

THE PIKE RIVER COAL ACCESS TUNNEL

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SUMMARY

This paper describes the development of the access tunnel to a seam of high quality coking coal located under Department of Conservation administered land, 50 km inland from Greymouth. The access tunnel is now approximately 2.1 km in length, and has been driven to intersect the coal seam.

This paper will give an overview of the project and discuss the logistical aspects of supplying large volumes of concrete from a distant batching plant in an environmentally sensitive area.

WHERE IS THE PIKE RIVER PROJECT LOCATED?

Pike stream is located in the Grey Valley, approximately 13km north of the road between Blackball and Ikamatua. The Brunner Coal Seam straddles the central ridge of the Paparoa Ranges, although the mine access, surface infrastructure, and the source of water take, the discharge, and pipeline follow along Pike Stream to the east. Pike Stream flows into Big River which then flows into Grey River.

ENVIRONMENTAL ISSUES

Because of the environmental values attached to the area being required for access to the mine and potential impacts from mining, extensive consultation took place between interested parties. Over a number of years, various technical, cultural and environmental issues were identified and then addressed to the satisfaction of all affected parties to the point where road construction work was able to start on site in early 2006.

There are stringent operational restraints in place that ensure that any environmental effects are minimised.

These environmental restrictions extend to complete bans on the washing down of equipment covered in fresh concrete. This includes the washing down of concrete chutes on any ready mix truck after discharge at site.

GEOLOGY

The coal seam is located 2.3 km from the tunnel portal, and is approximately 360 metres below the surface at the point of intersection. Initial investigations in this area and at stream beds above the proposed tunnel path indicated that most of the rock was expected to be of high quality with minimal fracture planes and likely to be self supporting, with relatively minor areas (less than 10%) requiring supplemental supporting systems.

The rock consists of two main types separated by the Hawera fault line. These two rock types are described as Cretaceous sediments to the west and, to the east, very strong granite/gneiss rocks from the Devonian period that have been metamorphosed from the original mudstones and sandstones. The steeply dipping Hawera fault separates the Cretaceous sediments and the coal measures from the Devonian granite/gneiss formation.

The geological data was obtained by field mapping from stream beds above the proposed drive, and exposed cliff faces in the area. Due to the mountainous conditions, the need for drill rigs to be installed by helicopter, and the environmental impacts from surface drilling, it was not possible to conduct any useful exploratory drilling along the path of the proposed tunnel route.

INITIAL WORK ON SITE

The tunnel portal is located in a relatively small footprint adjacent to the culturally significant White Knight Stream. Stringent operational considerations prohibited any debris entering this catchment, including runoff from the staging area. Immediately after the first full face blast in mid September 2006, it became apparent that there would need to be a rapid re-evaluation of the tunnelling methodology. Because of the poorer rock conditions one to two metres beyond the "outer shell" of the parent rock, the entire project's allocation of rock bolts and galvanised mesh were consumed in the first 2 to 3 months work on site. These more difficult conditions also meant that there was more water infiltrating into the tunnel, leading to problems with the tunnel invert degrading rapidly.

Instead of a largely self supported tunnel, the rock's properties and dense fracture patterns in the gneiss were such that large amounts of shotcrete were required to ensure long term stability of the tunnel. Initial shotcreting was by the dry process. This material was supplied in

bulk loads from our batching plant at Greymouth, and was applied over weakened areas of rock, reinforced with galvanised mesh. This operation was slow and also required significant volumes of shotcrete to be applied due to over-break.

SHOTCRETE MIX DEVELOPMENT WORK

By early December 2006, a decision was made to revert to robotic shotcreting, as hand spraying was not going to be sustainable given the likely volumes involved for the job. This required a completely different approach for the concrete supply to the job.

Allied Concrete's brief was to supply a concrete which could then be carted the one and a half hours to site, then held on site for a period of up to 13 hours at a slump of 180 mm. This would enable concrete to be used at short notice if the tunnelling operations encountered soft rock at any stage during the 24 hour tunnelling operations.

The material was also to be fibre reinforced using polyolefin type structural fibres, as used on the Northern Gate Project in Auckland, that Allied Concrete was also involved in. The concrete was to have a nominal strength of 40 MPa, based on cores taken from test panels made on site, or taken from selected locations within the tunnel.

Because of the high slump of the concrete, the concrete needed to be accelerated at the nozzle of the shotcrete machine to enable layers of concrete of up to 200 mm to be built up without slumping from the applied face.

The remote shotcrete machine arrived on site in January 2007. Initial trials at the Allied Concrete plant in Greymouth using our existing mix designs proved unsatisfactory, largely due to the grading of the sand that was available for this work. The standard spray mix would not go through the robotic pump unit unless the slump of the mix was very high, and it would not start pumping after relatively short stoppages. These problems were unacceptable given the nature of the work in the tunnel.

Extensive redesigning of the mix was necessary to enable the shotcrete machine to pump the mix within its operating range for pump line pressure and rated capacity. These trials extended over a period of several weeks and involved consultation with Sika's research laboratory in Zurich. The final mix design contained significantly higher proportions of aggregate than would normally be selected, to counter the impact of the relatively fine sand. This design proved to be very stable, with good pumpability properties.

Further mix adjustments were trialled to ascertain the limits for the mix design, this work quickly proved the adage that if it ain't broke, then don't fix it!

Once the mix design was finalised, together with the correct levels of accelerator necessary for good build properties, full scale shotcreting commenced on site.

PROVIDING QUALITY ASSURANCE AT A REMOTE SITE

The site is so isolated that there was no power, phone, (either RT, mobile or even satellite at times) for some time. The usual luxuries of reliable computer networks, short lead times to laboratories etc did not exist. Add to this the additional challenges of a very wet environment with cold winters and you have a very challenging site operation.

Because of the type of retarder used, it was impossible to carry out the usual QA programme on the concrete as delivered to site. This was because the retarder entrained large amounts of air; up to 15%. The spraying operation removed the excess air back to normal levels. This phenomenon meant that we were unable to carry out the usual QA tests at our plant. We were keeping batching records of each load delivered to the job, but were reliant upon site test panels and core tests to ascertain the actual strength of the concrete in-situ. This is a radical departure from normal QA systems.

Because compliance was being assessed on cores rather than control cylinders, there needed to be an adjustment made to correlate the nominal strength of the 40 MPa mix with the actual insitu strength of the shotcrete insitu.

Industry-based research indicated that a drilled core, when compared to a standard cured cylinder, would give strengths of only 72 to 81% relative to the control concrete. These results were from Auckland, in temperatures greatly in excess of those being seen on site at Pike River.

In our experience, the affect of low temperatures on strength gain can be drastic. 28 day strength drops of 20 to 30% are not uncommon.

Initial QA tests carried out on site were a cause for concern because of some apparently low test results. We were asked for additional technical assistance to explain some of the discrepancies that were being seen in the early test results that were coming from the site. It became apparent after reviewing the data (site temperatures, core densities and strengths) that the issue was one of slow early age strength development in low

temperatures, rather than production-based fluctuations.

In an attempt to minimise the temperature affect, test samples were subsequently placed in a controlled environment immediately upon completion and then cored at an age of approximately 21 days. They were then sent by courier to the test laboratory for conditioning and testing. This revision in site procedures saw a significant improvement in concrete test block strengths.

At the same time, cores were taken from the tunnel itself to check that the design strengths were being satisfied with the insitu strengths being achieved. This work highlighted the need to minimise the amount of accelerator used to set up the mix, as the ultimate strength of the concrete was affected by the amount of accelerator used.

TUNNEL STATUS

At the time of writing the tunnel is within 200 metres of the coal seam, with the Hawera fault some 40 metres away. The plant gallery and associated machinery spaces have been completed and work has commenced on the ventilation shaft.

VENTILATION SHAFT AND MACHINERY HALL

The 4 metre ventilation shaft is being constructed from the bottom up. On completion this shaft will be approximately 110 metres in length and contain an emergency access ladder.

The construction of this shaft is on country which slopes at 50 degrees. It has necessitated the construction of a helicopter pad above the tunnel, to support the initial drilling and subsequent tunnelling operations. The shaft, which passes through island sandstone, is being excavated by the raise bore technique in preference to the more usual top down method.

Allied Concrete is supplying 50 MPa concrete to this structure; the initial loads being flown to the site by helicopter.

We are supplying 50MPa concrete to the pit bottom which houses machinery, work shop and turning area. This is located over 2km into the tunnel.

Concrete delivered to site is discharged into a Jacon transmixer which then delivers the grades of concrete required to either robotic shotcrete machine, or tunnel floor and machinery pads.

CONCLUSIONS

The Pike River Coal Tunnel Project is very unusual in that it is a major civil engineering

project located within land administered by the Department of Conservation. The environmental restrictions are rigorous, and the site is isolated. The supply of concrete to the works has required an innovative approach from Allied Concrete, that necessitated extensive trials before full scale production commenced. Traditional QA systems have been replaced by extensive on site test panels and insitu coring of the completed works.

THE PROJECT AT A GLANCE:

Commencement date: Tunnel September 2006

Overall tunnel length: 2300m

Average daily tunnelling rate: 7–8 metres

Maximum daily tunnelling rate: 13 metres

Approximate volume of shotcrete supplied: 3,700m³

Volume of additional concrete for associated works: 1,100m³

Projected completion date: December 2008

(Auckland Branch NZRMCA; Unpublished Research, 2004)