S12-5
A COST DATA-BASED ESTIMATING MODEL FOR FINISHES IN THE KOREAN PUBLIC OFFICE BUILDING PROJECTS

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ABSTRACT: Recently, public office building projects are being recognized by many construction engineers and researchers, as the critical projects in the construction industry. The project budgets have sometimes exceeded due to the lack of core knowledge, experiences, skills and experts concerned in cost planning and estimating in the pre-construction stage. It has been highlighted that planning and estimating effectively the cost of public office building projects as critical in the design stage. Within this context, some cost data books and systems, such as RSMeans cost data systems and Spon's price book, have been systematically developed and used by many construction cost managers and organizations in order to effectively estimate and use their project budgets. As a result of this research, a cost estimating model for finishes has been developed, considering the cost data used in public office building projects.

Keywords: Public office building, Cost data, Cost estimating model

1. INTRODUCTION

Cost control activity during design phases is one of the important factors in public office building projects that have strict limitation in the budget. Public office building projects require elaborate cost control in the pre-construction stages to achieve economical and effective use of capital. One of the main purposes of cost control is to keep the total expenditure, which is frequently based on the cost estimate prepared by the estimators, within the client's budget (Seeley, 1984).

However, upon completion of the project, the clients in the public sector have seen the final costs exceeding the estimates during the design phases. Low accuracy, of course, brings about changes between the estimate and the final cost. However, the most important reason of the cost overrun is based on the owner or designer's change orders in the design or the specification without considering cost checks.

When the cost overrun happens, the design or the specification should be changed frequently after the completion of the design. Such changes have been considered as an easy way to recover from economical losses and stay within the initial budget because the original budget is hardly ever increases for the public sector projects in Korea. If the design is near completion, design changes usually occur in the finishes.

There have been several researches (Lee and Kang, 1995; Choi et al., 1999;, Kim and Koo, 1999; Yoon and Kim, 2000; Hong and Choi, 2001; Park et al., 2003; Kim, 2003) that develop models to estimate costs in Korea. Most of them, however, focus on estimating methods at the end of certain design stages with fixed design information. These models are suitable for cost check and comparison of design alternatives of finishes.

This research study has two primary objectives. The first objective is to develop a cost data of finishes for public office buildings in the scheme design stage. The second objective is to suggest an improved cost model based on the cost data.

2. Cost Control in the Pre-construction Stages of Public Office Buildings in Korean

2.1 Process

There is no significant difference in the design process between the UK and Korea. The architectural procedure suggested by the Royal Institute of British Architects is illustrated in Figure 1. However, the cost control process between the two countries is very different.

The cost control process generally consists of several phases. These phases also consist of three phases. The first involves the establishment of a realistic first estimate to confirm the cost limit. The second phase examines how this estimate should be assigned among the various parts or elements of the building construction. The final phase checks to ensure that the actual design details of the various elements can be constructed within the cost plan.

Compared with the UK, quantitative surveying is not common in Korea. Although several quantity surveying firms have been established in Korea recently, quantity surveyors are hardly involved in public projects. Most of the work related to cost control is performed by government officials or design firms. In the feasibility stage, where no drawings are prepared, government officials play an important role in cost control. However, the officials rely on professional institutes for a feasibility study, which determines the cost limit according to the preliminary estimates. In public sector projects, once the preliminary estimates are set, the cost limit does not usually change during the design process.

In the early design stages (i.e. the sketch plan stage), the design firm takes a role in cost planning and checks as well as design. Design firms have their own cost estimating departments or they cooperate with professional estimating firms. If a construction management company is involved, it carries out early cost estimating tasks. The cost estimating method in the sketch plan stage is usually the superficial floor area method, which predicts the costs of the structure, finishing and ground works. Cost checks are also performed on a trade basis.

When work drawings have been completed, bills for quantities are drawn up and specified by cost professionals. There are two different styles of bills of quantities - the elemental BOQ and trade bills. Only the trade bills are used in Korea.

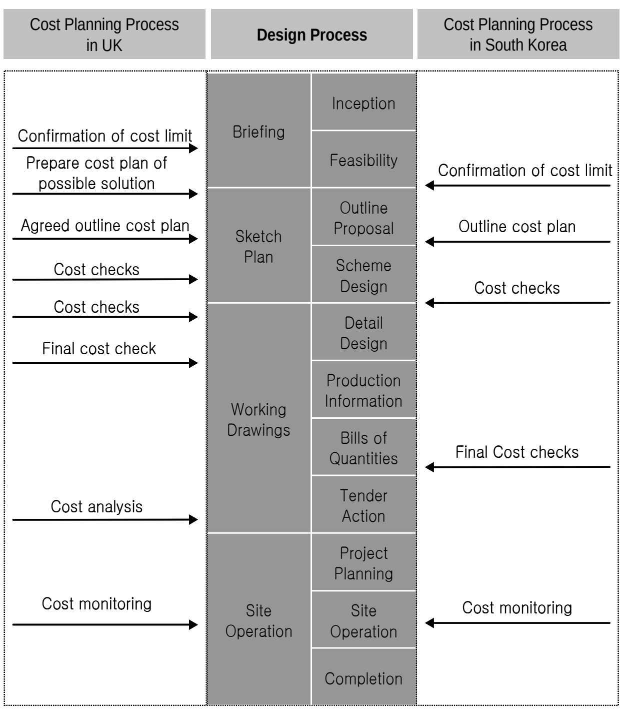


Figure 1. Comparison of Cost Planning Process

2.2 Problems

In Korea, government officials who are responsible for cost management in public office projects have repeatedly experienced the excess of cost estimates over the planned cost limit when the design is completed. The major reasons for this excess are the inaccuracy of early cost estimates and lack of continuous cost check processes during the design.

Government officials require a forecast of the final cost of the project. The cost limit is determined in the feasibility stage, where there is no design. This makes the cost limit difficult to change in the future if they want the final cost not to exceed the cost limit.

Throughout the construction industry, there have been additional difficulties in predicting costs due to the complexity and uncertainty of the type of work involved. To improve the accuracy of early cost estimates, the following three factors should be considered (Ashworth, 2004).

- An improvement in the quality of the designer's information, since a vague design can only result in an inaccurate estimate.
- A reappraisal of the methods currently used for estimating in an attempt to discover more accurately the determinants of construction costs.
- An identification of the qualities of the estimator, who contribute towards accurate estimation and consideration of how they might be improved.

In Korea, the superficial floor area method is mainly used for estimates in the early stages. In this method, the quality of the cost data obtained from previous projects is the most important factor in getting accurate estimates. Most cost data are accumulated by design firms, but very little research has been undertaken to establish a standardized cost data structure and methods of analysis. In addition to the quality of cost data, cost estimating methods needs to be improved. Cost estimates based on the cost per square meter of the gross floor area is far too subjective, since the variables of shape, height and quality will affect the choice of a rate.

Lack of expertise from the estimators in early cost estimating is another problem. Professional estimators are usually involved in bills of quantities. But in the early design stages, design firms are in charge with the task related to cost estimating. Unless the design firms have professional experts who are experienced in early cost estimation, the early estimates are likely to be inaccurate.

Cost checking during the design process is not repeated without the client's request. As a result, most cost checking is carried out too late. As a result, redesigns and re-estimates become more time-consuming and arduous.

Since the architect will design in elements, it is convenient to check the cost on an elemental basis. The results can then be compared with the cost targets in the agreed cost plan. However, in Korea, cost checks are carried on a trade basis. Trade-based cost checks make it difficult to make changes reflect during the design process. Elemental-based cost checks need to be considered in the cost checking process in Korea.

3. Cost Model

3.1 Definition and Types of Cost Modeling

Cost modeling is the symbolic representation of some observable system that exists or is proposed in terms of its significant cost; features for the purposes of display, analysis, comparison or control (Ashworth, 2004). Cost modeling, as a term, is used to refer both forecasting of construction costs for clients and estimating of resource costs for contractors.

Cost models are generally used to accurately represent the whole range of cost variables inherent in a building design to secure improved cost forecasts and/or design optimization (Seely, 1997). Deciding the purpose of a cost model will affect its form and the variables that can be incorporated within it.

There are many kinds of estimating methods that performed manually. In cost models, however, the computer can be used successfully in conjunction with any method described for the rapid retrieval of cost data, or for the calculation of an estimate using predetermined parameters.

There are two approaches for obtaining cost models (Ashworth, 2004). The first seeks to computerize the traditional estimating methods currently used in the construction industry. It has been argued that successful estimation requires a huge amount of data. This makes manual methods too cumbersome to handle. The second type of method adopts a radical approach to the problem of estimation by devising an entirely new method of price forecasting. These methods use the computer to manipulate the data, often with complex mathematical formulae. There is little practical evidence that these methods have been used, mainly because of their radical approach; the fear of the unknown, and the unfamiliar mathematics and techniques being used.

Fortune and Lees (1995) investigated various researches on the cost models and classified them under the headings in Table 1.

Table 1. Classification of cost models

Classification	Cost Models
Traditional Techniques	Judgment, Functional Unit, Cost per M2, Principal Item, Interpolation, Elemental Analysis, Significant Items, Approximate Quantities, Detailed Quantities.
Statistical Techniques	Regression Analysis, Time Series Models, Causal Cost Models.
Knowledge Based Systems	ELSIE Expert System
Life Cycle Costing Techniques	Net Present Value, Payback Method, Discounted Cash-flow.
Resource/Process Based Techniques	Resource Based, Process Based, Construction Cost
Risk Analysis Techniques	Monte Carlo Simulation

3.2 The Cost Model in this Research

The cost model in this research is based on the traditional technique of elemental analysis. As mentioned above, elemental-based cost checks are required in the cost checking process in Korea. This method allows the estimator or designer to quickly compare alternatives in various combinations within the design guidelines.

In Korea, professional cost estimators are in charge of cost estimating activities. However, their role on this task is limited when the design is almost finished. For this reason, the role of government officials and designers is more important during design stages. Although their decisions affect the final cost, they do not have enough experience to cost checking activities. To overcome these problems, the cost model needs to be computerized. Anyone, even those who lack expertise and experience on the cost estimating, can use it easily.

4. Cost Data

4.1 Importance and Characteristics of Cost Data

The collection, analysis and retrieval of cost and price information are very important in the cost model. At the root of cost forecasting and control activity we find the need for cost data to supplement the numbers, areas, volumes, etc. which have been used to describe the buildings. This data is critical in determining whether an estimate is reliable or not. (Ferry et al., 1999)

Cost data are required at various levels of sophistication in theory and practice of building economics. They are needed during the inception stage of the design process to provide clients with an indication of possible costs associated with a proposed construction project. They are also required at various levels of detail as the project proceeds through the design and construction stages (See Table 2).

Table 2. Cost Data through Design and Construction Stages (Ferry et al., 1999)

Design Stage	Traditional model type	Cost data
Brief /Sketch design	Unit	Cost/bed Cost/seat Cost/pupil Cost/space
Brief /Sketch design	Space	Cost/㎡ of gross floor area Cost/㎡ of functional area Cost/㎥ of building volume
Sketch design / Detailed design	Element	Cost of functional element expressed/㎡ of gross floor are
Sketch design / Detailed design	Features	Cost of grouped S.M.M. items (abbreviated quantities)
Detailed design / Working drawings	S.M.M items	Bill of quantities
Working drawings	Operations	Cost per network operation
Working drawings	Resources	Cost of labor, plant, material, supervision

* Design stage : Brief-Sketch design-Detailed design-Working drawings

Table 3. Published Cost Data

US[1]	**Design phase**	**Programming**	**Schematic Design(0%~30%)**	**Design Developmet(30%~90%)**	**Construction Document(90%~100%)**
	Estimating method	Rough-order-of-magnitude estimates	'Assemblies' Estimating	Preliminary Quantity take-off(QTO) & 'Assemblies' Estimating	Quantity take-off(QTO)
	Cost Data	Square Foot Costs	Assemblies Costs Systems Costs	Assemblies Costs Systems Costs	Unit Price
	Cost Classification	-	UniformatⅡ	MasterFormat UniformatⅡ	MasterFormat

UK[2]	**Design phase**	**Brief/Feasibility**	**Outline Proposals**	**Scheme Design**	**Detail Design**	**Production information /Bill of Quantities**
	Estimating method	Functional estimating, Size-related estimating	Group elemental outline cost plan	Detailed elemental cost plan	Checked cost plan	Completion of Bill of Quantities
	Cost Data	Costs per Functional Units, Costs per Square Meter	Elemental cost data	Detailed elemental cost data	Approximate quantities (SMM related)	Detailed quantities (SMM related)
	Cost Classification	-	RICS의 SFCA	RICS의 SFCA	SMM7	SMM7

AU[3]	**Design phase**	**Inception/Feasibility Stuties**	**Preliminary Sketch Plans**	**Final Sketch Plans**	**Detail Design**	**Contract Documentation**
	Estimating method	Approximate Cost Target or Budget	Preliminary Cost Plan	Budget Estimate and Cost Plan	Cost Control Continuing cost check	Final Bill of Quantities
	Cost Data	Building costs per Square meter	Elemental Costs	Separate Elemental Costs	Detailed Prices of work	Detailed Prices of work
	Cost Classification	-	Elemental Units of Measurement	Sub Elements	Australian SMM	Australian SMM

* Source : [1]*Assemblies Cost Data Building Construction Cost Data* published by RSMeans, [2]*Spon's Archtects' and Builders' Price Book* published by Taylor & Francis, [3]*Australian Construction Handbook* published by Rawlinsons

4.2 Published Cost Data

A traditional source of useful information is the prices books normally published annually by several well established organizations (Ferry et al., 1999) in the world. Because the data in the prices books reflect the conditions of the country where they were published, each has some differences. For comparison of these data, we select typical published cost data from the US, the UK and Australia as shown in Table 3. Each price book has several types of cost data, which is used for different purposes.

The types and structure of cost data in the published price books are similar to those in Table 3. Cost data during the early stages of the design process can be usefully related to function and design. During the later stages of the design process, cost is apparently more related to quantity and specification.

All the cost data in Table 3 is based on standardized cost classification and measurement. For example, in RSMeans, cost data in the early design stages is based on UNIFORMAT Ⅱ organization. Certain items that were formerly grouped into a single trade breakdown must be allocated among two or more elements. Elemental costs in the UK and AU have similar cost breakdown structure organized by the RICS (Royal Institute of Chartered Surveyors) and AIQS (Australian Institute of Quantity Surveyors).

4.3 Cost Data for Finishes

As shown in Table 0, cost data used in the scheme design stage is a detailed elemental cost which has sub-elements. For example, floor finishes have various sub-elements according to materials such as marbles or carpet. (See Table 4).

Table 4. Examples of cost data for floor finishes

Elements	Sub elements	Unit	Rate
Floor finishes	Surface finishes		
	Broomed	sqm	-
	Power float monolithic	sqm	-
	Steel trowel	sqm	-
	:		
	Marble		
	Wombeyan tiles, 450×300×10 ㎜	sqm	-
	Sililian pearl paving, 19 ㎜ thick	sqm	-
	:		
	Carpet		
	Nylon-Medium use	sqm	-
	Nylon-Heavy use	sqm	-
	Polypropylene, direct stick	sqm	-
	:		

* Source : *Australian Construction Handbook* published by Rawlinsons

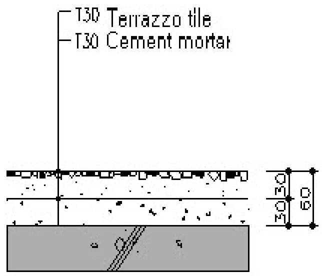
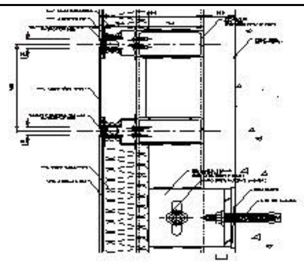
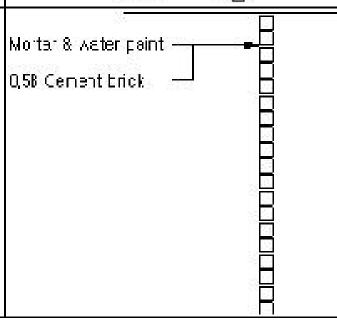
Class	STANDARD SECTION	CODE	COMPOSITE COST				SYSTEM COMPO_ NENTS	TYPE OR SIZE	Unit	QUANTITY PER S.F	SMM
			Total	Material	Labor						
Floor Finishes		FF-0110	56,349	15,537	40,812	-	Mortar30+Terrazzo tile flooring				
			11,170	1,848	9,322	-	Mortar	30 mm thick	㎡.	Q x 1	Plastering
			11,330	11,330	-	-	Terrazzo tile flooring	400mm x 400mm, 25mm thick	㎡.	Q x 1.03	Tile & Stone
			33,248	1,879	31,369	-	Pressure paste	12mm thick, 5mm pressed	㎡.	Q x 1	Tile & Stone
			601	480	121	-	Polished	sawdust	㎡.	Q x 1	Temporary work
External Walls		EX-0310	95,000	95,000	-	-	Aluminum sheet panel, Flat board, T=3, Fluorine Resin				
			95,000	95,000	-	-	Aluminum sheet panel	Flat board, T=3, Fluorine Resin	㎡	Q x 1	Metal
Internal Walls		PT-0220	27,895	4,827	23,068	-	0.5B Masonry (under 5000 pieces)				
			3,544	3,544	-	-	Cement brick	190 x 90 x 57	Ea.	Q x 75 x 1.05	Masonry
			20,889	1,101	19,788	-	0.5B laying	under 5,000 pieces	1000 Ea.	Q x 75/1000	Masonry
			2,861	-	2,861	-	Brick conveyance	human power	1000 Ea.	Q x 75 x 1.05 /1000	Masonry
			602	182	419	-	Concrete lintel	100 x 200	L.F.	Q/4.5 x 0.1	Masonry

Table 6. Example of sub-elemental cost data

The unit for the sub elemental cost is basically '㎡'. However, according to the measurements of certain materials, 'number' and 'm' are used.

5. A COST DATA-BASED COST ESTIMATING MODEL

5.1 Cost Database for the Cost Estimating Model

(1) Structure of cost data

Although a standardized form of cost data for bills of quantities exists, such as SMM (Standard Method of Measurement) or MasterFormat, there is no form for elemental costs in Korea. So, we developed a standardized format for elemental costs as shown in Table 5.

Table 5. Format of Elements for Finishes

No	Elements
1	Internal wall
2	Internal windows and Doors
3	Floor finishes
4	Wall finishes
5	Ceiling finishes
6	Stair finishes
7	External wall finishes
8	External windows
9	External area finishes (roof et al.)
10	Stair finishes
11	The others (Rest room et al.)

(2) Cost Database

Each element in Table 5 has various sub-elements according to the material used. Some materials are used together. For example, terrazzo tile-setting requires several works (mortar, pressure paste and polishing) and materials (Terrazzo tile). To consider that, several items are grouped into one sub element.

As a result, cost database for finishes consists of three parts: 1) standard section; 2) composite cost and, 3) illustration of grouped items (See Table 6).

- Standard section : When users find the rate for a certain type of sub-element, the images of standard section help them to search sub-elemental costs.
- Composite cost : The total composite costs are similar to sub-elemental costs. The difference is that the composite cost can be divided into material and labor costs.
- Illustration of grouped items : In this part, a simplified specification of items grouped into the sub-element is illustrated. The unit of the items is in square meters. If the unit of some items is different,

the quantity of the items is converted to square meters using a simple calculation.

This cost database is a key part of the cost estimating model. We developed a cost database by analyzing about 20 public office building projects. So almost 1,000 sub elements that can be used in those type of projects are included.

5.2 Cost estimating model

The estimating method in the model is the same as traditional cost models such as elemental estimating. This model, however, is more convenient to search cost data than manual based estimating model. The process has three steps as illustrated in Figure 2.

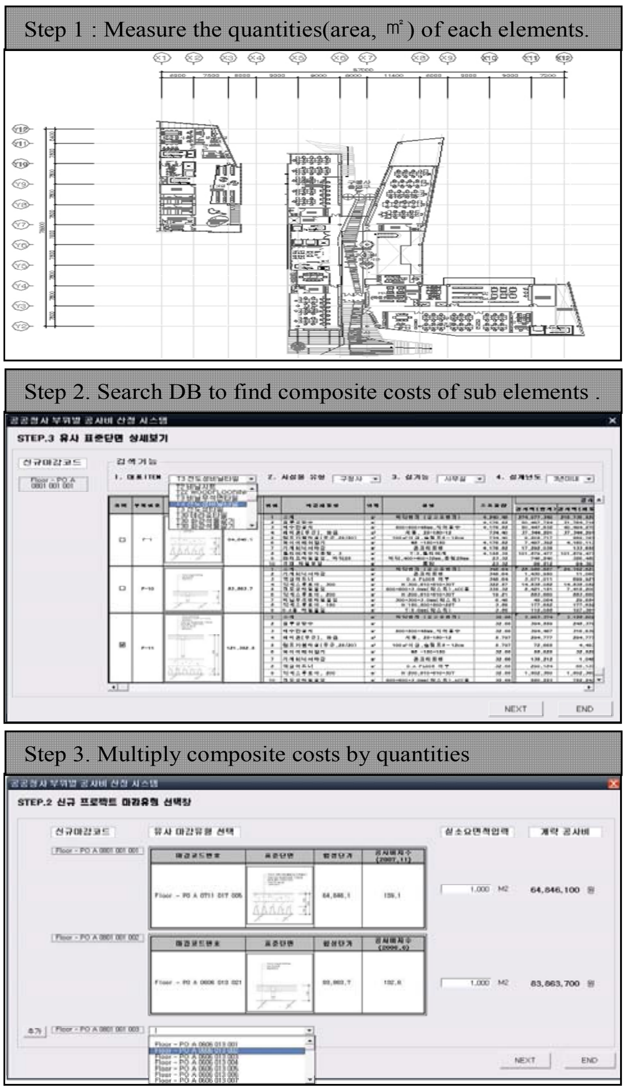


Figure 2. Process of the model

To verify the model, 2 public office building projects were selected for the case study. The case study found that this model predicted costs of finishes with 92% and 99% accuracy. It was concluded that the model has reasonable prediction accuracy.

6. Conclusion

In Korea, government officials are responsible for cost management of public office building projects. They have often confirmed that the final cost estimate is over the cost limit. The major reasons for this cost overrun are the inaccuracy of initial cost estimates and the absence of a continuous cost check process during design. To solve these problems, this research suggested a cost model for finishes in public office building projects in the country.

By examining and analyzing various cost estimation methods and models, elemental estimating was considered as the appropriate approach. For this model, the standardized cost breakdown structure and cost database on the elemental and sub-elemental costs was suggested. Finally, the cost estimating model was developed and verified by a case study.

Because this research is limited to estimating finishes of a project, future research on a cost model to predict the total costs of buildings will be required.

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