Applications of Building Information Modeling in Cost Estimation of Infrastructure Bridges

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ABSTRACT

Bridge Information Modeling (BrIM) is considered an innovation in bridge engineering and construction industry. This paper presents a methodology for using BrIM as an assisting tool in performing detailed cost estimates. The methodology depends on integrating visualization feature of BrIM with specific attributes of the BrIM model intelligent components. A program developed using C# language is used to extract the visualization conclusions and other components’ attributes to MS Excel spreadsheet. This sheet assists in performing detailed cost estimate, and reviewing the estimate. The paper also presents a methodology for generating cash flow and required payments. This methodology depends on integrating the developed program with 4D feature of BrIM.

Keywords: Bridge Construction, Bridge Information Modeling (BrIM), Cash Flow, Cost Estimating, Visualization

1. INTRODUCTION

Cost Estimation can be defined as a predictive process used to quantify, cost, and price the resources required by the scope of an asset investment option, activity, or project (Dysert, 2008). This task must be performed accurately to achieve the defined goals based on the estimation entity. For owners, they perform estimations to make sure that the cost doesn’t exceed the defined budget, and to assess the feasibility of executing the project. For designers, costs of different design alternatives must be estimated to obtain the most economical alternative. For contractors, cost estimation must be done taking into account two main factors which are: winning the bid, and obtaining the required profit. Cost estimation can be classified into two types which are: approximate cost estimation, and detailed cost estimation. Approximate cost estimate can be done by obtaining the quantities and multiplying these quantities by their unit costs. These unit costs can be obtained from experts’ knowledge, available manuals,
or historical data. Detailed cost estimate is more accurate but it requires intensive work by estimators. It requires also visiting the site to determine any factors that may affect productivity. Detailed estimates can be done as the following steps: obtaining quantity takeoff lists; obtaining material costs; obtaining laborers’ costs; obtaining equipments’ costs; calculating overheads, taxes, bonds, and insurances; and adding contingency and profit. Different models were developed for bridge cost estimation in literature (Kim, 2011, Fragkakis et al., 2011; Fragkakis et al., 2010; Kim et al., 2009; Sirca & Adeli, 2005; Morcous et al., 2001; Skamris & Flyvbjerg, 1997).

Building Information Modeling (BIM) is the development and use of a computer software model to simulate the construction and operation of a facility (AGC, 2006). The resulting model, a Building Information Model, is a data-rich, intelligent, and parametric digital representation of the facility, from which data appropriate to various users’ needs can be extracted and analyzed to generate information to make decisions and improve the process of facility delivery. BIM is a building industry development that represents a shift from electronic drafting to a model-based process. The main concern of BIM is the development of an integrated model that can be used in all stages of a project’s life cycle. A BIM model has many uses, including the following: it can be connected to time schedules, be used to generate accurate shop drawings, perform quantity surveys and cost estimates, and be used in facility management. BIM has many benefits that assist the project participants during the project’s life cycle. A number of benefits, as presented by ASHARE (2010), are: Parametric modeling, which is an important feature of BIM that enables objects and components within a model to be parametrically related; Time saving and cost reduction in all stages of the project; Automation of off-site fabrication; Enables better cost estimates and procurement management; and Assists in sustainable construction and climate protection. Coordinating construction sequencing by integrating schedule data with the 3D model creates the 4D aspect in BIM. The fifth dimension (5D) uses the 3D model data to quantify materials and apply cost information (McCuen, 2008). Applying BIM technology on bridges is named Bridge Information Modeling (BrIM).

Bridge Information Modeling (BrIM) has widely become an effective tool in bridges engineering and construction industry. BrIM is not just a geometrical representation of bridges, but it is an intelligent representation of bridges since it contains all information needed about bridges throughout their life cycle. Bridge Information Modeling (BrIM) has great effect on the improvements of the three main concerns of bridges stakeholders which are quality, schedule, and cost and it is needed for bridges since it creates consistency in information in different phases from design to maintenance (Marzouk et al., 2010). The 3D bridge model can be used for: Up-to-date shop drawings; Quantity takeoffs and bills of materials; CNC (computer – numerically – controlled) input files to drive automated shop equipment such as robotic welders or beam-line hole – punching machines for steel members, splice plates, etc.; Fabrication labor and material estimating and shop material management, etc. (Chen & Shirole, 2007). Marzouk and Hisham (2011a) utilized BrIM with the main components of bridge management systems in order to obtain efficient decisions related to maintenance and rehabilitation. Marzouk and Hisham (2011b) integrated BrIM with Genetic Algorithms to optimize the locations of mobile cranes during the construction phase of bridges, taking into consideration existing conditions of site, surrounding areas, safety, and schedule constraints.

2. USING BIM IN COST ESTIMATION

During cost estimating process, estimators typically begin by doing manual takeoffs from their drawings. This method increases the chance of human error and follows any inaccuracies there may be in the original drawings. The time spent by the estimator on quantification
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