ACARP Matters

Very High Coal Mine Spoil Dumps

reliable by design

The design of open cut coal mine spoil dumps has entered a new era of reliability with specific guidance on the applicability of the widely used BMA shear strength framework to very high (exceeding 350m) dumps and non-compliant spoils.

Reliable geotechnical designs for very high open cut coal mine spoil dumps can now be based on the results of an extensive research project administered by the University of Newcastle.

Much of the existing dump design information is based on the BMA spoil categorisation methodology, which was formulated by BMA in the 1980s and published by John Simmons and Dennis McManus in 1995 and 2004. The methodology identifies a spoil as one of four categories and, based on those categories, provides a set of spoil strength parameters for design to control the risks of dump instability. The methodology's rationale stemmed from many years of research and practice involving field observations, laboratory testing and back analyses.

At the time of development, the BMA spoil category based strengths were considered to be reliable for the types of materials encountered and the height of dumps being constructed, provided that designers applied the categorisation correctly. However as pits became deeper and different spoil types were encountered, the limitations of the BMA methodology became apparent:

- It is only based on data for spoil dumps less than 120 metres high, in which the pressures are relatively low compared with modern dumps that exceed 350 metres in height.
- The samples tested to determine spoil strength parameters contained only small particles no larger than 60 millimetres in diameter. Such small particles account for less than 10 per cent of typical spoil material. This means that the contribution to strength of the remaining 90 per cent of larger spoil material had not been tested other than by back analysis of dumps up to 120 metres high.

Because of the limited experience with the behaviour of spoil material in very high spoil dumps and lack of equipment to directly test coarse material under high stresses, designers could only extrapolate the existing low stress data from the BMA methodology into the high stress range. However, there was evidence from the behaviour of rockfill used in dams that shear strength could decrease under increasing stress. Geotechnical experts were concerned that extrapolation of the BMA framework could overestimate stability of very high dumps. In addition, the nature of groundwater conditions within spoil dumps and its influence on stability was virtually unknown. Research into several aspects of dump design was clearly needed to improve the reliability of spoil dump stability assessments.

A three year project was undertaken to test a targeted range of spoil materials and obtain field data on moisture conditions and groundwater within the dumps. The project was administered by the University of Newcastle and the principal investigators were John Simmons from Sherwood Geotechnical and Research Services and Stephen Fityus, Professor in Geotechnical Engineering, the School of Engineering, at the University of Newcastle. Andy Hammond from the University of Central Queensland contributed to the groundwater investigations. Mining engineer Leonie Bradfield undertook her PhD to design and build a large direct shear machine (LDSM) which she used to conduct 50 bulk sample tests on five different spoil materials from mining operations in the Hunter Valley and the Bowen Basin. The largest of its kind, the 720mm square LSDM is capable of testing samples of up to 600kg including spoil particles up to 120mm in diameter, and applying up to 4.5MPa of pressure which is equivalent to the stresses on the shear planes in dumps of 400 metres.

John said the testing regime was a major exercise.

“You’ve just got to appreciate the logistics of what Leonie achieved. We had multiple 44 gallon drums of spoil material in order to do these tests. We’re talking about several tonnes of each material for a reliable strength outcome” he said.

“I wish that we’d been able to test three times as much material and a wider range of different spoil just to put more flesh on the bones, but we were undertaking this work just as the industry was going into a massive downturn. We’ve got good indicative data but, from the point of view of proving to someone in practice, I’d like to see more data. The problem is that the data is expensive. To identify the strength of the material, you need at least six or eight data points and it costs something like $10,000 to collect and transport the sample and generate a single data point.

“Nevertheless, thanks to Leonie’s work, we now have valuable data about the most common types of spoil material and we’ve identified a range of less common but more problematic materials. Importantly, we’ve been able to confirm that there are no reductions in the design shear strength envelopes with increasing stress, for a wide range of the spoil materials that are typically encountered in Australian black coal open cut mining.”

Stephen Fityus said the results from the strength testing work were compared against the BMA spoil categorisation methodology to determine its validity for very high spoil dumps. Dump designers could now check to see whether their spoil material aligned with the BMA categories.

“The LDSM tests have identified some spoil materials for which correct application of the BMA categorisation methodology will not result in reliable shear strength envelope parameters. We call these materials non-compliant. We have been able to recommend some additional criteria that sites can use to determine whether their spoils comply with the BMA spoil categorisation, before using its strength values. There’s no need to take large samples and send them off to high end laboratories; simple slaking and dispersion tests can be used. It is enough to grab some spoil fragments from out in the pit, take them back to the office, put them in a bowl and observe their behaviour for 24 hours. Do they split apart or turn into a slurry at the bottom of the bowl; or are they unaffected by the water? When wetted, how sticky are they? This can tell us a lot about the applicability of the BMA methodology for a particular spoil” he said.

“If the spoil is non-compliant, we strongly recommend that material specific shear strength tests be undertaken to provide reliable design strength parameters. Alternatively, the material may be spoiled in a manner where it cannot adversely affect dump stability. Specific testing remains problematic, but the LDSM developed for this project is now an asset which may yet be of further service to the industry."

John said in addition to the strength testing work that was undertaken, the research team also investigated groundwater behaviour in spoil dumps.

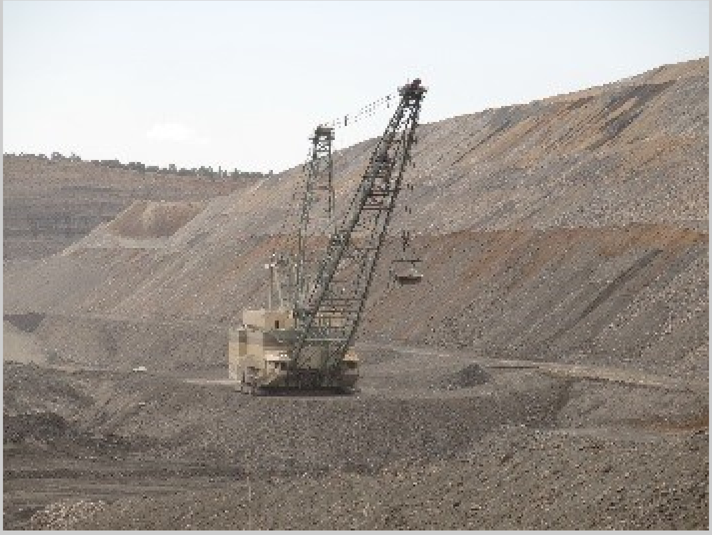
"We knew next to nothing about how groundwater works under spoil dumps. We had an empirical model which is based on a little bit of observation but it's for very a limited range of materials. During this project we tried to close that gap," he said.

"We put together everything we could find and everything that we already knew about groundwater movement. Stephen did the majority of the background work – the real academic hard yards – and I contributed the practical perspective. We also had a Master's student from Central Queensland University making lab measurements on some high quality samples. We now have some pretty definite guidelines about what we think is going on. Fortunately it's a good news story. It's not a problem that's of major concern to the industry because we've confirmed that what was already specified in the BMA methodology is accurate enough."

John said feedback from the industry about the research outcomes had been positive.

"Several mines are now trying to identify their non-compliant materials and ask serious questions about what better data they need to get. That might involve more testing or it might involve other ways of trying to approach the problem in terms of identifying reliable data," he said.

The outcomes from this project are expected to have a significant influence on future spoil dump design, because they highlight the very real limitations in the prior design approach and provide clear guidance for designers to identify and rectify these limitations for specific design applications.



Very high spoil dumps at Bengalla mine.

Leonie Bradfield using the large direct shear machine to test the bulk spoil samples at the University of Newcastle.

Very high spoil dumps at Mt Owen mine.

The bulk spoil samples arrived at the university in 44 gallon drums.

For further information:

The final report is available from the ACARP website. Report number C20019

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