Breaking new ground for Geotechnics in Infrastructure Delivery

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ABSTRACT

Technology has had a significant impact on the information available to us in all aspects of our lives. This has allowed us to do things that were previously not possible. Both in our personal lives and in our professional lives.

In the Engineering and Construction sector, technology has allowed for new ways to design and collaborate. Working in a BIM/Digital Engineering based environment changes the way information can be shared and connected. This way of working is mature in the vertical infrastructure (buildings) space and is now also becoming standard practice on civil linear infrastructure projects.

This paper will explore how the technology has changed and what this means for the Geotechnics profession. It will outline how geotechnical engineers take advantage of the information that is being produced. Conversely, how they can utilise similar technology in the way they analyse and communicate their own technical information. It will highlight how technology will allow for improved collaboration between Design, Construction and Geotechnics.

Keywords: Digital Engineering, BIM, interoperability

1 INTRODUCTION

Technology has enabled the mass digitisation of data. The benefits of producing, storing, analysing, and delivering information in a digital form has widespread opportunities for any business operation. With the appropriate structure and control of this data, project teams will realise:

- **Greater collaboration**, since all team members interact through a common data environment, this consequently becomes the single point of truth
- **Better decisions**, as all stakeholders have access to the most current available information at any point in time
- **Greater efficiency**, as information can be reused throughout the project lifecycle and recycled for subsequent projects
- **Improved value** for our clients, deliverables produced have greater intelligence and can be used beyond design and construction.
- **Improved Quality**, structured and controlled data allows greater traceability. Quality control can take place dynamically rather than at discrete checkpoints

To realise these benefits, project stakeholders must ensure that we standardise and clearly articulate the way we receive, manage, and produce information. This means ensuring that we follow standards on how we request information from our supply chain and clients. Information produced by any project participant should allow for the information to be used beyond a single purpose and enable interoperability with multiple systems. Teams must be structured in a way that promotes open data exchange and collaboration, therefore enabling more collaborative workflows.

This paper will explore how this way of working is impacts the geotechnical discipline and the opportunity it provides for greater collaboration and improved outcomes on infrastructure projects.

2 BACKGROUND

2.1 Industry Change

The way that Engineers and Architects design infrastructure has changed over the years due to the availability of design software that can develop designs parametrically based on engineering rules. Geometry can be rapidly generated in 3D space with rich data linked to the 3D objects. Multiple disciplines can regularly federate these models to resolve issues such as clashes or more rapidly optimise the design. The digital information developed through this design process can be passed on and built upon through various stages of the project lifecycle, avoiding rework between phases. The above process is normally what is referred to as Building Information Modelling (BIM). The use of BIM started in the vertical infrastructure space (Buildings) and its use is more prevalent in this space. As applications have matured in the civil space, linear infrastructure is starting to reach similar levels of maturity.

2.2 Digital Engineering

The term Digital Engineering extends the process of BIM to the integration of other engineering-based data sources throughout the project lifecycle. This could be through systems such as Geospatial Information Systems (GIS) or other design and construction-based information and systems.

2.3 Traditional Information Exchange

As the application of Digital Engineering is becoming more prevalent in the civil infrastructure space, the opportunities to improve the design and construction process are vast. Engineers who design infrastructure rely heavily on the data they have available to them at any point in time. Geotechnical information is critical to many designs, particularly in the design of subterranean structures such as tunnels.

Traditionally, engineers have relied on geotechnical reports being provided to them in analogue forms such as reports and borehole logs. Conversely, the geotechnical teams rely on instruction from the engineering team to determine areas of study and required investigation. The collaboration between the Geotechnical Engineer and Design Engineer tends to be transactional, based on the analogue data being provided to the design engineer to be manually checked against the design.

3 OPPORTUNITY TO IMPROVE COLLABORATION

3.1 Advances in digital geotechnical interpretation

In the same way that Engineering design software has advanced, so has the software used for undertaking geotechnical analysis. Technologies are now available that can assist the Geotechnical Engineer to produce 3D interpretations of investigative data.

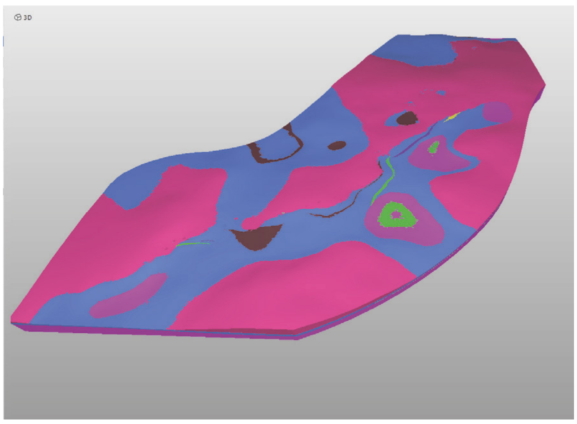

Figure 1. 3D Geotechnical model exported from Leapfrog

Secondly, technologies are available that allow analysis of the impact of a structural design based on ground conditions utilising the available 3D design geometry.

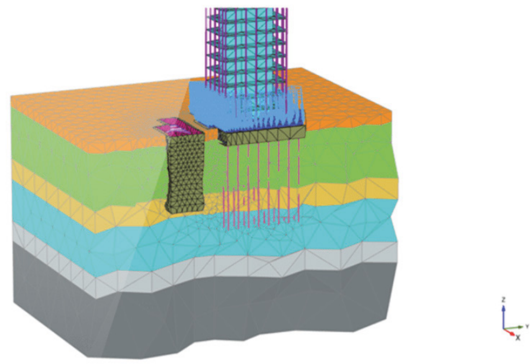

Figure 2. Analysis model in Plaxus (Courtesy of Bentley Systems)

3.2 Current Challenges

Despite many Geotechnical engineers taking advantage of 3D based analysis and interpretive tools, they still tend to sit in isolation from the broader design team. Design models that are received by a Geotechnical team, tend to require manual conditioning to be imported and utilised by 3D analysis software.

3D analysis or interpretive outputs are typically reviewed in isolation due to challenges in bringing the results into the design authoring tools that allow development of the design within the geotechnical context.

As this has been the case, historically the geotechnical teams are not typically setup as part of ISO 19650 (ISO, 2018) based workflows that allow the design team to federate and regularly collaborate on 3D design data through a Common Data Environment (CDE). These environments are setup with areas known as Work in Progress (WIP), Shared and Published with data moved between environments based on Suitability codes.

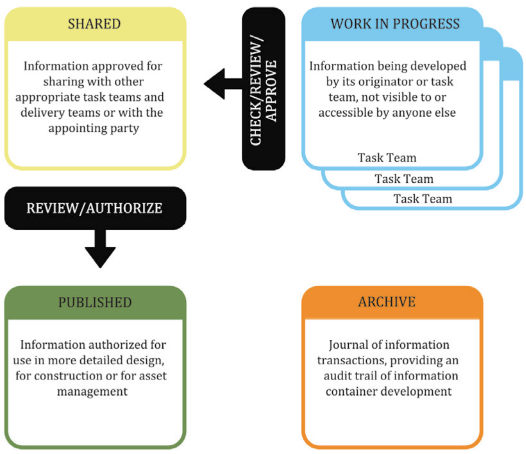

Figure 3. ISO19650 Common Data Environment workflow

3.3 Advances in interoperability

Interoperability is the ability to exchange data between software applications, which eliminates the need to manually copy data already created by one application. In the construction industry, exchanging data is of paramount importance due to its high level of fragmentation. Data can be exchanged using Application Programming Interfaces, proprietary formats of software providers, or vendor-neutral formats (Eastman et al., 2011).

The latter ones play the integral role in the construction industry because they preserve fair competition on the software market and to prevent the market from vendor lock-in (Borrmann et al., 2018).

Developed and maintained by buildingSMART International, IFC is the dominant international standard for exchanging BIM data in the built environment.

buildingSMART liaises with the International Standardization Organization ISO, regional and national standardization bodies for developing international, regional, and national standards.

The IFC data model has traditionally focussed on building projects, but the latest version (IFC4.3) has been enhanced to better support Infrastructure projects, in particular the domains of Roads, Rail and Ports and Waterways.

As part of this focus, the IFC4.3 schema has been developed as an open format that will allow for the exchange of geotechnical information, both data and geometry is then able to be exchanged between software vendor solutions used in various engineering disciplines. This will allow for improved collaboration between geotechnics and other disciplines.

4 OPPORTUNITIES IN GEOTECHNICS

The availability of an open format that will allow for an improved exchange of information between geotechnics team and the design team will enable improved workflows and collaboration by: -

- Allowing the geotechnics team to import the latest 3D design into their own software for the purposes of geotechnical interpretation and analysis.
- Allowing the design team to import updated geotechnical data in a 3D format directly into their BIM based design software, allowing the designer to optimise the design within the context of the geotechnical interpretation or analysis.

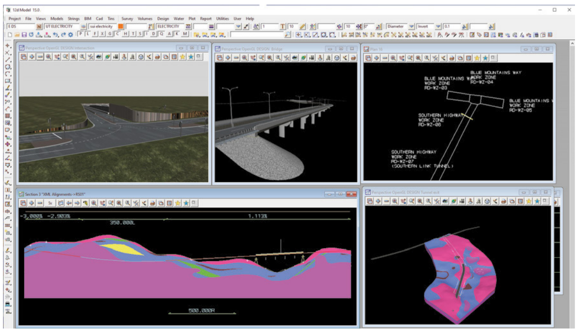

Figure 4. Example of Geotechnical site interpretation shown within civil design software using ifc exchange

Ultimately, this improved workflow will allow for a future of computer based iterative optimisation of a design directly in their design software based on various constraints which would include geotechnical information.

An example could be a road alignment that could be generatively developed based on constraints such as cut and fill balance, geotechnical conditions, environmental conditions, drainage/flood modelling, material usage, etc.

4.1 Defining requirements

To successfully utilise a more collaborative workflow between geotechnical and design, it will be important that the geotechnical team provides input into information requirements defined at the beginning of project. This will ensure that the design data being provided by the design teams are structured and exported in a way that ensures that it can be easily consumed by the software used for geotechnical interpretation and analysis. Conversely, the design team should also document their requirements for the data they require to be exported on a regular basis from the geotechnical teams for use within the design context. These requirements are usually documented in what is referred to in ISO 19650 (ISO, 2018) as an Information Delivery Plan, the plan defines the level of detail (LOD) and Level of Information (LOI) required by each stakeholder at various project stages.

4.2 Collaborative working

Aside from defining requirements, it is also important that geotechnical teams are setup on project within the Common Data Environments to enable collaborative workflows with the broader team. This will ensure that they will be getting regular design updates (typically weekly) as well as ensuring that the design teams are also getting the latest geotechnical information within the 'Shared' environments.

5 CONCLUSION

The advancement of technology and the introduction of Open formats such as IFC now mean that improved digitally based information exchange can occur between geotechnical, design and construction teams. This information exchange includes both 3D geometry, and the metadata linked to the geometry. This will allow for geotechnical teams to become more embedded in the development of designs that rely on geotechnical data, ensuring improved collaboration between project participants.

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