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Development of the 3D Computer System to Automatically Quantify Construction and Demolition Waste

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Abstract
The current trend of pursuing sustainable development in the demolition industry reflects the importance of reusing and recycling construction and demolition (C&D) wastes. Considering the situation of housing construction and existing houses in Korea, the demolition market is expected to be continually increased. Thus, for keeping up with this demand, it is necessary to be able to accurately forecast and manage C&D waste generated at the demolition phase. But because most of demolition companies are small in size and investment in technology development is insufficient, it is difficult to establish standards and develop an integrated system of appropriately managing C&D waste. Therefore, this study aims to develop a 3D system to automate estimating a quantity of demolition waste. This system will make it possible to integrate and manage in one system such activities related to demolition work as planning and scheduling of demolition work, and quantifying and planning for the disposal of demolition waste. Also, this 3D visualizing system can automatically quantify demolition waste by using a 3D object library, and manage schedule of demolition work by visualizing 4D CAD.

Keywords
Deconstruction, Demolition waste, Waste management, Integrated deconstruction management system

1. Introduction

Although the demolition market in Korea, created at early 1990s, has grown to 1 trillion won (US$724.3 million), it still depends on the conventional technology of small-sized, specialized companies. There are no middle to long term provisions keyed to changes in the market, such as higher and larger buildings and rapid growth of the market. The demolition industry in Korea does not have enough institutions, legal infrastructure, design standards, other standards, or regulations.

As shown in Figure 1, the aged houses older than 20 years which was 2.05 million households in 2001 are expected to increase to be 2.5 times in 2010 (4.95 million households) and to 4.5 times in 2011 (8.9 million households) with the trend of increase of aged houses as shown in Figure 1.

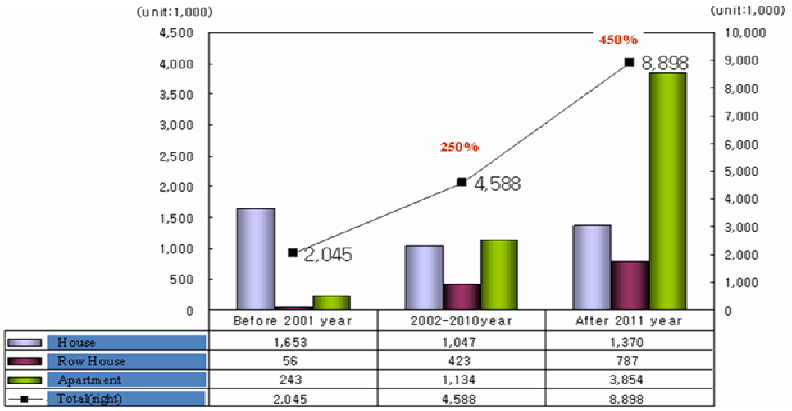

Figure 1: Increase of Houses 20+ Years Old According to House Type

Considering the average reconstruction year of the apartment houses, the demolition market is expected to grow by 25% up through 2015 and by 21% between then and 2025. As the market is expected to grow rapidly, it is necessary to estimate the amount of construction waste from the project and a good management system is needed for that purpose. Accordingly, this paper focuses on the development of a computer program to meet these needs.

2. Overview of the Demolition System

The purpose of this system is to manage the whole process of demolition from planning, to demolition itself, to waste management, in an integrated manner. This system focuses on automating the calculations of the quantity of demolition waste. As the Korean market does not have standards to calculate this quantity, demolition companies and project owners do their own estimates to calculate the quantity of demolition waste based on their past experience. It has resulted in many estimation errors frequently occurred by different agencies. Since estimates are often inaccurate, a standard basic unit code was used to estimate the quantity of demolition waste in this system. If there are drawings available, the quantity can be calculated using the actual size and materials specified in the drawings. Based on the quantity calculated as such, a weight conversion coefficient and a volume conversion coefficient are applied to calculate the weight and the volume of the waste. Based on the results, waste processing expenses are calculated and utilization plans are made. Additionally, in order to improve the productivity of the demolition process, schedule management function is added to help planners build a demolition work schedule.

The main modules of the integrated system for the demolition project are composed of a pre-demolition work plan, waste quantity calculation, demolition work plan, and waste management plan, as shown in Figure 2.

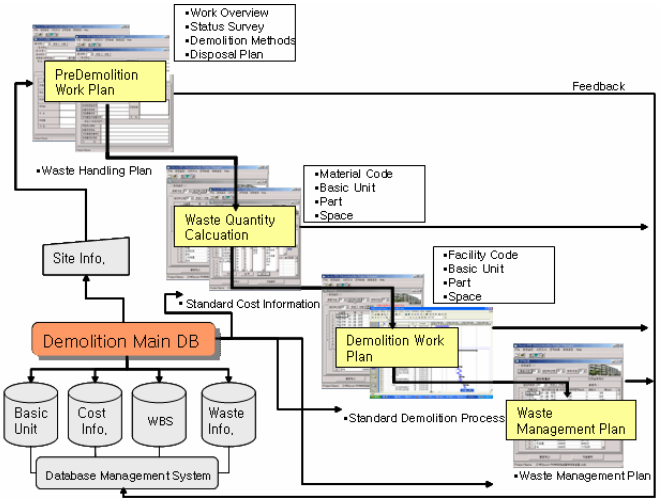

Figure 2: Outline of DCON-PM

3. Configuration of Automation Module for Waste Quantity Calculation

Waste quantity calculation is the most important element in the configuration of a demolition system. To make accurate estimations of demolition project costs, it is necessary to calculate the waste quantity precisely. However, in Korea there are no standards to calculate demolition waste and sometimes no drawings survive. Even when there are drawings available, it can be difficult to calculate the quantity from the drawings. Therefore, in this study, the cases were divided into those with drawings and those without drawings, as shown in Figure 3. The system enables visualization utilizing CAD drawing, when available, and uses basic units when drawings are not available. When it is difficult to utilize basic units, the quantity is calculated by using libraries of 3D objects.

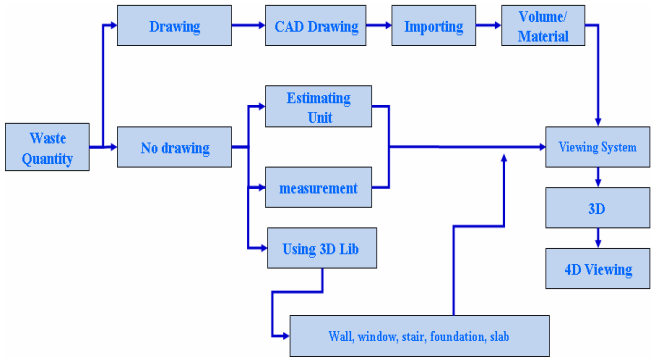

Figure 3: Overview of Quantity Calculation

3.1 Utilization of Basic Units

Basic units are classified into two categories: those for the whole demolition structure and those for the parts of the demolition structure. In this article, we propose to utilize whole basic units. To utilize them, the type of facility to be analyzed should be chosen first through a work breakdown structure (WBS) generator. It will be translated into WBS code and basic units for the selected facility information will be created automatically. This then is multiplied by the floor width to estimate the quantity of demolition

waste. The WBS generator data is saved in a database according to the prefixed format and users can search it easily according to the defined processes. The process diagram is shown in Figure 4.

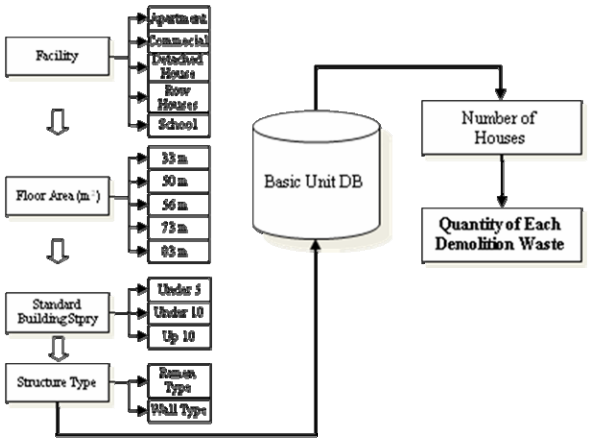

Figure 4: Quantity Estimation Utilizing Basic Units

3.2 Quantity Calculation by Actual Measurement of Drawings

This system contains the classification system for all the facilities, such as building, space, and parts, to calculate the demolition quantity. To calculate the quantity through actual measurement, WBS generators are created first like Figure 5 and then volume of the materials are calculated according to the width of the elements.

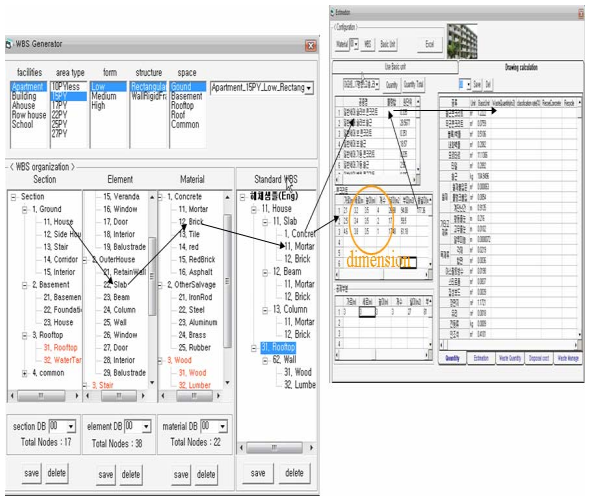

Figure 5: Actual Drawing Measurement Utilizing the WBS Generator

3.3 Utilization of CAD Drawings

When CAD drawings are available, 3D CAD drawings, such as those shown in Figure 6, can be created by importing CAD drawings through the viewer function and giving the elevation. It is configured to calculate the volume by writing the size of each 3D object and connecting it to the material codes stored in the database.

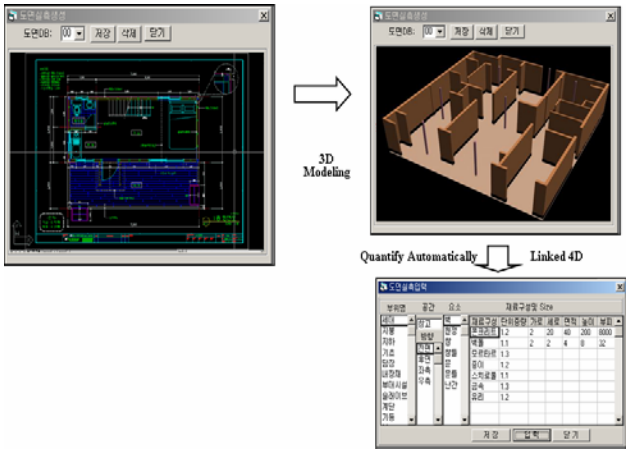

Figure 6: Calculation of Quantities Using CAD Drawings

3.4 Utilization of 3D Objects

When there are no drawings available, a representative drawing should be used to calculate the volume using the objects in representative drawings. The objects are registered in the database library so that users can create objects through simple clicks. Additionally, other information, such as the composition and the mass of the materials of the objects, are also saved for easy use. Usability is maximized by making the sequential selections to compose an object, such as selecting the facility information first, then the parts of the selected facility, and then the elements of the selected part.

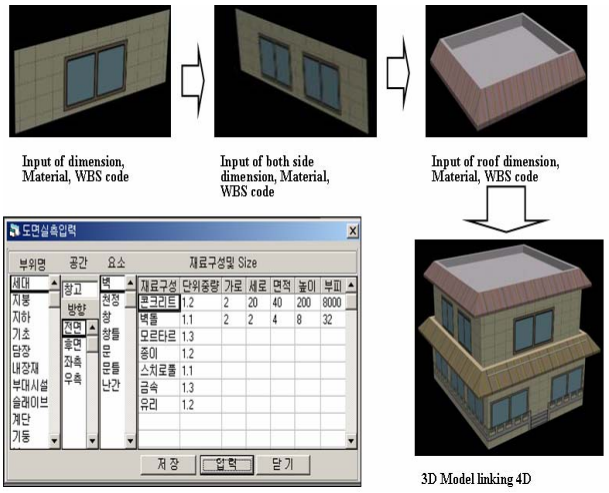

Figure 7: Examples of 3D Object Information Utilization

3.5 How to Make 3D Object Libraries

When the size is entered (Figure 8), the object has the materials, size, and quantity information that make up the object. When the object is registered, this information is registered in the Object Library. When a user has things to refer to regarding the quantity or other information, the user can call library at any time and read the information to make judgment.

If the user selects an object in virtual reality (VR), as shown in Figure 8, the corresponding VR is shown. When the corresponding VR is seen, dragging it with mouse will add it to the newly created object. The user can identify all the information by clicking the choices on the screen. The characteristics and

quantity of the material, as well as the demolition method, schedule, and potential or known hazardous materials are shown in advance. The user can establish a detailed plan based on the information before starting the demolition process.

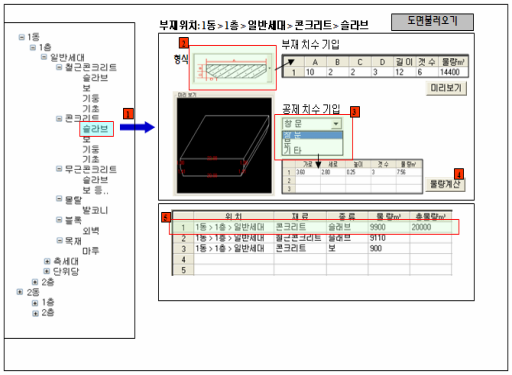

Figure 8: 3D Object Creation

4. Conclusions

As there are no specified standards in Korea to calculate waste quantity, project owners have had to calculate the material quantity for themselves based on their past experience. This new system allows the use of basic units when drawings are not available and to use actual measurements when drawings are available. However, using actual measurement of the drawings can be complicated and difficult, often taking a week or more, although most work must be done quickly because of the demands of the demolition projects. To improve efficiency and make it more realistic, it is proposed to automate the actual measurement utilizing 3D objects. The weight conversion coefficient and the volume conversion coefficient can be applied to the volume to estimate the waste processing expenses and establish the waste utilization plan. It will help to make a more realistic quotation and more precise demolition management plans. We believe that the accurate calculation and estimation of the demolition waste materials will make the waste management more efficient.

5. Acknowledgments

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6. References

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