USING MD CAD OBJECTS TO INTEGRATE INFORMATION FOR CONSTRUCTION PROJECTS

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ABSTRACT: Most information within a construction project roots in drawings and contract documents. Although several methodologies, such as A/E/C and 4D, have employed such a peculiarity to integrate project information, they failed to integrate information in terms of efficiency and consistency. In this research, a MD (Multi-Dimensional) CAD model is developed to improve the process of integrating information for construction projects. This research describes the processes of creating MD CAD objects and embedding information required throughout the project life cycle within MD CAD building components. In addition, a case study is presented to show the efficiency and effectiveness of using MDIIS (Multi-Dimensional Information Integration System) to integrate information for construction projects.

Key words : 4D CAD, Multi-Dimensional (MD), Information system

1. INTRODUCTION

In recent years, tactics to effectively integrate and manage construction information have been a major development in construction industry, and the A/E/C system is among the most popular methods to integrate project information [1]. However, most research on A/E/C emphasizes on a specific project process or a management task, the development of an overall information integration system is still under study.

Most information throughout the life-cycle of the construction project is originated from drawings and contract documents. However, drawings only present geometric information and have no links to other information within the construction process. In addition, there are no clear connections between the information in construction contracts and drawings. The process of information exchange and transfer between different participants within the construction process becomes time and labor-consuming. Therefore, the drawing-based information integration system should be feasible enough to meet all requirements in project management [3]. In addition, the attributes and flow of information in each construction phase should be taken into consideration.

Among the drawing technology, 3D CAD model is one of the most widely used in architecture and engineering design. But, as for its application in construction phase, 3D CAD only presents shapes and checks clash. Moreover, although 4D CAD, which combines 3D CAD with project schedule, is capable to present time relationship between building components[2][6], it still can’t provide an overall presentation of construction attributes. Besides, 4D CAD also can’t flexibly react with the modification of project design or what-if analysis [5]. It may attribute to 3D CAD is usually built based on the result of the architecture and engineering design. The information required throughout the construction phase is not naturally embedded within 3D CAD. As a result, 3D CAD is mainly used in the design phase of the project. Therefore, a more generic form of 3D CAD is necessary to improve the process of integrating project information.

This paper first describes the process of constructing elementary 3D CAD building components. These 3D CAD building components are developed based on commonly used contract items and structural components. In addition, the attributes of 3D CAD components are analyzed to the level that different aspects of the construction process can be identified. As a result, the information required throughout the construction phase of the project is embedded within 3D CAD components. Such 3D CAD components are defined as MD CAD objects since they contain the information required by multiple disciplines within the projects. Then the procedure that can automatically determine the project schedule according to MD CAD objects is explained. All information required throughout the construction phase is integrated by the above-mentioned procedure. A case study that utilizes the proposed Multi-Dimensional Information Integration System (MDIIS) is presented to show the system’s effectiveness in terms of cost and progress control.

2. THE ANALYSIS AND CREATION OF THE MD MODEL

2.1 Definition of MD Object

MD CAD object is a drawing object with multiple attributes. Conceptually, the building components are systematically analyzed, and their attributes, such as space dimensions, function, specification, method to build, can be generated according to the information within drawings and contract documents. Therefore, in this study, the object-oriented technology is applied to combine the attributes with CAD drawings to form the MD object. In addition, these MD objects are developed based on the contractors' needs and experiences, which make them more suitable to represent the real construction process.

To accelerate the creation of MD model and enhance their flexibility, default MD objects are stored into a database. Those default MD objects are the commonly used building components. According to any specific project requirements, designers may selected MD objects from the database and set up certain parameters to form a MD model for the project, as shown in Figure 1.

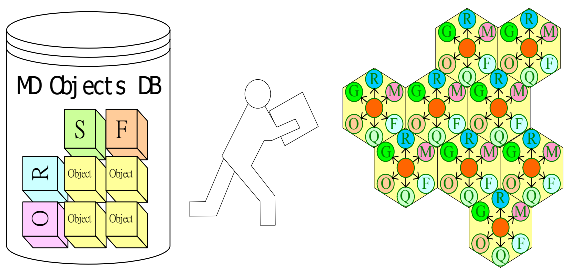


Figure 1. The creation of MD model from MD object database

2.2 Analysis of MD object's Attributes

In project's planning phase, WBS is widely used to identify each activity package. Each activity is identified as a basic unit for later works, including scheduling, sub-contract, quantity-estimation, etc. However, there is no clear connection between activities, work items, and drawings. Also, the actual situation involved in the work-item-based construction management is not taken into consideration. Therefore, WBS is not used for analyzing drawing objects in this research.

To fully describe the building components' attributes and relationships between components, the BPH method [4] is applied with a three-step component-identification rule. The BPH method identifies and describes building components according to six hierarchal levels: project, building, floor, area, system, and component. Then, the components are defined according to the three-step rule: hierarchy definition, object boundary definition and systematic analysis, as shown in Figure 2.

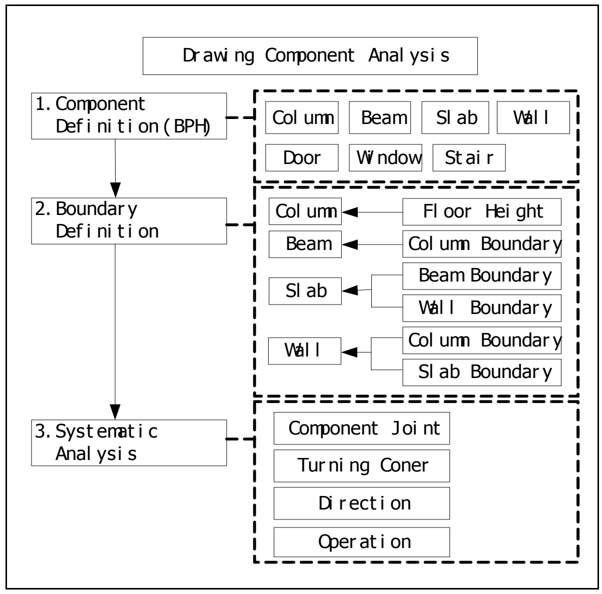


Figure 2. Procedure to analyze drawing objects.

Step 1 : Hierarchy definition

Firstly, the BPH method is applied. The main structure in construction drawings is analyzed based on floor boundary, and the actual construction work. If the square measure of single floor is above average, or the work items are too complicated to construct simultaneously, that specific floor should be divided into several areas. Later, basic building components, such as columns, beams, slabs, walls, etc., are defined.

Step 2 : Object boundary definition

After using the original component encoding (C1 for column 1, C2 for column 2, B1 for beam 1, W1 for wall 1, etc), components are further encoded according to its clockwise location, and object boundary is defined (column→beam→slab→wall). For example, 1F-C1-01 refers to the C1 type column in 1st floor, and its plane coordinate is 01 (X1, Y1); 2F-C2-02 refers to C2 type column in 2nd floor, and its plane coordinate is 02 (X2, Y2). The application of the encoding rule ensures the accuracy of information transformation.

Step 3: Systematic analysis

To ensure a building component is in regular geometry shape, such as rectangle, circle, triangle, etc., the analysis of components with turning corner should first follow the vertical, then horizontal direction. Also, the construction work method must be taken into account. For example, if the external wall and the internal wall coexist, the external part should be first constructed. Therefore, the completeness of external wall is essential for component dismantling in drawing analysis.

Attributes on space, function, and relationships between components are obtained by following the above-mentioned steps, and the project's work items are used to further analyze and acquire attributes on specification, material and operation. The "Codes for Construction Specifications" by Public Construction Commission, Taiwan, is used to define each work item, and the PCCES system (Public Construction Cost Estimate System) is applied to define the detailed information of work items.

To obtain time attribute, work items of the building components and working rate are used to calculate the activity duration. Besides, MD database is capable to connect work items with activities and helps managers control the exact progress during construction phase.

Following the above-mentioned procedures, the structures of MD objects' attributes are established. For example, the structure of MD column object's attributes is shown in Figure 3.

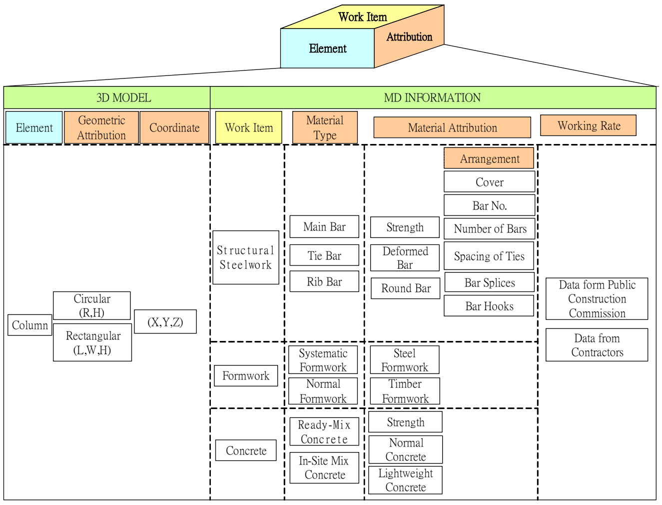


Figure 3. The structure of MD column object's attributes

2.3 Creation of MD Model

Through AutoCAD interface, designers may analyze drawing objects based on project's properties, select components from MD object database, and input parameters, as shown in Figure 4. Each component's attributes can be output into a file, and the file is linked with the drawing object by an ID code.

In addition, to accelerate the creation of MD model, MD objects are saved in project database in advance. Designers may select any MD objects of the same type from the database. Also, designers may easily vary each attribute' parameters through interface. At last, through information output and integration process, all construction information included in the MD model is integrated into an information database for the integration and management purposes of MDIIS system.

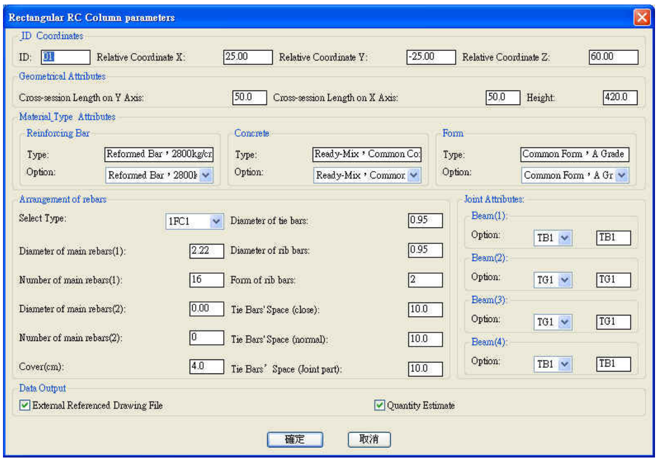


Figure 4. The parameter-input interfere for Column component

3. MDIIS SYSTEM

The information transferring process and the method to e stablish MDIIS system are discussed as follows:

3.1 Information transferring procedure

After the MD model is established, MD objects' attributes (space, resource, work item, etc.) are output into a spreadsheet (.xls file), and then input into MS Access for further calculation, such as calculating the quantity of components, certain materials, each component cost, or the overall construction cost, etc.

Information integrated in MS Access database program can be further output into MS Project for scheduling. The outcome from scheduling is again transferred back to Access database for integration. After calculation analysis, managers may generate resource requirement, scheduling and cost analysis under any combinations of time and space conditions. The project's information transferring procedure is shown in Fig. 5.

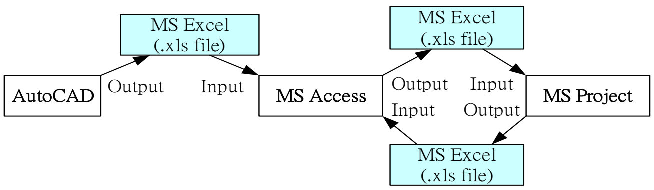


Figure 5. Information transferring procedure

3.2 Creation of MDIIS system

In MDIIS system, MS Office—MS Access and MS Project—are employed to facilitate project management, and Visual Basic is used to establish interfaces for information integration and transfer. The MDIIS system consists of 5 sub-systems: project planning system, information query system, construction tracking system, project check system, and cost-control system. As shown in Figure 6.

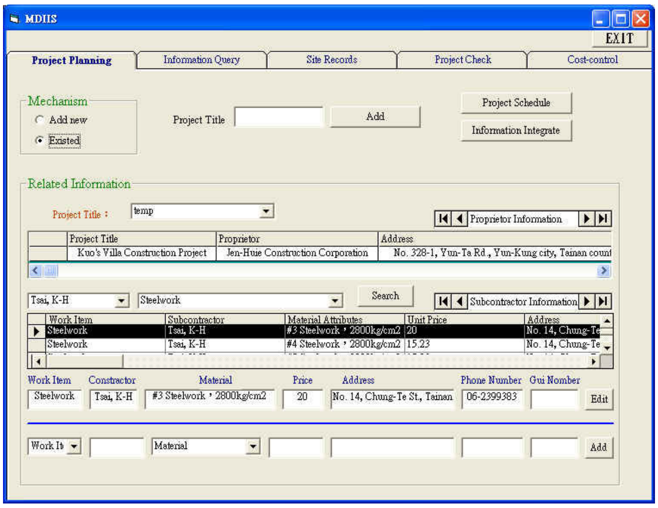
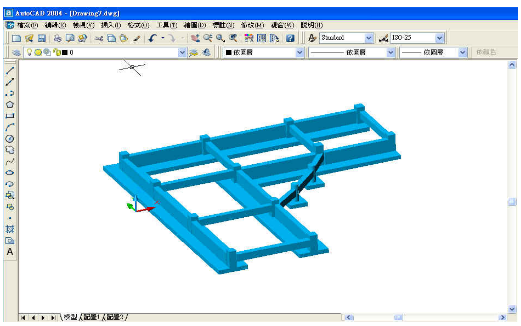


Figure 6. The interface of MDIIS system

4. CASE STUDY

A private villa's construction project is studied to evaluate the MDIIS system. For its distinctive exterior, villa's construction is different from usual residence's construction. Using traditional method to handle construction data might lead to calculation-error and be time consuming. Therefore, this case study is used to evaluate the MDIIS system in terms of its efficiency and convenience. The structural engineering of the construction project is studied. In application, the creation of MD model and MD object database, and the employment of information integration system are further discussed. In stage 1, building components can be selected from MD object database directly. In addition, the quantity of required resources is estimated. The creating process of project's MD model is shown in Figure 7. In the next stage, the MD model's information will be input to the MDIIS system. Compared with the manual quantitative estimation, the estimated outcome from MDIIS system is more accurate, as shown in Table 1. Also, any change of information in MD model will be simultaneously updated.



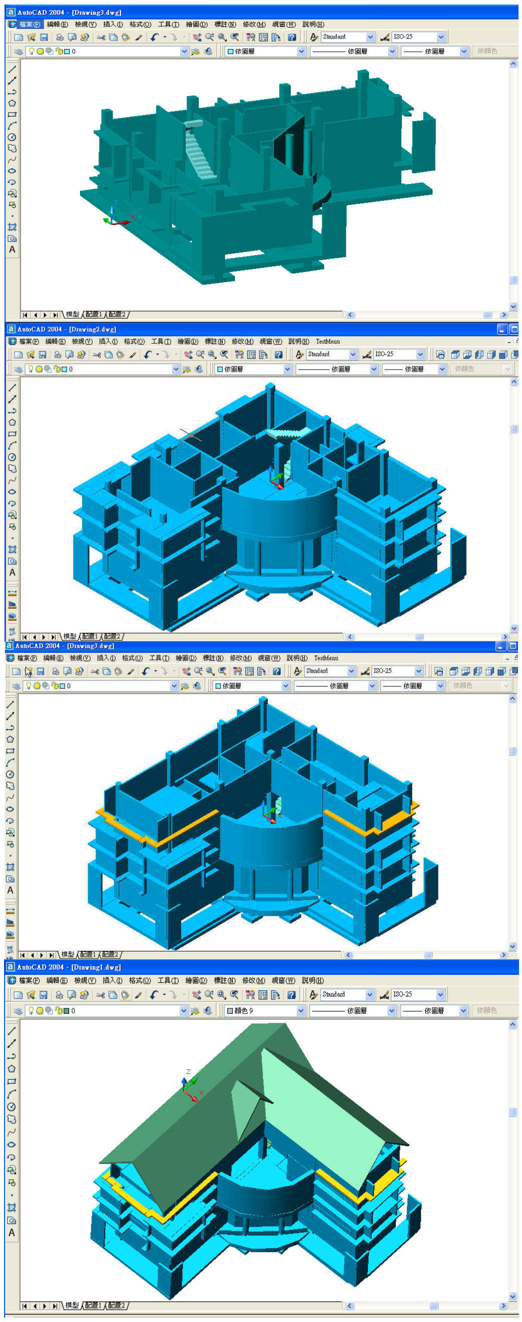


Figure 7. The creating process of project's MD model

Table 1. The difference of resources' quantity between site record and the estimations by MDIIS and contractor

	Rebar (T)	Difference	
		Quantity	%
Site Record	113		
MDIIS Estimated	116	+ 3	2.7
Contractor Estimated	122	+ 9	8.0
	Concrete(M^3)	Difference	
		Quantity	%
Site Record	451		

MDIIS Estimated	446	- 5	1.1
Contractor Estimated	462	+ 11	2.4
	Form(M²)	Difference	
		Quantity	%
Site Record	4,011		
MDIIS Estimated	3,913	- 98	2.4
Contractor Estimated	4,118	+ 107	2.7

In scheduling, the calculated information is input into MS Project. After the duration and sequence of each activity is determined, managers may calculate the starting and finishing time of each activity and those of the project. The time attributes will be transferred back to the database. Then, assisted with MDIIS system's inquiry function, any project information related to required resources and scheduling, such as work item's unit price and working rate, quantity of required resources (personnel, machinery, material), starting and finish time, cost estimation, etc., can be generated. MDIIS helps project managers to distribute and to use activities' resources effectively.

In cost control, managers may sketch a cost curve according to the project target. In construction phase, the completed activities should be recorded and calculated. Then, managers may sketch a time-scale check line and an activity's cost curve accordingly, as shown in Figure 8. If the check point shows that cost is overspend, it is suggested to refer to check system to reexamine the usage of resources. If any errors occur, revision should be done immediately.

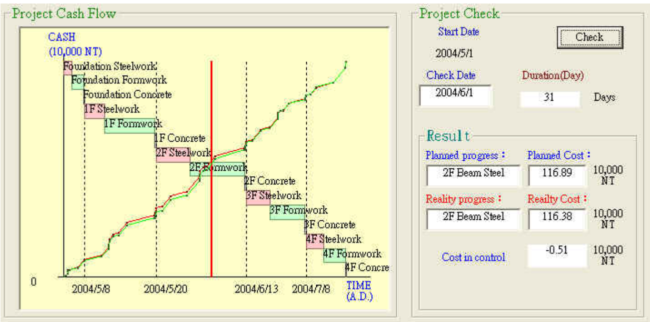


Figure 8. Project's cost control during construction phase

5. CONCLUSIONS

This research presents a MD-object-based project information integration and management system. Through systematic analysis, MD attributes of building objects are identified according to work items. In addition, the MD model ensures the coincidence and efficiency of information integration. Facing the diversity of project information and complication of interfaces, the case study shows that MDIIS system indeed provides a feasible and effective integrated platform for resources' calculation, progress and cost control.

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