THE APPLICATION OF 3D AND INTERFERENCE DETECTION IN CONSTRUCTION ENGINEERING

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Skyscrapers and Hi-tech factories are a hot topic among construction industry nowadays. As the function of buildings become more sophisticated, subcontractors of a project are more closely related. It is difficult task for designers to present a 3D construction project at a 2D level especially when the building is full of equipments and pipelines. Lots of cost and time will have to waste on resolving inadequacy of the original design. In this research we transform a 2D design into 3D drawing by means of Virtual Reality technology. Users can use functions such as zoom, pan, and scale and penetrate to present the drawing and preview the project in planning stage; therefore, designing mistakes can be eliminated. Not only does our application execute interference detection to review structure, appliances and piping system at a 3D level, but it also lists the raw material for cost analysis. Through the assist of this research, engineers can exam all data at designing stage. Thus, human negligence can be reduced and budget and schedule can be controlled better.

Keywords: Cconstruction Automation, Virtual Reality, Interference Detection, Cost Control, Construction Management.

1. PREFACE

Taiwan is an island with limited land. With 70 percent of mountain, the available area for planting and living are relatively small. Building of skyscrapers seems to be an effective way to increase living quality and make the most of the land resource after the economical progress.

In the process of planning a building, different specialties such as planning, designing, structure, plumbing, air-conditioning, communication, are required. In the early days, review of a project has relied heavily on senior engineers to avoid conflict of different specialties. Most plans are prepared with AutoCad. Users are able to review or duplicate by means of layer control. However, some interference cannot be detected easily.

Dr. Chiu □1□□2□has made 8 predictions of how computer will assist in architectural design in 2000, including:

A. Construct tools by using Design Oriented Modeling.
B. Virtual Reality.
C. Instant feedback.
D. Easy maintenance of data structure.
E. Auto design and evaluation.
F. Decision based on knowledge.
G. Computerized design.
H. Parallel Processing.

In AutoCad, we usually arrange figures with related category in the same layer□3□. We may put drawings into picture library by blocking related portions so the data bank can be used easily□4□. However, there are some limitations in 2D in which we need senior engineers to evaluate drawings to prevent mistakes.

2. RELATED STUDIES

A. P. Jacquot utilizes interference drawing to simulate foundation interference detection □5□.
B. J. David Frost and Sue MeNeil utilize interference detection to detect properties and damages of materials□6□.
C. Douglas A. Bruttomesso utilizes interference detection to handle non-destructive experiment □7□.
D. Bruce A. Superenant focused on interference between concrete and related materials□8□.

3. PURPOSE AND SCOPE OF RESEARCH

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In this research, we introduce the object-oriented concept and AutoPlant environment for following studies:

2.1 3D drawing

The object-oriented concept is introduced in this research. Every component of a building is viewed as an object. With the help of computer programs, 2D drawing is transformed into 3D. Users and subcontractors are able to preview 3D drawing at the designing stage. The introducing of 3D has simplified the of design process. With more and more advanced computerization, the effect of CAD will be greater.[9]

2.2 Preview of Actual Project

This research provides an interactive opportunity for engineers, by means of computer commands such as zoom, pan and penetrate, to have better understanding of the project before as well as during the construction, to get the feel of the actual space, and to review detailed designs for better management of a project.

2.3 Executing Interference Detection

This study not only executes interference detection towards structure, piping, but also lists interfered elements, which are further reviewed by designers. Therefore, Professor Shih points out in an excellent decision-making device should equip with auto-review function as well as "just-in-time" processing capability to fulfill the designers' need[10].

2.4 Calculation of Quantity

Each object has its own property of length, width, height and thickness. Our program runs statistics of individual objects in terms of quantity and specification. Their length, quantity, screws and so on are listed for quantity checkup and cost analysis. As "Technology Automation" points out in [11], CAD brings time-reduction and accuracy to human work. The construction industry can benefit from the accuracy in dimension, pre-drawn detailed drawing bank and consistency of specification and quotation.

3. RESEARCH METHOD AND CONTENT

The research method and content are divided into the following:

3.1 Collection of Related Data

Data are studied to determine if they are useful in 3D drawing and interference detection. They are analyzed for developing environments and advantages and disadvantages of hardware and software as well.

3.2 Use Object Oriented to Model Building

The dimension and location of building are grouped and categorized with object-oriented principle for further analysis and study.

3.3 Building Appliances and Piping Data Bank

3D models are developed and drawn by SpecGen, which specializes in environment development and provides elements to establish a thorough drawing bank for appliance, piping and structure systems.

3.4 Transformation of 2D into 3D

Most architects prepare AutoCAD drawing at 2D level. Here, we take advantage of environmental development and data bank to present 3D drawing. With this technology, engineers are able to review the project at designing stage of the project.

3.5 Inter-reference and Division of 3D model

Drawings among different subcontractors including structure, piping, air-conditioning and fireproof system are organized into models, which are either divided or combined in various directions and levels.

3.6 Executing Interference Detection

After cross-referring the dimension and location of different objects, engineers are provided with the result of interference detection, which lists interfered structure, plumbing, and appliances.

3.7 Printing Raw Material List

The quantity and dimension of raw materials can be obtained from the data bank. After calculation, users can get the data about dimension and quantities of inventory.

4. RESEARCH PROCESS

The research process is demonstrated in Figure 1.

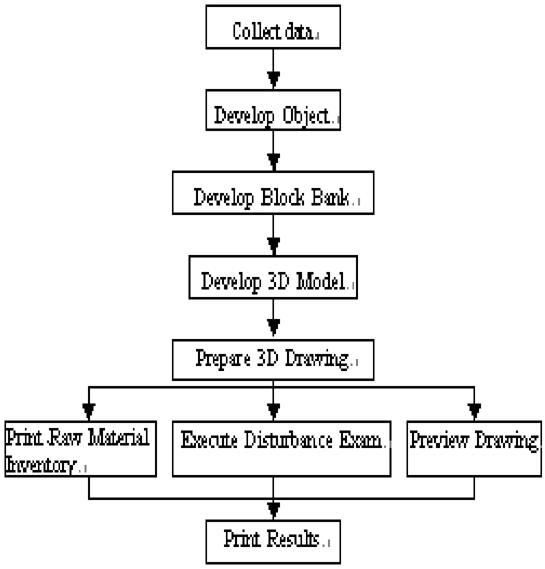

Fig.□ The study process of this research

5. RESEARCH RESULT

The research results are described as following:

5.1 Transform 2D to 3D

After designers complete the drawing at 2D level, the drawing can be transformed into 3D easily for engineer to exam the design. The 3D effect can be displayed in different angles through position adjustments. Figure 2 and 4 are 2D drawing. Figure 3 and 5 are Figure 2 and 4's transformed 3D drawing.

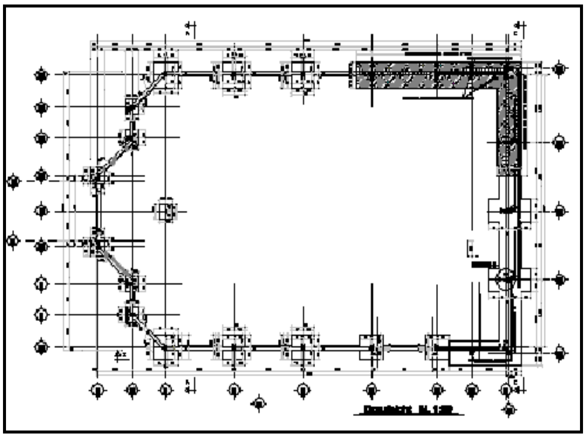

Fig.2 2D Drawing (1)

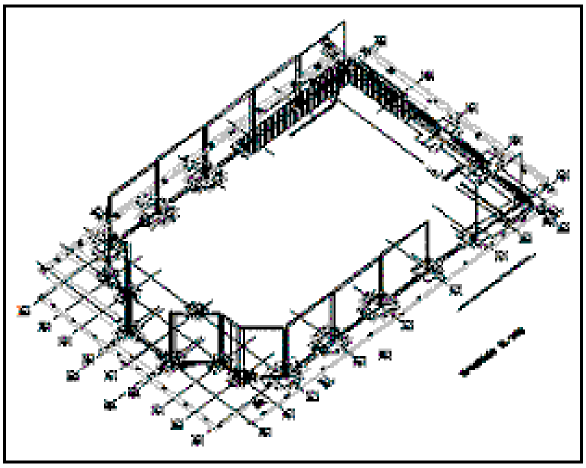

Fig.3 3D Drawing of Fig.2

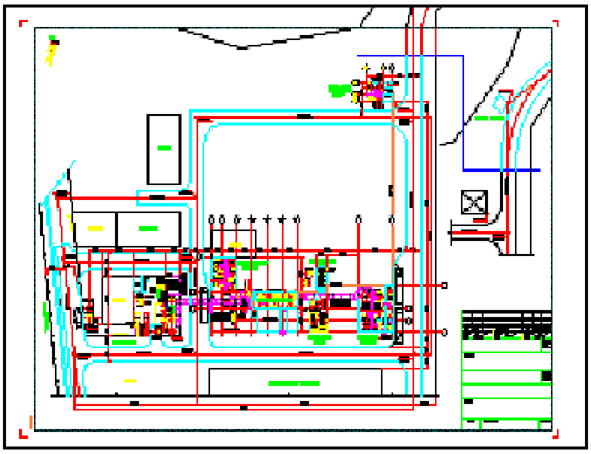

Fig.4 2D Drawing (2)

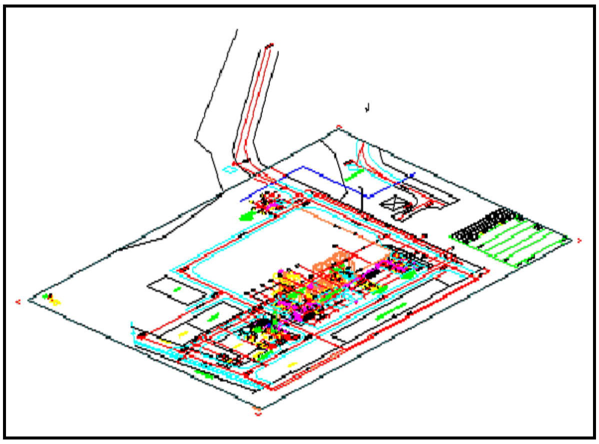

Fig.5 3D Drawing of Fig.4

5.2 Computerized Visual Reality Drawing

After the 3D drawing is developed, we can take advantage of the VR technology to preview the completion of a project and by means of functions such as penetrate, pan, transfer and zoom. Engineers can exam the structure and materials through virtual pictures such as demonstrated in Figure 6 and 7.

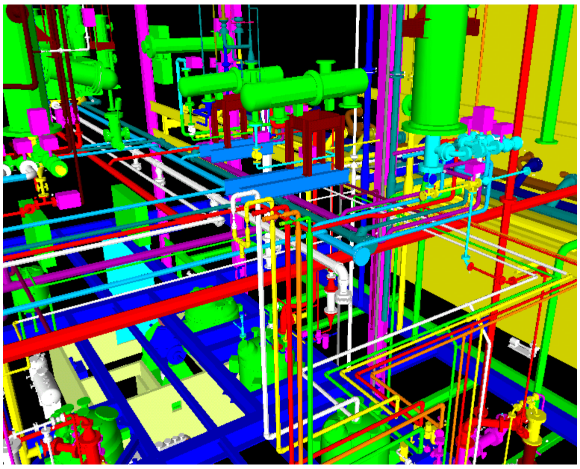

Fig.6 3D Virtual Picture (1)

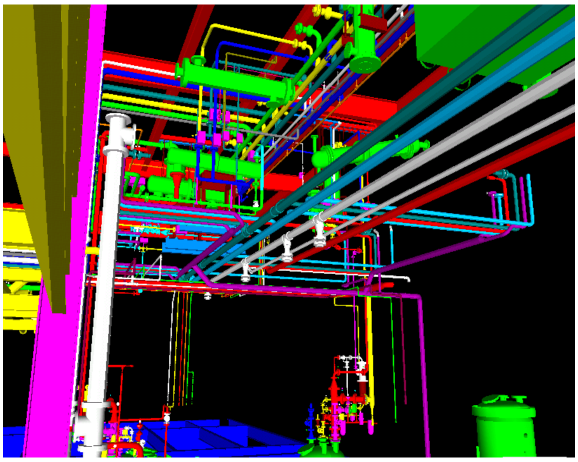

Fig.7 3D Virtual Picture (2)

5.3 Inter-reference of 3D Model and Division of Model

In this research, we use the external-reference to organize different drawings into one drawing through reference points instead of layer control. Fig. 8 is the drawing which is used for external-reference for Fig. 9. Fig.12 is the combination of Fig.10 and Fig.11 .

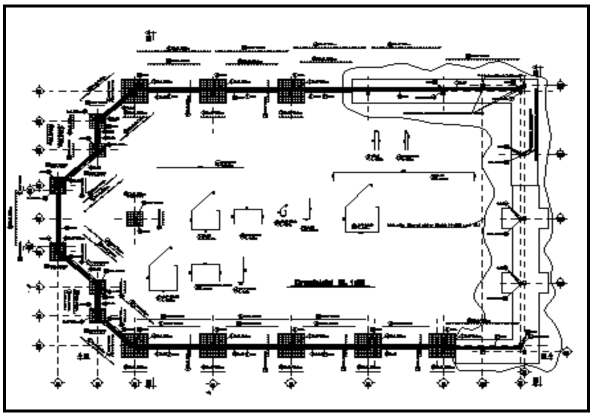

Fig.8 External-Reference Drawing

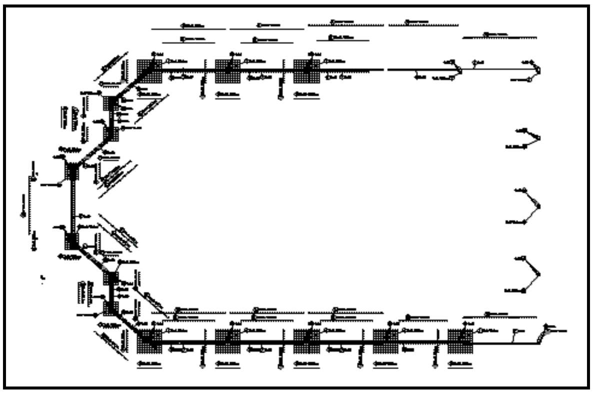

Fig.9 Drawing w/o External-Reference for Fig.8

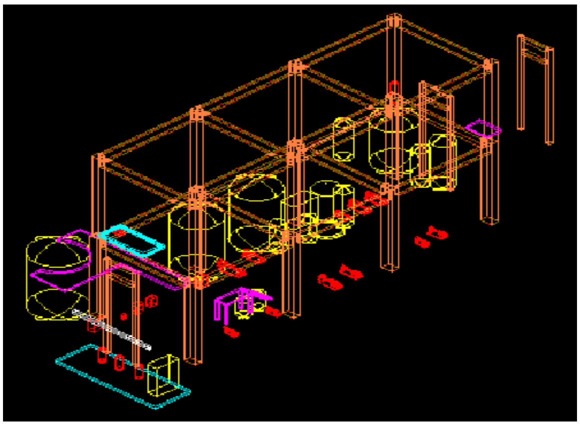

Fig.10 External-Reference of 3D Drawing (1)

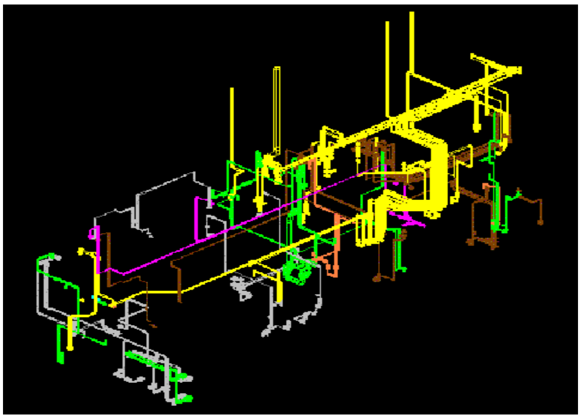

Fig.11 External-Reference of 3D Drawing (2)

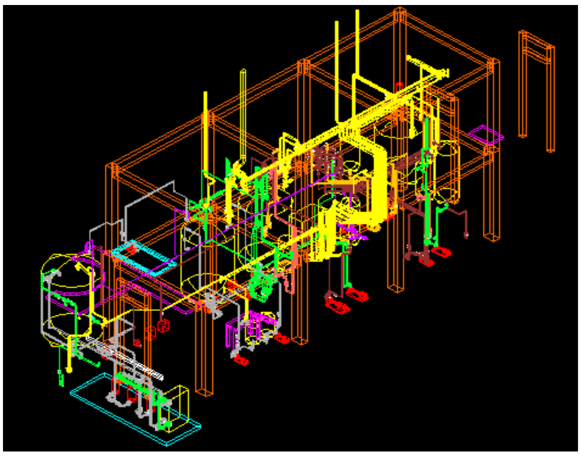

Fig.12 External-Reference of 3D Drawing (3)

5.4 *Execute Interference Detection*

It is difficult to detect interference among small objects. A lot of time and funds will be wasted once mistakes are detected during work. Figure 13 and 14 show the result of interference detection, which assist engineers for reviewing. (Circle lines mark the interference.) Figure 15 shows the related structure of interfered objects. Figure 16 uses charts to demonstrate the detection result in words.

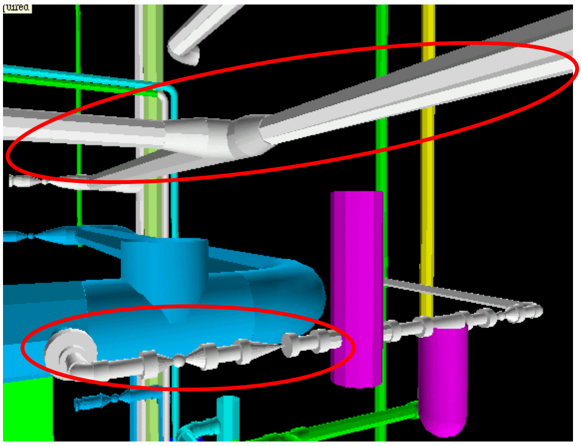

Fig.13 Interference Detection Drawing (1)

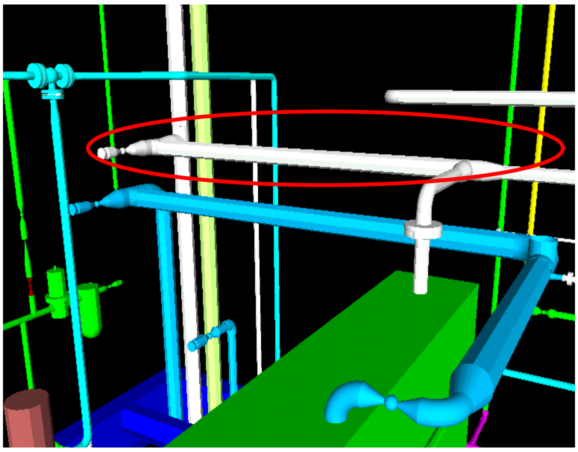

Fig.14 Interference Detection Drawing (2)

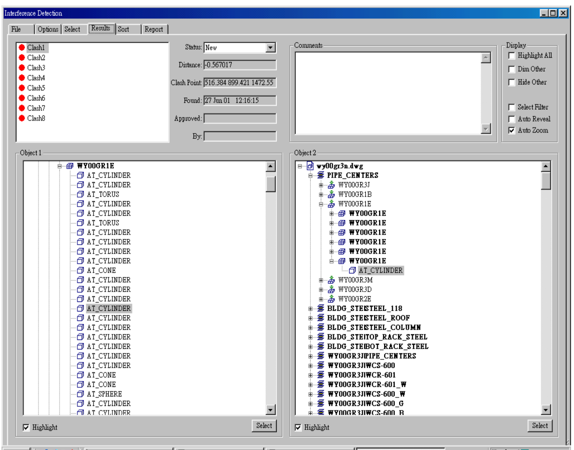

Fig.15 Interference Objects

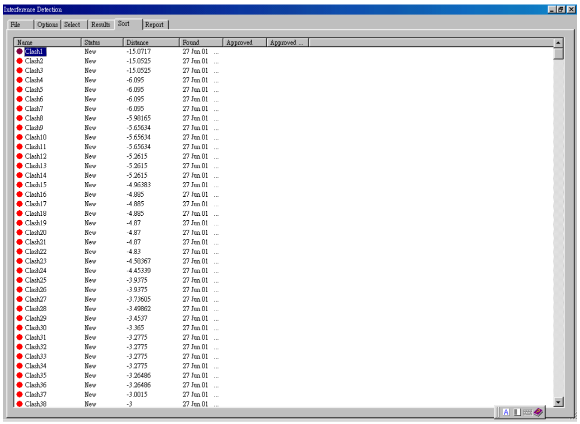

Fig.16 Interference Detection Report

5.5 *Print Raw Material List*

Due to sophistication and complication of appliances and piping in Hi-tech factories and skyscrapers, it is almost impossible to achieve speedy and accurate quotation. Figure 17 is an example of raw material list.

6/26/2001

Date/Time Stamp	Name	Description
Tue Jun 26 23:18:12 2001	P-89	
Tue Jun 26 23:22:14 2001	EH-344	
Tue Jun 26 23:22:37 2001	EH-382	
Tue Jun 26 23:23:29 2001	WP200-38D	WAUKESHA CHERRY-BURRELL CENTRIFUGAL PUMP
Tue Jun 26 23:23:40 2001	VH-3B3	
Tue Jun 26 23:23:49 2001	ET-3DB	
Tue Jun 26 23:24:02 2001	WPC-404	WAUKESHA CHERRY-BURRELL CENTRIFUGAL PUMP
Tue Jun 26 23:24:16 2001	WPC-41B	WAUKESHA CHERRY-BURRELL CENTRIFUGAL PUMP
Tue Jun 26 23:32:18 2001	EH-466	
Tue Jun 26 23:32:27 2001	EX-496	
Tue Jun 26 23:32:37 2001	P-4B7	
Tue Jun 26 23:33:41 2001	EH-55D	
Tue Jun 26 23:33:54 2001	EX-585	
Tue Jun 26 23:34:01 2001	EH-5AC	
Tue Jun 26 23:34:09 2001	ET-5C3	
Tue Jun 26 23:34:20 2001	EH-5DA	
Tue Jun 26 23:34:29 2001	WPC-5EF	WAUKESHA CHERRY-BURRELL CENTRIFUGAL PUMP

Fig.17 Raw Material List

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 *Conclusion*

In order to complete a construction project within budgets, schedule and security as well as achieve the targeted quality, each stage of construction projects, from planning, designing and constructing requires a detailed plan. As the size of projects grows larger and function of devices becomes complicated, sophisticated devices are necessary to compensate human inadequacy to reduce probabilities of mistakes.

The contributions of this research are:

A. To transfer 2D to 3D rapidly. Engineers are able to review the design in a 3D level easily and avoid possible human errors.

B. To provide VR tour. Designers, engineers and clients are able to visit the building before it is constructed. It is very useful to improve the communication between clients and designers.

C. Different designs are organized rapidly to review dimensions and functions through external reference so that common mistakes can be eliminated.
D. By means of interference detection, interferences among different structure, appliances and piping are shown and printed for organization purpose. The hided minor mistakes are located.
E. Because each object is stored respectively, all appliances and contents are completely organized and printed out for calculation by means of the rapid calculation of our system.

6.2 Recommendation

There are further studies can be followed:

A. Leakage Detection

Users should be able to receive information on possible leakages after typing the leaking floor, position and related data.

B. Review of completion of the planned schedule

We may integrate this system with scheduling tools to demonstrate the progress of the construction.

7. ACKNOWLEDGEMENTS

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10. □□pp.111-122□

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