

# Digital transformation in geotechnical engineering

## Digitalisation en ingénierie géotechnique

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**ABSTRACT:** Dealing with a huge amount of information, and being constrained by deadlines it is very important, nowadays, to add efficiency in managing design and execution processes. The first step was to create a transparent framework in all the company's departments, where everyone can access, share and review information, then to create and deliver automated and inter-connected workflows. Site visits simulated site organization or safety trainings are now made using virtual reality. To implement a digital model, it is necessary to know the tools, software suite that can create models, through which automated processes can be realized, interactive communication systems or for arranging and browsing information. Further, in the design department, many models of geotechnical structural solutions can be generated, studied, verified, adapted, and optimized in a very short time, due to automated generative design processes. All information is then stored in a cloud-based network and can be shared automatically through routine-based processes. Virtual reality helps also to understand site constraints, visualize design model applied on site, or to check built geotechnical structures on the site or in the office. Digital transformation in geotechnical engineering, is, in fact a complex and very exciting process for us, it is a strategic element of the company, which generates innovation processes and thus results in better services delivered to our partners.

**RÉSUMÉ:** Traitant une énorme quantité d'informations tout en étant contraint par les délais, il est très important, de nos jours, d'ajouter de l'efficacité dans la gestion des processus de conception et d'exécution. La première étape a été de créer un cadre transparent dans tous les départements de l'entreprise, où tout le monde peut accéder et ensuite créer et fournir des flux de travail automatisés et interconnectés. Les visites de chantier, les simulations de planification ou encore les formations à la sécurité au travail se font désormais grâce à la réalité virtuelle. Afin de mettre en œuvre un modèle numérique, il est nécessaire de connaître les instruments et la suite logicielle qui permettent de créer des modèles à travers lesquels des processus automatisés et des systèmes de communication interactifs peuvent être réalisés. De plus, dans le bureau d'études, de nombreux modèles de solutions structurelles géotechniques peuvent être générés, étudiés, vérifiés, adaptés et optimisés en très peu de temps, grâce à des processus de conception générative automatisés. Toutes les informations sont ensuite conservées sur Cloud et peuvent être partagées à l'aide de différents processus automatisés. La réalité virtuelle permet également de comprendre les contraintes du site, de visualiser le modèle de structure appliqué sur le site, ou encore de vérifier les structures géotechniques réellement construites sur le site. La digitalisation en ingénierie géotechnique est, en fait, une méthode complexe, un élément stratégique de l'entreprise qui génère des pistes d'innovation et se traduit ainsi par de meilleurs services fournis à nos partenaires.

**Keywords:** Digitalisation; transformation; virtual reality; generative; automation.

## 1 INTRODUCTION

The latest impact on all aspects of society and business involves a fusion of technologies that blur the boundaries between the physical, digital, and biological spheres. It is a force for change, the reason why companies must combine technology solutions for continuous innovation, which leads to rethink the way they operate.

Digitalization means progress, after all, and it has become increasingly discussed since the beginning of the pandemic. In the context in which construction sites are spread all over the country, the mobility of a person to go through all the construction sites, to

assimilate all the information and to physically see their progress became more difficult.

Therefore, the current needs to create a transparent framework, a place where each person in the company can access the desired information at a click away, to visit a construction site virtually or to collect technical information in real time, have led to the creation of a virtual environment, an interactive storage space, a suite of intuitive programs and the individual transposition into a special foundation site through virtual reality.

In other words, by embracing digital technology, construction companies can improve their way of work

by increasing efficiency, bring solid communication to another level and be much more sustainable.



Figure 1. Digital customization of a construction site.

## 2 THE NECESSARY STEPS FOR DIGITALISATION

To implement a digital model, it is necessary to know the tools, the suites of programs that can create models, through which automated processes can be realized, interactive communication systems or for arranging and browsing information.

The next step is to share within the network (cloud based) the information and processes that require the input of the users. This ensures a clear and transparent communication of the entire process.

By a simple notification, each user is informed and becomes aware of the appearance of an information, of the taking over of a certain task or of the status of a project or construction site.

The most important stage is the horizontal integration (within the company) – that is, a real-time interconnection between the company's employees and the intra- and inter-departmental cooperation. After establishing the internal routine and processes, vertical integration completes the process by involving business partners in the digital interconnection process (e.g., creating an automated flow of orders, notices, invoices, notifications, etc.).

Digital transformation is having a great impact on the construction industry, making its mark on the organizational concept and Soletanche Bachy subsidiaries.

## 3 DIGITAL TRANSFORMATION IN GEOTECHNICS

At the group level, within Soletanche Bachy, we believe that digitalisation contributes to improving productivity and profitability, reduction of "downtime", increasing the interest of our clients and

colleagues (interactive environment), capitalizing on the information and experiences gathered from our projects.

While every piece of information is filtered specifically and is stored altogether, having feedback from previous built projects is very important, whether it is technical, financial, or operational.

As such many breakdowns, high material consumptions can be avoided while the greenhouse gases emissions are reduced.



Figure 2. Digital site organization layout.

### 3.1 Design digitalisation

Design processes require comprehensive documentation, use of correct instruments and software and a continuous iteration regarding different structural models.

Therefore, it is very important to have routines which will allow automatic search for similar site conditions experienced on previous construction sites, for which, different design solutions were chosen. Of course, those preliminary trials, investigations, and tests (on piles, or on different materials, for example) will help significantly in choosing the right solution perfectly suited for project's purpose.

Nevertheless, return of experience for different solutions in various site conditions can have a great impact for the first step of project development.

The integration of all digital tools makes the design process smoother and with high level of precision.

For example, within a commercial centre foundation piles project, there are many iterations which can be done, to find the perfect balance between pile diameter, pile lengths, pile distribution and reinforced concrete footings.

Our tools make possible the integration of ground conditions, from current or past projects, architectural and structural detailing (columns dimensions, geometry of the building), loads and design and conformation local regulations to offer in a matter of seconds the most convenient piles diameter, distribution and even reinforced concrete footings.

Basically, what we call generative design is a design process that uses algorithms and artificial intelligence (AI) to generate a large number of design solutions that meet a set of constraints.

The user can then choose between the proposed alternatives and detail the project further, considering a lot of restraints as local conditions, site dimensions, materials efficiency, available machinery, and cost optimization.

Putting all the information altogether to have a unified model constantly adapted to real site conditions and updated by all the people which are working together for a specific project is a critical condition for improving the way all the information is shared, the processes used and the way that things are managed.

### 3.2 Construction site digitalisation

One of the biggest game changers in site management digitalisation is augmented reality (AR) which is bringing a sustainable support in project management, quality assurance and cost control. The software used, allows the user to envision different site layouts by superimposing 3D models into real life environments.

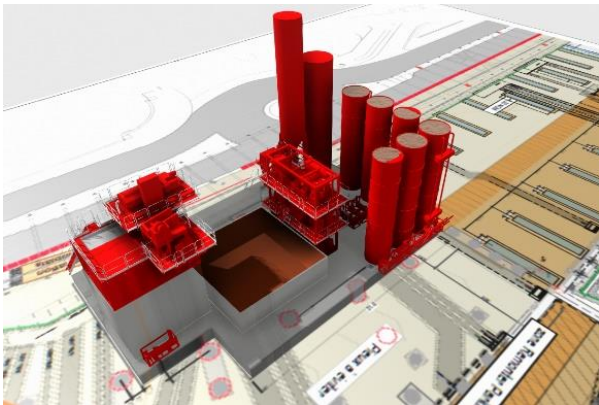


Figure 3. 3D projection of bentonite slurry plant.

This allows workers to see the planned layout of the project and to identify any potential problems early on. AR can also be used to provide workers with real-time instructions and feedback.

Augmented reality is used also to improve safety on construction sites, to highlight potential unsafe situations and to provide workers with instructions on how to avoid them. AR is also a great tool to improve collaboration between construction teams, engineers, architect and the final client.

Zetta-Lyze® is an interactive database platform, created by Soletanche Bachy, multi-application, multi-profile / profession, with multiple sources, easily accessible from anywhere, that offers real-time production information.

More than a working tool, it is a system for the automatic collection of design and production data of a project.

This data can be accessed, organized, and analysed, for an improved monitoring of the project in execution, simplifying our processes, and can be used for a response to a request for quotation, a discussion with a client.

Zetta-Lyze® allow engineers to prepare construction sites, store data, access all maps, display and analyse site data and edit reports.

Currently, there are over 1,150 connected construction sites and over 100 machines equipped throughout Europe, including Romania.

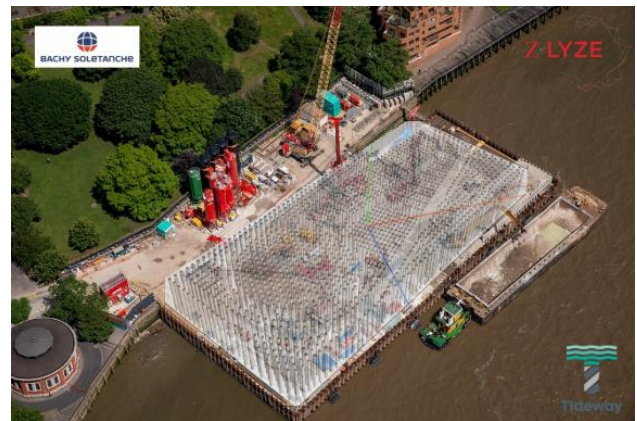


Figure 4. Site view on Z-Lyze.

### 3.3 Virtual reality

Research on the learning process shows that we acquire knowledge more effectively if we have the chance to test it in practice. Surviving a dangerous situation is therefore the best way to remember what should not be done and what should be done in the face of a real threat.

Virtual reality is used to enrich the introductory training in the field of health and safety, and after the completion of the theoretical part, the user enters our site through the VR kit.

The software allows the user to have a realistic experience on what to expect on a special foundation construction site.

This does not mean, however, that the user is automatically safe.

He can experience what it's like to fall into a trench or what can happen if he's within the working range of the machines. In this way, he is faced with potential threats, thanks to which in the real world there is a greater chance of remembering what can happen if he does not take the appropriate precautions.



Figure 5. Virtual reality safety training session – screenshot.

### 3.4 Integration of digital tools

Finally, at company level, we have decided that the best way to collaborate effectively is to reassemble all the tools we have created for our daily business.

There are a lot of processes, which when connected give a whole new meaning of the big picture.

From receiving the input for a design and build project, for example, all requirement data is cloud stored giving all workers access to initial data and alert everyone engaged in that project of any update or modification.

Because ground conditions data is essential for our engineering activity, all important information is uploaded in an internal ground database which extract and compare ground parameters from current conditions with the ones from previous built projects. In this manner, we are aware about possible difficulties which we may encounter on site.

Based on the ground report, digital tools can draw lithological profiles and propose deep foundation elements geometry.

After different restraints and criteria selection, design goes further with calculations integrated with finite element method (FEM) design software, offering results which automatically lead to a structural detailing of a special foundation element in an integrated drawing software.

At any moment, if any design input modifies, reiteration can be easily made and finally all the

elements can change accordingly (geometry, material properties, capacities, structural detailing and drawings for example).

From that point on, project is being shared with other departments within the company and can be used on site for different purposes, including augmented reality and virtual reality.

Actual progress of working, productivity, materials usage, as-built updates, quality issues, optimization proposals, as well as cost control activity can be accessed and monitored by the team, ensuring a better response time for any action required.

## 4 CONCLUSIONS

Digital transformation is a complex and very exciting process for us, it is a strategic element of the company, which generates innovation processes and thus results in better services delivered to our partners.

Overall, digital transformation brings the wind of change for construction companies, which nowadays must keep up with the required fast pace and to be one step ahead of any challenges may appear.

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