3D Topographic Map Generation of Fukushima Daiichi Power Plant

Visualization of the reconstruction plan for effective information sharing

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***Abstract*—The Great East Japan Earthquake that occurred on March 11, 2011 resulted in unprecedented damage in various parts of Japan. In particular, the Fukushima Daiichi Nuclear Power Plant of Tokyo Electric Power Company received extensive damage due to the tsunami generated by the earthquake. In our paper, we propose the creation of a 3D virtual map that is a combination of a CAD topographic map near the Fukushima Daiichi plant, aerial photographs, and topographs.**

Keywords—Fukushima Daiichi Nuclear Power Plant, Tsunami, Reconstruction Plan, Visualization, Computer Graphics

I. Introduction

The Great East Japan Earthquake that occurred on March 11, 2011 was a disaster on a scale not predictable by anyone and resulted in unprecedented damage in various parts of Japan. The Fukushima Daiichi Nuclear Power Plant of Tokyo Electric Power Company received extensive damage due to the tsunami generated by the earthquake. The damage was catastrophic in that it accompanied the release of radioactive material in the sequence of loss of power, damage to the reactor, and reactor core meltdown.

The area surrounding the Fukushima Daiichi Nuclear Power Plant was also contaminated by radioactive materials, and so access has been limited. As a result, numerous challenges have affected the work and preparation to decommission the power plant, to store and process contaminated water to cool the reactor core, and to deal with the contamination of groundwater and the actual damage of the reactor buildings. Since these problems cannot be solved in the short term, they should be treated as long-term problems. It is very important for the Japanese people, for the people in the community, and for the people in the world, to receive precise and real-time information about the rebuilding.

In addition to the nuclear power plant situation inside, reproduction of the terrain with real-time locations of contaminated water, as well as reproduction of the houses, roads, and forests in the surrounding area, is also important in terms of information distribution. Unmanned robots removing rubble in areas of high radioactive can contribute information for the 3D map of large areas.

Therefore, with the combination of CAD topographic maps near the Fukushima Daiichi Nuclear Power Plant, aerial photographs of the plant and computer-aided models (CAM), we are in the process of creating a 3D virtual map on a computer. Unfortunately, some of the latest data were difficult to obtain and are sometimes inconsistent with respect to the time axis. Moreover, by displaying tiled displays of the created 3D map on large computer screens, it is easier to understand the overall situation

In this paper, we evaluate the effectiveness of the display method of the 3D map. Further, we consider the problem of finding the most suitable updating and acquisition method of information necessary to deliver real-time information. The ultimate goal is to generate a plan for actual reconstruction of cities and areas damaged in 2011.

II. Proposed Method

A. *Software used in civil engineering*

The Infrastructure Design Suite and AutoCAD Civil 3D are well known in civil engineering fields. In this study, we use the Infrastructure Design Suite and Civil 3D of Autodesk, Inc. [1]. The Infrastructure Design Suite is application software specialized for civil engineering planning and various construction stages. Specifically, we use the Infrastructure Modeler that is included in the Infrastructure Design Suite. Civil 3D is a computer-aided design and modeling software used in civil engineering fields, and it is of also integrated with the Infrastructure Design Suite as one package, so it is possible to carry out the work efficiently. We also use 3ds Max and various data format conversion tools.

Figure 1 shows the general workflow for building a 3D model map. The first step is the collection of several types of planning and construction data. Most importantly, we need to collect several documents, such as two-dimensional CAD data of reconstruction plans and the related documents from local government offices, such as city government offices and prefectural government offices[2-3]. We also need to collect and arrange many kinds of information. For example, high-accuracy digital elevation data from airborne laser surveying were obtained for Iwate Prefecture after the earthquake. Figure 2 shows an example of a topographic map generated by using 50-meter mesh data. The 50-meter mesh data are stored in a database of the Geospatial Information Authority of Japan. We can utilize 10-meter mesh data that measured from airplanes at the specific regions.

By using both the obtained data and 3D CAD drawings, we have modeled the current terrain, roads, and residential areas (see Figure 4). We utilize the Civil3D modeling system and use the layer classification function in order to increase the efficiency of planning work. Figure 5 shows an example of renewal terrain based on the reconstruction plans. We superimposed aerial photographs over the terrain surfaces, as shown in the example of Figure 6 and Figure 7. Figure 7 shows the residential areas on the terrain created for the actual reconstruction plans of Ohtsuchi-machi in Iwate Prefecture.

The Infrastructure Modeler integrates these data and performs for 3D viewing, quick animation generation, and maintenance of the database.

Fig. 1. Workflow for builing a 3D map

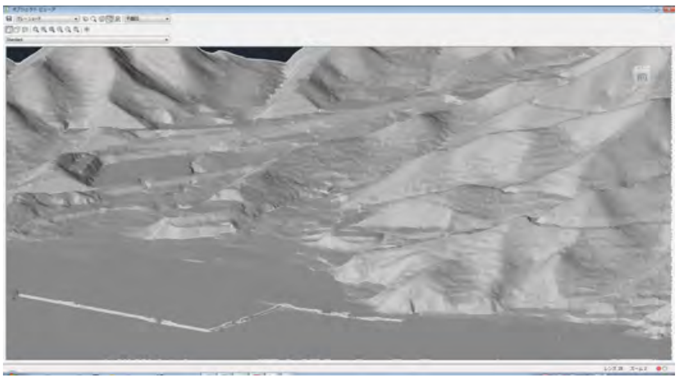

Fig. 2. Generated topographic map

Figures 8 and 9 show the results of 3D reconstruction plans created for the actual reconstruction plans of Rikuzen Takata-city and Miyako-city in Iwate Prefecture, respectively.

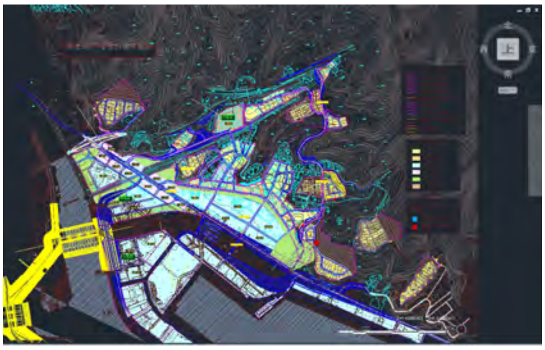

Fig. 3. Example of 2D CAD data of reconstruction plans

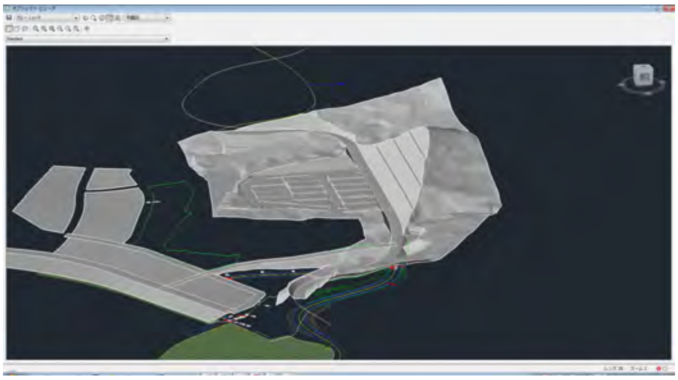

Fig. 4. Development of residential areas and roads

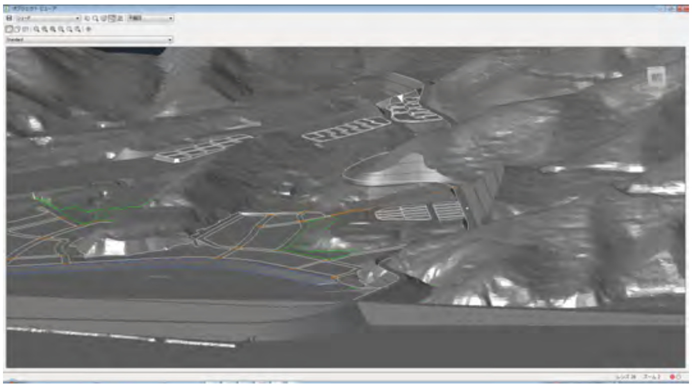

Fig. 5. Example of terrain creation of reconstruction plans

Fig. 6. Example of aerial photo overlayed onto terrain surfaces

Fig. 7. Example of aerial photo overlayed onto terrain surfaces and zooming houses in a residential area

Fig. 8. Reconstruction plan of Rikuzen Takata-city

Fig. 9. Example reconstruction plan of Miyako-city

III. 3D MAP OF FUKUSHIMA DAIICHI NUCLEAR POWER PLANT

In order to generate and maintain the 3D map of Fukushima Daiichi Nuclear Power Plant, we have built a database of the individual buildings of the power plant, residential area, and roads. These data should be inputed as accurately as possible. In addition to these data, we have placed CG model elements of typical objects, such as cars, people, and landscape features in order to make the model more realistic. These typical CG models are availabe comercially, but need to be converted to 3D CG models for the Infrastructure Modeler.

We classified files into folders of related items in order to make maintaining the 3D map information as easy as possible. The original building data of the power plant are stored in a “Fukushima Daiichi Nuclear Power Plant” folder, and the original aerial photograph data are in an “aerial photographs” folder. We stored all model files of Infraworks in an “Autodesk's model” folder. The aerial photograph are in a "raster images" folder, except raster images in the FBX format, which are stored in the FBX (FilmBox) folder.

We also stored a terrain model of the entire map in a “terrain” folder. The aerial photographs used in Infraworks to specify the location coordinates of the aerial photographs needed to be in a separate “world” file.

The aerial JPEG and JPW images were saved in a "raster" folder. The JPW files in the world file are the aerial JPEG images. The 3D model of the Fukushima Daiichi Nuclear Power Plant in the FBX folder was converted to the OBJ file format (FBX, 3ds format) for the model already published on the Web. It is possible for Infraworks to use any 3ds read files or FBX files, but since texture data associated with the 3D model (such as an image of a pattern) cannot be imported, conversion of a file to the OBJ format was done by using SketchUp (Trimble Navigation Ltd., USA), which is 3D modeling software for which there is also a free version available. The "map" folder was downloaded from the Geographical Survey Institute and stored; this folder contains an SHP file, which contains data on, for example, existing buildings, and GeoTIFF files of the terrain.

IV. EVALUATION

Figures 10–15 show snapshots of a walk-through video of the reconstruction plan of the Fukushima Daiichi Nuclear Power Plant. A walk-through video can be created interactively in the Infrastructure Design Suite and is effective for explaining the recovery plan of the power plant. This model was used for the study of the reconstruction plan of the town. In order to explain the status of the Fukushima Daiichi Nuclear Power Plant, we have a plan to show our video in real time and possibly all over the world from our website and a separate open website. Furthermore, the video could be displayed in information plazas in shopping malls and town halls.

Fig. 10. Walk-through of Fukushima Daiichi Nuclear Power Plant (1)

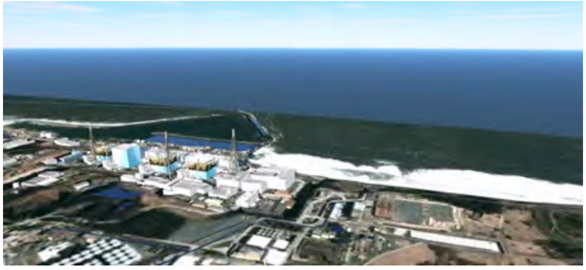

Fig. 11. Walk-through of Fukushima Daiichi Nuclear Power Plant (2)

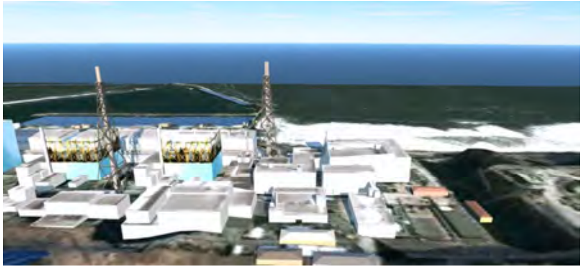

Fig. 12. Walk-through of Fukushima Daiichi Nuclear Power Plant (3)

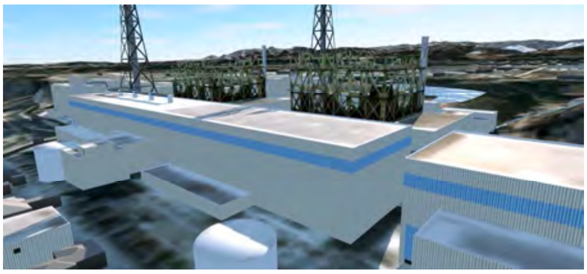

Fig. 13. Walk-through of Fukushima Daiichi Nuclear Power Plant (4)

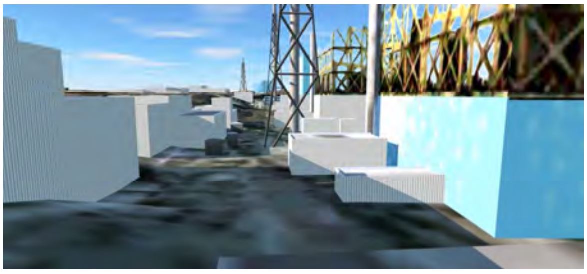

Fig. 14. Walk-through of Fukushima Daiichi Nuclear Power Plant (5)

Fig. 15. Walk-through of Fukushima Daiichi Nuclear Power Plant (6)

V. CONCLUSION

We presented the results of our efforts to construct a 3D model that integrates the reconstruction plan to replace the damage from the Great East Japan Earthquake. We also reported the case of using the 3D model reconstruction plan of the Fukushima Daiichi Power Plant. We have continued to store time-series data in our database, and it is very effective to view and compare present and future. Figs 16 and 17 show the current reconstruction plan of Rikuzen Takata City after the earthquake, and the terrain of the past before the earthquake, respectively. In this way, it is easy to visualize the change of the town.

In future work, we will improve and extend the software environment in order to input a large amount of 3D data in wider areas.

Fig. 16. Reconstruction plan of Rikuzen Takata City (After Earthquake)

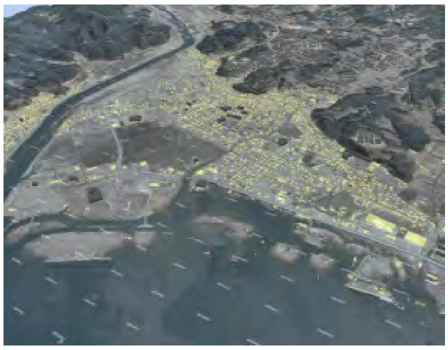

Fig. 17. 3D previous view of Rikuzen Takata City (Before Earthquake)

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