BIM and Cost Estimation Issues (5D): Case of Armenia

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Abstract. Building Information Modelling (BIM) as widely expanding technology in the Architecture Engineering, Construction and Operations (AECO) Industry aims integrating all aspects of building life cycle from conceptual design to demolition and deconstruction. BIM provides possibility of automating time planning (4D), cost estimation (5D) before the construction commencement, and time, cost management during construction. Though BIM adoption and implementation in the Republic of Armenia (RA) AECO Industry is going slowly, there are some developments that prove RA Government interest in BIM adoption for enhancing Industry efficiency and transparency. The research was focused on cost estimation automation and BIM integration issues in Armenia. For this the construction cost estimation backgrounds of a number of countries as Belarus, Italy, Kazakhstan, Kyrgyzstan, Russian Federation (RF) and USA were studied along with the practices of integration it with BIM technology. The results of the study were compared with the situation of cost estimation practices in the RA. The study reveals that for BIM technology and cost estimation incorporation, there are various barriers as local building codes, regulations, specifics of construction technologies, and common requirement of uniqueness for each erected building. As conclusion the author proposes further standardization of the Industry by developing construction elements’ reference books and databases for joint usage by designers, architects, building engineers and cost estimators for safeguarding future management of the quantity takeoff information.

1. Introduction
Cost estimation is an important function of construction management that requires specific professional skills and knowledge. The cost engineer or estimator is required to have essential knowledge about structures, building engineering and construction technology. Incomplete or incorrect estimates can lead to budget and time runoffs and to failure of a construction project. A comprehensive construction estimate sums up building materials, workforces and equipment for all units of construction works.

At each phase of construction project a corresponding method of cost estimation with varying degree of accuracy is being used to plan project investment budget and to control costs. The main cost estimating methods are:

- Construction cost estimation based on historical data of analogue existing buildings;
- Detailed cost estimate prepared after the completion of design phase;
  - Detailed cost estimates using unit cost method based on normative and/or indices methods;
  - Detailed cost estimates using resource-based unit cost method;
- Actual costs received as a result of completed construction.
Each of these approaches has its area of application depending on the phase of construction and purpose of received data execution. Broad or analogue cost estimates are usually being used for the preliminary cost estimation at the conceptual planning phase, for making financial feasibility studies, for decision making on project economics and project plan development.

Detailed cost estimates based of building codes and norms are generally being used for public construction cost estimation from community, state or municipal budgets. This is a responsible, time consuming job requiring qualified specialist skills. The detailed cost estimates based on market prices are mainly being used for cost estimation of private construction projects. This is also time consuming process that requires knowledge of market prices on construction materials, labor rates and costs of renting or purchasing equipment.

Actual costs received as a result of completed construction are usually used for comparison with estimated costs, cost control and other decision making purposes.

Building Information Modeling as widely expanding technology in the Architecture Engineering, Construction and Operations (AECO) Industry aims integrating all aspects of building life cycle from conceptual design to demolition and deconstruction. BIM provides possibility of automating time planning (4D) and cost estimation (5D) before the construction commencement, and time, cost management during construction. However, despite of ongoing wide discussions of the topic, the actual practice of BIM integrated cost estimation and management is falling behind [1, 2]. Furthermore, another important issue as building maintenance cost estimation and cost management during building lifetime is not being frequently discussed [3, 4].

Though BIM implementation in Republic of Armenia (RA) AECO Industry is going slowly, there are some developments that indicate RA Civil Engineering Council interest in BIM adoption for enhancing construction work efficiency and transparency. Cost estimation as integral part of any construction project needs automatizing by joining both: (1) functional possibilities provided by BIM technology, like quantity takeoffs and (2) established cost estimation techniques.

2. Review of construction cost estimation practices

In recent years the issue of construction cost estimation and management incorporation into BIM practices were intensively being discussed in scientific conferences and publications, practical workshops. The construction cost estimation backgrounds of Belarus, Italy, Kazakhstan, Kyrgyzstan, Russian Federation (RF) and USA were studied along with their practices to incorporate it with BIM technology. The purpose of the research was analysis and comparison with the situation of cost estimation practices in RA.

Armenia as a former soviet state is still using construction cost estimation norms and regulations developed during soviet time as SNiP¹ along with developed composite indices for cost adjustments to now days. So far, the practice is proved untimely as it fails to embrace technological changes and has inconsistencies with market prices. This practice is very similar to the one used in other previous soviet states like Belarus, Kazakhstan and Kyrgyzstan where together with the traditional SNiPs new developments of cost calculation norms GESN² are being used. The latest is a RF development therefor we first discuss the system of construction norms and building codes at RF. GESN books are updated version of the above mentioned historical norms modernized with contemporary materials and technologies. The name GESN comes from abbreviation in Russian (Государственных Элементных Сметных Норм). In English it will be State Elementary Estimation Norms, which is a collection of books of building codes merged by type of construction works [5]. They provide detailed technical data computation resources for the construction work, with a variety coefficients adjusting weather

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¹ Строительные нормы и правила (СНиП), Construction norms and regulations, Building Codes

² State Elementary Estimation Norms
conditions, elevation above sea level and different other settings. On the basis of GESN, the Federal Unit Rates (FUR), and the Territorial (Regional) Unit Rates (TUR) were formed as directories and reference books for normative prices. These directories present material, labor and equipment rates on the basis of specific base date: as of January 1, 2001, and are the normative basis for the cost estimation system for construction projects within the territory of RF.

The FUR book is used in regions of RF in which the TUR books are not developed [6]. TUR territorial collection of prices include local construction prices in a specific administrative area.

The Moscow municipality has developed the МТСН-98 and ТСН-2001 standards to determine the cost of construction in Moscow [7]. These databases are adapted to conduct management of urban economy, as in addition to building norms, they also contain other codes also as: norms for the city’s holiday decoration, urban equipment maintenance norms, etc. (see Table).

The BIM expansion urges developing platform for merging construction cost estimation and cost management issues with building information models. Armenia, Belarus, Kyrgyzstan and Kazakhstan along with other Commonwealth of Independent States (CIS) have very similar AECO industry building codes ensured by a system of normative documents on construction norms and regulations, operation flow charts and construction pricing regulations. There are several developments of RF software companies that aim to meet the needs.

Table 1. List of building codes and normative documents in RF

| Name of the Building Code/ Norm                  | Reference Dates | Abbreviation in English / in Russian |
|-------------------------------------------------|-----------------|-------------------------------------|
| State Elementary Estimation Norms               | 2001            | GESN / ГЭСН                          |
| Federal Unit Rates                              | 2001            | FUR / ФЕР                           |
| Territorial (Regional) Unit Rates               | 2001            | TUR / ТЕР                           |
| Territorial Estimation Norms of Moscow City    | 1998, 2001, 2008| TENMC / МТЧ, ТЧ                      |

The study of international experience indicates that in countries with post-soviet experience such as Lithuania, Latvia, Russia, Ukraine, Belarus, Kazakhstan BIM technologies have difficulties in applying with cost estimation local practices. Urged by integration processes the issue of incorporation of BIM possibilities with traditionally developed cost estimation practice is actively being discussed within the above-mentioned countries’ governmental agencies and at intergovernmental meetings, workshops with the aim of development and adoption of commonly acceptable new platform for cost estimation.

Cost estimation procedures used in Italy are a set of instructions for construction technology requirements. It includes detailed descriptions of work and construction production methods, specifications of materials, equipment and auxiliaries.

In North America, in the USA and Canada, is widely used the RSMeans [8] construction cost books along with other sources. RSMeans is widely being used in the public, municipal, as well as private construction sectors and is one of the leading reference books for construction prices in the North America. The databases presented in the books are being updated every year, with new materials and

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3 List of operational standards and normative documents of RF are presented in a number of websites as:
http://smetnoe.ru/smeta_v_bazah, http://xn--d1ab4b4b4ievn.xn–p1ai/sostavlenie_smetnoj_dokumentacii.html,
http://www.smeta-moscow.ru/podrobnoe-opisanie-uslug/smetry-v-fer-ter-gesn
jobs, and published in both paper and cloud based electronic versions. RSMeans also provide developed indices for cost adjustments to different years’ prices and to specific markets.

Other popular cost estimation guides and reference books are BNI books, Marshall and Swift databases, Historical Cost Analysis Generator (HAG). U.S. General Services Administration (GSA) is using General Construction Cost Review Guide (GCCRG) to perform preliminary estimates of large construction projects. It is a benchmarking reference book. The above mentioned HAG is used to collect historical costs on military construction projects. Besides the above mentioned databases, there are additional software tools as MCACES Microcomputer-Aided Cost Engineering System, SUCCESS Estimator\(^4\) that is an integrated estimating and cost management program [9].

3. Case of Armenia and Proposed Model for Design and Database Interconnection Using BIM Technology

The construction cost estimation framework needs upgrading in RA. Moreover it has to be designed in a way that facilitates 5D acquisition from building information models. The construction industry in Armenia mainly uses GESN code which is a collection of 49 normative books classified by category of construction work [5]. For application in Armenia, these standards need to be adapted to local conditions, as some traditional construction works practiced in Armenia are not included in these standards, while number of standards include construction works that are rarely or never used in Armenia.

The picture is different in commercial construction projects. The normative basis here is mainly determined by the agreement and choice of the client and contractor. In some cases normative calculations are not being applied at all. However, in recent years, large and medium size construction projects have the tendency to apply norms, as it ensures objectivity of calculations and the efficiency of financial flow management.

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\(^4\) SUCCESS Estimator is a software program developed by US COST
Figure 1. Proposed Model for Design and Database Interconnection Using BIM Technology

Currently the construction cost estimation in the RA is being conducted through semi-automated exercise by qualified professionals who make quantity takeoffs from 2D or in some cases 3D documents into digital spreadsheets. BIM technologies ease cost estimation process by automation of quantity takeoffs. The application of this function by Revit has been tested in a pilot project by the National University of Architecture and Construction of Armenia (NUACA). The study was made on a medium size warehouse building information model developed at NUACA. The results of the study elevated the following outcomes:

First - for applicability of the results of quality takeoff from digital model for cost estimation purposes is necessary to use standardized elements during design phase with detailed specifications.

Second - it is necessary to create dictionaries and reference e-books for elements and materials for general use by architects, structural engineers and cost estimators.

Third - additional software tools are needed to increase the degree of automation of the cost estimation process in construction.

The level of elements’ presentation detail in the BIM project is significant issue. The BIM implementers should develop criteria for the presentation of construction elements (objects, classes, nodes) for the level of detail clarification. Elements can be represented by generic names or by detailed specifications. The optimal level of detail for facilitating cost estimation processes is a matter of research. At cost estimation phase, information about elements could be obtained in a variety of ways: by extending the object definitions to the model or by creating an external, more detailed database outside the BIM domain supported by special software tools.

Besides the material received from quantity takeoff, labor and equipment are also needed for cost estimation. Here we have to deal with the specifics of construction technologies. The BIM technologies eases quantity takeoffs, but the possibility of automating construction technologies management is not yet available.

Possible ways of solving problems in the field under study are outlined, in a logic scheme presented in Figure, which shows the interconnection of the required databases and construction information modeling system. For partial representation of these problems, we propose the composition of the databases and their interconnection with the design process as shown in the Figure. Modernization of cost estimation practices is inevitable. It is dictated by international integration processes, general digitization of the economy and development of project management technologies.

Expanding international cooperation in the field of construction design and implementation, dictates a certain universality of design elements as well as a normative base structures and coding. This is difficult but solvable problem.

Summary

The results of the study were compared with the situation of cost estimation practices in the RA. The study reveals that for BIM technology and cost estimation incorporation, there are various barriers as local building codes, regulations, specifics of construction technologies, and common requirement of uniqueness for each erected building. The study made clear that for BIM technology implementation has to be standardized starting from design phase. Further standardization of the Industry by developing construction elements’ reference books and databases for joint usage by designers, architects, building engineers and cost estimators is crucial for safeguarding management of the quantity takeoff information.

Having in mind from one side the expanding internalization processes in the industry and from the other- the statement, that each building is unique, we have to remain on the standardization path while ensuring optimal detail level of elements and coding. Construction technology automation process is
connected to the in State regulations and construction technology specifics, which needs additional studies.

References
[1] Stanislav Vitasek, Josef Zak 2018 Cost estimating and building information modelling (BIM) in road construction (Proceedings of the Creative Construction Conference) pp. 403-410. DOI 10.3311/CCC2018-053
[2] Shen Z, Issa R R A 2010 Quantitative evaluation of the BIM-assisted construction detailed cost estimates (Journal of Information Technology in Construction) (ITcon) 15 234–257.
[3] Matejka P, Kosina V, Tomek A, Tomek R, Berka V & Sulc 2016 The Integration of BIM in Later Project Life Cycle Phases in Unprepared Environment from FM Perspective (Paper presented at the Procedia Engineering) 164 550-557. 10.1016/j.proeng.2016.11.657.
[4] Bouska R, Heralova R 2017 Opportunities for use of Advanced Visualization Techniques for Project Coordination (Paper presented at the Procedia Engineering) 196 1051-1056. 10.1016/j.proeng.2017.08.061
[5] Information on http://www.norm-load.ru/SNiP/Data1/55/55931/index.htm
[6] Lectures on FUR and TUR reference books, https://media.ls.urfu.ru/Projects/279/uploaded/files/52257_%D0%9B%D0%B5%D0%BA%D1%86%D0%B8%D1%8F%20(%D0%A4%D0%95%D0%A0%20%D0%82%D0%A2%D0%95%D0%A0).pdf
[7] Information on https://www.mos.ru/mke/function/tenoobrazovanie/baza-smetnykh-normativov- tsn-2001/
[8] RSMEANS, 2019, https://www.rsmeans.com
[9] Scott W, Cullen 2016 Estimating (Whole Building Design Guide) https://www.wbdg.org/resources/estimating

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