Development of National Geotechnical Management System Standards for Transportation Applications

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Abstract

Geotechnical data exchange with industry, academia, governmental agencies, and organizations could be easily accomplished with uniform standards. Software producers would also benefit from the deployment of uniform standards, which were nationally marketable and compatible with other software developers. The Federal Highway Administration (FHWA) in conjunction with the Ohio Department of Transportation (ODOT) formed a group to develop data dictionaries and data formats for geotechnical management systems. The group is coordinating its efforts with other national and international agencies and groups. The initial focus is on data transfer standards. The standards will likely be adopted as both national and international standards.

Introduction

State DOTs are faced with the continuing pressure to reduce staff while experiencing increased work loads. Our highway systems have grown significantly and are reaching their optimum design life. Consequently, DOTs are tasked with development and management of an ever growing transportation system. With limited resources, each DOT is striving to improve the efficiency of their operations and better manage their staff time, funds, and highway systems.

Management systems can provide a means to assist DOTs in managing their data and highway systems while improving decision making and efficiency. DOTs have adopted management systems for pavements, bridges, culverts, traffic signs, and other assets. These systems provide an efficient means for data storage, retrieval and utilization to enhance decision making.

State DOT geotechnical specialists are pursuing means to better manage geotechnical data (e.g., boring logs, lab test data), geologic hazards (e.g., landslides, rockfalls, mine subsidence), and assets (e.g., walls, reinforced slopes). Several states have instituted electronic data management systems to manage geotechnical data for large projects. Some states have hazard management systems in place. And some states are beginning to develop geotechnical asset management systems for elements such as piling or retaining walls.

The benefits of adopting an electronic management system for geotechnical information, assets, and hazards are significant. The lost efficiencies due to not adopting geotechnical management systems are equally significant. Consequently, many state DOT geotechnical specialists express an eagerness to adopt systems to manage the flood of incoming geotechnical data.

Ohio DOT at one time performed almost all geotechnical investigations with its own drilling crews. Now, those crews perform only about 10% of the subsurface investigations conducted statewide each year. The geotechnical investigation records for the state drilling crews are stored in a warehouse at the central DOT vehicle maintenance facilities once the projects are completed. Multiple projects are stored in each cardboard records box and the boxes are indexed by the section of warehouse shelf where they are stored. See Figures 1 & 2. Over 21,000 index cards are maintained to provide a reference to the project boxes. Frequently, box location and subsequent reference numbers are changed without updating the index cards. This makes the retrieval of information difficult and time consuming. It currently requires 20-30 person hours per week to retrieve information for planning and preliminary design of projects. Another complication involves problems with the storage facility for the data. The information

is subject to sever cold and heat, high humidity, and water damage due to roof leakage as shown in Figures 3 & 4. In many cases, the some of the project information is damaged, lost, or virtually inaccessible.

Figure 1 Storage of Ohio DOT subsurface investigation data.

Figure 2 Investigation data storage. Notice that the boxes are stored two deep.

Figure 3 Water stains on the floor from roof leakage.

Figure 4 Water stains on the floor from roof leakage.

This historical information is valuable for nearly all future highway projects including rehabilitation and widening. The information stored at the central office is valued at $½ billion. An equivalent amount of geotechnical data is also stored at District offices. It is estimated that the use of this information will reduce the amount of drilling for projects by 10-20% resulting in cost savings of $12-24 million per year.[1]

Subsurface investigation data and reports for consultant designed projects are placed in their respective project files residing at each District office. This information is held in the file until several years (usually about 7 to 8 years) after the completion of the project. Then, the project files are purged and disposed of. This practice may result in the loss of geotechnical data valued at an estimated $52 million per year.

Figure 5 This is the final storage location for $52 million of subsurface investigation data every year. The information will be difficult to retrieve in the future

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The use of electronic data management systems would not only permit data to be more securely stored and more easily retrievable, they would also permit the data to be widely shared throughout the state DOT, with their consultants, and with other agencies. In addition, they could provide information for better planning and more thorough subsurface investigation programs resulting in higher quality designs and fewer problems during construction.

Geotechnical management systems could also incorporate inventories of geologic hazards and geotechnical assets providing not only location information but also construction information, maintenance history, materials data, and other important site information. Geologic hazard management is becoming increasing important because of liability issues with state DOTs. Asset management has become increasingly important because the complexity and extensiveness of our growing highway systems and the corresponding difficulty in tracking asset information. Who knows where the retaining walls are, when they were built, what type they are, and the backfill and material information? This information will be increasingly important as the assets deteriorate with age.

Another important aspect of geotechnical management systems is the ability to provide information for budgeting decisions. The Ohio DOT is now fortunate to have an annual statewide budget for correction of geologic hazards. Ohio DOT has an operating management system for abandoned underground mines and is developing systems for rockfalls and landslides. When these systems are operational and are combined with a remediation cost program they will provide valuable information to justify future annual funding allocations.

Current Efforts

Virginia DOT and other state DOTs have successfully implemented geotechnical data management systems for specific large highway projects. These systems allowed the state DOT, consultants, and contractor personnel to input and access the subsurface investigation and testing data with security controls. Some state DOTs such as Florida, Kentucky, and Ohio are developing more comprehensive geotechnical management systems that will eventually include subsurface investigation, lab testing, in-situ testing, construction control and testing, assets inventory, hazard inventory and rating matrix, maintenance, and research information.

The United Kingdom Highway Agency (UKHA) has a system in operation that includes boring log data and geotechnical assets inventory and rating information. The system is used to manage their highway system and also to evaluate the effectiveness of the companies that they hire to manage their highway system. The UKHA estimates that proactive maintenance results in up to 80% savings.[2]

The Consortium of Strong Motion Observation Systems (COSMOS) is developing a geotechnical data management system that includes a Geotechnical Virtual Data Center (GVDC) that collects data from numerous utility companies, universities, and local, state and federal agencies and makes that information available for dissemination via the internet. COSMOS has drafted the boring log, downhole seismic geophysics data, and testing data parts of the system.

The Association of Geotechnical and Geoenvironmental Specialists (AGS), based in the United Kingdom, developed a data dictionary and flat file data format for storage of geotechnical data often used by their members. The data dictionary and data format are widely used around the world. The AGS standards are also used in the UKHA management system and were used as a starting point in the development of the COSMOS system.

Workshop

The FHWA and Ohio DOT jointly funded a synthesis of practice of the use of geotechnical management systems by state DOTs and others. A Geotechnical Management System Workshop, jointly sponsored by FHWA and COSMOS, was held in Newport Beach, California in June 2004 to present the results of the synthesis, to discuss state DOT geotechnical management system needs, and to present the work of COSMOS, UKHA, and AGS. A breakout session of the representatives of the nine state DOTs represented was held at the workshop.

The state DOT representatives were very interested in pursuing the development of standards for geotechnical management systems. These standards would include a data dictionary, and the data format. The data dictionary would define all data terms. The data format would define how the data is presented.

The establishment of a standard data dictionary and data format will allow the exchange of information among local, state, and federal agencies and others. A state DOT highway project could conceivably take advantage of subsurface investigation data obtained in the same area by the state geological survey, state EPA, USGS, US Army Corps of Engineers, USGS, and others. Once in a standardized format, the information could be exchanged electronically via CD or the web and utilized by any software that uses the same data standard.

The adoption of geotechnical data standards by state and federal agencies will have a positive impact on software suppliers and their customers. Software developers now use proprietary data standards which creates problems of compatibility of data exchange between software packages from different suppliers. If a state DOT currently wants to change from one boring log software supplier to another, the old data may not be compatible with the new data base. Many of these problems would be eliminated with a single data standard and would enable access to a larger market for product development based on the new data standard.

Starting with the data standards has advantages. The data dictionary and data format are the bases of all other management system work. They are also the most difficult and time consuming elements.

Geotechnical Management System Group

Based on the interest from the state DOTs represented at the June 2004 workshop, the FHWA and the Ohio DOT formed a Geotechnical Management System (GMS) Group.

The goal of the group is to develop an open and flexible geotechnical management system generic framework that can be web enabled; can be used to store, retrieve, and manipulate data; can store, retrieve, or other wise access geologic information; provides a means to efficiently and proactively manage geotechnical assets and geologic hazards; can store and manage project data and test data; can be used as a tool to share information among interested entities; and can accommodate modifications to meet local needs. The GMS group will direct the development of a data dictionary and data format.

The GMS group will accelerate, enable, and facilitate the development of geotechnical management systems by developing frameworks, standards and protocols that will create a large commercial market and competition for software development, management system maintenance, new software and application tools. All frameworks, standards, and protocols will be open and flexible allowing for customization within agencies, direct interchange of data and information among software from various sources, and future expansion and modification as needed.

A benefit of the work of the GMS group, to all entities in need of a geotechnical management system, will be the reduction of cost and time required to develop their customized systems. This will be accomplished by reducing redundancy in the GMS efforts and by the collaboration that ensures operational compatibility of GMS on both a macro and modular scale.

Members of the Geotechnical Management System Group:

- California DOT
- Connecticut DOT
- Florida DOT
- Georgia DOT
- Kansas DOT
- Kentucky DOT
- Minnesota DOT
- Missouri DOT
- North Carolina DOT
- Nevada DOT
- Ohio DOT
- Tennessee DOT
- Virginia DOT
- FHWA
- FHWA Federal Lands
- United Kingdom Highway Agency
- United States Army Corps of Engineers
- United States Environmental Protection Agency
- United States Geological Survey

The GMS group decided to use XML schema that is GML compliant as the data standard. HTML or hypertext markup language is used to define how data is presented electronically. It is the most widely used standard for web based presentation. XML or extensible markup language is the new standard that is being adopted because it is much more flexible. XML allows additional data elements to be added to a data base without completely changing the data base. This feature has significant advantages for a state DOT that wants to use the standard but also wants to keep some data that is not included in the standard. GML or Geospatial Markup Language follows XML schema with the addition of geographic tags to locate the data geospatially.

The development of the standards will be funded through a pooled fund project directed by the Ohio DOT. The final products will be a data dictionary and data format for geotechnical data including all or most geotechnical assets, geologic hazards, foundations, geophysical data, monitoring data, and geoenvironmental data. Data transfer standards called DIGGS (Data Interchange for Geotechnical and Geoenvironmental Specialists) will be developed first. DIGGS will later be expanded to also include the database standards.

With the cooperation of state and federal agencies and with the international participation of the major associations responsible for geotechnical data compilation, it is anticipated that these standards will be adopted as both a national and an international standard.

Geotechnical Data Coalition

A Geotechnical Data Coalition was formed with representatives from the University of Florida, AGS, COSMOS, FHWA, Ohio DOT, and the Construction Industry Research and Information Association (CIRIA). This group agreed to merge the existing data transfer standards into a unified standard. Special interest groups comprised of selected members of the coalition and other specialists perform the work of development of the data dictionaries and schema. All work is approved by the coalition before submittal to the GMS Group. The GMS Group will oversee and approve the work of the coalition.

A special interest group consolidated the existing data standards into a draft data dictionary and GML schema and is now surveying the data needs of the state DOTs and other agencies and groups. The survey is web based. It is vital

that the information be complete so that all state DOT needs and the needs of others are adequately considered. There will be a significant effort required by each state and group in responding to this survey. It is expected that a minimum of a person week of effort will be required by each state and group responding to this survey. It is the intent of this project that the results are applicable and beneficial to all states and participants.

CIRIA is contributing to the work of the coalition through a project funded by the United Kingdom Highway Agency to review existing data transfer standards and develop guidance on best practice. This project is well underway.

Most of the work by the coalition will be voluntary or contributed by others. The pooled fund project will reimburse travel expenses for meetings, printing costs, graduate student expenses, and some other costs.

The cooperative nature of this group is permitting the work to progress quickly. The first product will be a data dictionary and data format for borehole data. Foundations data will be addressed next. The other data categories (assets, hazards, geophysics, monitoring, etc.) will be addressed as quickly as possible.

Summary

There is a great need for the development and use of geotechnical management systems by state DOTs because of increasing workload, increasing data, reduced workforce, and the aging highway system. Geotechnical management systems will enable DOTs to efficiently store and retrieve data resulting in efficient use of time, improved quality, and less costly subsurface investigations. In addition, GMS systems would permit efficient management of geotechnical assets and geologic hazards. Management systems also provide the means for better budget justifications.

Consequently, there is a great interest among state DOT geotechnical specialists for geotechnical management systems and a desire for prompt implementation. A group of state DOTs and other agencies was formed and is working on the development of a standard data dictionary and data format for geotechnical management systems. The Ohio DOT has issued a pooled fund solicitation to provide funding for the development of the standards.

A coalition of organizations was formed to cooperatively perform the work of consolidation of existing standards, survey of state DOT and other agency needs, and development of the standards. This coalition will perform this work mostly on a voluntary basis.

Data transfer standards, DIGGS, will be developed quickly. A draft version of the boring log data dictionary and data format will be issued first. Transfer standards will soon be developed for other geotechnical data. The transfer standards will later be expanded to be used for database standards.

References

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2. Patterson, David and Spink, Tim, 2004, The UK Highways Agency Geotechnical Data Management System (HA GDMS), presentation at Geotechnical Management System Workshop