MOBILE BACKFILL PLANT FOR WAMBO PROVIDES COST EFFECTIVE YET FLEXIBLE SOLUTION

While alluvial soil proved the most cost effective solution for the client, the material's highly variable nature demanded a flexible and innovative approach.

Peabody Energy is the world's largest private-sector coal company and a global leader in sustainable mining and clean coal solutions. The company serves metallurgical and thermal coal customers in more than 25 countries on 6 continents and has mining operations across Queensland and New South Wales including the Wambo Coal longwall mining operation.

Background

Peabody's Wambo coal mine, in NSW, Australia, includes a longwall mining operation in the "Wambo" seam at a depth of 70-100m. Some sections of the Wambo longwall operation are overlaid by historic "board and pillar" workings. These workings exist approximately 40–50m above the Wambo longwall operation. During historic mining of the "board and pillar" workings, problematic ground conditions were encountered and Peabody identified a risk of sinkhole formation during underlying longwall extraction. Sinkhole formation was considered to pose a

CHALLENGES

- Over 100 boreholes across 3 hectares
- Variable characteristics of backfill material
- Flexible filling strategy and fill mix methodology required

SOLUTION

- LSTK delivery of fully mobile backfill plant
- Extensive testwork programme to define mix requirements over a vast range

BENEFITS

- Implementation of 250,000m^3 paste material
- Robust, flexible and cost effective solution
- Continuous mine operation throughout

considerable risk to both underground mining operations and the sustainability of an environmentally important alluvial channel that ran across the surface.

To manage this risk Peabody engaged Outotec to refill the "board and pillar" workings. These workings consisted of approximately 15km of largely horizontal roadway over a 3 hectare area, with a total volume of approximately 250,000m^3.

Scope

The scope of Outotec's materials management team was to develop a reliable, cost effective strategy that would deliver fill with adequate properties for maintaining stability during undermining. Outotec was tasked by Peabody with delivery of a lumpsum turnkey backfill solution for Wambo. To address this:

- Outotec worked closely with Peabody's rock mechanics consultants to derive the mechanical resistance required.
- Outotec undertook extensive laboratory studies to ensure that the requirements were satisfied.
- Outotec developed a flexible backfill operating strategy to ensure the fill was placed most cost effectively even when the feed source varied.

Cost effective material selection

Various materials were analysed in a comprehensive testwork programme. These included mine rejects (with high clay content), very fine crushed sandstone and natural alluvial soils. Based on extensive testwork, it was shown that the natural alluvial soils provided the most cost effective solution for Peabody. However, the problem with adopting this natural material was its highly variable nature. Consequently, in order to utilise this cost effective material source, a flexible fill and mix design strategy was required.

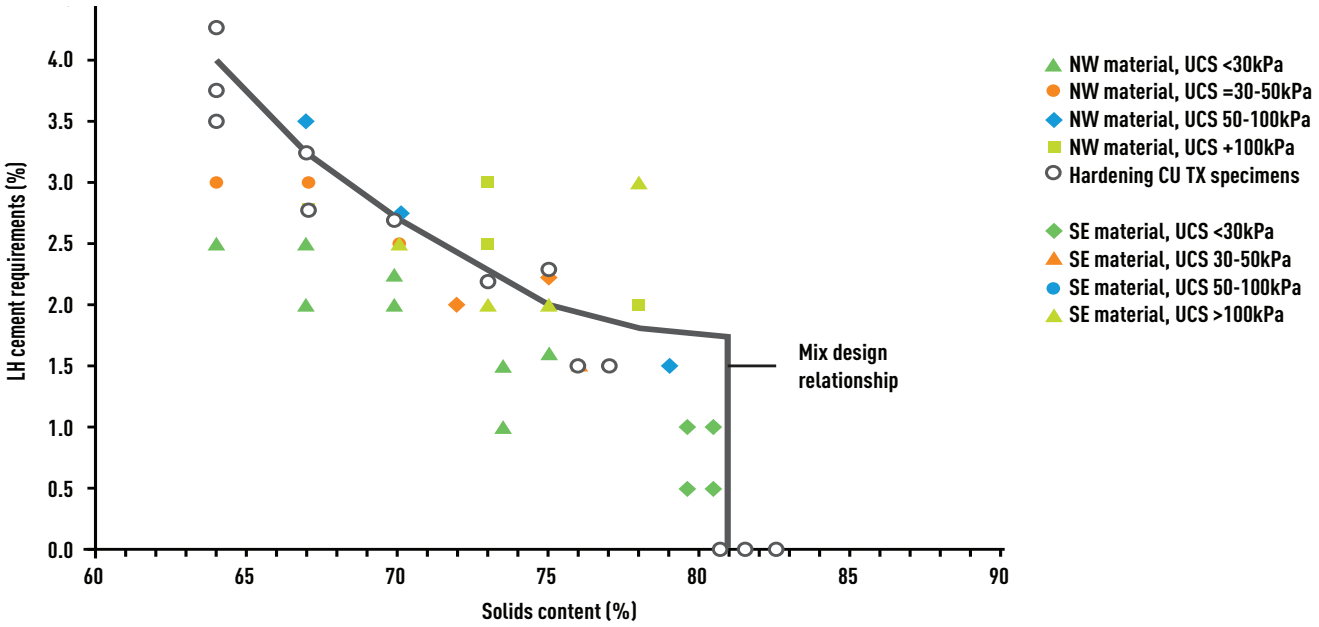
Flexible paste solution

To assess the fill flow properties, rheological testing was carried out on alluvial soil samples from the different locations across the available borrow pit area. These results showed highly variable rheological characteristics, indicating that maintaining consistent rheological properties during operation would be challenging. Furthermore, flowability was shown to be highly sensitive to changes in solids content.

Based on the perceived difficulty in maintaining consistent rheological properties and the likelihood of significant coarse aggregate content, control of a hydraulic delivery system (positive displacement pumping) from a fixed plant location was considered unmanageable. The only sustainable solution for this project was a mobile paste plant that could be placed directly above each borehole when filling.

To enable drilling of the fill holes, a roadway grid was required directly above the workings. This would allow the mobile paste plant, a twin-trailer, to move around the grid safely and be quickly re-established at each borehole. The plant consisted of a front trailer which housed the tailings feed hopper, main conveyor system with weightometer, mixer and hopper; and second trailer containing a generator and cement silo. The mobile paste plant achieved production rates in excess of 150m^3 per hour.

Road network over the old board and pillar workings.



Paste fill mix relationship.

Comprehensive testwork programme - Mix design

Outotec implemented a comprehensive testwork programme to ensure a flexible, robust and cost effective fill mix design. A paper "Fill design and implementation with challenging material – Wambo fill project" Helinski and Revell (2014), presented at ACG's MineFill 2014 in Perth, outlines this programme in detail. Testwork undertaken included direct shear and consolidated undrained triaxial testing – on both cemented and uncemented paste. The objective of this work was to:

1. Define the fill mix and mechanical properties to maintain rock mass stability.
2. Ensure that the fill itself did not pose a risk to underlying mining activities, specifically through "flow" liquefaction.
3. Ensure that the implemented design was sufficiently flexible to manage variability across the source material stockpile area.

In order to prevent sinkhole formation, the paste required sufficient stiffness and bearing capacity to support any roof failures. During the fill process, the fill would be exposed to a range of different stress paths. Should the fill material remain in a saturated state, it could potentially liquefy and remobilise into the underlying workings during this stage. Therefore, in addition to the rock support requirements, it was also necessary to ensure that the fill material could not remobilise.

Results of testwork showed that paste batched in excess of 81% solids strain-hardened upon undrained shearing. This showed that this material would not be prone to "flow" liquefaction. At this solids content the in situ fill material was shown to possess adequate strength and stiffness to prevent any sinkhole formation. Consequently, if placed at a solids content in excess of 81% solids, the paste could be deposited without any binder addition.

Below 81% solids the paste was shown to strain–soften upon undrained shearing, leading to "flow" liquefaction. Over the range of mix solids contents tested, the results showed that all paste with a UCS in excess of 30kPa strain-hardened upon undrained shearing. Paste of this strength was also shown to have sufficient bearing capacity and stiffness to prevent sinkhole formation.

Testwork showed a unique relationship between the binder addition (required to achieve this target strength and behaviour) and the mix solids content (for samples taken from across the alluvial soil stockpile area). The required binder addition increased as the mix solids content reduced.

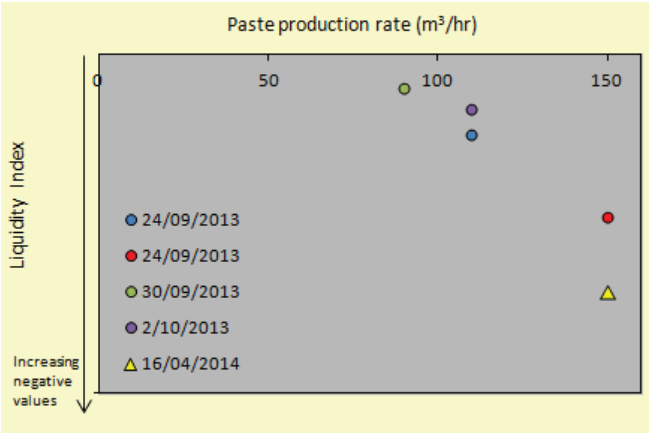
Consolidated undrained triaxial testing of Wambo paste.

Challenges

Both underground and open pit mining operate at the Wambo site and immediately prior to beginning of backfill operations, a modification to surface mining resulted in the preferred source of alluvial material being unavailable for extraction. Due to ongoing underground mining and the necessity to commence filling as soon as possible, a less favourable alluvial source (within the borrow pit area) was used. This material had a high clay content and consequently could only be batched at low solids contents. In addition the "sticky" nature of this material reduced production rates.

During Phase 1 of the filling program this problem was overcome by the Outotec team through "working" the material with earthworks equipment. In addition, the screening method was changed from MISU screening to conventional screening. This removed a significant amount of the clayey material by rejecting the clay lumps as oversize.

Atterberg limit testing was also undertaken on a number of alluvial soil feed samples during Phase 1. This testwork showed a clear relationship between paste production rates and increasing magnitude negative liquid limit values. During Phase 2 of operations, this relationship was used to confirm the preferred material source. This preferred material source significantly increased production rates during Phase 2. Also, during a significant portion of the operation, the mix solids content was sufficiently high to eliminate the need for binder addition.



Relationship between liquidity index and paste production.

Results

Outotec will deliver approximately 250,000m^3 of mine backfill by Q4 of 2014 through more than 100 boreholes on the Wambo project. The boreholes, lined with 125mm NB PVC casing, extended approximately 25–50m vertically into the old board and pillar workings. The project was executed such that both open pit and underground operations were able to continue throughout the fill process. Due to the robust fill strategy, the rigorous manner in which the fill mix was derived and the flexible operating philosophy:

- Filling operations continued without compromising the quality of the placed material when operational restrictions drove the need to utilize unfavorable fill material during Phase 1 of the project.
- When the preferred alluvial material was accessed, during Phase 2, a considerable portion of the fill was placed without binder at very high fill rates, delivering significant economic and production benefits to Peabody.