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Geotechnical Backanalysis, Plaxis, Monitoring Data, Digital Transformation

Cristian De Santos
cristian.desantos@saalg.com
SAALG GEOMECHANICS S.L., Barcelona, Spain.

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ABSTRACT

In the realm of construction, the influence of ground conditions on structural design is paramount, highlighting the importance of accurate soil characterization. Traditional approaches, predominantly laboratory and in-situ testing, are often marred by significant uncertainties. Advancing the estimation of soil parameters, backanalysis, or inverse analysis, emerges as a potent methodology. This process involves iteratively adjusting the input parameters of a conceptual model (for instance, a Plaxis Model) to ensure its outcomes align with the empirical data gathered from monitoring the physical system. This keynote introduces DAARWIN, a pioneering solution that integrates machine learning algorithms to streamline the backanalysis process. The application of DAARWIN across various construction projects underscores its effectiveness in refining soil parameter estimations, thereby mitigating geotechnical uncertainties and propelling the construction industry towards greater sustainability, efficiency, and safety.

1. INTRODUCTION

The use of backanalysis to identify soil parameters has received significant attention from the geotechnical community since the early 80s (Gioda & Maier 1980). The basis of geotechnical backanalysis consists in comparing a set of ground measurements with a conceptual model that represents ground and structures behavior. The parameters that best represent ground behavior are those that minimize the difference between measurements and model results, expressed as an objective function.

Complementary to backanalysis, sensitivity analysis can be carried out during design and construction stages of the geotechnical project to understand the influence of different ground parameters to model outputs (which might represent different design options) and help mitigate over-design (Calvello & Finno 2004).

Within the framework of the Observational Method (OM), ground observations are proactively examined during the construction phase to make decisions either to optimize the geotechnical design or to implement safety measures. In this context, a tool that can perform backanalysis at the same pace as construction progresses (currently referred as real-time backanalysis or RTBA) becomes handy, since ground parameters can be updated at each main construction phase and design improvements can be assessed with a calibrated model.

DAARWIN is a cloud-based web platform conceived to implement the general workflow of both sensitivity and real-time backanalysis with genetic algorithms in geotechnical engineering projects.

2. METHODOLOGY

The general backanalysis workflow (sensitivity analysis workflow can be considered as a subset of backanalysis and will be included in part in its description) implemented in DAARWIN consists of several steps. Each of them involves the collection, transfer, generation and storage of data from different sources and in different formats. Description of the backanalysis workflow steps is as follows:

1. In the Models module, FE models related to the geotechnical design (design options, cross-sections, schedule options, etc) are uploaded. DAARWIN is compatible with the commercial FE software PLAXIS (Brinkgreve et al. 2016) and it can extract data of interest from the model (model phases and units, soil and structural materials, and parameter values) and store this data within the system database.
2. On an interactive map representing the construction site, the user can define and geolocate instruments (i.e. inclinometers, extensometers, prisms, piezometers, tiltmeters, etc.) and its corresponding points (or depths) where data will be collected during construction. DAARWIN allows manual data entry via a spreadsheet template or automatically via integration to third-party automatic systems (FTP and API technologies). All datasets from instruments on-site are also stored within the system database. Once data is available DAARWIN provides in-platform visualization tools.
3. In the Link module, FE model nodes and stress points, where results will be obtained, are automatically associated to the corresponding instrument measurement points following the nearest point criteria. Project schedule is introduced in Construction Phases, where the site phases are linked to model phases.
4. The backanalysis calculation is defined in Run-Backanalysis, which launches on a cloud server the backanalysis process with genetic algorithms described in (de Santos 2015). Run definition consists of selecting different parameter ranges from model materials and instrumentation datasets associated to a model phase to minimize. The algorithm will perform multiple (order of thousands) FE model calculations in a cloud-based parallel framework with different sets of parameters (each of them referred as individual) and evaluate the objective function for each of them throughout different generations.
5. In Run-Sensitivity the user can also select multiple parameters from soil and structure materials defined in the model. Parameters can be bonded to reduce the search space and, hence, the computational load, and parameter constraints can be introduced. Users can select a wide variety of sensitivity analysis outputs such as: points, lines, existing structures within the model and project instruments. The same cloud framework is used to calculate the FE models involved in the sensitivity analysis.

3. RESULTS

The methodology was applied in two different cases studies, in an underground excavation project supported with temporary props, and in a skyscraper project.

In the first case study, data from an inclinometer was used to evaluate the possibility to remove or reduce the number of props, whereas in the second case study, data from a static load test in a pile was used to study the option to optimize the length of the piling system of the skyscraper foundation.

4. CONCLUSIONS

The presented lecture demonstrated that DAARWIN is a fully operative web application, and its holistic approach allows any geotechnical engineer, either from the designer or the contractor team, to assess the ground and structure behavior during the design and construction stages as follows: i) Evaluating the sensitivity of ground parameters for different design options via sensitivity analysis and ii) calibrating FE models during construction to propose and implement design improvements in relation to the OM framework. DAARWIN's approach with genetic algorithms and cloud-based architecture makes possible to perform the backanalysis at the same pace as construction progresses. Making construction a more sustainable, efficient, and safer industry.

REFERENCES

1. Gioda, G., & Maier, G. (1980). Direct search solution of an inverse problem in elastoplasticity: identification of cohesion, friction angle and in situ stress by pressure tunnel tests. Intl. J. for Numerical Methods in Engineering, 15(12), 1823-1848.

2. Calvello, M., & Finno, R. J. (2004). Selecting parameters to optimize in model calibration by inverse analysis. Computers and Geotechnics, 31(5), 410-424.

3. Brinkgreve, R. B. J., et al (2016). PLAXIS 2016. PLAXIS bv, the Netherlands.

4. De Santos, C. (2015). Backanalysis Methodology Based on Multiple Optimization Techniques for Geotechnical Problems. PhD Thesis. BarcelonaTECH. Barcelona.