TC37 Interactive Geotechnical Design

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ABSTRACT

The Observational Method (OM) is not widely accepted in practice, although there have been significant efforts in Europe to promote its use, resulting in very good reference documents, e.g. CIRIA Report 185 (1999), IREX (2005) and Geotechnet (2005). There are both legal and risk barriers to wider implementation of the method in some countries. In addition, there is a recognition that structural engineers have an important role in active design. TC 37 therefore conducted a survey during June – August 2009 to gage the use and practice of Interactive Geotechnical Design / Observational Method around the world. The main findings of that survey are presented here.

1 SURVEY METHOD

Since the ISSMGE does not have its own membership, circulation of the survey was problematic. The survey was therefore sent to each of the TC Chairmen, as well as to the Secretary or Country Representative of each of the ISSMGE member countries. People were asked to take the survey themselves, as well as to circulate the email through their membership or circle of contacts.

2 PARTICIPATION

Participation was somewhat disappointing, with only 31 replies (and only 3 replies from TC37 committee members). However, 11 countries were represented with most replies from the USA (11) and Netherlands (6). No replies were received from Africa or Australia, and only 1 from Asia.

The majority of replies were from geotechnical consultants (20) and academics (6).

3 APPLICATION OF INTERACTIVE DESIGN

The results indicated that Interactive Design is generally used in less than about 10% of projects. Canada may be an exception to this rule, generally in relation to resource based projects (mine tailings, slopes, etc)

Interactive design appears to me more likely for large dams (for hydro power, tailings or water supply), tunnel construction (e.g. NATM), ground improvement and landslide stabilization. Other comments suggest larger projects are more likely to adopt the approach.

All but one respondent said that there is scope for wider application of the observational method in their country or region.

Section 10 of the attached is an interesting list of examples / case histories of the application of Interactive Design, which indicate that there might be a good basis for a conference or symposium on the subject.

4 BARRIERS TO USE OF INTERACTIVE DESIGN

The largest barrier to more widespread adoption of interactive design appears to be that owners want to have designs finalized before construction starts, and that owners are reluctant to pay more for geotechnical advice. Fewer respondents commented that geotechnical engineers are concerned about potential legal claims if problems arise and that structural engineers do not allow it because they do not understand it.

In addition, most respondents provided more detailed comments on the barriers. The list is in the attached document (Section 8) and is worth reading.

In some instances, the building codes or regulations do not allow the approach (Portugal, Netherlands, parts of the USA).

It is also suggested that lack of experience or knowledge of the method is a barrier for many geotechnical engineers.

5 INCREASING USE OF INTERACTIVE DESIGN

Key aspects of successful application of the method are described in Section 12 of the survey. Finite element analysis techniques and a good instrumentation / monitoring capability seem to be a common theme. Also experienced engineers and engineering geologists are required.

Respondents were asked what could be done to increase use of Interactive Design in their countries, and the responses are summarized below:

- Case histories and dissemination of knowledge (amongst engineers)
- Short courses and continuing education
- Education of clients / owners as to the potential benefits
- Better instrumentation, data acquisition and more user friendly FEM analyses
- Changes to codes, contractual practice, and "claims culture"

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6 WHAT CAN ISSMGE DO TO FOSTER USE OF INTERACTIVE DESIGN?

The response to this question reflected the above list of what needs to be done, and it appears that the ISSMGE could usefully do the following:

- Knowledge dissemination
- Publishing case histories
- Arrange short courses
- Foster more publications and research (rather than lab or analytical tool based research)
- Educate public / owners on the value of Interactive Design
- Develop material for geotechnical engineers to use for client education

7 CLOSURE

The Survey provides a good basis for TC 37 to develop a program of activities during the next four years, specifically actions related to the items in the preceding two paragraphs.

SURVEY RESULTS (QUESTIONS AND ANSWERS)

1. In what country do you carry out geotechnical engineering?

Canada	2	6%
Brazil	1	3%
Norway	4	13%
Portugal	1	3%
Nepal	1	3%
United States	11	35%
Poland	1	3%
Columbia	2	6%
Netherlands	6	19%
Ireland	1	3%
Argentina	1	3%

2. Which of the following best describes your geotechnical engineering role?

Geotechnical contractor	1	3%
Geotechnical engineering consultant	20	65%
Academic, professor, teacher of geotechnical engineering at a University	6	19%
Government / public works (city, state, or country)	2	6%
Research institute	1	3%
Contractor/Designer/Installation Work	1	3%

3. Have you, or your employer, used interactive design / the observational method on one or more projects?

Never	3	10%
1 – 5 projects	16	52%
6 – 10 projects	0	0%
More than 10 projects	12	39%

4. When did you do most recently do one of these projects?

Never	3	10%
In the last year	15	48%
More than 1 but less than 5 years ago	9	29%
More than 5 years ago	4	13%

5. In your country, or region, how would you describe the use of the observational method in engineering practice?

Never used	1	3%	Norway
Seldom used (less than 10% of projects)	19	61%	Argentina, Brazil, Columbia, Ireland, Nepal, Netherlands, Norway, Portugal, USA
Sometimes used (10 – 30% of projects	10	32%	Canada, Netherlands, Norway, Poland, USA
Frequently used (30 – 50% of projects)	0	0%	
Used all the time (more than 50% of projects)	1	3%	Canada

6. On what sort of projects is the observational method used? Please describe.

- We use the observational approach on tailings/hydro/water supply dams routinely both for construction and long term safety routinely.
- Foundation of large industrial plants and retaining structures
- The observational method is used in tunnel construction and mitigation of landslides.
- Projects that I have come across are road projects and the observational method has been used to find out settlement under road embankments together with development of porewater pressure in order to check settlement and stability behavior of problematic areas. In addition inclination and porewater pressure measurements have also been used in different projects to control sheet pile wall excavations. Another project area is the control of embankment behavior where EPS was used as a load reduction method in road embankment construction.
- Dams, tunnels, environmental remediation
- Rock tunnels, dams, ground improvement, rock slopes
- Roads and structures on the weak soils, deep excavations and dewatering, soil improvements
- Projects where site conditions are either too varied to characterize with pre-construction investigations with a sufficient level of confidence, or where in place properties cannot be measured adequately using investigation techniques allowing predicting behavior beforehand with an adequate level of confidence. Also, projects using innovative or seldom used construction techniques where there is inadequate experience to predict behavior before construction with a high level of confidence. Also, projects where tolerance for acceptable behavior is so small relative to the precision of predictive abilities, that monitoring/observational method is needed.
- Historic structures experiencing distress
- Staged embankment construction, Tunneling, Dams including tailings management facilities, Deep cuts and retaining structures, Natural slope stability and stabilization, Geohazards, Projects in which instrumen-

taion and monitoring play a key role
- Pavement design, foundations, retaining walls
- Big budget, high profile and/or high risk projects. Some top notch geotechnical engineers use this method much more often than others. Most never use the method, in my opinion.
- On projects and/or sites that are complex. Some client's projects require a plan with course corrections based on data as the project progresses. This seems most prevelent on Design Build projects where preload settlement is predicted and monitored, and on federal government projects with complex quality requirements.
- Perhaps dams and similar projects, but even the dam jobs I've been involved with did not use it. NYS DOT had some problems with stability and settlement, and had no choice but to use the observational method. But actually it was more trial and error than classical observational method.
- Design/construction of excavation support, tailings impoundments and dams;
- In subsoil investigation
- Tunneling Foundation excavation
- Road embankment construction (80% of cases), usually in alliance contracts. Very few cases of underground construction, usually not full O.M. (e.g. designed by codes, monitoring to check and implement measures).
- Large construction projects in which monitoring would also be taking place without the observational method
- Vibrations settlements dewatering
- Earthwork and large excavations; both to enable a quick response on slow but undesired deformations thus preventing real damage to existing constructions or decrease of safety of infrastructure
- Public works of relative importance. Private projects of great importance. Research
- Infrastructure projects with huge construction pits in urban areas
- Tunnelling through difficult zones (e.g. NATM, fracture zones in rock stabilized by lattice girders and spiling). Grouting of rock and soil (recorded grout consumption/pressure build-up etc decides input in the next grouting round and possible use of combination grouting). Soil nailing and tie-back anchors (suitability tests on some nails/anchors made in advance decides the number/length of anchors).
- Road design

7. Are there any barriers to wider application of the observational method in your region? Check all that apply.

No	2	6%	Canada
The risks are considered to be too great	4	13%	Netherlands, Nepal
Most owners want final designs before construction starts	22	71%	Argentina, Brazil, Columbia, Ireland, Netherlands, Norway, Portugal, USA
Owners do not want to pay more for geotechnical advice	17	55%	Argentina, Brazil, Columbia, Ireland, Norway, Poland, USA
Structural engineers and architects do not understand the observational method and therefore do not allow it	5	16%	Netherlands, Poland, USA
Geotechnical engineers are concerned that they might be subject to legal claims if problems arise as a result of using the observational method	12	39%	Columbia, Netherlands, Norway, USA
The building codes, or laws, do not allow the observational method	7	23%	Portugal, Netherlands, USA
Other barriers	10	32%	Canada, Netherlands, USA

8. Please describe other barriers to use of the observational method in your country or region?

No – rarely any barriers to use in design and operation of dams in Canada Few if any institutional barriers but there are unintended barriers because some geotechnical engineers don't apply the technique properly because of lack of understanding.

The public sector clients are generally reluctant to apply the observational methods as there is a chance of cost and time overruns in the projects.

Permitting with agencies

Unwillingness of owners to accept risk of increased cost during construction relative to bid prices in exchange for potential cost savings if conditions are consistent with baseline portrayed in contract.

the building codes and laws are still unfinished

cost

Not being included in most university curricula. Most students and recently professors themselves are not aware of the observational method or if they are they don't appreciate or understand completely its role and use. Not really mentioned in Codes and Manuals Risks not really understood by clients/owners who in the recent past were driven by schedule and wanted some 'certainty' as to successful execution and completion. They felt schedule would be impacted - schedule was more important than money

Time constraints by the designer.

Lack of confidence in, experience with, or knowledge of the method.

The above question's proposed answers suggests that the pitfalls of the method discussed by Ralph Peck may be in play. Ralph pointed out that observing first and planning later is not the correct application of the observational approach. Many use it as a substitute for planning/study/borings, and attempt to "wing it" as they try to figure out what subsurface conditions construction forces are encountering. I guess a major barrier to its application is a misunderstanding of how and when to use this method.

For relatively small or routine jobs, it is not practical or necessary. It must be a big job like a big dam, but even then for the reasons listed above, it probably will not be used.

People are not very easy to receive new theories or methodologies

Very conservative attitude in US public construction

Contractual aspects (such as who deals with the risks, who benefits from savings). Not all problems are suitable for O.M. (for example is monitoring is difficult to obtain, for example vertical equilibrium). Monitoring is not always available in an easy and cost efficient way.

Owners generally want a fixed price. With observational method, costs could be lower if the situation turns out to be favourable but could also be higher if the situation is less favourable.

Logistic reasons.

Permits do not allow it

Reluctance to apply the observational method when the engineer's experience of such a system is limited or absent.

Stakeholders outside the project (i.e. owners of adjecent buildings, infrastucture) want 100% safety guarantee in ad-

vance (thus don't like the uncertainty/residual-risk that might be present using o.m.)

These methods extend the period of construction more than what is acceptable by the owners

Intermediate data evaluation and modifications to the execution are often associated with delay and therefore not appreciated.

Not much experience using the observational method mainly due to given reasons

9. Do you think that there is scope for wider application of the observational method in your country or region?

Yes	30	97%
No	1	3%

10. Do you know of case histories or examples of the observational method in the last 5 years that provide a good illustration of its application? Please describe.

Many examples were provided in each country responding to the survey, but are not included here for brevity.

11. What do you consider are key aspects of a successful application of the observational method (e.g. finite element analyses, centrifuge tests, instrumentation)? Please describe.

Answers not included for brevity.

12. What do you think should be done to increase use and application of the observational method in your country?

Answers not included for brevity.

13. What can the ISSMGE do to foster the use of the observational method in practice?

- This support in and of itself is useful.
- It can promote the use of the method showing as much as possible successful applications.
- Proper knowledge dissemination
- Knowledge dissemination through seminars and conferences
- Arrange short courses and make information available on the subject matter.
- Get good case histories published.
- Provide forums for communications to owners of successes.
- Show the economical adventages of this method
- Foster more publications about applications, and fund research at university level. There are too many lab test research projects and computer tool formulations populating the journals that have little practical application.
- Create a white paper geared towards owners
- Develop better linkages with industry (consultants/contractors).
- The Practitioners Forum at ICSMGEs is a good start but more can be done
- Develop "recommended procedures and best practices" through appropriate TCs
- Host International Symposium/Workshop
- Support development of observational methods that can be used by geotechnical practitioners. Lobby large government agencies like the US Army Corps of Engineers to utilize observational methods.
- Develop the resources noted above, including case studies that demonstrate the technical AND financial benefits of the method.
- Develop the resources noted above, including case studies that demonstrate the technical AND financial benefits of the method.
- Provide good case histories, provide guidance on how to organize, plan and execute a project with the OM.
- Try to educate the public/owners of the value of the OM that it may save money, may result in a better, safer product, more environmentally friendly, etc. A more logical way to do things and similar.
- In the US, liability is a big concern. I do a lot of expert witness work, and in the cases where the OM was used, or kind of used, those who used OM always got nailed. I always got the feeling the courts/juries felt the OM meant the designers didn't know what they were doing. They were just trying a bunch of different things. It is quite easy to convince a judge or jury of that. Obviously something went wrong, or there wouldn't be a court case. Defendants try to convince court that what they did was correct, using OM, etc. Plaintiff says OM is a bunch of bull, they didn't know what they were doing, and they're just trying to rationalize their screwups. And now have hindsight and can point out the mistakes. Score for the plaintiffs.
- Develop talking points to use as part of client education.
- Clear presentations of real projects in which the Observational Method was used. Not only the succes stories but also the failures. In this way the engineers can learn the strength and weaknesses of the OM.
- Publish in an accessible form (or in several different forms, such as book, website, CD) a source of information on geotechnical risk management and on appropriate case histories.
- It can be very useful if countries can 'borrow' succeses to help the introduction in another country. Refering to best practices abroad, supported by the ISSMGE might help
- Increase the number of conferences and seminars around the world,
- Keep more contact with universities
- Exchange international experiences
- Influencing codes/laws, holding courses in new techniques, setting up advisory boards of experienced people in various fields to act as active support in different projects.
- Give examples in projects of the benefit.

15. (Optional) Please provide your name, employer, and email address so that we can contact you for further information.

Answers not included for confidentiality, but all respondents provided name and email address.