DEVELOPMENT OF BIM STANDARD DATABASE SYSTEM FOR THE REMODELING OF DETERIORATED APARTMENT

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Abstract

A remodeling project for deteriotated housing stocks tends to be an important issue in resources recycling because it does not destruct whole building but destruct particularly. However, compared with new building projects, remodeling project has disadvantages in adding destruct work and repair and rehabilitation work as well as causing difficulty in decision making from diverse project stakeholders. BIM as total tool for creating and managing information in building life cycle has potentialities for solving these problems. However it is difficult to apply BIM to remodelling project as a result of BIM database was constructed focus on new building project. Therefore a need for constructing BIM standard system for remodelling project is arisen. This paper constructed BIM standard database and verified application of BIM standard database in remodelling project. For this research, this paper analyzed the present state of estimation work and scheduling work through the expert interview, conducted the analysis of database in BIM program with Vicosoft BIM program, and evaluated application of remodelling BIM standard database with case study. This paper was expected to effectively utilize as actual data in remodelling project.

KEYWORDS: Remodeling, BIM, Old Aged Apartment

INTRODUCTION

Remodeling is becoming a hot issue for it can recycle resources by removing only some parts of existing structure instead of removing the entire structure and also it can reduce construction cost and period compared to new construction and reconstruction. However, There are difficulties in carrying out the construction as remodelling involves partial removal and repair and reinforcement unlike new constructions and there is a number of client organizations.

Especially, the design and drawings are modified many times to reflect the decisions of clients in the middle of the project and most constructors are not experienced with remodeling works that it is also difficult to calculate the cost and period of construction. BIM is emerging as a comprehensive tool for producing and managing the information created during the life cycle of a building to resolve problems of remodeling works. However, current BIM has database for new constructions but does not have database appropriate for remodeling works that it is quite inconvenient as all elements of the building must be modeled in order to calculate construction cost using BIM.

Under the circumstances this study suggests the BIM Application Framework for the comprehensive management of remodeling projects along with Remodeling BIM Standard DB in order to comprehensively manage the project through simple 3D modeling for removal work and framework construction.

PRELIMINARY RESEARCH

Problems of Existing Remodeling Work

In a remodeling project, the work is progressed based on client's decisions after the design is completed and the removal, repair, and reinforcement works must be completed before the new construction. This system, applied to most remodeling projects, causes many problems – for example, the opinions of the client are not fully reflected in the work, construction period is extended, and the construction plan is incomplete (Donggeon Lee et al., 2008) and the design does not fully utilize existing structure, the drawing for existing structure is not available or different from actual structure, the structure needs more reinforcements than the plan, dust and noise are produced during disassembly and removal, the standard specification is not available, the period for the work on the structure is extended, the productivity is lowered due to small amount of placement in the site, and the opinions of residents are not fully reflected (Heesung Cha et al., 2006).

These problems are caused by the difficulty in immediately responding to design alternatives and the fall-off of the accuracy of the construction plan due to the increased uncertainty from using existing structure. Especially, the extension of construction period is caused by the incapacity in establishing a reasonable construction plan due to lack of experience in remodeling projects.

These problems can be settled down by using BIM in the remodeling project. In other words, the prompt review and suggestion of alternatives using BIM can resolve the issue of not reflecting the client's opinions fully, BIM Simulation will let the constructor to be prepared for possible uncertainties when the construction plan is insufficient, and applying work data from each stage of construction to BIM can resolve the issue of extended construction period.

Building Information Modeling (BIM)

Current Status of BIM

The concept of BIM was first introduced by Chuck Eastman and Robert Aish in the 1970's and has been used since then and it was popularized by Jerry Laiserinin the 2000's (Laiserin, 2007). Currently, many companies and the academic circles are reviewing the applicability of BIM for its potentials.

Advanced nations including America are making great efforts to introduce BIM effectively in many different areas including the system, BIM standard development, BIM standard development, and BIM application development. In America, NIBS (National Institute of Building Sciences) established and is distributing NBIMS (National BIM Standard) which includes BIM theory and methodologies. In Finland, the public corporation, Senate Properties, developed the BIM guideline titled BIM Requirements 2007 (Jongcheol Seo, 2009). Software developers are also developing and commercializing applications such as Revit series by Autodesk, Digital Project by Gehry Technologies, and Constructor, Estimator, and Control by Vico Software.

Preceding studies made inside and outside the country are summarized in Table 1 and they include the development of automated estimation system, material quantity calculation automation method, object model-based process cost integration model, scope-time-cost integrated management, and design-cost information integrated management.

Table 1. Preceding Studies on BIM-Based Estimations

Division	Analysis of Characteristics	Source/Basis
Development of Automated Estimation System	Suggested the method of preparing the bid statement by comparing the quantity data which is calculated from 3D Cad building element information and analyzing the estimation process for the development of estimation automation system	Sewook Oh et al., 2001
Recipe-Based Material Quantity Calculation Automation	Introduced the estimation system based on Constructor and Estimator by Vico Software and supported the excellence of 3D CAD oriented estimation system through the comparison with 2D CAD based estimation system	Cheolho Choi et al., 2006
Automation of Finishing Process Modeling	Suggested the automation of finishing process modeling as a way to resolve the problem that 3D CAD based estimation takes longer time than 2D CAD based estimation	Seongah Kim et al., 2009
Object Model-Based Process Cost Integration	Suggested the method of creating building object and process object which include CBS and WBS as parameters and using them in the process and cost management under JAVA environment	Seungjun Ahn et al., 2009
Scope-Time-Cost Integrated Management	Suggested the integrated model of feasibility analysis, cost determination, and construction plan using 3D models in design-construction stages	Staub-French & M. Fischer 2001
Ontology on Relationship Between Design and Cost Information	Developed ACE(Activity-Based Cost Estimating), the software prototype which uses the ontology reflecting the knowledge of estimators concerning when, how, and why the estimation changes due to the change of design	Staub-French et al. 2003
Time-Cost Integrated Management	Suggested the method of applying nD CAD model, Object Sequencing Matrix, and Genetic algorithm for the optimum time-cost integration schedule in a construction project	C.-W. Feng, et al. 2009

Problems in Applying BIM to Remodeling Work

Current BIM is regarded as the system that creates 3D modeling and checks interferences. In other words, BIM is not regarded as the system it was designed to be, the system that produces and manages all information throughout the life cycle of a building. Also, excessive efforts are invested to modeling since it does not specify the level of details of the 3D

modeling which becomes the basis in applying BIM, and there is no applicable BIM database when applying BIM to remodeling work or only the ones containing data about new constructions that there is no BIM Database appropriate for remodeling. Under the circumstances, this study suggested the BIM Standard DB for Remodeling.

REMODELING BIM STANDARD DB DEVELOPMENT

BIM is an integrated tool that produces and manages all information created during the construction life cycle and it has a very high applicability in overall construction fields (Jinhee Lee et al. 2007). However, the use of BIM is quite rare in domestic remodeling projects. This is attributed to the absence of the framework applying BIM for remodeling, cost estimation system for remodeling works, and the BIM Database for construction management.

Framework Applying Remodeling BIM

In a remodeling work, the remodeling designs reflecting client's requests are prepared, the construction cost and period are calculated based on the design, and then the work is carried out based on the decision of the client on the design. To apply BIM to remodeling project, it is necessary to perform 3D modeling by deriving elements of the process based on client's requests, calculate cost and period based on the estimation of the quantity of materials required for remodeling, and select the remodeling design based on the client's decision and use it in the management of the work. Fig 1 shows the structure of the framework that applied Remodeling BIM.

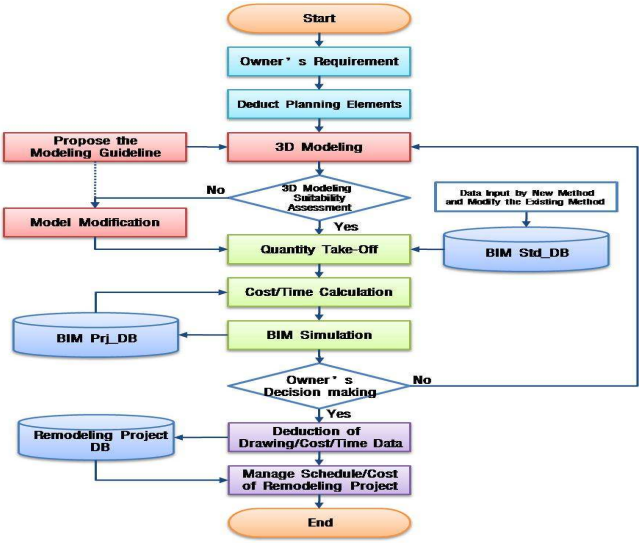

Fig 1. Framework Applying Remodeling BIM

Structure of BIM Standard DB

The development of Remodeling BIM Standard DB requires a link system to connect 3D model and BIM Data, and this study used the Recipe, Method, and Resource system of Vico Software. Also, Location Factor was prepared to use this system.

The structural elements of the building (wall, slab, etc.) were used to divide spaces within the building, and it is necessary to divide spaces with location factor to distinguish recipes as each space (exterior, interior, balcony, public area, duct area, bathroom) requires different type of work. Fig. 2 explains the type of work required by each location factor through the example of a wall.

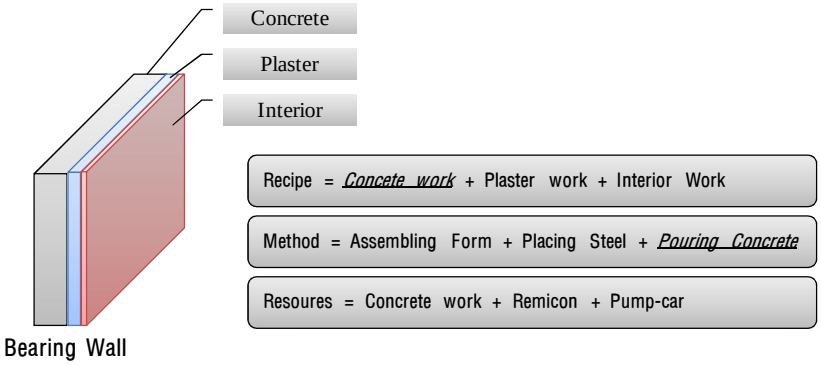

Fig 2. Structure of BIM DB

When establishing the link between 3D model and BIM Data, 1 BIM Data is linked to all objects created through 3D modeling that it is necessary to model all elements of the building in the 3D modeling. However, it is possible to increase the efficiency in linking BIM Data by setting the data connected to the object based on the link system called Recipe.

Take the modeling of bearing wall for instance. With existing BIM, it is necessary to model all 3 objects of the wall such as the concrete wall, the plaster wall, and wallpaper finishing and link concrete work data, plastering work data, and wallpaper finishing work data to each object whereas it is possible to model the bearing wall with 1 object and connect it to a recipe titled “Bearing Wall” with the BIM suggested in this study and serve the same purpose as the existing BIM.

Location Factor of BIM Standard DB

A recipe for connecting 3D model and BIM Data is required in order to prepare the BIM Standard DB for remodeling projects. This recipe is used to connect 3D model and BIM Data and the location factor has to be created to use the recipe.

The structural elements of the building such as the wall and slab divide spaces within the building, and it is necessary to divide spaces with location factor to distinguish recipes as each space (exterior, interior, balcony, Public area, duct area, bathroom) requires different type of work.

The following explains the type of work required by each location factor through the example of a wall.

-Exterior: Concrete work or masonry work, external plastering work and surface treatment (lower floors: marble, higher floors: paint)

-Interior: Concrete work or masonry work, plastering work and wallpaper finishing

-Balcony: Concrete work or masonry work, plastering work and balcony surface treatment (waterproofing work)

-Public Area: Concrete work or masonry work, plastering work and Public area surface treatment (lower floors: marble, higher floors: paint)

-Duct: Concrete work or masonry work, insertion of facilities and installation of auxiliary hardware

-Bathroom: Concrete work or masonry work, plastering work and waterproofing work, tile finishing

The recipe connects each location factor to the matrix. Table 2 shows the structure of recipe for the wall element.

Table 2. Wall Element Recipe Matrix

	Exterior	Interior	Balcony	Public Area	Duct	Bathroom
Exterior	E + E	E + I	E + B	E + P	E + D	E + B
Interior		I + I	I + B	I + P	I + D	I + B
Balcony			B + B	B + B	B + D	B + B
Public Area				P + P	P + D	P + B
Duct					D + D	D + B
Bathroom						B + B

E: Exterior I: Interior B: Balcony P: Public Area D: Duct T: Bathroom

Development of Remodeling BIM Standard DB

The recipe system for remodeling work was created based on the Location Factor suggested above. Remodeling Recipe was divided into removal, repair and reinforcement, and new construction. New Construction Recipe was divided into bearing wall, non-bearing wall, and slab and floors are divided into higher floors and lower floors. Fig 3 shows the structure of Remodeling Recipe.

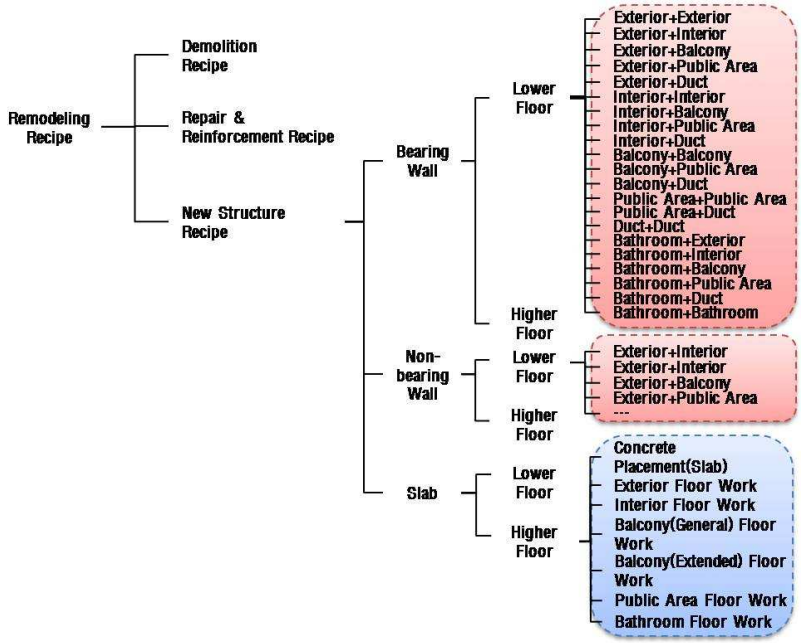

Fig 3. Structure of Remodeling Recipe

Remodeling BIM Standard DB was structured based on Remodeling Recipe structure. Remodeling BIM Standard DB was divided into Recipe, Method, and Resource, and Method and Resource were designed with standard estimating system. Fig 4 shows the structure of Remodeling BIM Standard DB.

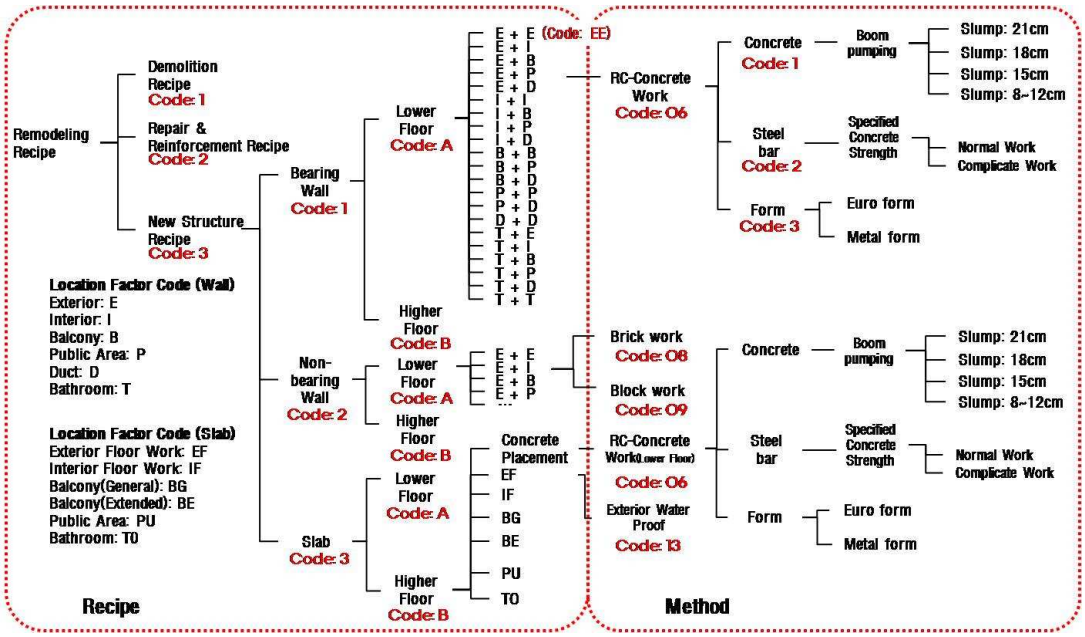

Fig 4. Structure of Remodeling BIM Standard DB

MODELING GUIDE FOR THE APPLICATION OF REMODELING BIM STANDARD DB

If the existing BIM is used for the estimation, it will be necessary to model all elements of the building for 3D modeling. This will take too much time for 3D modeling, and this will hinder quick decision making process in the remodeling project. As a relief for this issue, this study suggested a Modeling Guideline to estimate more accurate quantity and reduce modeling time through simplified modeling. The following is the Modeling Guideline for applying BIM Standard DB

1. Divide modeling into “Existing Building”, “Element to Remove”, and “New Element”

→ In the modeling stage, overlap existing building element (recycled structure), element to remove (elements removed from existing structure), and new element (newly constructed element) in the same position according to the remodeling process.

2. Divide the structure into Bearing Wall, Non-Bearing Wall, and Slab and divide them into higher floors and lower floors

→ Divided structure into bearing wall, non-bearing wall, and slab in the modeling process and also divide them into higher floors and lower floors.

→ Include floors 1~3 to lower floors category and floors 4 and higher floors.

3. Distinguish layer by giving layer name during the modeling

→ Name each layer to link BIM Data by the layer name.

4. Even when the structure can be modeled into 1 object, the structure has to be divided according to the Location Factor. Refer to Fig 5.

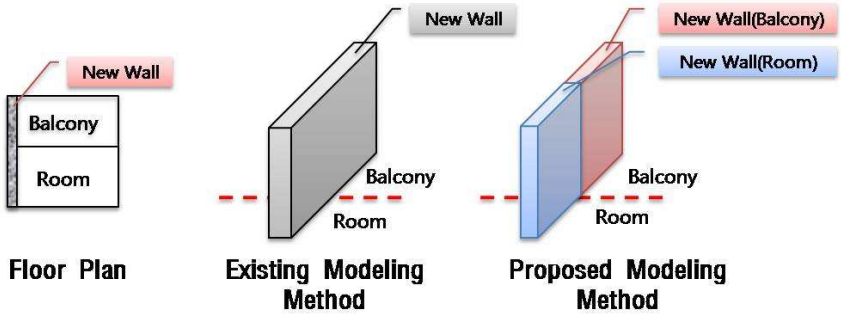

Fig 5. Example of Modeling Guideline

APPLICATION OF REMODELING BIM STANDARD DB

Project Overview

This case study was performed in order to evaluate the applicability of the Remodeling BIM Standard DB.

For the case study, an approximately 15-story tall building that matches conditions validating a remodeling work among apartment houses that include existing plane and the plane for remodeling design. The apartment house in D region of Seoul was selected for the case study, and the building's net leasable areas were 59.19m2, 69.17m2, and 79.79m2 and there were 40 households, 72 households, and 84 households in two buildings for each net leasable area size, in respective order. The building was constructed in the wall column structure.

Case Study Procedure

The case study will be comprised of the preparation of the 3D CAD drawing, the application of BIM Data, and the comparison of modeling time and quantity data after the application of BIM Data.

The case study will be performed in the order of (1) the preparation of 3D CAD drawing in existing method, (2) the preparations of 3D CAD drawing in the suggested method, (3) the application of BIM Data in existing method, (4) the application of BIM Data in the suggested method, (5) the comparison of modeling time (conventional method, when using existing BIM, and when using Remodeling BIM Standard DB), (6) the comparison of quantity calculation time and data (conventional method, when using existing BIM, and when using Remodeling BIM Standard DB). The following programs will be used to perform the case study.

-3D modeling and objectification tool : ArchiCAD 10

-Cost information input tool : Estimator 2007

-Object and BIM Data Integration Tool : Constructor 2007

Contents of Case Study

According to the procedure of case study, (1) the 3D CAD drawing was prepared using the 2D CAD drawing of existing building to prepare 3D CAD drawing in existing method and (2) a 3D CAD drawing was prepared by using 2D CAD drawing of existing building and the suggested Modeling Guideline in order to prepare the 3D CAD drawing for the method suggested in this study. Figure 6 is that the 2D CAD drawing and 3D CAD drawing that is the current and proposed type's 3D CAD modelling.

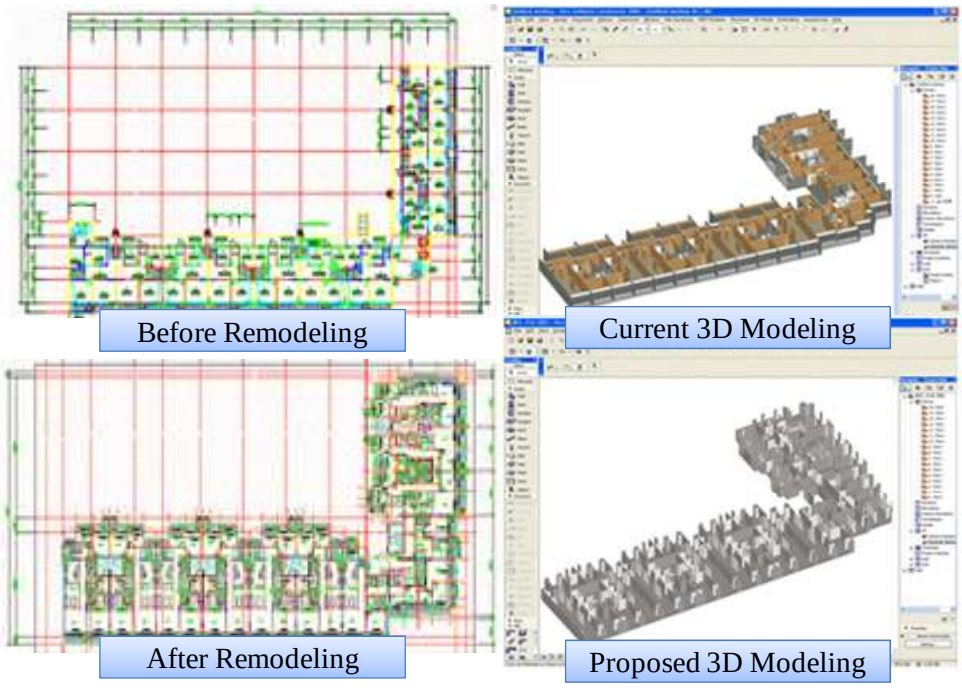

Fig 6. 2D CAD floor plan & 3D CAD Modeling

3D modeling in existing method requires the modeling of all elements, but the suggested method performed the modeling with wall and slab data only that it could reduce modeling time.

Table 3. Comparison of 3D CAD Modeling Time

	2D CAD Based Method	Existing BIM Method	Suggested BIM Method
1 Unit Modeling	-	About 7 Days	About 1 Day
1 Building Modeling	-	About 25 Days (About 7 Days * 3Units + 4 Days)	About 5Days (About 1Day * 3Units + 2 Days)

*1 Building Modeling is composed of 3 Types of Unit

Currently (3) the program is working on the data link to each object of the 3D model using BIM DB employed by the program in order to apply the BIM Data of existing method. In the succeeding study, (4) the link between the suggested recipe and the 3D model will be established in order to apply the BIM Data of suggested method and (5) the modeling time of existing 3D modeling method and that of suggested 3D modeling method. (6) For the comparison of quantity calculating time and data, the quantity will be calculated in the conventional method, in the method with existing BIM, and in the method with suggested BIM. The conventional method uses 2D drawing to estimate the quantity, which is the same as the existing estimation method. The estimation method using existing BIM uses the BIM DB employed by the existing program, and the estimation method using the suggested BIM

uses suggested BIM Standard DB to estimate the quantity. While the existing method takes a very long time for estimation as it calculates all elements concerned with the quantity estimation based on 2D drawing, the use of BIM is expected to reduce the time sharply by automatically estimating the quantity by linking 3D model and BIM DB.

CONCLUSION

Nowadays remodeling has become a prevailing option because it can recycle resources and reduce cost and time compared with reconstruction. However, uncertainty is increasing due to the removal and repair and reinforcement works and the difficulty in decision making process is also serious due to a great number of client organizations. Also, it is difficult to estimate construction cost and period precisely due to lack of experience with remodeling works.

BIM is emerging as the tool for producing and managing the information created during the life cycle of the building as a solution to the said problems, but currently, BIM is only applied on the level of 3D modeling, and the BIM DB to reflect the information on the level of construction is not available.

Under the circumstances, this study suggested a BIM Standard DB appropriate for remodeling work to solve this problem. The study will also suggest the framework for applying the BIM DB for remodeling and the structure of the Remodeling BIM Standard DB. Also, the study will suggest the 3D Modeling Guideline for effective modeling and evaluate the applicability of suggested BIM Standard DB through case studies.

The outcome of this study is expected to sharply reduce time of work to help the client to make decisions quickly, and consequently make great contributions to the success of the remodeling project although the estimation of the quantity of material may become less accurate as the decision of the client has heavy impact on the success of the project and the design is modified at least 5~6 times during the project due to the characteristics of remodeling work. We hope the Standard DB for applying the Remodeling BIM suggested in this study helps the application of BIM in remodeling projects.

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