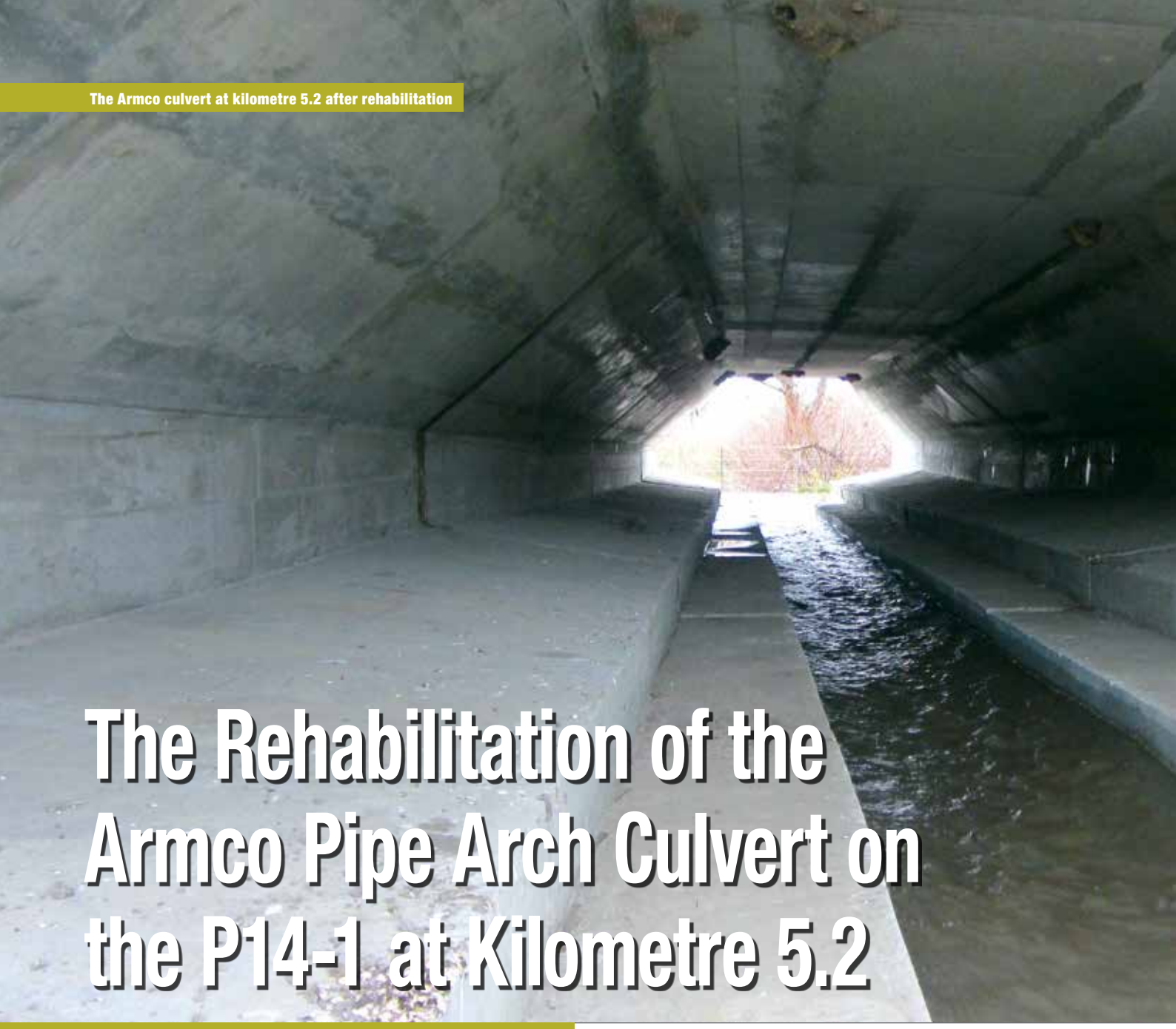

The Armco culvert at kilometre 5.2 after rehabilitation

The Rehabilitation of the Armco Pipe Arch Culvert on the P14-1 at Kilometre 5.2

FINALIST – Technical Excellence Category

KEY PLAYERS

Client
The KwaZulu-Natal Department of Transport
Professional team
Naidu Consulting (Pty) Ltd
Main contractor
WK Construction South Africa (Pty) Ltd

OVERVIEW

The KwaZulu-Natal Department of Transport (KZN DOT) has committed itself to infrastructure upgrades and the maintenance of existing road networks through routine inspection.

Towards this aim, Naidu Consulting (Pty) Ltd was appointed by the KZN DOT to inspect, conditionally assess and report on various existing Armco culverts on provincial roads within District 22.

During their inspections on the P14-1 (R622) a badly deteriorated Armco culvert was flagged at kilometre 5.2. This high-trafficked road in the KwaZulu-Natal midlands services the large commercial agricultural community of Mooi River and Greytown.

The culvert has a 6 m span, 3.6 m rise and 32 m length, with approximately 4 m of fill above. The invert was so severely corroded that it was no longer able to resist the full lateral earth pressures, and buckled in cross-sections for the full length of the culvert.

The structure's roof had also significantly distorted and was becoming noticeably bigger in the period between the monthly inspections. Structural failure was imminent, with the gradual failure being felt in the depression of the pavement caused by the continuing settlement of the fill above.

The badly deteriorated culvert

Bad deterioration on the invert

The P14-1 had to remain open to traffic at all times

This was of deep concern as heavy agricultural, timber hauling and construction vehicles regularly travel the road, and the culvert relies on its invert to resist the heavy lateral forces. In that state the highly corroded invert could buckle at any time.

This high-risk culvert was therefore flagged for emergency rehabilitation or replacement. As a safety precaution, horizontal bracing was introduced to prevent the culvert from buckling any further. This bracing was maintained for the full duration of the design and construction periods.

SITE CONSTRAINTS

The P14-1 had to remain open to traffic at all times as there was no alternative access routes to service the adjacent farm properties. A detour was investigated, but, due to the high fill embankments and the associated steep costs, it was not feasible.

A traffic management plan, including a "stop and go" system, was therefore enforced to regulate the frequency and speed of vehicles, thereby ensuring safe working conditions in the culvert. Construction work was halted during peak traffic hours.

DESIGN SOLUTION

Three design options were investigated: culvert replacement by the trench method, slip-lining the culvert, and the construction of a new reinforcing structure within the existing Armco Culvert.

Due to site and cost constraints it was decided to construct a reinforced concrete structure within to resist all loads on the existing culvert. Construction could then occur without removing the existing culvert. This option offered the required flexibility to work with the distorted culvert which could maintain the cross-section hydraulic requirements and have minimum impact on the overhead traffic.

CONSTRUCTION

Upon commencement of the works it was soon realised that construction of the new invert, walls and roof slab was going to be a challenge given the culvert's shape and existing distortions. At the start, there was difficulty in placing steel to very strict tolerances to ensure that critical sections of the culvert maintained correct slab thickness and adequate cover.

In casting the roof slab, low-slump self-compacting economical grout was used, as it had the required strength at maturity. The grout was pumped overhead from the upstream side through a series of pipes with varying discharge points to allow for even distribution, thereby eliminating the formation of any voids.

A number of loading combinations were reviewed, in addition to secondary factors such as creep and shrinkage, which were of concern in the design of the top slab, as the top slab was cast in a single pour.

In total 240 m^3 of concrete were cast and 34.5 tons of reinforcement were used to successfully complete the construction of the concrete culvert.

CONCLUSION

Designer and contractor had to work closely, incorporating innovative design and construction methods to overcome the challenges arising from this project. Construction commenced in March 2012 and was completed on schedule and within budget in only three months. R4 million was saved by opting to construct the culvert within the old one and by using the existing Armco as a permanent shutter, as this eliminated the need for a detour which would have had to be constructed to a Class 2 surfaced road standard.

Thanks to the DOT's timely investigation, prompt team engagement and technical ingenuity, a potentially catastrophic structural failure on an important, high-trafficked provincial road was prevented. □

To ensure safe working conditions, the bracing remained in place throughout the period of construction

Steel had to be placed to within very strict tolerances to maintain correct slab thickness and adequate cover