COMMUNICATION OF GEOPHYSICS IN UNDERGROUND INFRASTRUCTURE PROJECTS

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Abstract

In infrastructure planning in Sweden there has been a clearly increased use of geophysics during the last five years. At the same time requirements on BIM deliveries both concerning geophysical data and the following interpreted models is a fact from the main clients. This implies both possibilities and challenges for all parties. Geophysics contributes to them both.

For a long time, it has been challenging to communicate the geological or geotechnical model for other engineering disciplines, basically because we use different tools. All design (road, bridge, railway) is carried out in CAD software, whereas geophysical data and results are most often presented in more specialized software. This has made joint interpretation or joint visualization far from straight forward.

Since geophysics is often carried out in 2D profiles and databases, and data formats capable of handling most geo related data are becoming available, geophysics is bridging the gap between different samplings and soundings, and it is now possible to visualize both the facility, all geo data and the geo model in the same tool and in a convenient way. And eventually a new and efficient way of communicating the underground space has evolved.

The GeoBIM concept is developed aiming at improving the possibility to make use of all geotechnical data, both in an ongoing project and over time in infrastructure planning in general. In this paper, the results from full scale tests in a few large underground urban infrastructure projects in Sweden will be presented. It will clearly show how the communication of the geo model both inside the project team and with clients and stakeholders has improved a lot, reaching a better fundament for decisions.

It is all about communication!

Background

The everyday mission for the geotechnical engineer is to find out and in the best possible way define and describe what the underground is like, i.e. mechanical properties and geometry, sometimes called geotechnical modelling. In this work, a lot of data is handled and many different software is used. The number of methods used not seldom exceed one hundred, including geotechnical sounding and sampling, geophysics, environmental sampling and testing, hydrogeology and geotechnical laboratory testing. One of the biggest challenges is to make use of all the data during the interpretation and the modelling. In Scandinavia, there is since the 1990s a standardized data format for sampling and sounding data, which makes it straight forward and convenient to handle and joint interpret all this data, regardless which drill rig or data collection unit used. However, geophysics is far from that standardized and hence there is often some job to bring geophysical and geotechnical data together, and hence the full potential of the combined data set is not reached. It is a communication issue.

The traditional way of joint interpretation includes a lot of drawings, plots, diagrams, tables spread on desktops, walls, floors, screens etc. In the digital world that has evolved during the last 10 years, many new opportunities for joint interpretation has opened. As the BIM requirements on also including underground data and models are now flying around the globe, it is accompanied by a few initiatives showing the potential of communicating geophysical data and interpretations in 3D models together with designed facilities, see Figure 1. In project meetings, this possibility clearly has shown to help clients and other stakeholders to understand the great potential in geophysics for reaching a proper 3D geo model. As clear as being close to a game changer.

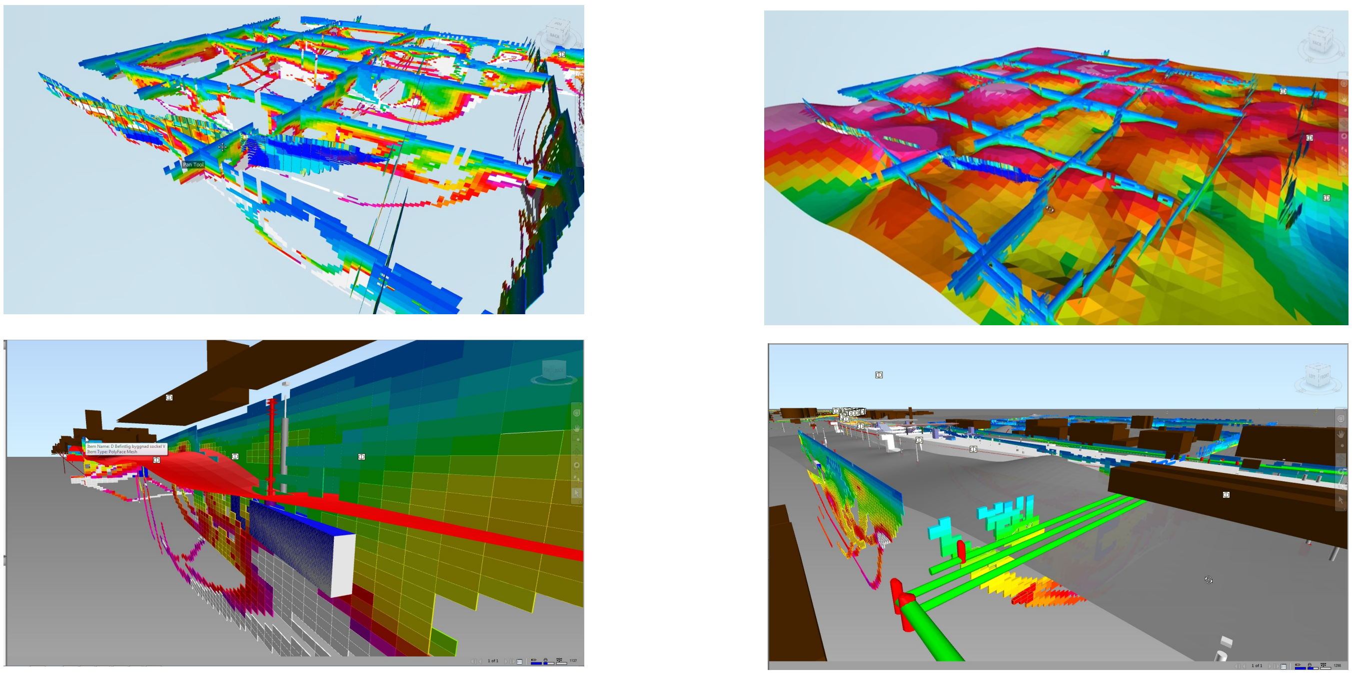

Figure 1: 3D visualization of DCIP and seismic results together with interpreted model, boreholes and the designed pipes and tunnel facilities, Varberg 6 km railway tunnel project, Sweden. The different colors of the bedrock model represent elevation (masl), where red is the highest elevation.

The rise and fall of geophysical and geotechnical data

Geophysics and other geotechnically related data is produced at many times in a project along its road to the archive for long time management. The different stages could be separated as:

- Storing data (during project)
- Modelling
- Designing
- Visualizing
- Data management (long term / archiving)

Infrastructure design phase

The final aim of investigating and interpret the underground space is to deliver a geo model to the design team for the actual facility, which is a continuous process to at all times have the most updated geotechnical conditions available for design of foundations, handling of settlements etc. Those design disciplines most often use design software of CAD-type. For an efficient workflow, this requires that the geotechnical modelling tools can communicate with the design software. For QA purposes, it is also powerful if all sounding and sampling data can be visualized in 3D in the design software, see Figure 2. This again requires data formats capable of communicating with each other. Today this is not always the case.

To work according to a BIM vision within an unbroken digital information supply chain the geo model and its objects need to be delivered to the design departments in a format which they can instantly use to steer their design. The information process therefore must be streamlined for many different tasks, which requires information interpreted and evaluated by all geotechnically related engineering expertise.

Each project has its own geotechnical challenges since the geological conditions and the requirements of the construction vary. Therefore, the choices made during the modelling are also project-specific. As a result, several different models are often produced as the knowledge of the geotechnical conditions increase. Hence, a rational information management and modelling methodology is required, as the time schedule of projects is often tight. Geophysics gives us a unique opportunity to get a lot of information in a short period of time, which is a prerequisite for the geotechnical modeling of an infrastructure project. As long as the geophysical data and results are easily communicable.

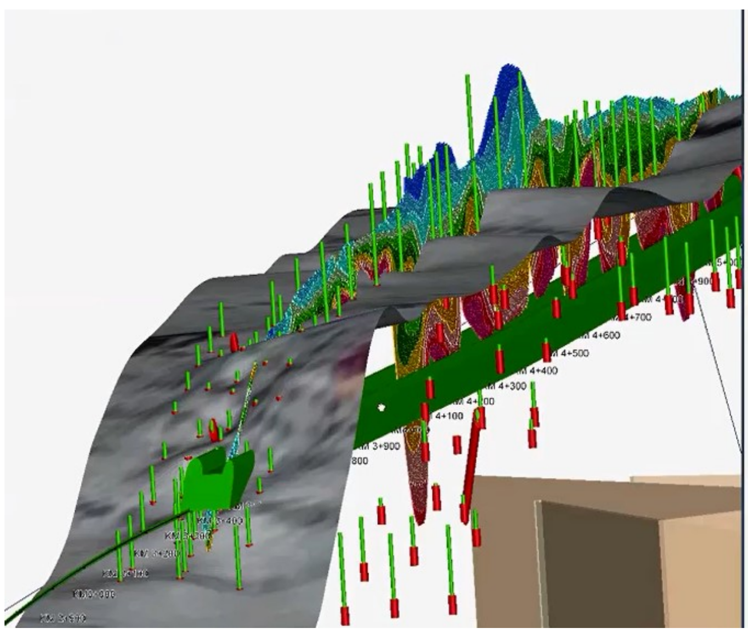

Figure 2: Geophysical and geotechnical data visualized together with the current tunnel design and parts of the existing structures (Norrbotniabanan railway, Sweden – rock tunnel, boreholes, DCIP profile, bedrock model. Autodesk Navis works).

Visualizing data and 3D model

Traditionally geotechnical and rock mechanical engineers, geologists and hydrogeologists are the disciplines working with the geotechnically related data, reporting the final models in 2D on drawings and in written reports for further use in the design process. These models seldom reach the full potential in terms of how much value there is in the geo model. With modern tools, much more can be gained from the geo models, at all stages of a project, and by this supporting the whole design process in a better way than today, aiming at a more optimized project. By using modern visualization tools (3D) better QA of all data is reached, a larger group of stakeholders/actors can be engaged/involved, the geo model can be communicated in a pedagogic way and better and more optimized understanding and design can be gained, see Figure 3. In large projects communication is the key factor for success. The GeoBIM concept [Svensson M., 2017] has proved to be successful in communicating all geo related data and models in infrastructure planning.

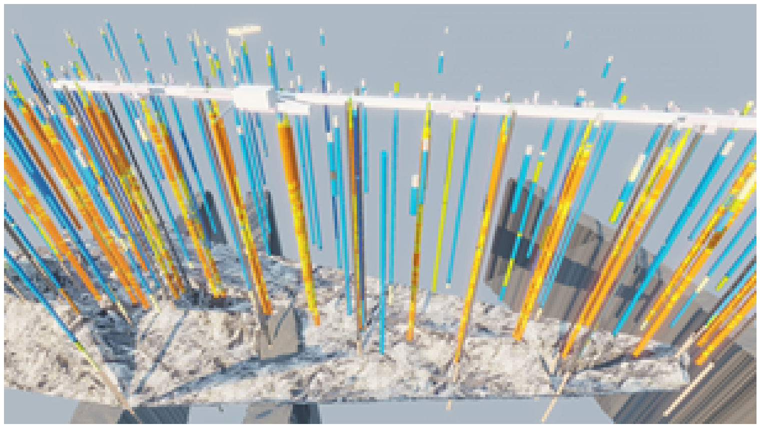

Figure 3 A geotechnical 3D model visualized together with core drilling data and parts of the current design of the facility in a software using computer game technique to get photo realistic images. A powerful tool to communicate a geotechnical model to the non-geo public. European Spallation Source, Lund (www.ess.se) (Svensson M., 2015)

The GeoBIM concept

The core of the GeoBIM concept is a database capable of handling - importing, storing, exporting – all geotechnically related data that is used in an infrastructure project, hence including data from geophysics, geotechnical sounding and sampling, rock cores, borehole geophysics, laboratory tests, groundwater and contaminated soil investigations, see Figure 4.

The database configuration

Essentially the database store point information with location and eventual relation to other points. The point carries a value and this value is related to a measurement (information of measurement method etc.) as well as a dimension (what has been measured). This approach ensures that information from new methods may easily be added, and large amounts of data can be handled rationally since data are handled as a point cloud. The database model is implemented in a PostgreSQL database located in the Cloud.

Database access

In order to access the information a database viewer and a web map has been connected, which are accessible through a GeoBIM Portal (**www.geobim.se**) where project members can login to their projects. This enables the project member to get an overview as well as a detailed view of the data and related documents, e.g. seismic profiles.

From within the GeoBIM Portal project members are also able to import data from investigations and export data in various data formats depending on the task being performed and software used. As an example, a project member responsible for the geotechnical modelling might be interested in all geo data that can improve the interpretation of a rock surface model meanwhile a geochemical engineer might want data to analyse a pollution propagation. The output from both these tasks are then used combined with raw field data in a BIM model, to review and share the results.

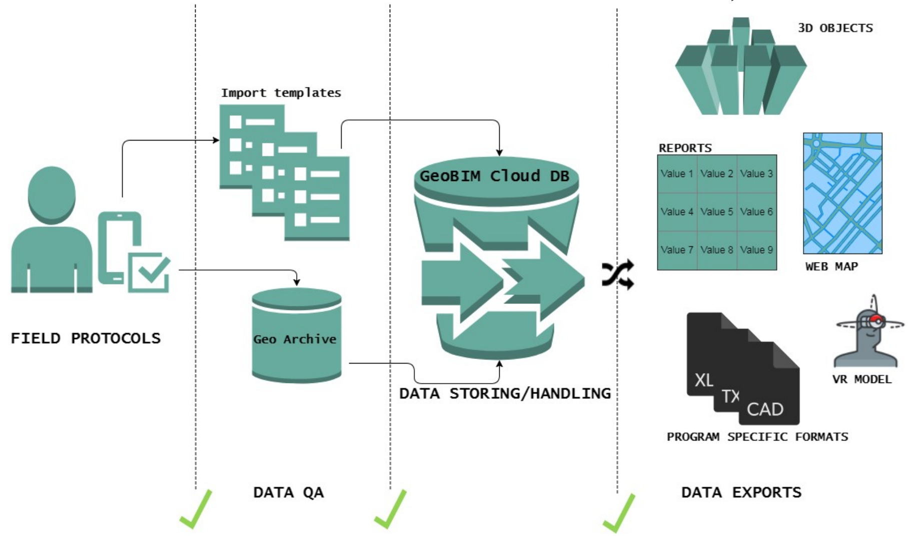

Figure 4 The GeoBIM concept process, enabling a completely closed digital chain from field data collection to 3D model.

When geo models are produced by skilled staff making use of all available data and reviewed by cross discipline experts so their interrelationships seem correct, then a best possible interpretation has been performed. These models may thereafter be used for a best possible design and best possible quantity calculation etc.

Conclusions

Today a lot of different methods (>100) delivering data in many different data formats are used in the infrastructure planning industry, including geophysics. To make optimal use of all data a proper database and an efficient workflow is needed to communicate both data and models for the end user – the design team. The GeoBIM concept suggests such a tool and process, capable of efficient digital handling of all geotechnically related data from field to long time management. The end user will be able to access data via the web. The core of the concept is the GeoBIM database, from which data can easily be exported for 3D modelling etc.

After having implemented the GeoBIM concept in four large infrastructure projects in Sweden and more than ten other projects it is obvious that the GeoBIM methodology should be considered as a state of the art tool for communication of underground geo data and models.

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