DEVELOPING WEB-BASED 5D SYSTEM CONNECTING COST, SCHEDULE AND 3D MODEL

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ABSTRACT: BIM having started from architecture is being used in civil structure, but there are very few examples despite its effectiveness. In this paper, based on BIM technology, it is presented the method and result of developing web-based 5D system connecting cost, schedule and 3D model from the cable-stayed bridge. Through the system, the user can understand easily schedule on specific time and during some period and extract cost directly. This system also can manage various data types such as drawings, 3D models, documents and photos, for enhanced communication between stakeholders.

Keywords: BIM; EVMS; web-based 5D system; connecting cost-schedule-3D model; cable-stayed bridge

1. INTRODUCTION

The speed of applying IT technology to construction industry has been very slow. One of the most important reasons is the uncertainty. Generally, the crucial process in computerizing process is standardization. It will have advantage only if it is unified and repetitive. Unpredictable events happen in especially, civil construction, on many occasions, because its target is nature. For instance, if we erect two exactly same bridges at the different position, totally different works will be going on, because the nature conditions are different, even if they look similar. Like it, it is also difficult to forecast weather, even though the super computer is used. Nevertheless, there have been many strides in construction IT and many results have been gained. The BIM (Building Information Modeling) is most remarkable of them. The essence of BIM, which is the process of inserting data in 3D model and utilizing it visually, is integrating all the information which is scattered.

Daelim Industrial Company has developed the system managing cost and schedule data, so-called EVMS (Earned Value Management System), but because it consists of text and table, it is very difficult to understand data. So far it has been necessary to develop 5D system connecting EVMS data and 3D model in order to know easily and utilize data visually.

Various 5D planning programs such as Estimator, Digital Project and Common point, have been developed, but they are not suitable for Korea because code convention in Korea is totally different from other countries [1].

In last year, 5D system in stand-alone form was developed [2], but it has annoyed the user because he or she had to install the program in every computer. So, it is noted that web-based 5D system is indispensable so that the user can access the system anywhere. Even though there had been some technical problems, they were fixed perfectly. The methodology and results are presented.

2. 2nd GEUMGANG BRIDGE

The 2nd Geumgang Bridge, which is target structure, is being under construction now. The construction period is from 2008 to 2011 and it is located at the multifunctional administrative city, i.e., Sejong city in the middle of South Korea. A total length is 880m and it has 6 lanes of both bound. It is composed of cable-stayed bridge section (main span 200m and side span 140m) with composite steel plate girder, and approaching section (540m) with composite narrow steel box girder as shown in Fig. 1. The stiffening girder is I shaped edge steel girder with precast concrete deck, and the pylon is round, asymmetric and 100m high. The reason why this bridge was selected is its atypical pylon shape, and for quantity take-off, 3D model had been created in design stage.
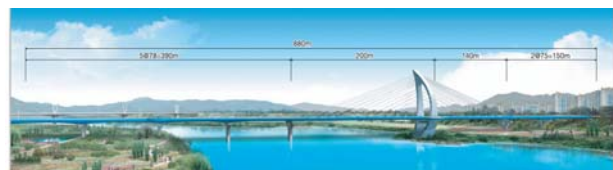

Fig. 1. Overview of 2nd Geumgang bridge

3. EVMS

EVMS is the system of analyzing performance and expecting final project cost and schedule by managing schedule and cost of project and utilizing a structure of standard classifying, based on schedule managing system. In EVMS, standard cost structure, standard schedule structure and standard link structure have been already established.

EVMS is composed of WBS (Work Breakdown Structure) and CBS (Cost Breakdown Structure), and WBS at the level of sub-activity is connected with CBS at the 5th level of cost item by matching table as shown in Fig. 2. The 3D model is connected with WBS at the level of activity, so CBS will be connected automatically with 3D model. Therefore 3D model should be divided as to be adequate for activity in WBS. The reason why 3D model is connected with WBS at the level of activity, is related to the limitation of representing the detail. In order that 3D model shows sub-activity, 3D model has to be split much more minutely, but it is nearly impossible because the memory capacity of computer has limitation to show all of them. As the computer technology is developed very fast, it will be completely solved before long.
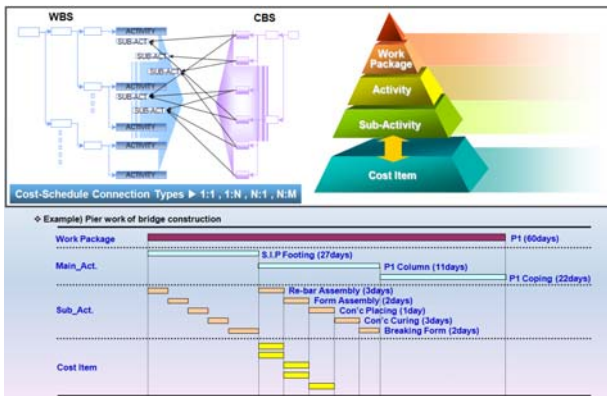

Fig. 2. Structure of EVMS

4. MODELING

4.1 Creating 3D Model

The fundamental work to do is to create 3D model from conventional 2D drawings. In the process of creating 3D model, we could correct the error of 2D drawing and check the complicated shape so that we prevented delay of schedule. Initially, it had been made with Revit Structure 2009 as shown in Fig. 3, but it was converted to Microstation V8i format. Some errors were fixed and the detail was enhanced as shown in Fig. 4.
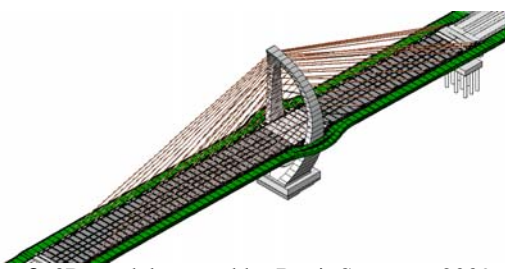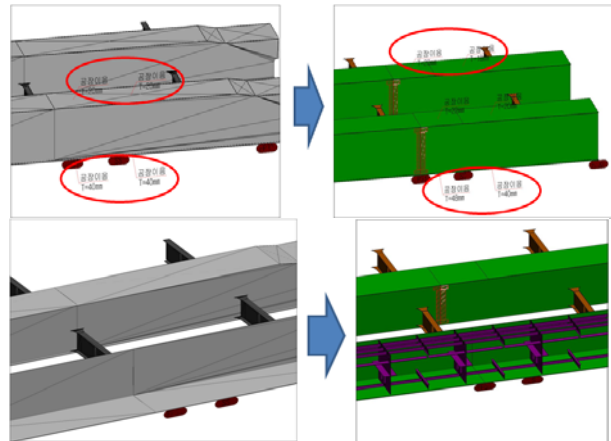

Fig. 3. 3D model created by Revit Structure 2009

Fig. 4. 3D model updated by Microstation V8i

4.2 Splitting 3D Model

Generally speaking, when the 3D model is created, the level of splitting object, that is the scope of modeling and the detail vary according to objective of applying. For example, if we want to check the interference between members we will have to do minutely, but if we want to see the process of schedule we will only do briefly.

In the case of splitting 3D model for 4D or 5D simulation, the increase in data size is inevitable because of many objects, therefore we should decide the suitable level of detail considering aim and efficiency. In this case, the suitable level is activity, considering the capacity of computer, as mentioned earlier. If an activity were given on the different objects, those objects would be perceived as same activities.

Because the aim is to simulate in 3 dimensions connecting EVMS data and 3D model, 3D model was split according to activity in WBS as shown in Fig. 5. The name of each object should be equal to corresponding to WBS code so that the automatic link can be possible.
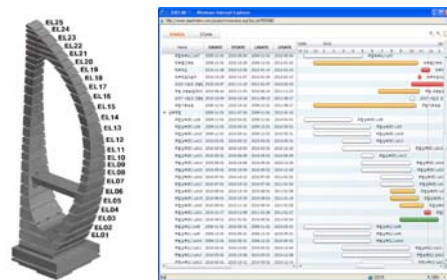

Fig. 5. Splitting 3D model according to activity

4.3 Converting 3D Model

The process of converting 3D model is necessary in order to publish it in the web. The very first work is reducing the number of objects in converted 3D model, because the number of objects increases enormously after converting. The Virtool program of Dassault which makes it possible to publish in the web, has different data structure from the other 3D modeling program such as Revit Structure, Microstation and etc.

The initial number of objects before converting is 158, but the final number after converting is 70,606 as shown in Fig. 6. Therefore, lots of objects must be classified and

grouped as original form of element so that it maintains the original 158 objects.
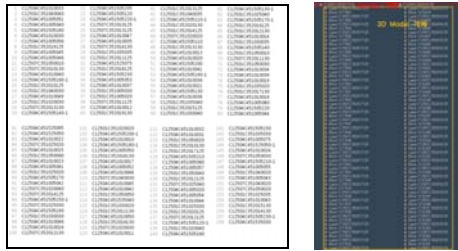

Fig. 6. List of objects before and after converting

The second work is smoothening surface. When 3D model is converted, the surface can be distorted and rough, so smoothening one by one is necessary as shown in Fig. 7.
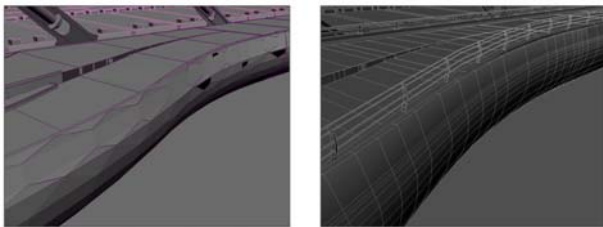

Fig. 7. 3D model before and after smoothing surface

The third work is reducing model size. When it is converted, the surface or volume are broken into the point or line, so the number of elements becomes tremendous. By finding unnecessary parts, deleting and grouping them, the model size can be reduced as shown in Fig. 8.
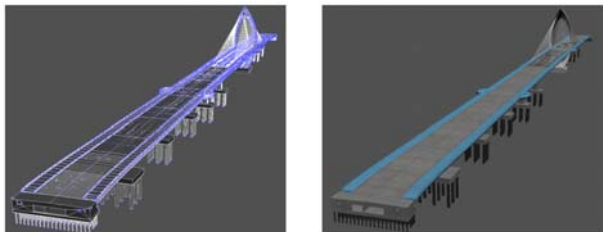
Fig. 8. 3D model before and after reducing size

The graphic effect can make 3D model realistic. The quality of 3D model's surface is monotone just after converting, but it can be changed by texture mapping as shown in Fig. 9.
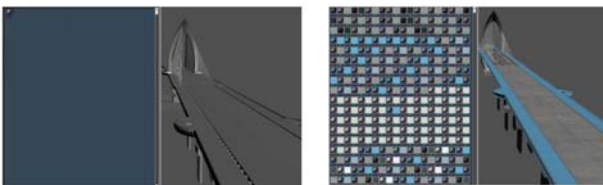

Fig. 9. 3D model before and after texture mapping

After that, the color mapping work starts. It is noted that each mapping should have less than 1 MB in order to publish in the web as shown in Fig. 10.
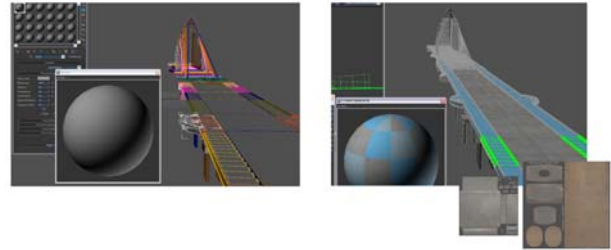

Fig. 10. 3D model before and after color mapping

These rendering works can make it similar to real structure as following as shown in Fig. 11.
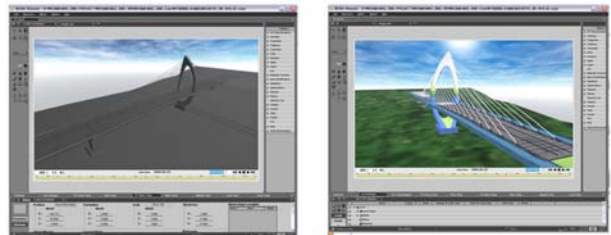

Fig. 11. 3D model before and after rendering

The camera setting and programming can make the interactive results as shown in Fig. 12.
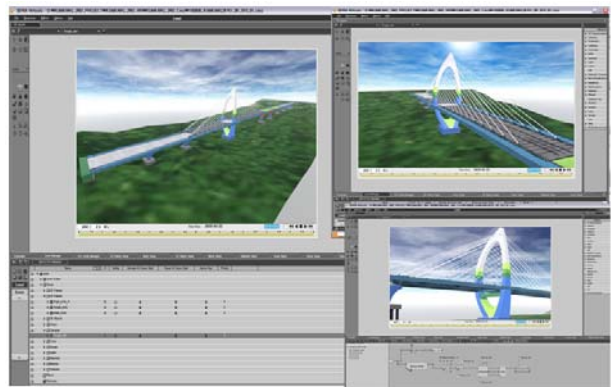

Fig. 12. 3D model after camera setting and programming

5. SYSTEM DESIGN

5.1 System Architecture

The system is the web-based system of open architecture structure and has the interactive linking and conversion with EVMS.

The server system has a typical 3-tier structure as shown in Fig. 13. In the user's aspect (application layer), 3D player compatible with DirectX and OpenGL is used. The presentation layer uses the state-of-the-art technologies such as Flex and Silverlight observing web standard. The cost and schedule data are imported from EVMS through web service and they are managed in MS-sql server.

5.2 Linking with EVMS

As mentioned earlier, the automatic linking is realized by mating the name of 3D object and WBS code in EVMS. When there is a request for data with user ID and

password, EVMS web service supplies cost and schedule data in XML form.

Once schedule data and 3D model are connected, cost is shown automatically, because EVMS has already the link information of cost and schedule.
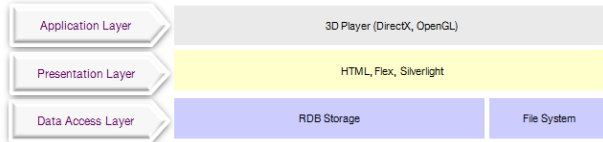

Fig. 13. Structure of server system

6. RESULTS FROM WEB-BASED 5D SYSTEM

The system which connects cost, schedule and 3D model and update data automatically has been established.

System layout is in Fig. 14. Initially, the type of administrative program where data are inserted and modified, was planned as stand-alone, but solving technical problem made it possible to complete web-based system where all the functions can be performed on the web and authorization varied according to ID.

Fig. 14. System layout

6.1 Schedule Simulation

The system can represent the status of schedule on specific date or in specific period. It can also show the running activity (green), the delayed activity (red or orange), the finished activity (white) and the planned activity (grey) as shown in Fig. 15.
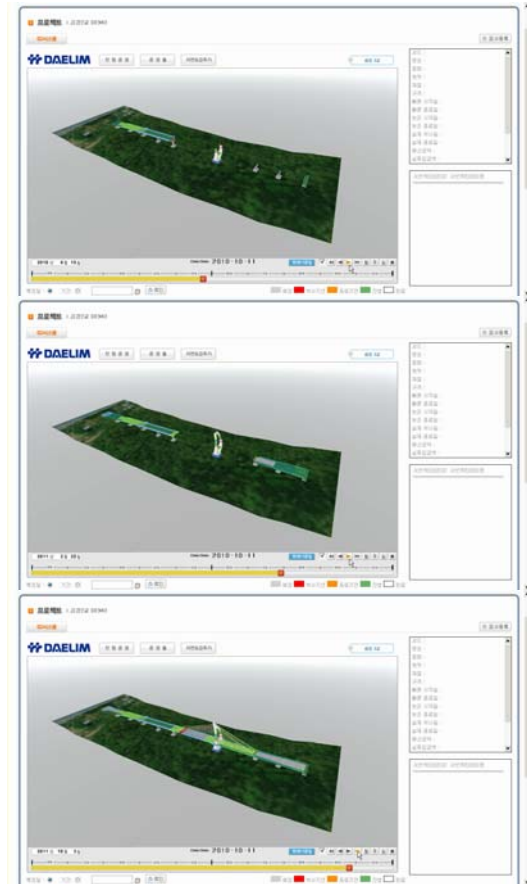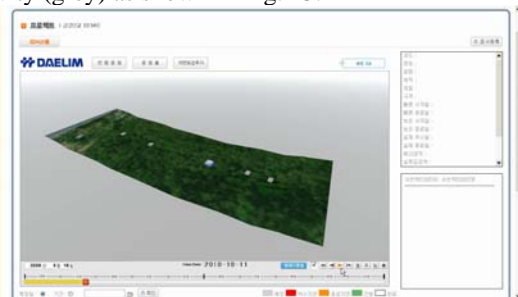

Fig. 15. Schedule simulation

6.2 Information Management

On the specific object, it contains basic schedule data and other various data such as 3D model, photo, document and drawing) as shown in Fig. 16. Moreover, the user can enter many valuable data such as general project information, material, volume, name and so on, and can open and manage them anywhere because it is web-based system.
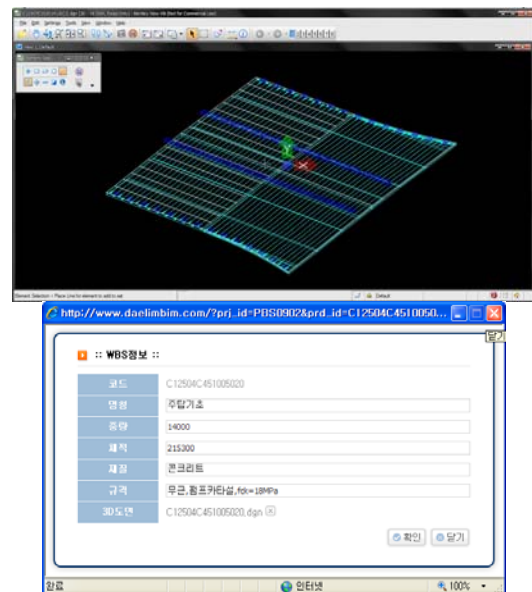
Fig. 16. Information management

6.3 Cost and Schedule Management

It is possible to check real-time cost and schedule information through Gantt chart and S-curve respectively. The user can select more than one object, then the cost information about selected ones can be shown in list form or MS Excel form as shown in Fig. 17. Before this system is developed, it is very tedious work to calculate the cost concerning specific activity. Now they are totally solved and can be represented visually.

Fig. 17. Cost and Schedule management

7. CONCLUSIONS

It has been presented the method and result of developing web-based 5D system connecting cost, schedule and 3D model from 2nd Geumgang bridge, which is the cable-stayed bridge having asymmetric and round pylon under construction now. It is adopted the approach of downloading cost and schedule data by web-service, because this phase is researching stage, and the data were connected with 3D model designated by unique ID (WBS code).

Through the successful completion of web-based 5D system, it became possible to check the information (drawings, 3D models, documents and photos) at a 3D object, Gantt chart and S-curve in real time.

In the future, it will be enhanced the communication between stakeholders and the interaction between headquarter and site. Recently, the effectiveness of BIM has been emphasized, but the integration of overall system and the accuracy necessary for user is still far-off. Gathering these small efforts, it is thought that BIM will be settled in near future, as the paper drawing became electrical CAD file, which had been considered impossible in 1970s.

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