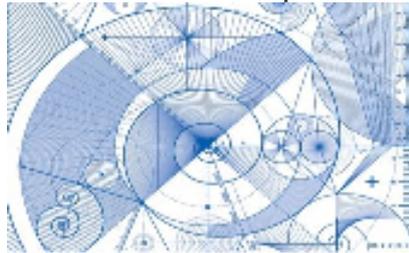




[Spring 2010](#)

Solid grounding - the future of geotechnical engineering [Print this article](#)

Many observers predict that climate change, coupled with increased construction activities and urbanisation, may cause a significant increase in the frequency and impact of incidents such as flooding, landslides and debris flows, all of which will create a greater focus on the importance of geotechnical engineering. Brendan O'Kelly at the Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, presents an overview of some of the possible future directions of the discipline



In the ground engineering sector, there is an increasing demand to maximise the use of each site (i.e., construction of deeper basements; complex underground structures and foundations to resist even higher applied loads) along with the universal demands to optimise design, reduce costs and reduce construction time in a safe working environment.

These demands will lead to greater use of more innovative and cost-effective design methods, including the observational method, and advanced numerical methods that place greater reliance on probabilistic and statistical methods to account for risk and uncertainty. Developments in computation, measurement and communication will provide new opportunities and also enhance existing processes.

Observational method

The observational method is a continuous, managed and integrated process of design, construction control, monitoring and review that enables previously defined modifications to be incorporated during, or after, construction, with the aim of achieving greater overall economy without compromising safety (Nicholson et al., 1999).

The design is based on a working hypothesis of the anticipated behaviour under the most probable subsurface conditions rather than the most unfavourable conceivable deviations from these conditions used in traditional design methods. The gaps in the available information are filled by observations from site investigations and instrumentation as the construction proceeds.

Numerical analysis

Numerical methods, principally finite element and finite difference, will be increasingly used to simulate the complete history of the project and will provide information (e.g. ground settlements and soil-structure interactions) for each construction stage.

The full numerical approach using 3D analysis, in combination with simple but reliable soil models capturing the significant stress-strain-stiffness characteristics and anisotropy (the state or quality of having different properties along different axes) of the ground foundation, contributes to the efficient application of the observational method.

Monitoring

The success of the observational method relies on robust real-time monitoring and measurement techniques in order for informed review and decisions by the designer in relation to any modifications or the implementation of contingencies. The monitoring data obtained during the early stages of construction is used to calibrate the numerical models. Much greater application of recent and further technological developments can be expected, including fibre optics, wireless communication, measurement from satellites and the use of internet databases.

Eurocode 7

A major development in geotechnical engineering during the latter part of the 20th century was the preparation of Eurocode 7: Geotechnical Design. Eurocode 7 is one of a new set of harmonised European codes of practice for structural design that will supersede existing national standards across Europe by 2010.

It aims to achieve a certain degree of reliability in geotechnical design and hence is based on a probabilistic approach. It offers the use of three design approaches that apply partial factors of safety on the actions and the material parameters or resistances at different stages of the design calculation. In addition, the new code of practice specifically addresses the importance of the serviceability limit state design.

Ground investigations and laboratory testing

Although significant improvements have been achieved in undisturbed sampling, the natural structure of a soil specimen is altered to some degree when taken from the ground. Whenever feasible, it is more appropriate to measure the engineering properties of the soil in-situ. This is because its mechanical response is principally controlled by the state of effective stress, stress history and the inherent soil fabric.

Consequently, the trend towards using remote sensing techniques and advanced soil probes that can carry out continuous sampling and testing in-situ will continue.

In recent years, there has been a trend for a greater use of field geophysics and continuous soil-profiling techniques. This move has included the cone penetration test with measurement of piezometer data (CPTu) to determine quickly and more cost-effectively the ground conditions, identify stratification and obtain a better understanding of the ground behaviour.

A variety of other CPT-deployed tools have also been developed over the years in order to provide additional subsurface information, including environmental site characterisation and groundwater monitoring activities.

Other tools, including laser-induced fluorescence, soil conductivity/resistivity and cameras for capturing video imagery, can also be advanced in conjunction with the CPT probe. In field geophysics, geophone sets are used to measure the seismic shear-wave and compression-wave velocities of the ground from which the stiffness parameter values of the different soil strata can be determined.

Databases

In many locations, particularly urban, much construction is carried out in essentially similar ground conditions. Hence, it would be desirable that the development of publicly-accessible databases of existing ground information will continue.

Compact hand-held technology is also being increasingly used to input and collect digital data (including photos and GPS coordinates) during site walkover studies. These data can then be uploaded to a geographic information system database.

Generalised stress path testing

Standard laboratory apparatus are limited by the stress conditions that they can simulate. For instance, the conventional triaxial apparatus can only subject the test specimen to axi-symmetric loading conditions. However, most ground engineering problems usually include multi-directional loading, in which the direction of the major principal stress can re-orientate relative to the vertical direction.

The next generation of laboratory apparatus, which include the hollow cylinder torsional apparatus (O'Kelly and Naughton, 2005), facilitate generalised stress path testing and incorporate local instrumentation fitted directly to the surface of the test specimen in order to accurately measure the full suite of soil stiffness parameters that are required as inputs for 3D numerical analysis.



Landslip damage to road infrastructure **Response to natural disasters**

With increased population and the levels of investment in flood-prone areas, flood protection structures will become more critical due to more extreme river discharges and higher coastal flood-water levels. The stability of both existing and new slopes, cuttings and embankments could be challenged by heavier rainfall. Advanced geotechnical input is necessary in order to understand and reduce the hazard risks.

Renewed efforts are needed to develop a predictive understanding of the landslide processes and triggering mechanisms, and for better and timely forecasting of landslides. Recent work is making greater use of information and communication technology including flood forecasting systems (new satellite data, weather radar) and monitoring (e.g. remote sensing, scatter techniques) in order to facilitate real-time landslide hazard identification.

Concluding thoughts

Geotechnical engineering will increasingly involve construction of even larger/deeper foundations to support even bigger structures; more transportation and service tunnels; as well as more construction on weaker ground.

Sophisticated numerical analysis, along with greater use of risk analysis, will be increasingly used to simulate the complete history of the project, as well as providing detailed information for each construction stage.

Innovative materials and construction methods will be increasingly used to reduce the embodied energy in construction, including:

Greater use of many forms of ground improvement and reinforcement

More advanced remediation techniques for the utilisation of brownfield site

Greater use of marginal fill materials in the construction of earth structures

Systematic reuse of existing structural foundations in the redevelopment and reconstruction of urban areas

Future-proofing new foundations

Bibliography

Nicholson D., Tse C-M. and Penny C., 1999. The observational method in ground engineering: principles and applications. Report 185, CIRIA, London, 214pp.

O'Kelly B.C. and Naughton P.J., 2005. Development of a new hollow cylinder apparatus for stress path measurements over a wide strain range, ASTM Geotechnical Testing Journal, 28(4), 345–354.

Past issues

- Please Select -

Regular features

[This month's editorial](#)

[News](#)

[CPD updates](#)

[Region, division, society events](#)

[Courses and seminars](#)