Geomechanics for Rock Slope Engineering: The Domain of Engineers or Geologists?

Introduction

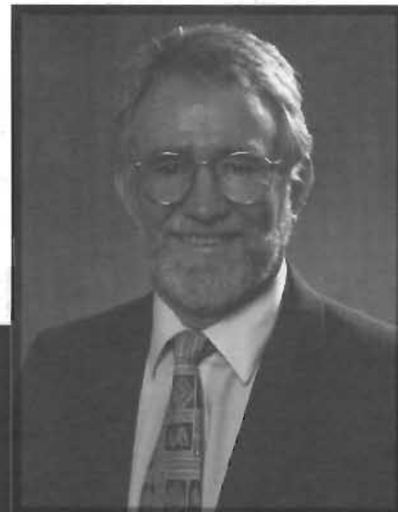
Slope stability analyses aimed at forecasting slope reliability are considered to be fundamental to the safe, economic and environmentally sustainable development of major surface engineering works. Slope failures have a negative impact on the costs of a project, and on the perceptions of the community on the role played by geologists and engineers in their designs. Unfortunately, there appears to be a gulf between the approaches adopted by engineers and geologists who work on these slope stability projects.

During the last 20 years or so a range of analytical tools have been successfully brought into the geotechnical industry. These include empirical, limit equilibrium, numerical modelling and probabilistic methods of analysis, as well as various three-dimensional modelling and visualisation techniques. Which tool gets used on any particular project invariably reflects the background of the user. Engineers generally follow the mathematically convenient abstractions of materials engineering or soil mechanics and opt for the numerical modelling approach. Geologists, whose focus is more on natural process than mathematics, lean towards the three-dimensional visualisation and modelling techniques to help determine the geological causes of slope failures or landslides. Both approaches have their merits and both have led to a better understanding of the failure of man-made and natural slopes.

The Challenge

I believe that there are two aspects to the gulf between the engineering and the geological sides of the geotechnical industry. One I will call techno-sociological, the other is technical. I will address the techno-sociological first, through the Australian experience.

In Australia, engineering geology truly began in the early 1950's when the Australian Government commenced work on the Snowy Mountains Hydro-Electric Scheme for power generation, flood control and irrigation purposes. The Snowy Mountains Hydro-Electric Authority (SMHEA) specialised in the design and construction of dams, underground power stations and tunnels, and developed an enviable, global reputation for excellence in engineering geology. Most, if not all of the engineering geologists that were employed by the SMHEA gained their first degree in geology and their engineering and construction skills on the job. After gaining this work experience many returned to university and obtained post-graduate degrees in engineering.



CSIRO's Division of Exploration and Mining Deputy Chief – Dr John Read

The Australian Geological Survey Organisation (formerly known as the Bureau of Mineral Resources, Geology & Geophysics or, more simply, the BMR), the geological surveys of the different Australian States and many quasi-government agencies involved in resource development and distribution projects followed SMHEA's lead and developed strong engineering geology sections.

These excellent training grounds provided for engineering geologists evaporated during the 1980's mainly as a result of the completion of major projects and pressures on public funding. Consequently, most of the staff progressively moved into either engineering consultancies or the mining industry and none of the engineering geology sections operate today.

Significantly, no tertiary education coursework leading to a degree in engineering geology was permanently established by any university in Australia during this time. This was due

The Ok Tedi Mine, Papua New Guinea

primarily to the small enrolments associated with such a niche market within either a geology or an engineering curriculum.

One outcome of this is that as a branch of science and engineering, engineering geology in Australia has stagnated (Baynes, 1996) and those who once referred to themselves as engineering geologists now generally prefer to call themselves geotechnical engineers. Secondly, the new stock of geotechnical engineers come from an engineering background, armed with first degrees in engineering and little or no training in geology.

The technical aspect of the gulf between the engineering and the geological sides of the industry can be tracked to the engineering penchant for adopting the mathematically convenient abstractions of materials engineering or soil mechanics. The exponential growth in computing capacity we have witnessed in the last decade has also strongly influenced the manner in which we model rock mass deformation. It is now not only mathematically convenient but also computationally convenient to obtain approximate solutions to those problems where say, complex three-dimensional underground openings are to be excavated in anisotropic rock masses. This may be convenient and geologically acceptable in the confined underground situation, but it is not convenient nor geologically acceptable for studies of surface features such as natural or man made slopes.

One part of the difficulty is the very low stress environment in slopes, which virtually guarantees that existing or incipient structures in the rock mass will be exploited before a through-going failure surface develops. Another is the nature of the assumptions that are made when the attributes of rock masses are classified.

Rock Quality Index (RQD), Rock Mass Rating (RMR), and the Hoek & Brown strength criterion were breakthroughs and over the years have contributed to the success of many projects. However, their application requires the type of skill that can only be gained from a thorough understanding of their limiting assumptions and the 'hands-on' experience not available to more recently graduated practitioners.

The challenge, then, is how to:

(a) obtain more engineers and numerical modellers who are also good geologists, and

(b) bring the knowledge and experience of the geological and mathematical groups together in a way that will benefit everyone working on projects where slope stability is an issue.

The first belongs to the world of tertiary education and needs to be conveyed in the strongest possible terms to that forum by everyone in the civil and mining engineering industries. The second can be addressed, for example, through the Australian Centre for Geomechanics by bringing together researchers, field engineers and management to pursue research objectives that build on the fundamental observation that the performance of man made and natural slopes are governed by the same principles. Only the time scale is different and, to be successful, numerical modelling of slope instabilities must be underpinned by a good geological model and must be capable of taking anisotropy into account.

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Reference

Baynes, F.J., 1996. *Where is Geotechnical Practice Heading – An Engineering Geologist's Perception.* Jaksa, Kaggwa & Cameron (eds.), Proc. 7th Aust. NZ Conference on Geomechanics, Adelaide, South Australia, 583-584.

Patrimonio Landslide at the Aguas Claras Mine, Belo Horizonte (the city in the background), Brazil

The visible effect of cave mining below an open pit on pit wall and surface stability