

# DEVELOPMENT OF BIM-BASED DECISION-MAKING SUPPORT SYSTEM FOR APARTMENT REMODELING

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**ABSTRACT:** Compared with other industries, the construction Industry has many parties(A/E/C) as well as many types of construction activities. Especially, as for the remodeling project, the owner group the remodeling union consists of various stakeholders union and requiring the additional activities of demolition except for the existing new building construction project. Like this, the remodeling project has its own characteristics different from a new building construction project. As for the remodeling project, the Owner's decision making for a remodeling alternative has to be preceded, and other parties are required to propose a remodeling alternative which satisfies the Owner's requirements. However, because of time constraints, many types of problems occur during the decision-making process. In consideration of this, in this research, the authors would like to suggest a decision-making support system to help the Owner's decision-making in the early stage of a remodeling project. For this paper purpose of a remodeling decision-making framework based on Building Information Modeling(BIM) was suggested to help with the Owner's decision-making for each remodeling item and the decision-making support system was evaluated through Case Study.

*Keywords: BIM; Decision-making; Remodeling; Remodeling Item*

## 1. INTRODUCTION

Compared with other industries, the construction Industry has many parties(A/E/C) as well as many kinds of construction activities. Especially, as for the remodeling project, the organization of Owner consists of many Owners called remodeling union, and the construction activities of remodeling work have a characteristic different from a new building project, requiring the activities of demolition and maintenance in addition to the existing new building construction project. Like this, the remodeling project has its own characteristic different from a new building construction project.

As there are many Owners in remodeling construction project, an early stage decision making of a remodeling alternative is very important for the success of the project.

As for the remodeling construction project in Korea, the Owner's decision making on the remodeling alternative suggested by other parties(like architecture, engineer, contractor etc.) in the project should be preceded in the early stage of construction projects.

As for the process to prepare remodeling alternatives, the parties in the project prepare the remodeling alternatives based on the rough requirements from the Owner. Through the Owner's decision making on those remodeling alternatives, one remodeling alternative is finally selected.

However, when the Owner suggests new requirements in the process of Owner's decision making, the other parties in the project need to prepare remodeling alternatives. In this case, they have to perform twice the works of drawing, estimations of construction cost and construction period for the new remodeling alternatives, and because of this problem, there happens waste on both of manpower and material resources. And when the preparation of new remodeling alternatives is delayed, the Owner's decision-making will be delayed, too., and accordingly, the performance of remodeling business will not proceed as scheduled.

In consideration of this paper, I would like to suggest a decision-making support system to help the Owner's decision-making in the early stage of a remodeling business to decrease the problems happening in the process of Owner's decision making. It can be helpful for the Owner's decision-making in the early stage to provide him with the 3D Model, construction period and construction cost for each item of remodeling works in the early stage of a remodeling business.

This paper planned to help the Owner's decision-making in the early stage by providing him with the 3D Model, construction period and construction cost for each item of remodeling works in the early stage of a remodeling business.

For this purpose, I will suggest a remodeling decision-making framework based on BIM(Building Information

Modeling) to help with the Owner's decision-making for each item of remodeling works, and evaluate the decision-making support system by applying this process to the buildings, of which remodeling business is now being promoted.

The progress sequence of this research is as follows.

- Investigation on the existing remodeling process:  
Research on the process of preparation of existing remodeling alternatives through documentary records and interview with specialists
- Investigation on the problems of existing remodeling process.
- Drawing of Conclusion on the RCBS(Scope Breakdown Structure) of Remodeling : Drawing of Conclusion on the RCBS is made by finding out the items of remodeling through questionnaire on Owner's opinion.
- Suggestion of Framework for Decision-making support system based on BIM : Based on the problems of existing remodeling process and remodeling RCBS, a support system framework to prepare alternatives will be suggested to reflect fast the Owner's requirements in the remodeling project

## 2. BACKGROUND RESEARCH

### 2.1 Building Information Modeling (BIM)

The idea of BIM has been mainly used by Chuck Eastman and Robert Aish since 1970s, and got to be generalized by Jerry Laiserin in 2000s.

BIM is a comprehensive management instrument[2] to immediately produce various kinds of documents and books, creating and managing all the information included throughout the life cycle of a building, and it can be used as a tool for simulation to check the intervention of works and progresses by combining the 3D graphic information, progress data and the construction cost data[3]. [4] By using this BIM instrument, about 19% of construction period can be saved by optimizing such period[4], and about 30% of construction cost can be saved by checking the non-conformance to the drawings[5].

### 2.2 Current Process for Apartment Remodeling Project

Designing process for Remodeling is generally proceeded in the sequence of the occurrence of motivation resulting from the deterioration of a building, the first phase Investigation & diagnosis, planned designing, the second phase Investigation & diagnosis, basic designing, implementation designing.

For each stage, the planning includes the site survey and the feasibility study on the remodeling, the first phase investigation & diagnosis includes the Investigation on the degree of maintenance and reinforcement of the deteriorated building, the planned designing includes the establishment of remodeling alternatives, survey on various kinds of designing requirements, the rough estimation for the remodeling works, and the preparation of proposal on the remodeling, the second phase investigation & diagnosis includes the grasping of

detailed present status, the basic designing includes the selection of a system construction method & evaluation and decision on the maintenance of capacity and replacement method, and the implementation designing includes the review & decision on an alternative and the preparation of detailed estimation. The details on the table 1 are as follows.

**Table 1.** Current process for a remodeling

Remodeling design process	Activities
Preliminary design	·site survey & feasibility study
Preliminary Investigation	·diagnosis on deterioration ·diagnosis on maintenance & reinforcement
Schematic design	·establishment of remodeling alternative ·survey on various kinds of designing requirements ·approximate estimate ·preparation of proposal on remodeling
Site analysis	·detailed site survey
Design development	·selection of a system construction method ·decision on the maintenance of capacity and replacement method
Detail design	·review & decision on the alternative ·detailed estimate

### 2.3 Problems with Current Design Process Remodeling

The problems with the Designing Process of Existing Remodeling were drawn out by means of interviews with the specialists working in building designing offices. Each building designing office has much experience in the performance of remodeling project, and the interview was performed with the specialists who have directly participated in the remodeling projects. The interview proceeded with being focused on the items related to the remodeling designing process, on the Owner when preparing remodeling alternatives, on the problems happening while preparing the remodeling alternatives, and on the time required to perform the remodeling designing works, etc.

As a result of the interview, one of the big problems with the remodeling designing process is the one concerning the timing of contract with the Owner. In the existing remodeling designing process, the remodeling contract is made by the Owner at the time after the planned designing phase is completed. Because of this, there happens difficulties in the performance of either the planning phase works or the first phase Investigation & diagnosis works. Also in the stage of planning, the practical preparation phase of remodeling alternatives, as the works required should be done before the contract is finalized, it is difficult to provide technical support in the field of facilities and structure for the purpose of the preparation of the alternatives. As the provision of technical support in the field of construction is difficult

too, there happens a problem that approximate estimation, etc. may not be made as required. The figure 1 is shown in the problems with existing remodeling design process.

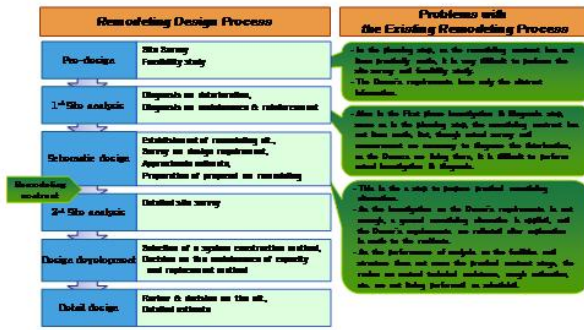


Fig 1. Problems with Remodeling Designing Process

Because of the problems like this, there happens difficulties with the Owner's early decision making on the remodeling alternatives, and when the Owner demands new requirements, it is very difficult to check over the facilities, structure and construction sector of the project.

### 3. REMODELING SCOPE BREAKDOWN STRUCTURE (RCBS)

In the existing remodeling designing process, it is very difficult to clearly grasp the Owner's requirements. And as the Owner's requirements are very rough, it is difficult to prepare the remodeling alternatives as required by the Owner.

Because of this, this Remodeling Scope Breakdown Structure(RCBS) is hereby suggested to more easily communicate with the Owner in the early stage of the remodeling project by objectively grasping the Owner's requirements.

This remodeling RCBS was prepared by arranging the remodeling items required by the Owner, which was made so that the Owner can grasp the remodeling items more easily. The remodeling RCBS is as shown in the following Figure.

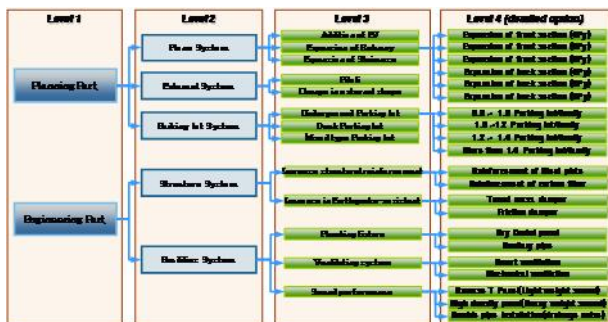


Fig2. Remodeling Scope Breakdown Structure

The structure of remodeling RCBS is divided into 4 levels. Level 1 was organized into planning and engineering sector, as for Level 2, the planning sector was organized into plane, external shape, parking lot system and the engineering sector was organized into structure, facilities system, which is prepared to suggest the

structure and facilities system by reflecting the construction cost and construction period demanded by the Owner to the utmost limit, and they will be applied through the analysis on the correlation between the construction cost and construction period of the structure and facilities system. Level 3 consists of detailed items of each of the items in Level 2, corresponding to remodeling item, and level 4 is the detailed option of the items in level 3, suggesting the practical work scope and the remodeling items.

### 4. BIM-BASED DECISION-MAKING SUPPORT SYSTEM FRAMEWORK

The problem with the remodeling designing process is the fact that the remodeling contract is made after the completion of preparation of remodeling alternatives and that when the parties in the project prepare the remodeling alternatives in accordance with new requirements, it is difficult to cooperate with others than the designing sector, and if the preparation of remodeling alternatives is delayed, the Owner's decision making is delayed, too, making the performance of remodeling project difficult.

BIM-BASED DECISION-MAKING SUPPORT SYSTEM was prepared to apply to remodeling alternatives in the future by suggesting the remodeling alternatives in real-time basis in response to the Owner's new requirements using the BIM to minimize the problems that may happen in the existing remodeling designing process as well as by storing the technical reviews in the Database.

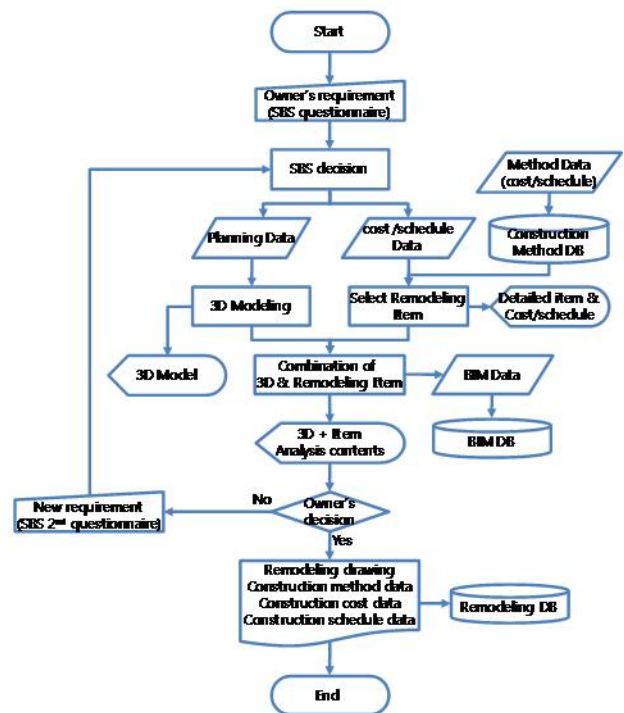


Fig3. BIM-Based Decision-making Support System Framework

The BIM-BASED DECISION-MAKING SUPPORT SYSTEM Framework was prepared through the consultations with both the specialists with experience in remodeling designing and those with experience in BIM designing. Remodeling RCBS was applied in preparing the BIM-BASED DECISION-MAKING SUPPORT SYSTEM Framework to make the Owner's decision making easier. The BIM-BASED DECISION-MAKING SUPPORT SYSTEM Framework is as shown in the following Figure 3.

## 5. BIM-BASED DECISION-MAKING SUPPORT SYSTEM

The BIM-Based Decision-Making Support System was built on the basis of the Framework of the BIM-Based Decision-Making Support System. Though this Decision-Making Support System has not been completed, it has suggested the information on each step of the Decision-Making Support System.

The BIM-Based Decision-Making Support System consists of total 5 steps. Step 1 consists of Scope Breakdown Structure (RCBS), Step 2 of RCBS Evaluation, Step 3 of 3D Modeling, Step 4 of Evaluation on Remodeling Performance and Step 5 of BIM Simulation.

### 5.1 Step1: Scope Breakdown Structure (RCBS)

Step1 was composed so that the RCBS items can be confirmed in order to make the Owner's requirements clearer and to check them quantitatively.

In this step, it was arranged so that we can enter into the Database mainly the items corresponding to RCBS planning part and rough information corresponding to the expenses. In case of the planning part in RCBS, the items corresponding to Level 3 of RCBS was selected, composing it so that the items of Level 4, its detailed option, can be selected. In case of the parts of expense and period, it was composed so that the rough construction cost and construction period required by the Owner can be selected. The contents of Step 1 in the Decision-Making Support System are as shown in Figure 4.

### 5.2 Step2: RCBS Evaluation

Step 2 was composed so that the items selected in Step 1 can be reconfirmed once again, and there are evaluations on the remodeling RCBS. In this Step, the Owner can check what kind of structure and facilities have been practically used by suggesting the detailed remodeling items from the point of view of structure & facilities suitable for the construction cost and construction period selected by the Owner in Step 1. The system screen of Step 2 is as shown in Figure 5.

### 5.3 Step3: Preview 3D Modeling

Step 3 is the phase to roughly show the changes in the plane according to the remodeling alternatives. In this step, you can check the existing state both of the main

building and of one family unit, and the planes of remodeling alternatives, conforming to the plane system and external shape in Step 1. This can improve the Owner's understanding on the remodeling alternatives by making him easily confirm the state of a building before and after the remodeling through the check of the changes in a building using the 3D Model.

For the model prepared in this Step, BIM Modeling should be performed to combine the 3D Model with the remodeling Item Data. The system screen of Step 3 is as shown in Figure 6.

### 5.4 Step4: Performance Evaluation

In Step 4, the Owner can roughly grasp not only the external shape of a building concerned but also the performance of the building. In this Step are described the 3D Model of a remodeling alternative and the performance of a building, and through this, the Owner can grasp the level of the performance of a building, including the level each of Structure, Sound and, Environment-friendliness.

In this Step, the performance evaluation should be prepared according to the remodeling items from the point of view of structure and facilities suggested in Step 2. The system screen of Step 4 is as shown in Figure 7.

### 5.5 Step5: 5D Simulation

Step 5 is the phase to make the Owner check the progress status of the remodeling works by combining the remodeling Items suggested in Step 2 with the 3D Model suggested in Step 3. In this Step, we make the Owner more easily understand the progress status of the remodeling works by showing him how the state of a building will be changed as the time goes by, using the remodeling progress schedule and 3D Model. The system screen of Step 5 is as shown in Figure 8.

## 6. CASE STUDY

This Case study was performed to make an evaluation on the BIM-BASED DECISION-MAKING SUPPORT SYSTEM suggested in this research paper.

### 6.1 Project Description

The above APT was selected as an object to be applied on the basis that there are existing plane of an APT building together with a plane of a remodeling alternative, and that we can confirm the information on the remodeling alternative. Because of this reason, the Suseo-D APT was selected as the object of case study.

The exclusive use areas of each family unit of the APT building is 73.78m<sup>2</sup>, 103.81m<sup>2</sup>, 103.83m<sup>2</sup> respectively, which APT complex consists of 4 buildings with 330 units. Out of the 4 buildings, one was selected to proceed with the Case Study.

### 6.2 Procedures to Proceed with the Case Study

Case study was performed by entering into the Database of BIM-BASED DECISION-MAKING SUPPORT SYSTEM the information described in the remodeling alternative of Suseo-D APT. In this performance, the evaluation was made by comparing the designing process for the existing remodeling project with the work time of the Framework suggested in this research paper. The work time for the existing remodeling designing process was confirmed through the consultation with the remodeling designer. However, as it was impossible to confirm the work time correctly, the work time for the remodeling designing works was roughly calculated.

**6.3 The Work Time for the Existing Remodeling Design Process**

The work time for the existing remodeling designing process was confirmed through the consultation with a specialist with experience in designing works of remodeling project.

The time required for the designing work to prepare the existing remodeling alternatives seemed to take about 2 weeks with around 2~3 people, and the time required to review the items from the point of view of structure and facilities and to prepare the presentation, brochure and the proposal on the remodeling project seemed to takes about 4 weeks. Therefore it was concluded that it takes about 6 weeks to complete the preparation of the remodeling alternatives, and there were many opinions that the time allowed was too short and that it was difficult to review over the structure, facilities, etc.

**6.4 Performance of Case Study**

The remodeling alternatives of Suseo-D APT was performed in accordance with the BIM-Based decision-making support system Framework.

**Step1. Scope Breakdown Structure**

This Step is to clarify on the Owner's requirements using the RCBS, entering into the Database the information suggested in the proposal on the remodeling of the building concerned. The contents entered include the addition of EV, expansion of balcony, change in the external shape of a building, underground parking lot, construction cost, construction period. The contents are as shown in the following Figure 4.

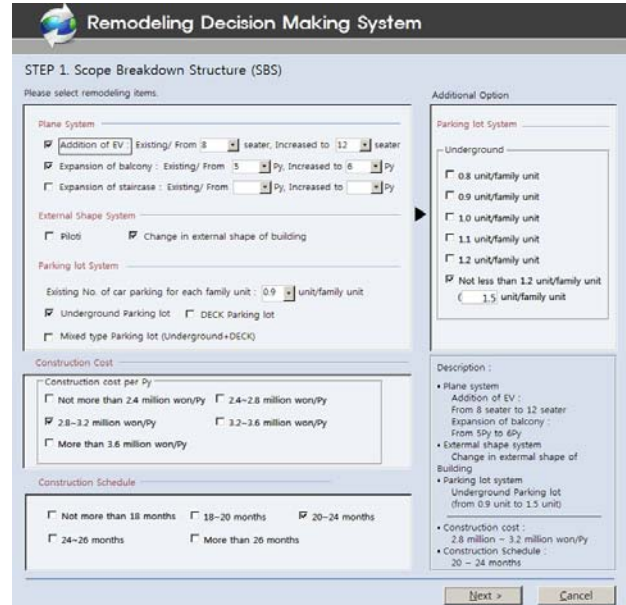
**Step2. RCBS Evaluation**

This is a Step to express in text the information chosen by the Owner. The most suitable construction method is selected on the basis of the information on the cost and period of construction chosen by the Owner. The information of the Case study in Step 2, which has been entered into the Database, is as shown in the following Figure 5.

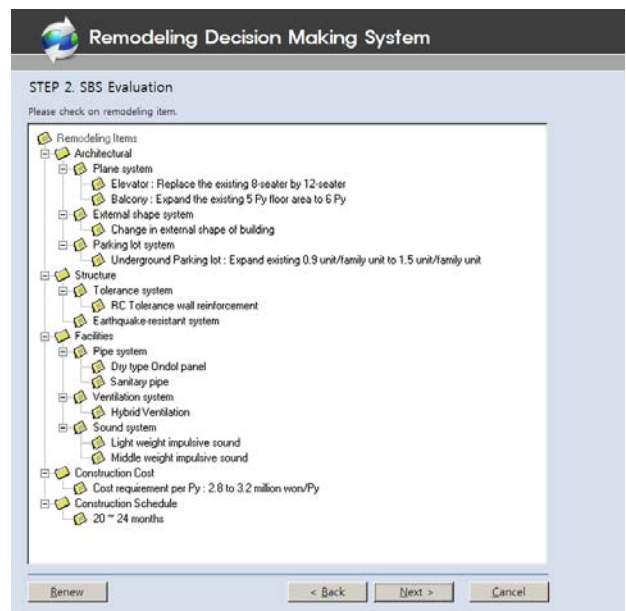
**Step3. Preview 3D Modeling**

This Step is to express in 3D Model the information chosen by the Owner. The 3D Modeling was performed on the basis of the remodeling plane suggested in the proposal on the remodeling. It was confirmed that the

work to change into 3D Model the drawings suggested in the proposal on remodeling took about 5~6 hours. The information on the Case study in Step3 is as shown in the following Figure 6.



**Fig4. Step1: Scope Breakdown Structure (RCBS)**



**Fig5. Step2: RCBS Evaluation**

**Step4. Evaluation of Performance**

This Step is to show the 3D Model of the remodeling alternatives and the information on the evaluation of performance. In this Step, I prepared the information on the performance evaluation as per the selected items of structure and facilities by evaluating it as structure level, sound performance and environment-friendly level. The information on the Case study in Step 4 is as shown in Figure 7.

**Step5. 5D Simulation**

This Step is to perform the Simulation by combining the 3D model, Structure & Facilities Data, construction cost Data, Construction period Data of remodeling alternatives. The information on the Case Study in Step5 is as shown in the following Figure 8.



Fig6. Step3: Preview 3D Modeling

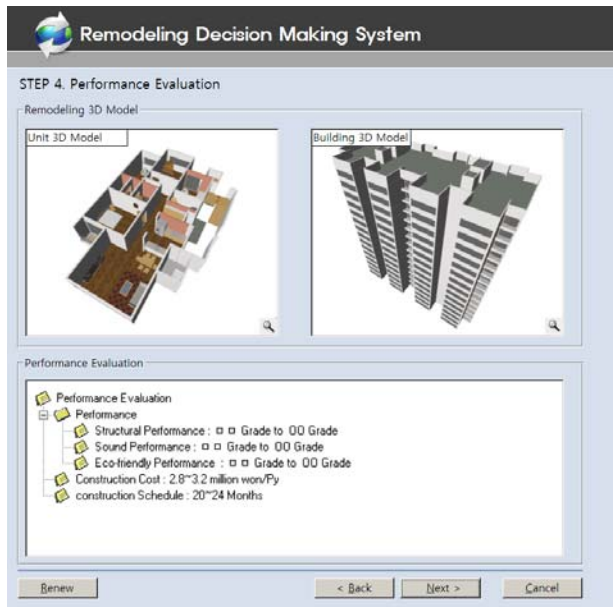


Fig7. Step4: Evaluation of Performance

### 6.5 Result from Case Study

According to the result of the Case study performed, it took about 5~6 hours in performing the initial 3D Modeling, about 3~4 hours in connecting the cost with the progress data and about 1~2 hours in performing the Simulation.

When reflecting the information on the Owner's new requirements, the revision work of 3D Model took about 1~2 hours, the connection of cost with progress data took about 1~2 hours. However, the Simulation work took about 1~2 hours same as when the initial work was

performed. In other words, according to the Case study performed, we could see that when the Owner's new requirements happens, we can proceed with the work very fast in view of the existing remodeling designing process.



Fig8. Step5: 5D Simulation

## 6. CONCLUSION

As the housing remodeling project are dependent on the owner group with diverse objectives, it has its own feature different from a general new building construction work.

Especially, as the contract on the remodeling project is made after the preparation of remodeling alternatives is completed, it is difficult for the Owner to make a decision in the early stage, and it is very hard to cope with the Owner's new requirements.

In consideration of this, in this research, the problems of the existing remodeling designing process have been grasped to solve the above difficulties, and a Remodeling Scope Breakdown Structure (RCBS) was suggested to more clearly grasp the Owner's requirements. It can be helpful for the Owner's decision-making in the early stage to provide him with the 3D Model, construction period and construction cost for each item of remodeling works in the early stage of a remodeling business.

In this connection, by applying the Remodeling Scope Breakdown Structure, the Framework of BIM-Based Decision-making Support System and the overall structural state of the system were suggested, and the effective value of the BIM-Based Decision-making Support System has been confirmed through Case Study.

As a result of the Case study performed, the authors could see that when the Owner's new requirements happens, the authors identified the remodeling alternatives were effectively faster than when applying the existing remodeling designing process.

However it took much time to enter the data into the DB of time period and cost and revise them to select the construction method through the BIM-Based Decision-making Support System. If the contents of the Database of the BIM-Based Decision-making Support System have been prepared in advance, it is expected that the efficiency of the remodeling construction will be enhanced.

It seems necessary not only to update the contents of the DB of time period and cost of the construction method but to additionally make a study on how to make use of BIM DB and Remodeling DB.

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