PROCESS RESEARCH FOR DEVELOPMENT OF STRUCTURAL COST ESTIMATING MODEL BASED QUANTITY

- FOCUSED ON PUBLIC OFFICE BUILDING PROJECT -

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ABSTRACT: When managers estimate exact construction cost at early stage and design phase, they can reduce construction cost in a more efficient way than to predict at construction stage. But, the current of public construction cost estimation and management is concentrated almost after detailed design phase. Therefore, construction cost management in design development phase to generally use approximate estimating is not correct. Also, the existing construction cost used the method that estimated by gross floor area-based cost estimates at design development phase. So, it is difficult to show the specific amount of materials and basis about the estimated cost of the construction. This study derived problems and limits of construction management at design development phase in case of public office building project through review of literature and current survey, and suggested estimating process model process of structural construction cost go improve these matters.

Keywords : Public Office, Approximate Estimates, Cost Estimating Process Model, Design Development Phase

1. INTRODUCTION

1.1 Study Backgrounds and Purpose

The total construction cost forecast(estimating) forecast which shall be prepared when setting up building project is important thing in a key of problem solving, and project scale and project scope is decided according to the construction cost.

In the building project of domestic public field, managerial frame of basic construction cost is presented according to Total Construction Cost Manual. Also, management task toward construction cost is defined when completing of each design phase.

Through these series of processes, forecasted and reviewed cost is used by related participants in the construction by stakeholders. The owner needs cost estimating to examine accomplishment possibility, and designer to compare various design alternatives, and contractor to perform bidding.

However, cost management(estimating) of domestic public construction is concentrated in the next phase of detailed design one with relevant tasks, and thus cost estimating in the early stage phase which is executed centering on approximate estimating can be said very vulnerable.

In contrast construction cost is required largely in the construction phase, saving possibility of construction cost is bigger in the former phase than construction one. Therefore, there needs active support to task standard and estimates technique toward former phase before detailed design phase.

In methodological aspects, we see there is not big problem when gross floor area-based cost estimates used widely at present as a basic method of construction forecast is applied to primary forecast of construction cost. However, forecast of construction cost in the phase of completing schematic design and forming design development is encouraged to check the construction cost through quantity take off and cost estimating by elements

and work trade based on more detailed design information than the former phase.

However, in domestic cases, this is replaced with gross floor area-based cost estimates same as the project primary phase, and thus owner cannot but take potential risk accordingly because the owner is not able to grasp the proper construction cost till cost confirmation after detailed design.

Also, the estimation of design development phase is more detail than schematic design information and approximate estimation is carried out before detailed design phase. In private companies, they are confirming budget by developing system along with construction of DB. However, in case of estimation and cost management of design development phase at public office buildings, they execute only detailed estimation after completion of detailed design, while finishing review of project feasibility at conceptual phase in the initial project. So, it was investigated that there was a shortage of proper adequacy review by design phases, and cost management in the design development phase was not executed.

Therefore, this study will propose development of an structural approximate estimating process model which has connection in the design development phase with detailed design one when is ahead of detailed estimation after completing detailed design phase of cost management agent, objecting to public office buildings.

1.2 Study Scope and Method

This study get process research for approximate estimating model of structural construction cost as its scope, by utilizing design information in the design development phase at the public office buildings which have similar functionality among public construction projects. Structure of this study means foundation, column, beam, wall, stairs in addition to frame, and designates member object such as reinforced concretes work, steel work excepting finishing work. Structural construction cost of this thesis means direct construction cost exempting overhead expenses[1].

The study method and procedures are as follows.

First, this study will carry out theoretical review of the existing researches on approximate estimating, and defines scope and purpose of construction cost required in design development phase.

Second, the study will analyze problems on calculation method of construction cost which is operated for reviewing of cost management and expenses at the existing schematic design phase, and based on this results the study will propose structural approximate estimating process model concept considering connection between design development and detailed design phase.

Third, this study will execute data analysis for development of structural approximate estimating process model. Also, the study will propose calculation model process of structure cost connected with design information in design development phase based on historical cost data of public office building project.

2. Preliminary Review

2.1 Schematic Estimation by Phases and Definition of Schematic Design Phase

Classification by design phases of Korea public Procurement Service(PPS) and Ministry of Land, Transport and maritime Affairs(MLTM), British RIBA[2] and ACostE[3], America AIA[4] and AACE[5] is classifying it according to task characteristic of each phases from planning phase to detailed design one along with available design information. To forecast construction cost, available information shall be used, and these information is operated as main factors of forecast method like impact factor which is defined in the existing literature (The Ministry of Land, transport and Maritime Affairs 2003, Public Procurement Service 2004) and studies (Son Bo-sik and 2 persons 2007).

By using the above concept, this study classify available estimation technique by design process of construction project same as table 1.

Table 1. Estimating scope by design phases

Domestic		U.S.A		U.K		Estimate Classification
PPS	MLTM	AACE	AIA	ACostE	RIBA	
Conceptual Design	Conceptual design	Class 5 (Order of magnitude)	Pre-Design	Order of magnitude	Briefing	Conceptual Estimate
	Scematic Design					
Pre Final Design	Design Development	Class 4 (Study)	Schematic Design	Study	Sketch Plan	Approximate estimate
		Class 3 (Preliminary)	Design Dvelopment	Budget		
Final design	Detail Design	Class 2 (Definitive)	Construction Documents	Definitive	Working Drawings	Detaied Estimate

Design development phase of this study scope corresponds to American AACE estimation classification standard Class3 ~ Class4 among table 1 contents, and estimation technique is composed of approximate estimating.

Design development phase is to materialize contents of schematic design, and execute various reviews to minimize change possibility in the detailed design phase, and is approved by owner on the detailed drawings including materials, equipment volume and capacity according to system expansion of relative field.

2.2 Existing Schematic Estimating of Design Development Phase

[1] Structural construction cost means the sum cost of reinforced concrete work of <architecture work trade>303, steel work 304 based on classification system of comprehensive architecture information, Ministry of Construction and Transportation Notice 2001-230.

[2] Royal Institute of British Architects

[3] The Association Cost Engineers

[4] American Institute of Architects

[5] Association for the Advancement of Cost Engineering

Construction cost is varying the contents and character according to project phases. Construction cost is composed of amount of material and unit price generally. Amount of material doesn't change with essential amounts, but unit price is variable as numerical value considering exterior condition. Therefore, the unit price is changed and is needed comparison and judgment in application. And dependence degree of specialist is high. Also, the cost is decided by competition, and subjective characteristic which is difficult in absolute comparison.

However, the current approximate estimating has been carried out based on price analysis of composite floor area-based cost estimates mainly. This is inadequate to apply recent building which is made with complicated feature and structure. Also, this has limitation in counting positive measure to detailed design alternative about design information at the design development phase, even though there is not big problem to estimate construction cost at conceptual phase.

2.3 Connection between Approximate and Detailed Estimation

By surveying existing literature, Son Bo-sik (2008) indicated the basic problem in approximate estimating at design development phase such as construction cost estimation was carried out by sum standard of elemental unit price according to work trade classification, and proposed an improvement method in which construction cost is calculated by adding actual result information of historical cost data with quantity and unit price. Also, Choi Seok-in (1999) analyzed that to calculate comprehensive production cost roughly by floor area-based estimates of main materials was favorable in time, but there was a disadvantage of not knowing the detailed cost. So, he proposed that it was the most appropriate method to calculate rough quantity of main factors based on design development drawing, considering domestic reality.

Estimation is processed based on available design information decided by design phases. The following table 2 is the contents that straightened up available information and estimating scope according to design phases.

Table 2. Information and Estimation Scope by design

Classification	Available design information	Estimation method
Planning phase	• Forecast scale of building • Usage and facility type • Existing similar building data • Field inventory information etc.	• Reference estimation
Conceptual design phase	• Planning phase information • Space program such as rough total floor area and real allocation • Building form including its plane and elevation • Structural type	• Schematic estimation
Design Development phase	• Confirmed design outline after conceptual design phase • Main area outline, number of stories, story height, schematic drawings, finish level, electric/facility system. • Rough structure plan	• Reference estimation • Approximate estimation
Detailed design phase	• Design information available to construction execution	• Detailed estimation

In design development phase which is study scope of this thesis, confirmed designing press reveals after schematic design phase, and design information such as main area outline, numbers of stories, story height, schematic drawing, finish level, electric/facility system etc. are materialize, even though it is confirmed information level of detailed design phase. Specially, available design information decided at design development phase forms and materials classification system of design information and components necessary in detailed estimation. Based on these information, it is possible to calculate output of structure quantity.

2.4 Problems and Improvement Measure

Through literature review, we could suggest its problems and limits of approximate estimating at existing design development phase when executing public office building project as followings.

First, there needs model and system to support construction cost estimating. As current estimate task of construction cost is concentrated on next step of detailed design phase, development of practical model and system is necessary to assist estimate task of construction cost about previous phase which is larger in possibility of construction cost saving.

Second, existing approximate estimation through composite elemental unit cost of floor area-based cost estimates is improper to the approximate estimation level required at design development phase. So, this study suggests approximate estimating process model which has connection with cost estimating task of detailed design through mixing rough estimates by elements utilizing available design information at design development phase and approximate estimation, other than existing cost analysis of floor area-based cost estimates which contains uncertainty.

3. Concept and Characteristics of Estimating Process Model of Structural Construction Cost

3.1 Concept of estimating process model of structural construction cost

When estimating structural construction cost in detailed estimation, we confirm the design outline and drawing information first, and take off quantity by elements composing structure. Also, we calculate amount required for labor cost, materials and machine by using standard unit cost and price information etc. Adding material cost, labor cost, machine expensed and others, administrative expense, profit, and VAT calculated through the above is the structural construction cost.

The concept of structural estimating process model in this study is processing approximate estimation by

elements based on available design drawing information at design development phase. And then this process model calculates quantity by applying research result figure through classification and analysis of historical cost data. After these series of process, this process model forecasts construction cost by multiplying latest price to calculated quantity and items. Comparison between calculation process of detailed estimation on construction cost and approximate estimating process model can be graphed as the following fig. 1.

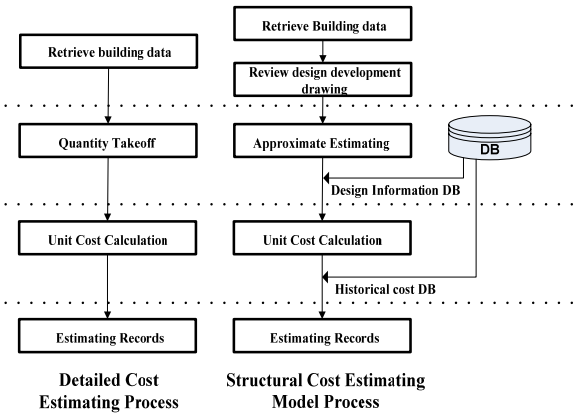

Fig 1. Comparison models of detailed estimation and schematic one

3.2 Characteristics of schematic estimation model

Approximate estimation procedure at design development phase proposed at this study and characteristic of approximate estimation process model considering connection with detailed estimation at detailed design phase are as follows.

1) It is possible to confirm design factor information decided and to reflect actual drawing information, by processing approximate estimation based on available design information at design development phase. (connection between approximate estimating and detailed one)

2) This model established result database through classification and analysis of structural construction cost, and can make adequacy of calculation results through utilizing various database by elements.

3) Existing approximate estimation requires a lot of times in recalculation and alternative review in case of design change order and alternative review. But this approximate estimating process model is possible to recalculate rough estimates quantity only by applying the changed part and further review and task of design alternation is easy. By this, efficient management of structural construction cost at detailed design phase practically is possible.

4. Process Establishment of Structure Cost Estimating Model

4.1 Historical cost data outline

For establishing model of structural construction cost regarding public office buildings which are objects of this study, the study executed data analysis about total 14 results data including 7 provincial office buildings, Military Manpower Administration and National Tax Service buildings and 5 post offices during 2001~2006. Approximate estimating process model suggested in this study is aimed to calculate structural construction cost based on the quantity. The model confirmed information to estimate cost preferentially, and classified and analyzed the construction cost and quantity based on result data of structure construction cost.

Procedure of analysis is same as follows.

First, the model analyzed component ratio rate system of work trade on structural construction cost.

Second, the model analyzed relation of quantities on analyzed major work trade.

4.2 System analysis of component ratio on structure construction cost

Estimating model of structural construction cost suggested on this study at design development phase started from classifying composition system of construction cost at public office buildings through analysis result construction cost(bill of quantities). Analysis method can be categorized by work trade construction and quantity ratio between work trade. Construction cost of work trade analysis was carried out component ratio of relevant project between construction cost of work trade and composition ratio versus amount of construction cost on relevant project, by using bill of quantities of construction cost after completing detailed design same as fig.2.

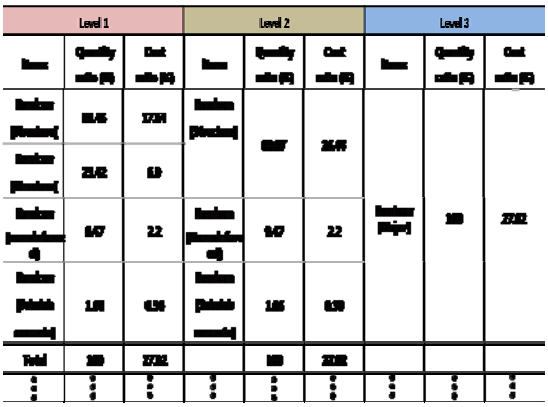

Fig 2. System analysis process of composition ratio on structural construction cost

Analysis method is analyzing amount and ratio by grouping with same work trade based on historical cost data. This study executed ratio analysis of construction cost and quantity by classifying by same major works such as concrete and pump-car placing.

Table 3. Classification of composition ration on major works among structural construction cost (partly).

	Major Works	'A'Public Office Component Ratio	'B' Public Office Component Ratio
Reinforced	Ready-mixed Con'c	27.02%	27.16%

Con'c Works	Forms	22.08%	28.40%
	Reinforcing	27.70%	23.16%
	Pump-car Placing	6.40%	4.51%
	Reinforcing Rod Processing & assembling	16.66%	15.46%
	Reinfored Etc Works	0.13%	1.31%
Steel Works	RH Steel	27.67%	26.20%
	BH Steel	2.84%	0%
	Steel Painting	6.98%	14.36%
	Deck plate	15.08%	15.01%
	Steel Processing & assembling	26.20%	24.43%
	Steel Welding	2.85%	2.25%
	Steel Erection	4.60%	2.35%
	Steel Plate	4.27%	2.87%
	Bolting	4.19%	3.91%
	Steel Etc Works	5.32%	8.61%

Analysis results of construction cost by work trade based on historical construction cost bill revealed that major works such as steel concrete construction including Concrete, formwork, steel, pump-car placing, work trade of steel-processing and assembling was composing 95%~99.5% of total steel concrete construction cost, and other work trade was not over 5%. Composition ratio of sum in major works such as steel(Rh+Bh), steel beam painting, deck-plate, steel-processing and assembling, steel welding, steel erection, steel plate, bolting work was occupying 90%~96% among total steel construction cost, and others was not over 10%.

4.3 Quantity ratio statistics analysis of major work

This study executed quantity analysis based on classified work trade data about concrete, pump-car placing, reinforcing, steel-processing and assembling, steel and steel erection and did comparison between quantity ratio statistics analysis, in addition to major work analysis versus total construction cost. The results were same as fig. 3.

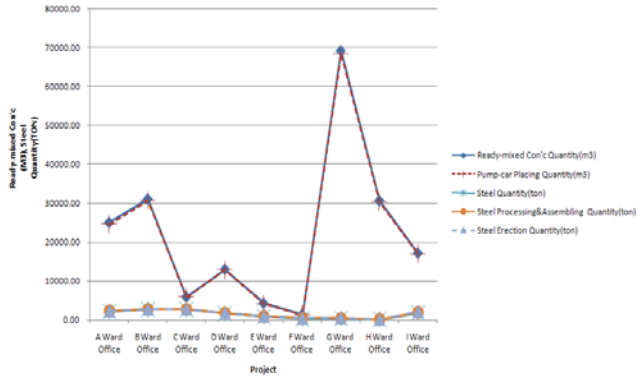

Fig 3. Statistic analysis of quantity of pump-car placing, steel- processing and assembling, steel erection according to concrete and steel quantity

Concrete and pump-car placing, reinforcing rod and reinforcing-processing and assembling quantities revealed fixed ratio among major works of reinforced concrete, and steel quantity and steel-processing and assembling, steel erection quantity among major works of steel construction showed fixed ratio. Besides, there was not fixed ratio by results of comparative analysis between major works.

4.4 Development of estimating process model on structural construction cost

As historical cost data analysis, we were able to calculate quantity of relevant attached work trade(minor work trade) if quantities of concrete, formwork, reinforcement quantity and steel one[6] (major work trade).

In approximate estimating process model supposed in this study, major work trade is calculated through approximate estimation, and structural construction cost is estimated by applying similar proportion cost of the past statistic to minor work trade. Managing agent of public office construction of external design agency can estimate major works quantity by elements utilizing design development drawing information in case applying approximate estimating process model to calculate structural construction cost of new project.

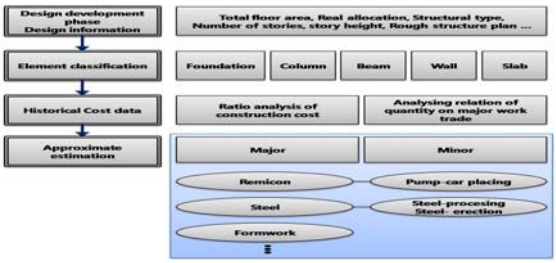

Fig 4. Approximate estimate process in structural cost estimating process model

Concrete and formwork among major works is possible in approximate estimation, output of reinforcing rod quantity is hard to forecast because bar arrangement is different according to its load and location, even though it is same size. Therefore, we can utilize the estimating method of reinforcing rod quantity per unit volume, ton/m3 which existing concrete volume is divided by reinforcing rod quantity, and then establish it to database. Afterward, we can progress as estimating reinforcing rod quantity after inquiring similar case. Also, other etc cost which is sum of not including in the major works among structural construction cost of reinforced concrete construction and steel construction expenses can be estimated by applying proportional statistic price versus anticipated total construction amount (refer to 4.2). Table 5 is showing establishment status of database on reinforcing index by project and elements.

[6] Concrete, form, reinforcing among major work trade of reinforced concrete are classified as major work trade and pump-car placing, steel-processing fabrication are classified as minor work trade. Also, steel which is representative work trade of steel work is classified as major work trade and other appendix work trades are classified as minor work items.

Table 5. Data analysis sheet of reinforcing index by elements (partly)

No.	Foundation (ton/m3)	Column (ton/m3)	Beam (ton/m3)	Slab (ton/m3)	Wall (ton/m3)	Stair (ton/m3)	Etc (ton/m3)
1	0.118	0.215	0.268	0.063	0.107	0.156	0.098
2	0.104	0.162	0.303	0.066	0.116	0.124	0.129
3	0.111	0.159	0.302	0.061	0.113	0.133	0.123
4	0.092	0.169	0.306	0.091	0.121	0.092	0.167
5	0.099	0.286	0.113	0.09	0.107	0.128	0
6	0.165	0.282	0.318	0.078	0.156	0.12	0.053
7	0.09	0.268	0.218	0.074	0.111	0.167	0.079
8	0.094	0.245	0.203	0075	0115	0.15	0.079
9	0.094	0.315	0.274	0.066	0.096	0.208	0.082

This estimating process model of structural construction cost uses statistical result quantity of construction cost based on similar cases in the past, and analysis directions of data makes proportional statistics of unit quantity apply to fit in approximate estimation characteristic by work trade based on quantity of past cases. That is, it sets concrete, formwork, reinforcing, steel which is representative materials in structural construction as standards, and estimates approximately structural quantities of the project through similar cases after analyzing quantity of relevant work trade corresponding to each materials, and then estimate construction cost by multiplying latest price at the time of quotation. The conception drawing of approximate estimating process model is same as fig. 5.

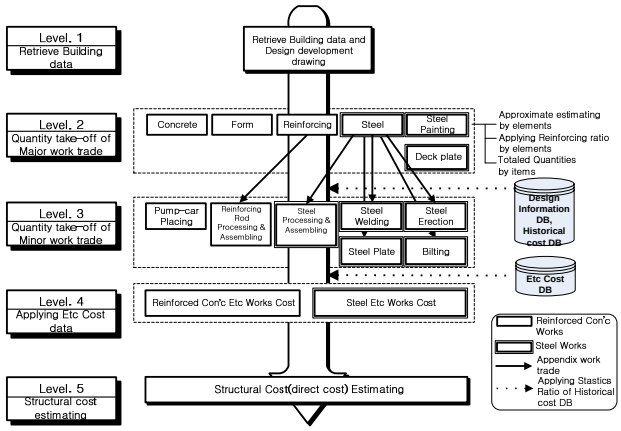

Fig 5. Total conception drawing of estimating process model on structural construction cost

5. CONCLUSIONS

This study derived problems and limits of construction management at design development phase in case of public office building project through review of literature and current survey, and suggested estimating process model process of structural construction cost go improve these matters.

In domestic construction of public office buildings, management of construction cost at previous phase of detailed design was using estimation method of the gloss floor area-based cost. This method was not able to grasp proper cost of building till confirming period of the cost after detailed design, and was short connection with cost management task of detailed estimation, and thus inefficient construction cost management was processed.

Estimating process model of structural construction cost to develop and support to the above, first, this can reflect actual drawing information at design development phase, and makes it easy to prompt reflection on design change order and to examine alternative of design. Second, this process can improve the adequacy of output results by utilizing established DB, and make connection with construction cost management at detailed design phase by suggesting estimating process model of structural construction cost based on quantities.

Forthcoming study is encouraged to verify development and availability of this proposed model, to accumulate DB and to study user interface design for user convenience. Also, continuous study on estimating model of total construction cost regarding various public office buildings shall be carried out, along with computerization system development.

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