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Schematic Estimation Process using Architectural Object BIM Library

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Abstract: The construction industry has been evolving with the development of information technology. According to this trend, the current industry changes from 2d drawings to Building Information Modeling(BIM). Current studies on the BIM-based estimation have problems such as Quantity Take-Off(QTO) specificity toward a particular software, the uncertainty of the amount in accordance with the model quality. These studies focus on QTO based on BIM rather than schematic estimation. In addition, studies on the connection with the QTO and unit cost for schematic estimation are insufficient. The purpose of this study is to propose schematic estimation process by utilizing construction codes and QTO in architectural object BIM libraries. Construction codes are classified in detail in order to input codes inside each. This study has connected unit cost and construction classification codes that obtain from BIM model. The results of this study will be helpful in decision-making and communication for schematic estimation of the design phase. It will improve the efficiency and reliability problems of existing schematic estimation.

Keywords: Architectural object BIM library, Building Information Modeling (BIM), Construction Code, Schematic estimation

I. Introduction

In construction industry, Schematic estimation is the most important factor in financing the project as a factor in considering the feasibility and economics of business in the early planning stages of the construction. Schematic estimation is the difference depending on the amount of the competence between a lot of professional experience and skills. In addition to that, it has a problem throughout the course of error in the amount of change in the design by hand. Also, public institution was investigated for using over-budget in Analysis of construction expenses classified by public facilities 2014[1].

BIM-based schematic estimate expects a significant effect about accuracy and reliability. Because it can be automatically calculated by using the attribute information of the BIM model[2]. But BIM-based estimation technology writes specific models and requires information in detail, therefore, it requires too much of extra expenses and time in order to replace current estimation methods[3]. In order to solve limitations, this study proposed schematic estimation process using architectural object for automatically linking QTO information with cost information.

II. Review of related studies

Construction dictionary has defined schematic estimate as how to approximately calculate the construction cost in the past actual construction data. Related Studies was a way to link the QTO information with cost information by each adding the attribute information from BIM model. The problems that found in related studies largely follow:

· QTO's uncertainty of the BIM model's quality

· Lack of estimate's information

· Unclear standardization of schematic estimation

· Lack of reliable data

TABLE 1
Review of related studies

Researcher	Research's content
Cho, Young-Sun (2015)	This study proposed BIM-based way of calculating the cost of construction take advantage of the segmental type combined DB in order to increase the accuracy and efficiency of BIM-based estimation
Yoon, Myoung-Chul (2013)	This study presents the LOD criteria according to create a BIM model. It proposed LOD's criteria according to modeling creation in step-by-step design. It proposed schematic estimation for each step of BIM process.
Kim, Han-Saem (2013)	This study defined the LOD levels of a BIM-based modeling and schematic estimation in structural work of tall building. It proposed a way to conduct a quality review of the physical data on the process to improve the accuracy of the cost.
Kim, Han-Joon (2013)	This study proposed an Open-BIM data model's construction based on schematic estimation. It is derived classification system for object-specific attribute definitions and QTO
Park, Young-Jin (2011)	This study is classified by utilizing the space factor for QTO information. It proposed schematic estimate-on model that automatically ca-lculate though the association with database.

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III. BIM-BASED SCHEMATIC ESTIMATION PROCESS USING ARCHITECTURAL OBJECT BIM LIBRARY

BIM-based schematic estimation process is automatically in connection with unit cost information by extracting QTO and construction classification code in BIM model. For this, construction classification codes have been classified in detail in order to input codes inside specific architectural object properties and input it in architectural object. The architectural object BIM library makes completed construction classification code by combining a part of construction classification code in instance property with a part of construction classification code in material property. BIM model that created by using architectural object library can be calculated QTO information for specific construction classification code. Extracted construction classification code from BIM model is automatically linked with cost information database for specific construction classification code. Finally, construction cost is calculated through this process. It is expected to improve the accuracy and reliability of the schematic estimation. If unit cost database is constantly updated, output is able to deal with the changing unit cost.

A. Analysis for construction operation code system

It was announced about the construction information classification in Public Procurement Service. As a result for analyzing Construction operation codes, it consists of hierarchical structure. It can be divided into four components(main class, medium class, minor class, subclass). A completed construction code is made by combining each class. In the case of ADF101000000, it is divided as follows.

· AD – reinforced concrete construction

· F1 – concrete placement

· 01 – concrete placement by people

· 000000 – general concrete placement by people

B. Methodology to applying into architectural object BIM library

This Process is conducted by REVIT 2015. Method in adding separate code for specific-object property is derived as follows. Main class is added in material property of specific-object type instance. The other classes are added in specific architectural object BIM library.

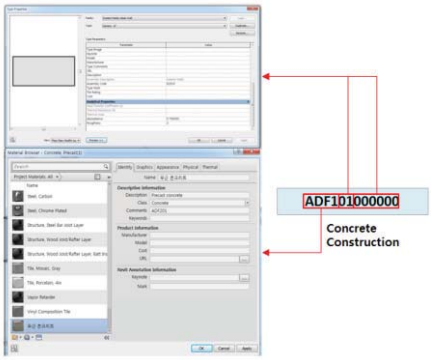


Fig. 1. Method to add properties of code in architectural object

Divided each construction code extracted From BIM model constructed by architectural object BIM library. It creates the single completed construction code by processing each code.

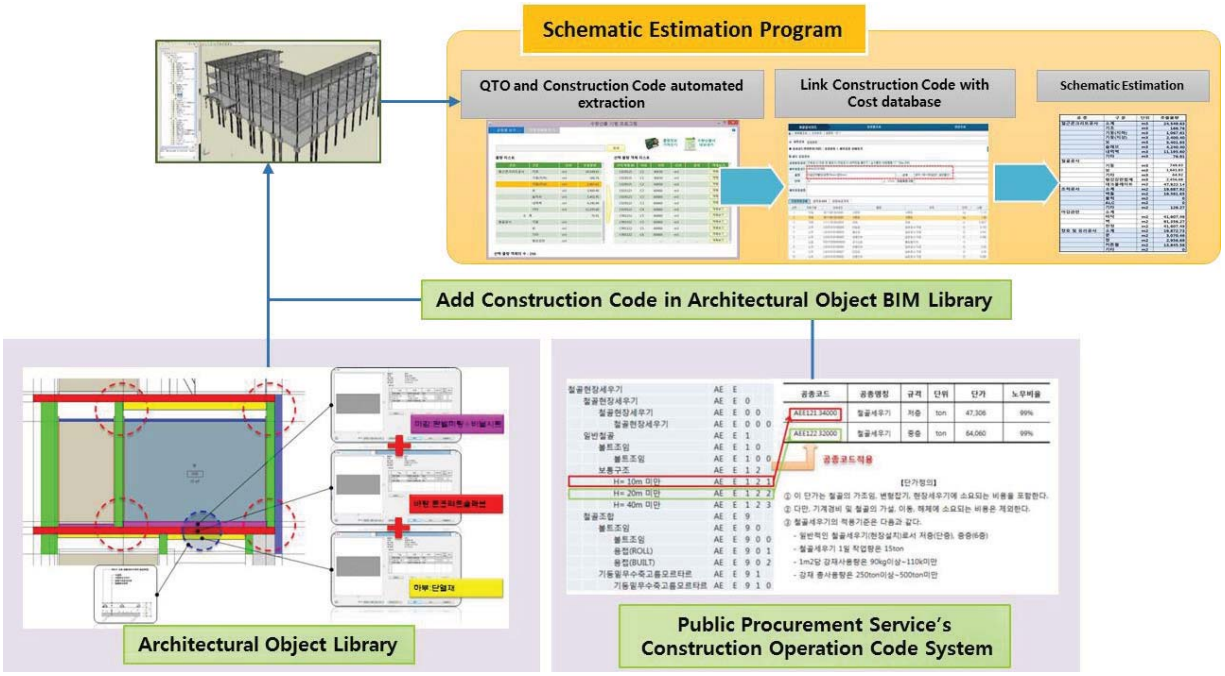


Figure II. BIM-based schematic estimation process

IV. QTO METHODOLOGY TO SPECIFIC CONSTRUCTION TYPE

It is necessary to define a method to QTO information for model-specific part. In this study, BIM object for calculating structural work and interior finishing work define BIM objects as follows based on the IFC guide that published by buildingSMART International [9].

TABLE 2
REVIEWED BIM OBJECT FOR BIM-BASED SCHEMATIC ESTIMATION

Construction classification		BIM object review items
D	Reinforced concrete work	Foundation, Column, Beam, Wall, Slab, Stair, Roof
E	Steel-frame work	Steel frame (Column, Beam, etc)
F	Stone masonry work	Wall
G	Plastering work	Space
H	Waterproof work	Space
I	Carpenter's work	Space
J	Metal work	Space
M	Tile & stone work	Space
N	Painting work	Space
O	Interior finishing work	Space

Structural work's QTO information is calculated for applying formula after shape information is extracted from BIM model. Interior finishing work's QTO information is calculated for linking shape information with *interior material finish set* database.

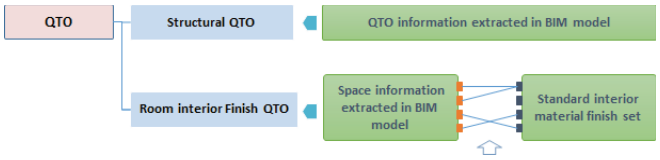


Fig. 3. BIM-based QTO process

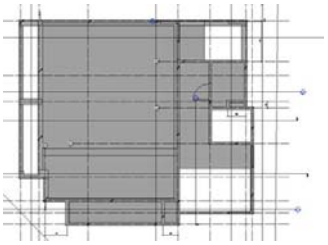
A. QTO Methodology to Structural Work

Architectural objects involving in structural work refer to values that access in properties of IfcElementquantity from IFC file. The following table describes names of IfcElementquantity and values of the IFC.

TABLE 3
QTO PROPERITIES IN ARCHITECTURAL OBJECT

Object	QTO information	Entity Name	Quantity Name in IFC
Column	Volume	VOLUME	IfcGrossVolume
	Area	AREA	IfcCrossSectionArea
	Area	AREA	IfcOuterSurfaceArea
	Column Height	LENGTH	IfcLength
Beam	Volume	VOLUME	IfcGrossVolume
	Area	AREA	IfcCrossSectionArea
Slab	Volume	VOLUME	IfcGrossVolume
	Area	AREA	IfcGrossArea
	Width	LENGTH	IfcWidth
	Perimeter	LENGTH	IfcPerimeter
Wall	Volume	VOLUME	IfcGrossVolme
	Bottom Area	AREA	IfcGrossFootprintArea
	Side Area	AREA	IfcGrossSideArea
	Wall Length	LENGTH	IfcLength
	Wall Height	LENGTH	IfcHeight
	Wall Width	LENGTH	IfcWidth

QTO value calculated by applying the formula to IfcElementquantity. The following figure describes the example of QTO in structural work. In case of formwork's area, QTO is calculated by multiplying perimeter and width.



Classification	Unit	Formula	QTO
Concrete	M^3	GrossVolume	1,060
Formwork	M^2	Perimeter*Width	261,605
Reinforced bar	ton	GrossVolume*0.03	31.8

Fig. 4. Example of QTO

In the case of other architectural objects, QTO's value calculated by applying the formula to IfcElementquantity

B. QTO Methodology to Interior Finishing Work

Interior finishing information refers to IfcElementQuantity from IfcSpace. QTO value is calculated by linking IfcElementQuantity with *standard interior material finish set*.

TABLE 4
QTO PROPERITIES IN SPACE OBJECT

Object	QTO information	Entity Name	Quantity Name in IFC
Space	NorminalHeight	Length	IfcNorminalHeight
	ClearHeight	Length	IfcClearHeight
	GrossPerimeter	Length	IfcGrossPerimeter
	NetPerimeter	Length	IfcNetPerimeter
	GrossFloorArea	Area	IfcGrossFloorArea
	NetFloorArea	Area	IfcNetFloorArea
	GrossCeilingArea	Area	IfcGrossCeilingArea
	NetCeilingArea	Area	IfcNetCeilingArea
	GrossWallArea	Area	IfcGrossWallArea
	NetWallArea	Area	IfcNetWallArea
	GrossVolume	Volume	IfcGrossVolume
	NetVolume	Volume	IfcNetVolume

QTO value calculated by applying the formula to IfcElementquantity. The following figure describes the example of an interior slab finishing QTO in interior finishing work. In case of formwork's area, QTO is calculated by multiplying NetWallArea and QTO of unit area.

V. METHODOLOGY FOR LINKING QTO WITH COST DATABASE

Schematic estimation is calculated by multiplying the approximate QTO information and unit cost information in the early stages. It is calculated by linking extracted QTO information and combined construction code with cost database.

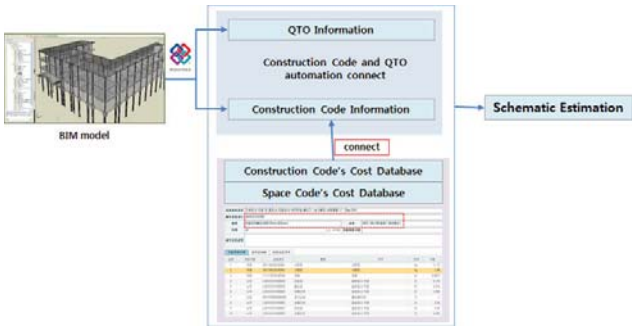


Fig. 5. Data flow for schematic estimation

A. Estimation Methodology to Construction Type

The QTO information refers to chapter IV. Unit Cost information database is based on unit cost and construction cost that make an official announcement in Public Procurement Service. Connection between QTO information and cost information is made possible by construction code that is in architectural object and cost database.

Table 5
DATABASE TABLE FOR SCHEMATIC ESTIMATION PROGRAM

Construction code		Classification	Type	Unit	Unit cost
DA	DA301	Formwork (smooth)	0~7m	M^2	21,162
	DA201	Formwork (general)	0~7m	M^2	18,710
	DA101	Formwork (coarse)	0~7m	M^2	15,055
	DA401	Formwork (euro form)	0~7m	M^2	14,233
DF00	DF00	Concrete curing	-	M^2	222
	DB000.20000	Reinforcing bar work (general)	Simple	Ton	376,725
	DB000 21000	Reinforcing bar work (Joint)	Simple	Ton	280,962
	DB000 22000	Reinforcing bar work (Joint)	Simple (cast)	Ton	235,759
	DB000 31000	Reinforcing bar work (Joint)	Complex	Ton	308,090
	DB000 32000	Reinforcing bar work (Joint)	Complex (cast)	Ton	251,315
DF20	DF20	Concrete placement	Slump 15	M^3	10,132

In the case of concrete curing in structural work, cost about concrete placement is calculated by multiplying DF20's unit cost and volume of the concrete(IfcQuantityVolume). Cost about concrete curing is calculated by multiplying DF00's unit cost and area of the concrete(IfcQuantityArea). For example, concrete slab's curing cost in figure III is described.

· unit cost of DF00 · QTO of Slab = Concrete curing cost

· 222 · 1,060 = 235,320

In the case of interior finish work, cost about interior finish is calculated by multiplying IfcQuantityElement in space object and unit cost in *standard interior material finish set*.

B. Development of the prototype estimation program

The following figure is to build database for schematic estimation. The database consists of three items. It is constructed to analyze the essential information in accordance with the schematic estimation method.

· Building elements and Space information from IFC

· Cost information of each construction type

· Work summary for schematic estimation

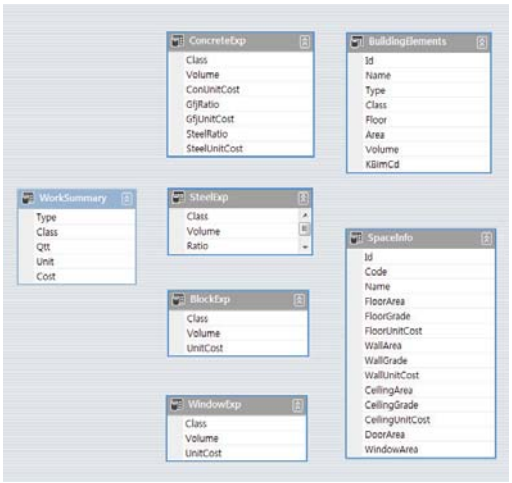


Fig. 6. Database table for schematic estimation program

It is implemented the Open-BIM based prototype schematic estimation program with reference to database table. To check for operating program, it performs test through BIM model. It is a 15-storey building that input construction classification codes.

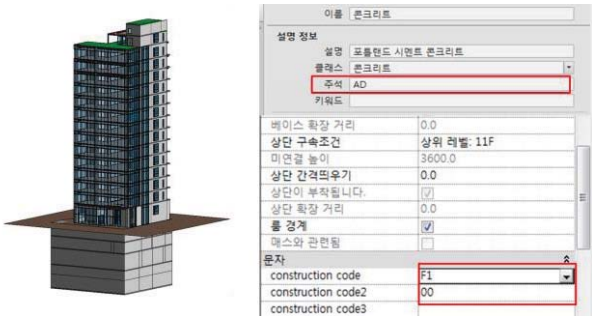


Fig. 7. Test model for schematic estimation

As a result for testing schematic estimation, it is calculated about structural work and interior finishing work.

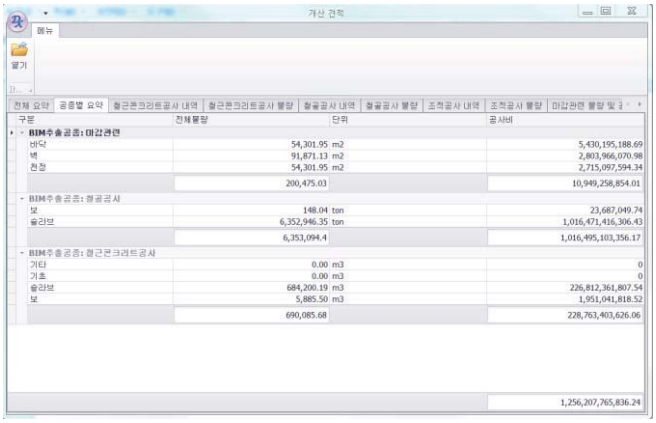


Fig. 8. Schematic estimation program

VI. CONCLUSION

This study proposed a schematic estimation process using architectural object BIM library that input the construction codes in property information. Through this, it automatically links QTO information with construction code.

This study is expected to improve work efficiency as well as reliability of construction cost. Also, if the cost database is periodically updated by public institution, it expects to be able to reflect the changing cost information in real time. The results of this study will be helpful in decision-making and communication for schematic estimation of the design phase.

Limitations of the study are conducted only in some construction. Also, construction of the architectural object BIM library is required to prior to schematic estimation. It will be conducting schematic estimation about the rest of construction and verified against the actual construction cost value.

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