# SYSTEM TO PROVIDE 3D INFORMATION ON GEOLOGICAL ANOMALY ZONE IN DEEP SUBSEA

**[1]WOO-SEOK KIM, [2]O-IL KWON, [3]BYUNG-CHAN KIM**

Korea Institute of Civil Engineering and Building Technology, Korea Institute of Civil Engineering and Building Technology, BasisSoft Inc.
E-mail: [1]kws@kict.re.kr, [2]kwonoil@kict.re.kr, [3]bryan@basis.co.kr

**Abstract -** This study is intended to analyze the geological anomaly zone for ultra deep seabed l and visualize the geological investigation result so as to develop the exclusive system for processing the ground investigation information which is convenient for the users. Particularly it's compatible depending on file of geophysical prospecting result and is realizable in Layer form and for 3D view as well. The data to be processed by 3D seabed information system includes (1) deep seabed topographic information, (2) geological anomaly zone, (3) geophysical prospecting, (4) boring investigation result and (5) 3D visualization of the section on seabed tunnel route. Each data has own characteristics depending on data and interface to allow interlocking with other data is granted. In each detail function, input data is displayed in a single space and each element is selectable to identify the further information as a project. Program creates the project when initially implemented and all output from detail information is stored by project unit. Each element representing detail information is stored in image file and is supported to store in text file as well. It also has the function to transfer, expand/reduce and rotate the model. To represent the all elements in 3D visualized platform, coordinate and time information are added to the data or data group to establish the conceptual model as a whole.

**Index Terms -** Geological anomaly zone, geophysical investigation, 3D information system, subsea tunnel

## I. INTRODUCTION

The study on building the ultra long and deep subsea tunnel of which length is 50km and depth is 200m at least, respectively, is underway in Korea. To analyze the geotechnical information required for designing and building subsea tunnel, topographic/geological information analysis using 2D seabed geophysical prospecting and topographic, geologic, exploration and boring data were analyzed comprehensively and as a result, automation method to identify the geological structure zone under seabed which is needed to design the deep and long seabed tunnel was developed using geostatistical analysis. In addition, software using 3D visualized ground information to provide the information includes Gocad, MVS, Vulcan and DIMINE [1]. So, this study is intended to analyze the geological anomaly zone for ultra deep seabed l and visualize the geological investigation result so as to develop the exclusive system for processing the ground investigation information which is convenient for the users [2].

## II. THEORETICAL BACKGROUND OF 3D INFORMATION MODULE

To represent the subsea ground information, Geometry object was defined in 3D space and geometric object appropriate to each ground mass information was generated and represented in 3D space. Ground mass information has basic coordinate information of X, Y, Z in 3D space and color information.

The process to develop the program to generate the required virtual object in 3D space uses many space-related mathematical formulas and theories. Based on such formulas and theories, virtual object is generated on computer screen, which is called Geometry. Depending on Geometry implementation method, it uses Polygon or NURBS method [3] [4]. Polygon method is most commonly used as the standard for Geometry. Before NURBS method, it was the only way of generating Geometry in 3D. Polygon stands for lexically polygonal shape and Polygon is the face based on mathematical face. Basic unit of the figure is the point, line and face and the line is the connection between the points (in fact, numerous points are linearly aligned) and the lines form the face. Polygon is 2D face based on such principle. 2D faces without thickness form a 3D Geometry, which is the Polygon style modelling. Fig. 1 shows the sphere implemented by Polygon and NURBS in a wire frame state.

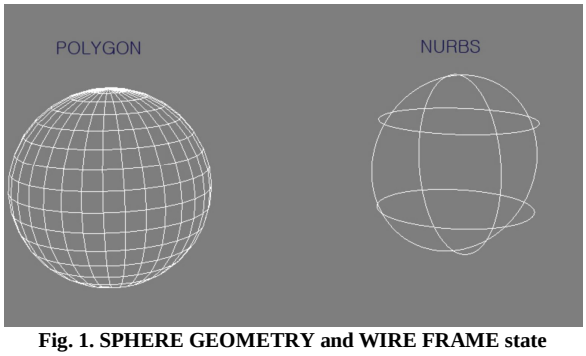



**Fig. 1. SPHERE GEOMETRY and WIRE FRAME state realized by Polygon and NURBS**

Fig. 2 is the rendering result of sphere implemented by Polygon and NURBS. It's difficult to identify the difference of 3D Geometry method from surface rendering result. Fig. 3 shows the spheric Geometry generated as a result of binding the polygon, the basic unit. Where, that in red is the polygon which is the basic unit to represent the sphere.

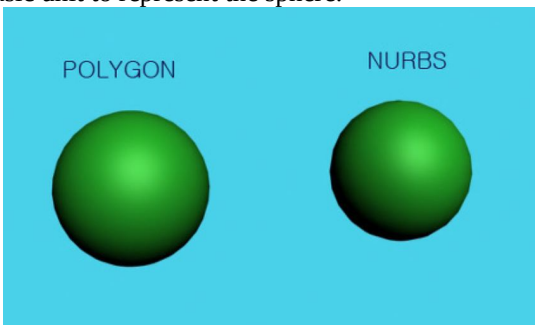



**Fig. 2. Rendering result of sphere made of POLYGON and NURBS**

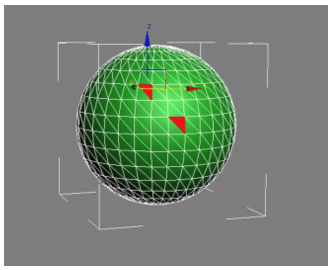


**Fig. 3. SPHERE GEOMETRY generated by binding polygons**

The most basic 3D Object in 3D software includes Sphere, Box and Cylinder and this basic object is not organized with a single element but basic 2F Polygons, making it 3D Geometry. 3D Geometry comprising of Polygons is also dubbed as Polygon Mesh. Mathematically the minimum number of point necessary to form a single face is three. Triangular face is formed by linking 3 points and thus the minimum unit of Polygon object which is based on mathematics is just a triangular Polygon and thus any 3D Polygon objects have the structure that are linked with Polygon, the minimum unit.

In most of 3D softwares, basic polygon unit comprises of rectangular polygon, not triangular polygon. But it just looks like that and in fact, such rectangular polygon comprises of 2 triangular polygons binding each other. When representing all objects with a triangular polygon, it represents too many edges when modeling the complex object which appear too complex when compiling. Thus though it's the object linked with triangular polygons, the edge in the center is excluded from view point when a rectangular polygon is formed for the convenience of compiling. Fig. 4 shows represent spheric geometry in Polygon mode and it appears the sphere comprising of rectangular polygon but in fact, it's found to comprise of triangular polygons when selecting all edges.

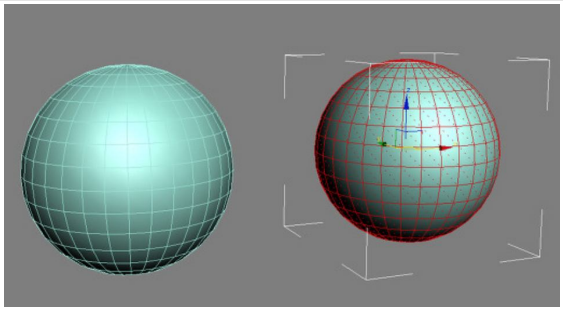


**Fig. 4. Spheric Geometry in Polygon mode**

## III. SUBSEA GROUND 3D INFORMATION SYSTEM

Using the data class and 3D visualization module defined previously, subsea ground 3D information system was developed. Subsea ground 3D information system comprises of 5 functions including topographic information, geological anomaly zone, geophysical prospecting, boring data and tunnel alignment. The data from 5 functions is represented in a space and detail information is identified by selecting each element. The project was organized to control the detailed information. The program can generate the project by initial implementation and all output from detailed information is stored by project unit. 3D space to represent all elements from main screen is drawn. Each element that represents the detailed information can be stored in image file and supports the function to store in text file. In 3D space, it provides the function to move, enlarge/reduce and rotate the model [5].

### (1) Deep seabed Topographic information

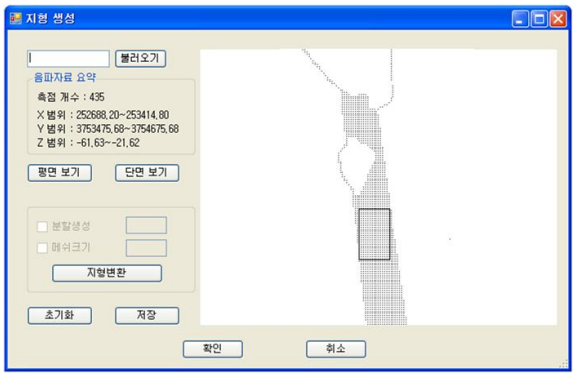



**Fig. 5. Topography generation input window (ver. 1.0) in Korean version**

Topographic data generation input window provides the function to read sonic prospecting result file (xyz file) and digital map (DXF file) When the filed is called, summary information on point is displayed. Total number of point and maximum and minimum value by axis are displayed in 3D space [6]. Topographic information imported is identified on screen with nodal points. Based on nodal point imported, a triangular net can be generated and a

simple option to control the generation of triangular net is provided. Maximum size of the triangle and the limit in acute angle of triangle which are the basic element of triangular net that forms the 3D curved surface can be set. Topography generation result can be stored in XML file or CSV file. When the topography is generated, the result is stored at internal database for use. Fig. 5 shows the topographic data generation input window.

**(2) Tunnel alignment**

Tunnel alignment can be defined by inputting the coordinates directly. A tunnel is defined as the shape with a circular section and tunnel diameter can be defined. Each point defined in tunnel alignment is linked to represent the tunnel. At intermediate stage, tunnel is represented by linking the points in alignment information and at final stage, it's represented by linking the points smoothly after interpolation of the points in 2D curve. Input coordinates are represented on grid where the coordinate may be added or deleted. If the tunnel alignment coordinate is CSV file, tunnel alignment may be imported by calling function. Tunnel alignment information is coordinate information and if x, y, z value is sorted by " , " and stored, TEXT file with different extension may be imported also. The separator is basically designated as " , " and supports the gap or tap as well.

Tunnel alignment inputted can be identified by section and plan view and 3D view function is provided. At intermediate stage, tap was organized by view and at final stage, 3D view only is available and tunnel alignment will be identifiable by stage. In 3D view, movement, enlargement/reduction and rotation function are provided. When tunnel alignment is generated, tunnel alignment information is stored at internal database for use in other sub-functions.

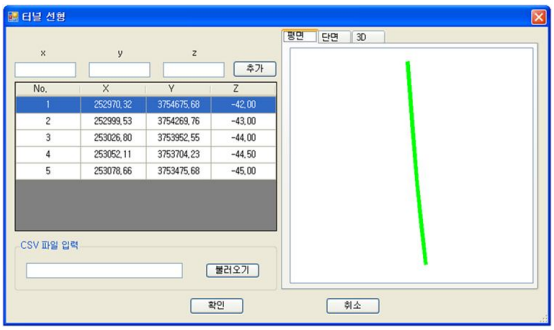



**Fig. 5. Designated input window for tunnel alignment (ver. 1.0) in Korean version**

**(3) Geological anomaly zone**

Geological anomaly zone is the function to read the analysis result by R program and represent in 3D space [7]. As geological anomaly zone analysis result is in coordinate values, it's designed to represent it in spheric value. As anomaly zone is small for a whole topographic area, it provides the function to enlarge each spheric element representing anomaly zone. It enlarges the scale up to 10 times in 3D space without changing the actual data.

As geological anomaly zone analysis result is the result data on plan, the function to draw by projecting it on ground surface is needed. It searches the polygon including topographic analysis point through crossover operation of the topography and topographic analysis result and performs projection operation with polygon face. Geological anomaly zone result is able to start or stop view function in 3D space.

**(4) Geophysical prospecting result**

As geophysical prospecting result is the data represented on vertical plane, it provides the function to define the test surface (vertical plane) in 3D space to represent the geophysical prospecting result [8]. As geophysical prospecting result contains many measured values of the points and corresponding points, it may be either directly illustrated in 3D space or the result may be processed by analysis program and result image may be stored and represented. At intermediate stage, test surface is defined and the result image is represented on test surface. At following stage, direct representation method is added depending on result. As geophysical prospecting analysis result is represented similar with geological anomaly zone, common function was defined and sub-function was divided for development

**(5) Boring investigation**

Boring investigation comprises the location and slope of borehole and name of stratum by depth. Individual borehole information may be input through boring log input window. Borehole information is summarized and defined in TEXT file. When inputting borehole information in accordance with defined form, information on several boreholes is called together. Borehole is represented in circular column and as it's small for whole space, it provides the function to enlarge the scale. Borehole location is indicated by flag on geomorphic surface so as to identify the borehole from the location above the surface.

## CONCLUSION AND PLAN

To represent the all elements in 3D visualized platform, coordinate and time information are added to the data or data group to establish the conceptual model as a whole. And, 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 bed formation mechanism by system's version update. 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.

## ACKNOELEDGEMENT

This research was supported by the Korea Agency for Infrastructure Technology Advancement under the Ministry of Land, Infrastructure and Transport of the Korean government. (Project Number: 13 Construction Research T01)

## 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] 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.

[3] D. A. Kopriva, "Implementing Spectral Methods for Partial Differential Equations: Algorithms for Scientists and Engineers (Scientific Computation) 2009th Edition", Springer, 397p, 2009

[4] M. Heng, "Smooth and Time-Optimal Trajectory Generation Methods: NURBS Parameterization, Feedrate Modulation and Feedrate Optimization", VDM Verlag, 132p, 2008.

[5] 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.

[6] I. V. Florinsky, 1998, Accuracy of local topographic variables derived from digital elevation models, International Journal of Geographical Information Science, Vol. 12, pp.47–61, 1998.

[7] O. I. Kwon, Y. Baek and J. H. Kim, "Mapping submarine bathymetry and geological structure using the lineament analysis method", The Journal of Engineering Geology, Vol. 24, No. 4, pp. 455-461, 2014.

[8] M. Y. Anne and H. S. George, "A note on the seafloor coupling characteristics of the new ONR ocean-bottom seismometer", Marine Geophysical Research, Vol. 16, No. 2, pp. 91-103, 1994.

★★★