

GEOTECHNICAL CHALLENGES FACING THE ROADS AND MARITIME SERVICES

G. Vorobieff, S. Yuen and C. Walker

Engineering Technology Services Branch, Network Management Division, Roads and Maritime Services, NSW

ABSTRACT

Heavy rainfall in early 2012 caused several highways to be temporarily closed due to flooding or slopes that had collapsed leaving the roadway impassable. Rainfall is still one of the most challenging elements for geotechnical practitioners to provide 24/7 community access to the road network. In the future limited funding for maintenance will require more accurate slope assessments, real time monitoring, innovative durable slope treatments and the development of methodology to assist in cost effective risk management of slope assets.

In the past the RTA (now RMS) has utilised subject matter experts within the organisation and the consulting industry to assess slopes and other geotechnical structures. The use of external practitioners to support the RMS to maintain the road corridor is unlikely to change in the future as the demands to finish sections of the Pacific and Princess Highways continues.

- The top five issues facing RMS geotechnical practitioners are:
- Slope risk assessment and management, and cost effective design solutions
- Deep wall excavation and the elimination of potential damage to the road corridor
- Effective site investigations, interpretation and quality reporting
- Mine subsidence and its impact on the infrastructure
- Ongoing training of young staff before the ageing practitioners retire

This paper will detail these challenges and how RMS geotechnical staff are managing the implementation of technical directions, specifications and training to manage new projects and the effective maintenance of the road corridors in NSW.

1 INTRODUCTION

RMS is committed to provide 24/7 community access to the NSW state road network and accordingly, our major projects on the Hume and Pacific Highways are designed to higher standards than regional roads to ensure that the strategic roads are unlikely to close due to inundation or geotechnical distress. State and Local Governments are faced with the harsh reality of reviewing the level of funding available to maintain the road infrastructure along with other competing priorities. It is also unfortunate that heavier than normal rainfall levels have been experienced in recent years and the cessation of a long drought in NSW.

The global financial crisis resulted in higher capital costs for building developers and this appears to have resulted in seeking lower construction costs to ensure a suitable return on investment on projects. This appears to have led in some cases to 'short cuts' being taken to excavate the deep basements of these building projects. This paper details the outcomes that RMS is experiencing when developers and builders do not 'heed our warnings' of suitable retaining walls for deep excavations. The geotechnical consulting industry is likely to see the result of these misfortunes in higher premiums due to ongoing litigation.

RMS develops specifications and practices that allow a level playing field to all suppliers and contractors, and the limits placed in our specifications represent minimum (or maximum) values of components to achieve the design strength and durability requirements. When new products or changes are required by one supplier to meet the needs of RMS specifications, it is standard practice for the supplier to demonstrate that changes being proposed do not have an adverse impact on the design intent. Some of these design requirements detailed in RMS documents are based on empirical information or from RMS experience where early distress has shown that previous limits were unsatisfactory. Empirical information can take years to establish and computer modelling or extrapolation cannot always assess small changes to the components of a material leading to a shorter life of the structure. Those suppliers introducing innovative products must carry out sufficient performance testing and trials to confirm design models and limitations, and durability.

This paper details several emerging issues facing the RMS geotechnical, asset and project managers. The top five issues are:

- Slope risk assessment and management, and cost effective design solutions
- Deep wall excavation and the elimination of potential damage to the road corridor
- Effective site investigations, interpretation and quality reporting
- Mine subsidence and its impact on the infrastructure
- Ongoing training of young staff before for the ageing practitioners retire

This paper will detail these challenges and how RMS geotechnical staff are managing the implementation of technical directions, specifications and training to manage new projects and the effective maintenance of the road corridors in NSW.

2 IMPACT OF RAINFALL AND SUBSEQUENT NATURAL DISASTERS

Most of NSW was subjected to drought between 2001 and 2007, and rainfall levels returned to average in 2008/2009 but not all parts of NSW received the large rainfall intensities such as in northern NSW in 2009. Table 1 lists the mean and annual rainfall values for various regional centres and Sydney. Some observations from Table 1 worth noting are:

- In 2011 the towns of Hay, Armidale, Wagga Wagga, Grafton, Sydney and Coffs Harbour received more than 25% above their mean annual rainfall. Goulburn had received 81% of its mean annual rainfall last year.
- In March 2012, the monthly rainfall of Hay, Wagga Wagga, Bega and Goulburn had exceeded the 95% percentile indicating an extraordinary wet month and yet the rainfall in Grafton was less than 30 mm.

With the drought over in NSW in about 2007, rainfall levels increased to above average and there is evidence that over the last 3 years rainfall levels in several districts have been very high with no predicable locality pattern.

Table 1: Monthly, annual and statistical rainfall data from various BoM weather stations in NSW (BoM, 2012).

Location	Mean Annual Rainfall (mm)	Annual Rainfall 2006 (mm)	Annual Rainfall 2010 (mm)	Annual Rainfall 2011 (mm)	Ratio ^A	March ^B 2012 rainfall (mm)	95% percentile ^C (mm)	Highest ^C (mm)
Hay	403	173	739	650	1.61	152	107	200
Armidale	516	621	866	1060	2.05	28	NA	192
Dubbo	569	229	NA	577	1.01	125	NA	174
Wagga Wagga	569	267	1019	721	1.27	214	145	249
Bega	584	402	1020	721	1.23	324	NA	324
Goulburn	640	466	915	519	0.81	179	NA	181
Grafton	993	1064	1081	1271	1.28	26	248	317
Sydney	1084	867	1040	1251	1.15	199	308	393
Coffs Harbour	1698	1684	1991	2294	1.35	358	378	512

Notes:
A. The ratio of rainfall in 2011 to the mean annual rainfall for the site.
B. Many NSW towns experienced very heavy rainfall in March this year.
C. The 95% percentile and highest March monthly reading from all records for the site.

The results of heavy rainfall in 2009 along the northern NSW region are shown in Figures 1 and 2. Some of these distresses represent technical risk but would have required substantial funding, and sufficient time for the design and construction of a treatment. It is always a ‘balancing act’ to allocate sufficient funds for treating medium to high-risk slopes given that the triggers to a collapse are sometimes unpredictable. For instance, Waterfall Way in the upper northern region of NSW which is a relatively lightly trafficked classified road experienced over 100 landslides in 2009 but the cost effectiveness to fully upgrade the route is low in comparison to other potential risks. However, this would have been unacceptable for the strategic highways, such as the Pacific Highway.



Figure 1: The damage to the Pacific Highway at Byrons Lane north of Grafton due to a riverbank slip in 2009.



Figure 2: Heavy vehicles waiting for northerly access on the Pacific Highway at Raleigh in 2009 due to inundation.



Figure 3: One of the 100 slips on the Waterfall Way in 2009.

3 EMERGING ISSUES

3.1 SLOPE RISK ASSESSMENT AND MANAGEMENT, AND COST EFFECTIVE DESIGN SOLUTIONS

The RMS slope risk assessment training course has been operating since 2001 and some 400 geotechnical practitioners from around Australia have completed the course. The course objectives are to:

- train industry and internal practitioners in the use of the RMS Guide to Slope Risk Analysis (RMS, 2012a) and to undertake geotechnical risk assessments as part of RMS Asset Management relating to slopes and public risk/safety and
- assess the competency of participants to ensure that a satisfactory standard has been reached.

RMS places high standards on both the delivery of the technical material and examination of participants wishing to get approval to carry out slope assessments for RMS. High standards are set for the course and are achieved in most consulting contracts, however recent RMS audits of slope risk assessments are finding a some inconsistent applications of applying appropriate procedures or quality controls resulting in erroneous risk ratings. RMS will be working closely with industry to overcome these inconsistencies.

In cases of natural disasters, RMS has relied on both staff and consultant practitioners to assist RMS when slopes give way and cause partial or full road closures (see Figures 1 and 3). With the higher levels of rainfall occurring after the 6-year drought in NSW, some of the slopes that had recently failed could not be predicted as design models cannot be constructed for the hundreds of slopes, and funding levels are not readily available to treat all slopes with a high risk assessment level of 1 or 2. Given that geotechnical and climate scientists cannot predict the short-term rainfall events and other triggers at a particular slope, RMS will continue to manage the risks according to the risk management plan derived for the site.

Cost effective solutions are also requested in the Scope of Works and Technical Criteria (SWTC) for major projects in the following sections of the main document:

- Performance and Design Requirements: The Contractor must design and construct the Project Works to deliver the performance requirements of the deed, and the maintenance diaries for drainage, structures, pavements and batters.
- Durability: Must be addressed throughout the design and construction of all Assets and must be reflected in the Design Documentation, Project Plans and the Maintenance Plan.
- Whole of Life Costs: The design must include an analysis of the whole of life costs of the design, including the development of predicted maintenance diaries for all slopes and batters. The predicted maintenance diaries must be developed from the initial maintenance diaries included in the SWTC.

Included in the performance requirements, the Contractor must consider and address all safety issues and requirements relating to safety during construction, operation and maintenance in the development and production of the Design Documentation. This 'safety by design' requirement has been incorporated in the SWTC for many years and is now required under the new WHS Act.

Geotechnical consultants engaged by RMS and bidding on major projects will need to continue to demonstrate the design solutions are value for money.

3.2 DEEP WALL EXCAVATIONS

The authorised and unauthorised excavations adjacent to RMS roadways still present ongoing problems for RMS. It is unfortunate that some developers dismiss our comments after wall designs are reviewed. The result of this approach by developers can result in depressions on the footpath and kerbside drainage damage, and at worst lane or partial road closure. Particular attention is drawn to excessive ground deformation which can cause water mains close to the excavation to crack, feeding water into the excavation and resulting in further damage to the road easement and instability risks.

The result of the damage raises the following questions:

- Where does duty of care lie for the geotechnical engineer engaged by the developer or structural engineer when changes to the design drawings take place?
- What can and should the representative from Principal Certifying Authority be doing about the problem?
- What are the obligations of the Council building inspectors to be available to take action to eliminate/reduce the unacceptable risk?

Two typical problems faced by RMS are:

The design drawings do not detail or are not concise and clear on the construction sequence and therefore, the subcontractor can be uncertain as to how to deliver the specified work on site (see Figure 4).

The temporary retaining wall excessively tilts during construction resulting in the footpath and kerbside pavement being distressed.

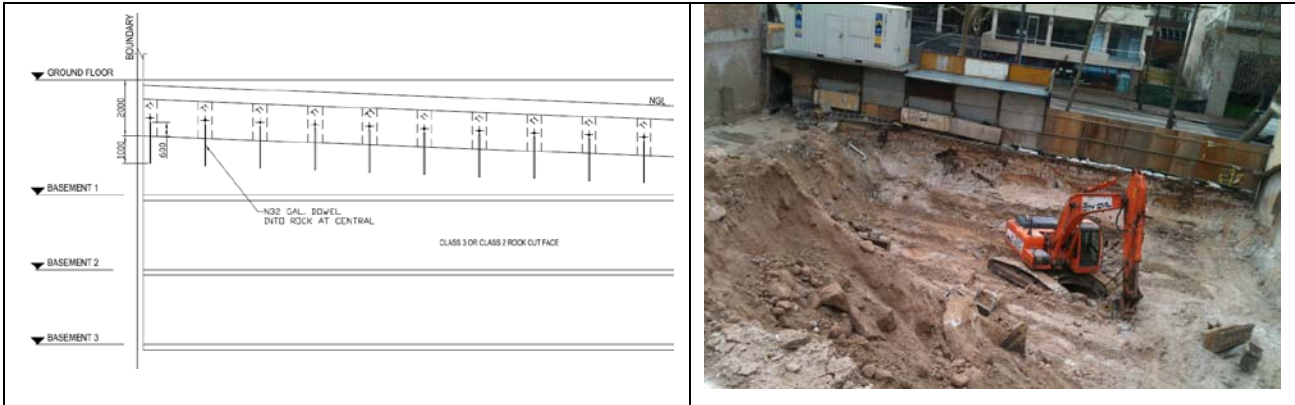


Figure 4: The design drawings show driven piles for this excavation site but the site shows no piles at this advanced stage of excavation.



Figure 5: The temporary repairs to the pavement and footpath shows the results of a deep wall excavation incident.

Some geotechnical practitioners are seeking accreditation to work on building and road projects, but this may not be the best solution. The AGS and the professional re-insurance industry, along with local government support, must consider ways to ensure that the engagement of geotechnical professionals (i.e. the design brief) covers both the design of deep walls and inspection of the works during excavation. If this is not adhered to by the geotechnical profession, insurance coverage could be voided.

As part of RMS’s approach to improve this engagement, RMS released in early 2012 a new Technical Direction (TD) titled “Excavation adjacent to RMS infrastructure” (RMS, 2012b). The purpose of the TD is to provide unambiguous technical instructions for all proposed excavations by private and commercial developments whose influence zones, and/or any temporary structures extend into the road reserve and RMS easements. It sets out the requirements for RMS concurrence upon referral of a Development Application involving excavation adjacent to classified roads affecting the road infrastructure.

Some of the key engineering issues that are to be addressed and noted in the TD are:

- appropriate forms of retention structure
- stability
- deformation
- durability
- quality of design and construction

RMS believes this is a problem beyond the Sydney metropolitan area and could occur in any regional centre. RMS is keen to work with AGS and local government officers to find solutions rather than find answers from the costly legal environment or worst of all to have an incident occur resulting in potential safety issues and/or property damage with all

the consequential impacts. RMS does not want unnecessary increases in insurance premiums across the profession as this cost increase will flow onto all building projects. The need to work together to find a solution to this issue is urgent.

3.3 EFFECTIVE SITE INVESTIGATIONS AND QUALITY REPORTING

Time and financial pressures can result in project managers limiting the scope of site investigations. It is unusual to have too much geotechnical information from a site investigation. A lack of information is likely to result in an overly conservative design or an inappropriate design, and can often contribute to construction problems and disputes. For its PSC engagements RMS is seeking:

- high quality ‘factual’ data, such as high core recovery and accurate geotechnical logs,
- reliable interpreted geological and geotechnical models, and
- the application of this information to design development and construction issues.

Many published management papers will remind us all that quality and safety is just part of doing business. In the geotechnical profession, an active quality system should be an essential part of doing business. Organisations need to find efficient and cost effective ways of operating quality systems in their organisation. If that results in the purchase of an expensive software package, it is often better for the company’s competitiveness for the costs to be spread over a range of projects. However, following on from the quality adage ‘Get it right, first time’ a company that effectively uses a quality system should quickly recover the costs.

RMS has almost completed a proficiency CBR testing program of all RMS and private laboratories in the State. RMS will continue to carry out proficiency studies on a range of test methods to assist laboratories’ testing consistency and accuracy, and to ensure that only laboratories meeting RMS’s basic testing requirements work on RMS projects.

3.4 MINE SUBSIDENCE AND ITS IMPACT ON THE INFRASTRUCTURE

In 2012 RMS updated its “Mine Risk Assessment Guideline” (RMS, 2012c). The guideline facilitates the assessment of risks posed to relevant assets of RMS from proposed mining activities. These mining activities could include but are not limited to either underground subsidence or open cut mining. It also provides a set of tools to enable a preliminary assessment of these risks to be determined and provides directions as to the appropriate response to the mining proposal. This includes escalation of decision making when a preliminary risk assessment indicates unacceptable risks.



Figure 6: The view of the Hume Highway after the installation of the compression slots in the bound subbase in both carriageways.

One of the most intensive studies of the impact of mine subsidence on RMS roads was carried out when BHP Billiton requested to carry out long wall mining directly under the Hume Highway at Douglas Park. A recent report titled “Mine Subsidence - Road Pavement Impacts on the Hume Highway at Douglas Park” (RMS, 2012d) and published by RMS found the overall pavement learning’s may be summarised as follows:

- Pavement structural modelling (both global and local) can be used effectively for risk mitigation with ‘systematic’ subsidence.

Sustained irregularities in the vertical subsidence profile are good indicators of geological features requiring much tighter trigger levels for response to compressive ground strain

The experience from the Douglass Park site recommended that RMS:

- does not select a concrete pavement type in the design process for new pavements in mine subsidence areas, especially if significant longitudinal compression of the pavement is possible.
- use full depth asphalt pavement to mitigate the risk of compressive failure and traffic hazards (if logistically and economically feasible).

The findings from the study were used to specify a full depth asphalt pavement configuration on sections of the Hunter Expressway project, even though the cost of this option was significantly more than plain concrete.

The remote monitoring system, use of optical fibres for displacement measurements and the transverse stress relieving slots will now set the approach for further cases where mine owners request long wall mining under major roads and highways.

Whilst a significant amount of resources over the last 4 years has been directed at maintaining and designing new pavements subject to mine subsidence, open cut mines have now arisen as another primary concern for the road network. In early January, heavy rain followed a blast event at an open-cut mine resulting in a crack being formed from the face of the mine across the New England Highway. As shown in Figure 7, the 50 mm wide crack meandered down the hill and across the three-lane highway. It was fortunate the location of the crack had no streams running across the path of the crack. Monitoring was set up adjacent to the road site, and data from the instruments indicated that the width of the crack increased on average 4 mm per week until a large buttress was constructed against the 100 m high exposed slope. Movement monitoring and repairs to the highway are ongoing.



Figure 7: The view of the crack in the road easement (left) and temporary repairs to the pavement (right) on the New England Highway.



Figure 8: The view of the western face of the open-cut mine (left) and the buttress under construction (right).

The mine excavation was kept just outside the 100 m limit specified in NSW legislation for open-cut mines, and this limit is now to be reviewed by RMS and RailCorp to ensure that these types of events do not occur again.

3.5 ONGOING TRAINING FOR RMS PRACTITIONERS

RMS has recognised for several years that the number of professional engineers and scientists for civil construction will be limited due to the aging workforce and the attractive salaries offered at mines. Currently all graduate geotechnical officers employed by RMS work at various offices and with different experienced staff over a three period. After two years within the graduate program, graduates may apply for permanent positions where available. At this stage RMS has offered all our graduates permanent positions, and RMS has retained most of those graduates well into their career.

The ageing workforce is commonplace for most road agencies. At RMS 40% of our geotechnical staff are over 50 years in age and these scientists/engineers are likely to retire or an average of 60 years of age and take with them their experience and wealth of agency history.

Currently, RMS geotechnical engineers and scientists are spread over offices at Parramatta, Wollongong, Wagga Wagga, Parkes, Grafton and Newcastle. It is considered appropriate that RMS has a balance of local staff and a head office technical capacity. It is recognised that a similar expectation of consultants located at major regional centres is likely to be economically unviable but not impossible. However, the regional level brain drain is concerning RMS and other road agencies.

In 2012 Austroads published a report titled “Attracting and Retaining Engineering and Technical Skills in Remote and Regional Offices” (Austroads, 2012) and its purpose was to share practice and stimulate discussion that leads to effective approaches for attracting and retaining engineers and paraprofessionals in remote areas and regional offices.

One of the recommendations was for road agencies to cooperate together to consider strategies that would take more investment but offer further innovation to deal with the predicted tightening of the labour market for engineers and engineering para-professionals. For example, it was noted in the report to:

- Cooperate together to adapt the ‘DoctorConnect’ web site model to provide a quick way to show engineers where jobs are and what advantages would pertain to taking them up linking with other government employers if possible.
- Explore the possibilities and value of a whole of Austroads program designed to increase participation of women and indigenous people in engineering roles at all levels. This could involve shadowing, mentoring, scholarships and other tailored development, some of which could involve rural or remote work.

RMS started developing a Knowledge Management (KM) strategy and action plan in 2009, and the first in-house community was with the pavement engineering discipline. This year work commenced on a geotechnology community where staff across the organisation, including project managers, can post questions or issues onto wiki pages where staff can contribute to discussing solutions or providing reference to previous solutions. The geotechnology topics are wide and varied ranging from materials and testing, site investigation, slope rehabilitation, foundation improvement, innovative product assessment, to policy development and quality control issues.

It is recognised that KM is common amongst consultants and the opportunity to expand access to the RMS community to limited private practitioners has yet to be evaluated. Other strategies to transfer knowledge to younger practitioners are to:

- develop new training courses managed by RMS and delivered by both staff and specialist industry experts,
- encourage and sponsor the take-up of University postgraduate courses to receive high level training,
- provide on-job knowledge transfer opportunity and
- prepare new guide notes to specifications and test methods to explain the background and historical information.

As noted previously, training already occurs for the slope assessment program, and other courses being considered are the design and assessment of soil retaining walls, safe slope design principles and designing culvert extensions.

4 CONCLUSIONS

RMS continues to face numerous challenges to maintain 24/7 access to the road network, and senior managers acknowledge that these challenges should be addressed by a strong partnership between in-house and external expertise. Also, RMS will continue to use the services of geotechnical consultants and it is hoped that the AGS can continue to produce a forum to impart knowledge and experience, lift standards of practice and assist with the evaluation of new products.

5 ACKNOWLEDGEMENTS

The comments and views expressed in this paper are those of the authors and not necessarily of the Roads and Maritime Services of NSW.

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