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Empirical Analysis of Man-hour Data to Support a Cost-Plus Pricing Approach for Estimating BIM Service Costs

Bonsang Koo[1], Ghang Lee[2], Chung-woon Kim[3] and Byungjin Shin[4]

Abstract: Building Information Modeling (BIM) is a nascent technology in Korea, and currently lacks formal guidelines to assist Architectural and Engineering (AE) firms in estimating BIM service fees, while also allowing government agencies to allocate budgets for the rendered BIM services. This research provides a method to estimate costs for BIM services based on the cost-plus pricing framework. The approach requires a generalized estimate of the man hour per floor area data to calculate the direct labor costs. Man-hour data were collected from forty five projects that have implemented BIM. Interpolation of the man-hours was performed to develop a general reference table for 'Type 2' (i.e., public schools and office buildings, etc.) projects. By providing an objective approach for estimating the costs of BIM services, it allows clients and AE firms to agree upon a fair cost for BIM related services, and thus expedite its adoption in Korea.

Keywords: BIM, Cost Estimating, Cost-Plus, Man-hours

I. Introduction

Korea's Public Procurement Service (PPS), which is the sole agency for procuring government facilities, has increasingly mandated the use of BIM for the design and construction of public buildings. The agency has required projects worth 50 billion Korean won (KRW) to use BIM by 2015, and this requirement is to be extended to all public custom-service projects by 2016 [1]. However, a recent survey by the Korea Institute of Registered Architects (KIRA) showed that 75% of all architectural firms do not have experience in using BIM in their design process [2]. Furthermore, the survey revealed the need for a transparent and fair method to be reimbursed for the additional costs that would incur by providing BIM models in addition to the standard drawings and specifications.

Currently there is an absence of a formal approach to estimate the costs for BIM services provided, and thus cost are estimated and contracted on a project basis, making them ad hoc and inconsistent.

In this research, we developed a method to estimate costs for BIM services using a cost-plus approach. The approach requires a generalized estimate of the man-hour per floor area data to calculate the direct labor costs, and a breakdown of the different types of BIM services performed in the design phases of projects.

II. Research Background

A. Design Cost Estimation Schemes in Korea

There are two main schemes for estimating design costs in Korea: the 'construction cost percentage (CCP)' method, and the 'cost-plus' pricing method [3]. The CCP method is a form of lump sum pricing, in which a maximum fixed price is calculated as a percentage of the total estimated construction cost. The percentage increases in proportion to the construction cost, the type of facility (e.g., a stadium (Type 1) versus a school building (Type 2)), and the level of detail required for the drawings and specifications. The percentages are provided in a form of a reference table.

The cost-plus approach uses man-hour data and engineer's unit costs to calculate the total direct labor costs for design services rendered. Indirect costs (e.g., fixed costs and expenses) are subsequently added as a percentage of the direct labor cost.

Most design costs in the public building sector have been estimated using the CCP method. Currently, there is no published man-hour data by any government authority that can be used to calculate design costs using the cost-plus approach in South Korea.

B. Examples of established Cost-plus approaches

In contrast, man-hour data for engineering services is available for the civil engineering domain in South Korea. In 2013, the Ministry of Land, Infrastructure and Transportation published the 'Civil Engineering Cost-Plus Standards Guidelines' [4]. The guideline provides detailed man-hour data for different infrastructure types, such as roads, bridges and tunnels. Japan provides a cost-plus approach for design cost estimation of its public buildings. The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan publishes man-hour data for different types of buildings and also provides a simplified format to perform quick estimates [5]. Both approaches are possible as they provide man-hour standards for AE firms to use in calculating their labor cost estimates.

Such implementations have spurred research in the architectural domain in South Korea. Most recently, the Architectural Policy Association of Korea (APAK) published a white paper, which provides a good basis for formalizing the cost-plus approach for design services [6]. For mandatory or core services, they collected man-hour data using gross floor area in square meters as the basis

1 Associate Professor, Dept. of Civil Engineering, Seoul National University of Science and Technology, Seoul, Korea. bonsang@seoultech.ac.kr
2 Associate Professor, Director of the Building Informatics Group, Dept. of Architectural Engineering, Yonsei University, Seoul, Korea. glee@yonsei.ac.kr
3 Graduate Student, Dept. of Civil Engineering, Seoul National University of Science and Technology, Seoul, Korea. thekopion@gmail.com
4 Graduate Student, Dept. of Civil Engineering, Seoul National University of Science and Technology, Seoul, Korea. byungjin0826@gmail.com

unit, and created a reference table of man-hours that increases proportionally to the total floor area. For non-core or supplementary services (e.g., code compliance check, renderings), they used the man-hour data to develop coefficients, which reflect the amount of additional man-hours required. The framework allows i) division between core to supplementary work, ii) distinguished man-hours based on different facility types iii) explicit breakdown of specific tasks. This approach was adopted in developing the cost-plus framework for our research.

III. Methodology

A. Database Overview

To develop a cost-plus approach for BIM services in the design phase, we collected cost relevant data from forty five projects that have employed BIM in South Korea, spanning from 2009 to 2014. The majority of the projects include office buildings (13) schools (10), and apartments (7), which are classified as Type 2 projects in Korea. The design costs range from 1.3 billion KRW to 11.3 billion KRW (1.1 million USD to 9.8 million USD), while the majority of the payment method is based on the lump sum contract.

B. Descriptive statistics

Basic statistical analyses revealed the percentage of BIM contracted price in relation to overall design service fee. The average is 2.1%, while the maximum and minimum percentages are 16.09% and 0.39%, respectively. A mapping of the percentage to total design cost showed that BIM contracted price decreases rapidly as the design fee increases, which in turn is proportional to increase in the size of the project (i.e., total floor area of the project). This shows that, at least in South Korea, that large projects do not result in a proportionally linear fee increase for the BIM services provided.

We also compared the actual contracted price to the amount to be received if a cost-plus approach had been adopted. The results revealed that the majority of the projects have been underpaid within the context of the analysis.

C. Interpolation of man-hours to total floor area

To develop a generalized man-hour table, we first mapped the man-hours to the total floor area of the projects, then interpolated the data using different functions (logarithmic, exponential, and polynomial) to find the best fit. The logarithmic function proved the best fit with the highest R-squared value. The function was then used to extrapolate the man-hours for equally scaled total floor areas as shown in Table I. This table provides the man-hours of Type 2 buildings for core BIM services for Type 2 facilities.

TABLE I
MAN-HOUR REFERENCE TABLE FOR TYPE 2 PROJECTS

Type 2		Total Floor Area (㎡)					
Design Phase		5,000	10,000	30,000	50,000	100,000	200,000
Man-hours	SD	109	218	655	1092	2,184	4,368
	DD	185	370	1,109	1,848	3,696	7,392
	CD	286	571	1,714	2,856	5,712	11,424

IV. Conclusion

With the increased adoption and mandate of BIM, AE firms have requested the need for a cost-plus approach to objectively estimate the additional costs incurred for providing BIM related services in the design phases of a project. The cost-plus framework requires man-hour data.

To develop the cost-plus framework, we collected man-hour data from forty five projects that have implemented BIM. Initial analysis of the data showed that BIM costs represented a small percentage of the design costs, with an average of 2.1%. Also, actual contracted prices were significantly lower than when calculated using a cost-plus estimate, reinforcing the need for a formalized framework. Interpolation of the man-hour data was performed to develop a reference table for Type 2 projects. Future work is required to develop a breakdown of the core and supplementary service involved in BIM provisions.

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