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Application of tunnel information system for construction supported by international cooperation

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ABSTRACT: The system (ITIS, Intelligent Tunnel Information System) which can manage and analyze the tunnel information in design and construction stage has been developed through several years' research. This system is being modified and improved for the international sharing of tunnel construction information. Since each country has each management system for tunnel construction information, the new system should allow the different forms of information. In this research, Austrian system (DEST, Data Evaluation System for Tunneling) is adopted for the international cooperation with Korea. The system under development (ITCISS, International Tunnel Construction Information Sharing System) is operated in web-based environment. Therefore, it is possible that the tunnel construction information can be shared and cross-reviewed internationally by use of ITCISS.

1 INTRODUCTION

Recently, tunnels with length over 10 km are constructed increasingly all over the world including Europe and Asia. In Korea, various tunnels are planned to be constructed for express way, subway, railway and utility. However, tunneling cost in Korea is relatively higher than in Europe, thus current problems of tunnel construction in Korea should be investigated. Sufficient investigation and analysis of European tunnel construction information is also required for the precise comparison. Tunnel construction information (monitoring, face mapping, construction history etc.) and its practical use on site should be examined carefully for the establishment of the sharing system because the philosophy of tunnel design and construction could be different between countries.

In this research, core components of tunnel construction information are determined by analyzing various management systems of tunnel construction information and the standard relational database model is established for international tunnel construction information sharing system (ITCISS). Also, internet-based ITCISS is developed to share tunnel information during construction between Austria and Korea for the initial development. In addition, ITCISS is designed in consideration for extension of this system and connection with other countries.

2 TUNNEL INFORMATION SYSTEM

2.1 *Requirements of database system*

The data stored in the system would be provided from many construction sites of different countries, which have not only conventional and compatible type of information but also their unique type of information characterized by their own construction method, construction condition, geological environment and so on.

The requirements of database system for the storage and manipulation are:

- That the data would be stored in a commercially and practically acceptable database standard, enabling future access and migration.
- That the data could be protected against unauthorized access, and was secure during use from accidental or deliberate corruption.
- That the data could be accessed as soon as it becomes available at any location.
- That manipulation and display of the data would need no special knowledge and should be intuitive for the user.
- That creation of data by the contractor should be simple and consistent, using commonly available software and transmission techniques.

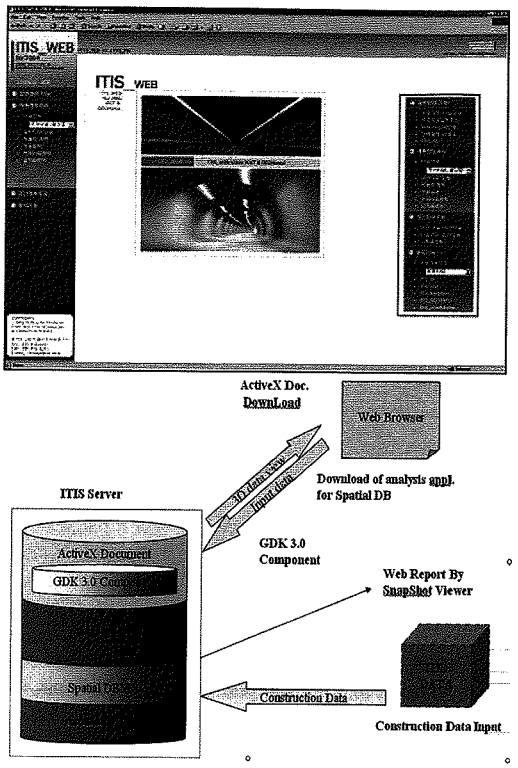
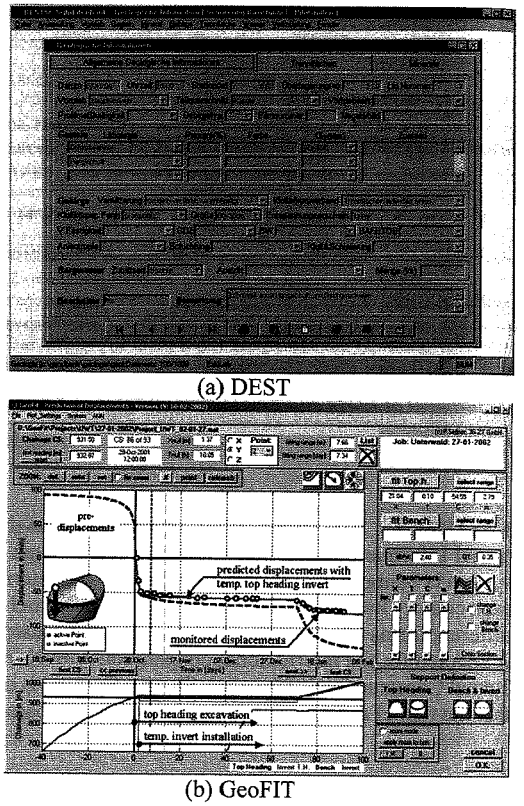


Figure 1. ITIS GUI feature.



(a) DEST

(b) GeoFIT

Figure 2. DEST & GeoFIT GUI feature.

2.2 *Existing system*

ITIS (Intelligent Tunnel Information System) had been developed by Korean Institute of Construction Technology (KICT) for the purpose of integrated D/B management, analysis and visualization system for geotechnical projects especially tunnel construction in Korea (Hong et al. 2002, see figure 1) ITIS is being modified to make up integrated tunnel construction information system both in domestic and foreign countries.

For tunnel information system shared between different countries, several important constraints such as database structure, system architecture, environment and infrastructure of operation should be considered. The first counterpart country is decided to be Austria because New Austrian Tunnelling Method (NATM) is applied commonly in Korea.

DEST (Data Evaluation System for Tunnelling) is an in-house database system developed by Institute for Engineering Geology and Applied Mineralogy of Graz University of Technology. Geofit is an in-house software developed by Institute for Rock Mechanics and Tunnelling of Graz University of Technology for the interpretation of geodetic monitoring data (see figure 2).

3 INTELLIGENT TUNNEL INFORMATION SYSTEM (ITIS)

3.1 *System outline*

Arriving at the correct design for the information system before embarking on its development is very important. Site investigation, tunnel design and construction data are generally existed in forms of manually completed documents, project reports, regional geotechnical maps and geotechnical relational database, etc. And the analysis of these data that located against some form of map or plan is generally two dimensions. ITIS is an integrated D/B management, analysis and visualization system for geotechnical projects especially in tunneling. It is a true client-web server database system. The client-web server model for distributed computing allows multiple client PCs to request data from a single server PC on which resides a database and the software for servicing client requests. The structure of ITIS is shown in figure 3.

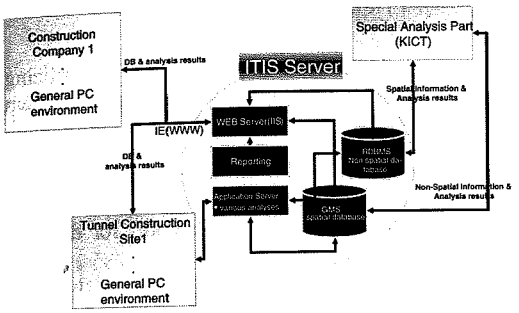


Figure 3. System structure of ITIS.

3.2 *Visualization of the information*

In ITIS system, the techniques of 3-D visualization and VR are used to visualize a complicated geotechnical structures in the 3-D space and many kinds of analysis and investigated data in tunneling. Because tunnel construction is performed under 3-D space with complex discontinuities such as fault, joint and bedding, 2-D drawing design is difficult to figure out, so 3-D graphic technique is necessary to utilize and give out information rapidly and efficiently. Besides, VR technique can make users control all the movements and actions not by programmers but by his willing. That is, users can enter into VR space, experience the defined world, and interact each other by their eyes, ears and hands. Thus, it is one of the substitutive recommendations to apply VR technique to visualization of geotechnical information in order to make users comprehend it easily. All useful information acquired from 3-D graphic technique and site investigation can be used to simulate many possible and critical circumstances that may be faced or experienced during construction. In addition, VR is helpful to choose the appropriate construction procedures(see figure 4).

4 ITCISS (INTERNATIONAL TUNNEL CONSTRUCTION INFORMATION SHARING SYSTEM)

In this research, two different systems (ITIS (Korea) & DEST (Austria)) are to be integrated for sharing system of tunnel construction information. Numerous experience and construction information are stored in each system, so that ITCISS can be a very meaningful tool in the light of combining them with powerful analysis modules in one system. For this purpose, all the data should be produced under consistent quality control and the various types of data (figures, pictures or qualitative description) should be digitized and managed in an appropriate system.

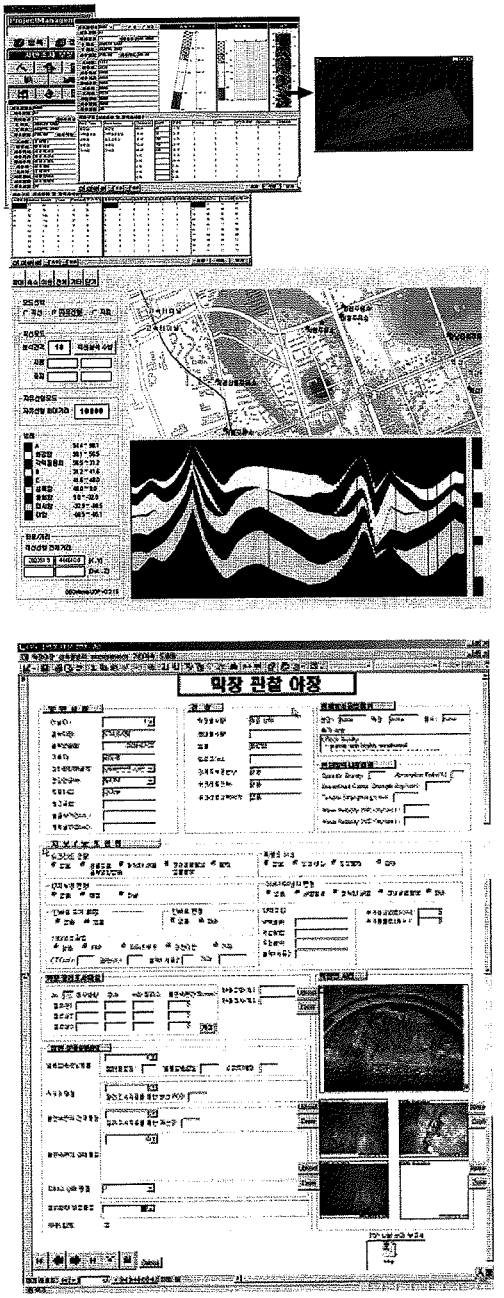


Figure 4. Visualization of the information in ITIS.

Table 1 shows the differences of ITIS and DEST. To combine the database systems and access in each country, linkage between ITIS and DEST was developed as shown in figure 5.

Table 1. Comparison of ITIS and DEST.

Item	ITIS	DEST
System architecture	On-line Networking RDBMS	Stand-alone General DBMS (non relational)
Principal functions	GIS-application (Visualization/Various stability analysis modules included)	Powerful analysis for monitoring (with GeoFIT module)
DB items	Non changeable DB schema (Unified database)	Changeable DB schema by user (Site-specific database)

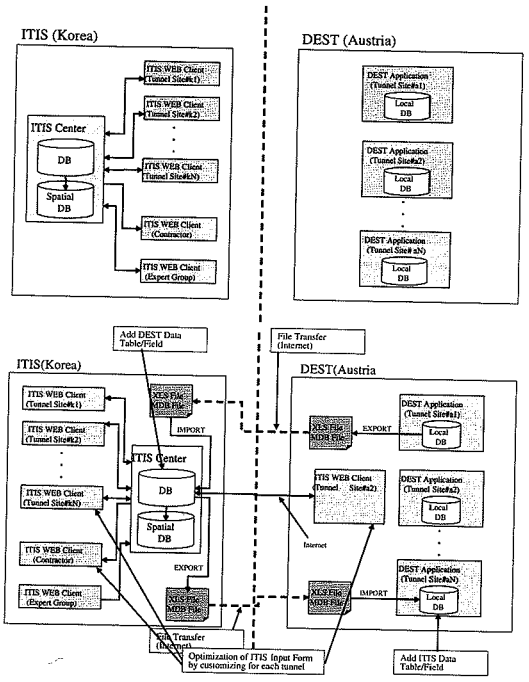


Figure 5. Linkage between ITIS and DEST in ITCISS.

5 CONCLUSIONS

This paper introduced improved way of utilizing tunnel construction information as a model system sharing international tunnel construction information. Advanced system to share tunnel construction information between countries can be meaningful not only in accumulation of various experience and data but also in cooperation of on-line support for decision making on site.

Several topics are being researched, related with database system. For instance, the database system of construction information will be used for the research of the expert system for tunneling, prediction of tunnel displacement or risk Assessment of excavation. The application of this database system will be enhanced more and more in the future and the cooperation with related countries will produce a fruitful result.

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