode	Cegła zwykła		0,12
502	5401	DC_MaterialNode	Styropian		0,05

Fig. 5. The IFC file fragment with the visible hierarchical structure

Source: Own study

In Poland, Zuzia BIM or Norma EXPERT applications are possible to apply for the valuation of costs on the basis of a bill of quantities read directly from a virtual model created in the IFC format. A model, which integrates architects', designers' and installers' results of the work, is the basis for estimating the amount of works, and then construction costs. The Zuzia BIM application consists of two parts: the Vision BIM application [1], [6], which allows for reading and visualizing a virtual building model and the appli-



cation, which enables classical cost estimating. The amount of work is calculated semi-automatically, i.e. a user indicates an item or group of items (figure 6) and the calculated amount of works are automatically put in the Zuzia 11 BIM program in the right place describing the set scope of works (figure 6).

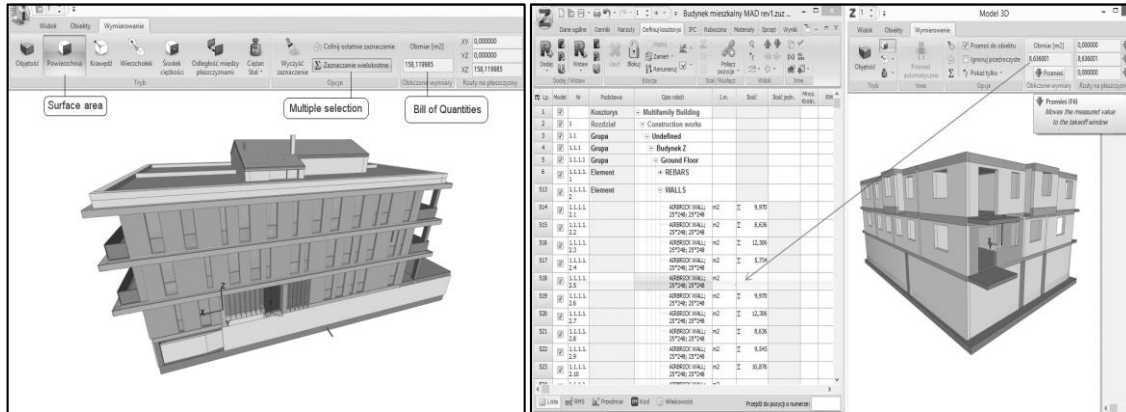


Fig. 6. The calculation of the surface of external walls of the front elevation (left) and the transfer of the calculated amount of works into the cost estimating program (right)

Source: Own study

CONCLUSION

BOQ is part of project documentation, but it plays a supporting role and is designed to enable a valuation of costs. Requirements for a bill of quantities as part of project documentation and a bill of quantities as the basis for an investor's cost estimate allow not only differences in the way of describing the BOQ basis and consequently costing, but also in terms of the material scope taken into account in those documents.

In the authors' opinion there is a need to link a bill of quantities with cost estimate and other documentation of work so the taxonomy of works must be developed or the scheme existing in the world adopted in Poland. It is also necessary to develop uniform BOQ principles, which estimators could directly use. A list of temporary and accompanying works seems to be required as well. Such terminology is applicable in BOQ definitions and technical specifications, however, it has not been clarified what kind of works they are. Hence, errors appear in bills of quantities, then in cost estimates created on the grounds of those BOQs and, as a result, problems with the settlement of such works appear.

It seems that a good practical solution would be if a contractor could contract specialized units independent from designers to perform bills of quantities. This would allow a contracting authority to obtain an objective evaluation of the completeness of a project. The Regulation of the Minister of Infrastructure of 2 September 2004 [3] regarding a bill of quantities as a component of project documentation prevents such a procedure. A contractor is allowed to verify projects and BOQs by himself / herself. Or an investor could employ independent companies to have such a verification (audit) carried out as suggested in [7].



As is clear from the signals from the Polish market, practitioners using computer aided BOQ based on 2D documentation in the electronic form (*.dwg or *.pdf formats – vector graphics) estimate that the time to prepare a bill of quantities can be shortened even twice compared to methods based on the traditional (printed) form of technical documentation. The signals coming from markets where the use of BIM has already been normal practice in the implementation of construction projects (e.g. Finland and Great Britain) indicate that the use of BIM reduces five or even six times the time needed to prepare a bill of quantities in relation to methods based on the traditional (printed) form of technical documentation. Currently the authors have been conducting research on the effectiveness of BOQ performed on the basis of the three approaches described in this article. The results of the research will be presented in the authors' subsequent publications.

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