DEVELOPMENT OF DEEP SUBSEA 3D INFORMATION SYSTEM CONCEPT MODEL

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Abstract - In this study which is intended to develop the system module providing 3D information on subsea ground, development of ground information data process which is the core module of 3D information system and ground information visualization module was conducted. Ground information data process module was compiled with the data in same format for 3D visualization of subsea ground investigation result and analysis data and correlation among the data was calculated to make the ground information expressed linking each other.

Index Terms - Subsea ground, 3D, Visualization, Information system, Module

I. INTRODUCTION

In the global era, Subsea tunnel construction technology to build the transportation network hub is a must to obtain the accessibility that links the continents or the countries and is the core technology in structuring the multi-purpose hybrid marine infrastructure in a way of securing the subsea tunnel technologies and integrated life safety and operation technologies considering high water pressure. Japan is interested in building the subsea tunnel to be linked to the Eurasian Continent via Korea based on construction technologies accumulated through Seikan Tunnel, Tokyo Bay Aqua-Line and Tokyo Bay-crossing subsea tunnel and Korea needs to build the global transportation network through subsea tunnel in a b bid to obtain the access to the continent as well.

A long subsea tunnel, unlike land tunnel or shallow subsea tunnel, is the deep tunnel exposed to high water pressure but in-depth ground investigation of tunnel route is practically difficult. Therefore, geological survey or ground investigation for a long subsea tunnel requires different concept of the method from traditional ground investigation. For geological survey or ground investigation for subsea tunnel, it's necessary to identify the anomaly zone through the review of topographic and geological structure formation mechanism including fragmental zone of fault which may be related to formation of the coast of Korean Peninsula and theoretical approach on ground erosion and sedimentation record considering geohistorical features, thereby supplementing the limit with boring and physical prospecting. Besides, development of automatic module that allows the analysis of subsea ground through topographic and geological analysis is also needed and the system for 3D visualization of topographic and geological condition of subsea tunnel in a way of linking the physical prospecting data and boring data is required also. In this study, development of concept model was conducted as the basic study for developing the deep subsea 3D information system.

II. INVESTIGATION OF COMMERCIALIZED FOREIGN 3D VISUALIZATION S/W

For the purpose of developing 3D information system concept model, investigation of 3D visualization S/W used in other countries was conducted and the typical softwares includes “Gocad”, “MVS” and “Vulcan”.
When it comes to “Gocad”, It's been recently introduced to Korea for the purpose of 3D visualization of geological information, which is efficient for prediction modeling of geological data and is able to integrate complex geological structure, Multi-z surface and complex fault as well as gridding/upsaling to dynamic simulation [1]. Input source data includes OpenWorks®, GeoFrame®, ADCII, LAS, SEG-Y format and similar database. Fig. 1 shows the example of visualization using “Gocad”.

“MVS” stands for The Mining Visualization System which is commonly used for mining visualization. 3D fault (geological structure), tunnel (portal) and mining pit modeling are possible, particularly to 3D model for complex topographic or geological structure [2]. Fig. 2 shows the example of visualization using “MVS”.

When it comes to “Vulcan”, it is Explorer & Base module comprising of Geology, Block Model Viewing, Statistics, Vulcan 3D CAD, Data Transfer and Plotting. Particularly in geological module, the process for boring data, rock and geophysical data is possible and is commonly used for 3D geological analysis. It's compatible with ODBC connection to SQL Server™, Oracle¢ and MS Access™ and is often used for modeling program [3]. Fig 3 shows the example of visualization using “Vulcan”.

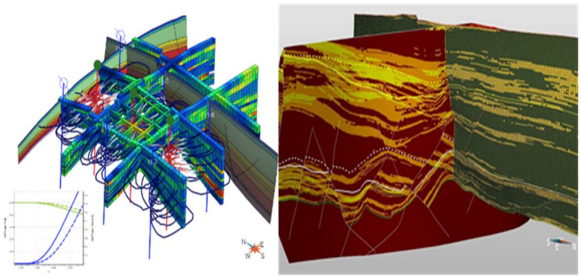


Fig. 1. Example of visualization of "Gocad"

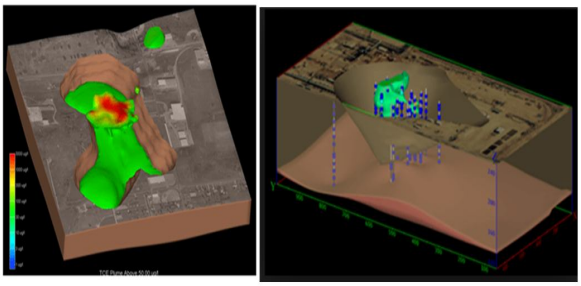


Fig. 2. Example of visualization of "MVS"

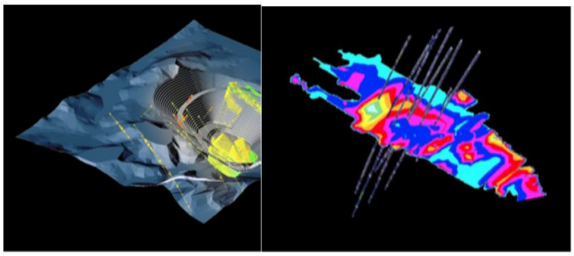


Fig. 3. Example of visualization of "Vulcan"

The characteristics of foreign 3D visualization softwares investigated are summarized as follows.

i) Information visualization programs are mostly used for mining-related geological information or resource design such as the output
ii) Complex program function and difficult operation technologies
iii) Geophysical statistical knowledge and experience are required
iv) For some programs, no Korean version is available
v) High procurement and maintenance cost

Existing information visualization programs are mostly used for mine resource design and are generally complex and difficult to use. Furthermore, the price is generally high except some softwares. On the contrary, 3D information system concept model is the dedicated system for analysis of anomaly zone, visualization of additional ground investigation data and design and is designed to use for required ground information only and particularly it's necessary to develop the system which is compatible depending on file type of geophysical prospecting result and is realizable in Layer form and 3D View. Moreover, it would be desirable to develop to accommodate rotation and section view.

III. GEOLOGICAL INFORMATION DATA PROCESS METHOD TO IDENTIFY THE INPUT FACTOR

A. Metadata

Metadata is the structuralized data which explains other data. It's the data given to the contents according to the certain rule in a bid to effectively detect and use the necessary data among the large amount of the data containing various information [4]. It is the information following the data to analyze and classify the structuralized data and add the additional data. For instance, among the topographic analysis result, it gives the rule to the data corresponding to geological anomaly zone which is subject to visualization.
Implementation for metadata organization is divided into three phases. Fig. 4 shows the metadata, the data necessary for visualizing the subsea ground information is classified into (A) phase, the process of data classification and connection for using the data by module is (B) phase and interface design for data movement between modules is (C) phase. Input data for forming the metadata shall be set in combination with metadata elements. It shall organize the metadata which is compatible with a single or multi-layer as the element required for changing to the system input data from the topographic information data, boring data and geophysical prospecting data [5]. Then it is necessary to consider data capacity and speed. Lastly, it is necessary to make the data into data conversion algorithm by layer depending on input data for data conversion interface design and database shall be organized by conceptual, logical and physical design. In addition, data required for subsea ground information visualization shall be classified and connected for use by module and based on this, interface shall be designed to allow data movement among modules.

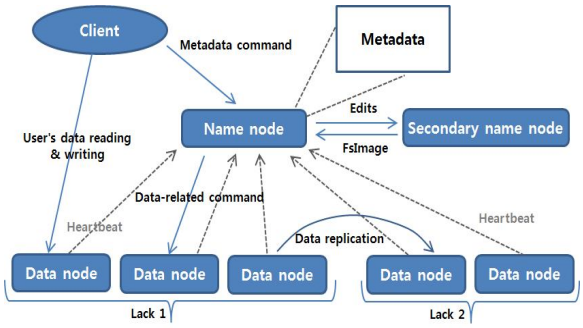


Fig. 4. Explanation of metadata

B. Data process technique

As the geological information data process technique to identify the input element, analysis of input data from subsea topographic and geological structure, physical prospecting and boring was conducted. It's necessary to have data characteristic analysis and class design for 3D expression and organization of basic

element in standard data form for 3D visualization [6]. And in designing the data conversion module for 3D visualization of subsea topographic and geological information, interface design for data classification and adapter connection to line the data to 3D module so as to prepare for additional data connection are important. Fig. 5 shows the diagram on interface design and Fig. 6 shows the diagram on adapter organization.

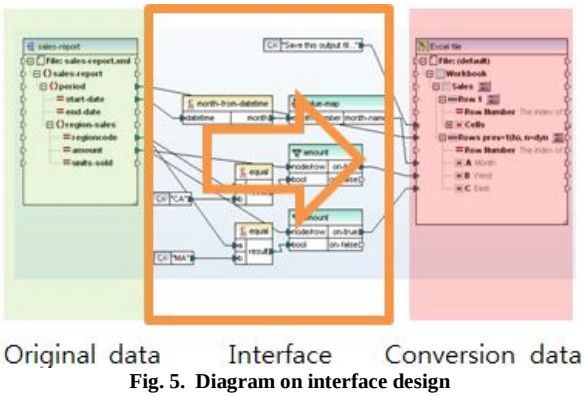


Fig. 5. Diagram on interface design

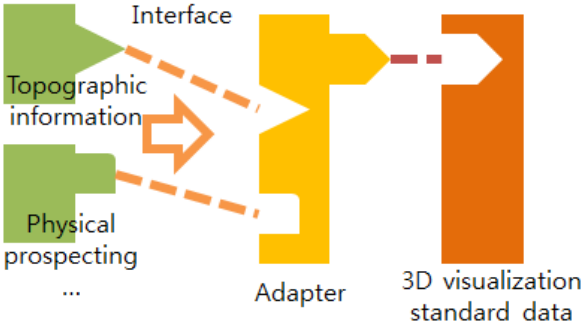


Fig. 6. Diagram on adapter organization

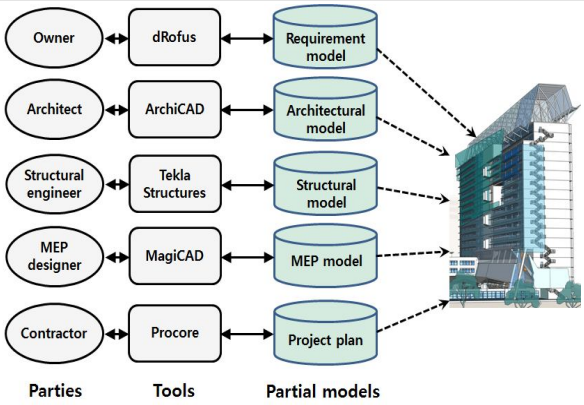


Fig. 7. BIM standard module

IV. IDENTIFICATION OF OUTPUT DATA TYPE CONSIDERING BIM CONNECTION

Output data type considering BIM connection from the 3D information system module is also required. BIM formats include 3IFC, DGN and XML [7]. Fig. 7 shows BIM standard format to link with BIM tool, then it is desirable to produce related information in IFC (Industry Foundation Classes) file but IFC includes not only the information of relevant element to be expressed but also related structure and connection information. As subsea ground 3D visualization module was developed to indicate the ground information only, attribute data of the structure is insufficient. Thus it would be better to separate element shape from the attributes of location information in 3D visualized module so as to produce the shape data first. Shape data needs to be produced in STL (Stereo Lithography) file form which is one of the standard data formats that expresses 3D shapes.

V. DETERMINATION OF 3D INFORMATION SYSTEM CONCEPT MODEL

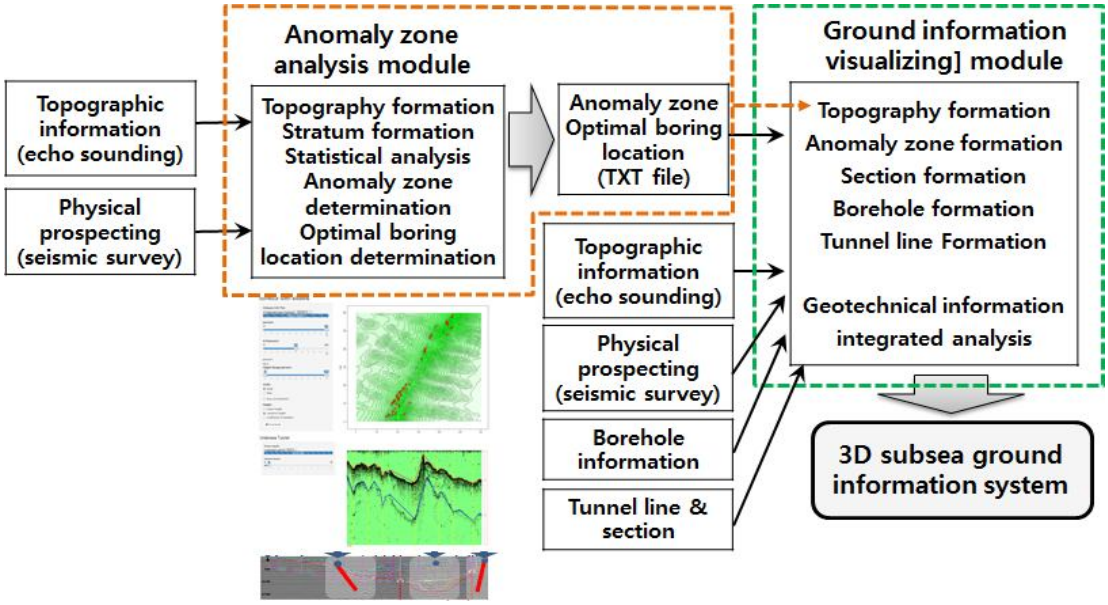


Fig. 8. Development concept of 3D information system

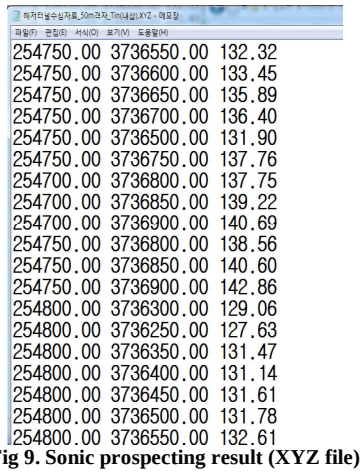
The data processed by subsea ground 3D information system is the outcome as a result of analyzing the topographic information, tunnel alignment, borehole information, physical prospecting and statistical analysis. Each data has own attributes and interface was given for interlocking with other data. To express the all elements from 3D visualization platform, information on data itself or data group coordinates and time was added to establish the overall concept model. Fig. 8 shows the development concept of 3D information system.

Subsea topographic information accommodates two data including sonic prospecting result and contour map. Fig. 9 shows the sonic prospecting result which is the TEXT file stored in ASCII form with XYZ extension. Sonic prospecting result is the file comprising of coordinates and thus all measuring points are stored in the list by organizing the coordinated class. Sonic prospecting class has measuring coordinates list and boundary information in 3D space of the coordinates. When overall range and size of each element are identified when indicating the objective, space movement calculation could be processed quickly. When reading all measured points in order, maximum and minimum value to 3 axes in 3D space are calculated and boundary information is stored.

Coordinates forming the contour line are obtained by reading contour information from digital map CAD file. Contour line on digital map comprises generally the poly line elements and thus the information on poly line points is obtained by reading the poly lines. Information on points forming the contour line on digital map is more dense than sonic prospecting result and thus to improve the calculation speed and reduce the data size, algorithm to arrange the points from digital map at the interval similar with sonic prospecting result was implemented.

Digital map was organized to process the DXF file which is the open format in CAD file, which is as Fig 10. Layers necessary for the digital map only were adopted by reading layer information in DXF file. As the name of layers is different by digital map, it's arranged to show whole layer information when calling DXF file so as to select the necessary layer by the user. Topography class accommodating the digital map was organized with the field to store DXF file name, layer list and the layer number selected by the user.

Topographic information comprises subsea ground exploration result and point cloud from digital map, which is as Fig 11. As the number of coordinates obtained from contour map is more than subsea ground exploration result, algorithm which identifies the coordinate per unit length of the designated line or selects the layer by height to reduce the number of coordinates was used. When point cloud information is formed, geomorphic surface is formed. Using the arranged point cloud, overlapping and adjacency of the data obtained by plane mesh generation algorithm are reviewed and invalidated data is removed to reduce the error and enhance the quality when forming the geomorphic surface.



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254750.00 3736550.00 132.32
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Fig 9. Sonic prospecting result (XYZ file)

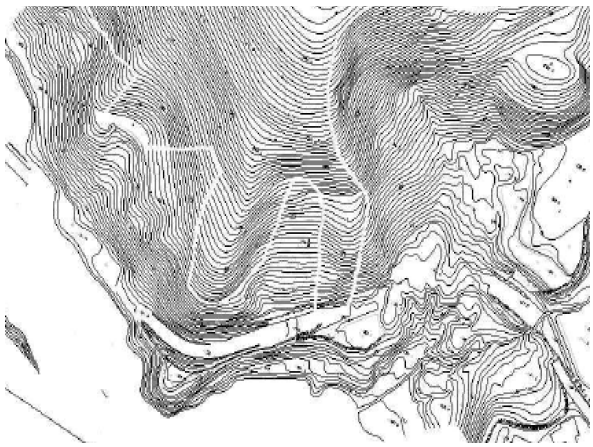
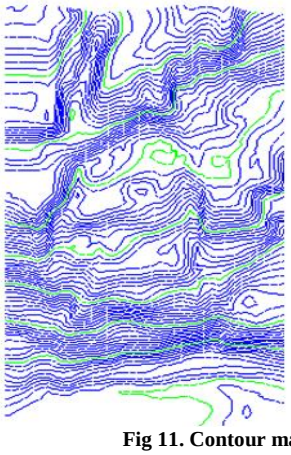


Fig 10. Digital map (DXF file)



	X	Y	Altitude
1	-10.0	300.0	195.0
2	-10.0	295.0	195.0
3	-10.0	290.0	195.0
4	-10.0	285.0	195.0
5	-10.0	280.0	195.0
6	-10.0	275.0	195.0
7	-10.0	270.0	195.0
8	-10.0	265.0	194.0
9	-10.0	260.0	193.0
10	-10.0	255.0	192.0
11	-10.0	250.0	191.0
12	-10.0	245.0	190.0
13	-10.0	240.0	189.0
14	-10.0	235.0	188.0
15	-10.0	230.0	188.0
16	-10.0	225.0	188.0
17	-10.0	220.0	188.0
18	-10.0	215.0	188.0
19	-10.0	210.0	188.0
20	-10.0	205.0	188.0
21	-10.0	200.0	184.0

Fig 11. Contour map and point cloud

CONCLUSION AND PLAN

In this study which is intended to develop the system module providing 3D information on subsea ground, development of ground information data process which is the core module of 3D information system

and ground information visualization module was conducted. Through this study, development of the deep subsea 3D information system is under consideration. Besides, it's planned to develop 3D modeling technology to develop the technology to identify the characteristics of subsea ground and anomaly zone in a way of linking the line structure analysis of subsea topography and geology and subsea ground formation mechanism. Particularly actual exploration around the Korean Peninsula will be implemented to obtain the subsea topographic and geological data as well as identify the measure to reduce the exploration cost.

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REFERENCES

[1] J. Y. Kwak and J. B. Choi, "3D Modeling and resource estimation of the Archean greenstone belt gold deposits in Australia by using GOCAD S/W," MSK, Proceedings of the Annual Joint Conference by the Mineralogical Society of Korea, Vol. 1, pp. 3-5, May. 2013.
[2] https://www.ctech.com/products/mvsevs-product-suite/mvs
[3] https://www.mining-technology.com/products/vulcan-3d-pp
[4] T. W. Kang, S. H. Choi, J. R. Hwang and C. H. Hong, "The study related to the meta data for the attribute mapping from IFC to CityGML," KSGPC, Journal of the Korean Society of Surveying, Geodesy, Photogrammetry and Cartography, Vol. 30, No. 6, pp. 559-565, 2012.
[5] Y. G. Jang and S. H. Lee, "Development of Geotechnical Information Input System Based on GIS on Standardization of Geotechnical Investigation Result-format and Metadata," KSCE, Journal of the Korean Society of Civil Engineers, Vol. 28, No. 4D, pp. 545-551, 2008.
[6] J. H. Lee and M. G. Park, "A Display System of Realtime 3D Bathymetry Using Remote Sensing Exploration and Cloud Computing Technologies," KMMS, Journal of Korea Multimedia Society, Vol. 17, No. 2, pp. 152-159, Feb. 2014.
[7] J. E. Kim and C. H. Hong, "study on location correction method of indoor/outdoor 3D model through data integration of BIM and GIS," KAIS, Journal of the Korea Academia-Industrial cooperation Society, Vol. 18, No. 3, pp. 56-62, 2017.

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