Temporary structure to restore service

Brakspruit Bridge Project

HIGHLY COMMENDED – Technical Excellence Category

KEY PLAYERS

Client
Transnet Capital Projects

Main consultant
GOBA (Pty) Ltd

Main contractor
Stefanutti Stocks Civils

SUMMARY

A train derailment in September 2010 caused part of the original Brakspruit Bridge between Hoedspruit and Phalaborwa to collapse. Through the application of sound engineering principles, teamwork and sheer determination a temporary structure was designed and built in just five weeks, returning the line to service. During the preliminary design stage for the replacement structure, the option of constructing a new bridge adjacent to the existing one was considered, but discounted due to the scarcity of fill material for the new approach embankments. An innovative new structural system was then designed using established technology that eliminated any further disruption to the train service. The permanent structure was completed safely, and in an environmentally sensitive manner within budget and programme despite challenging circumstances.

BACKGROUND

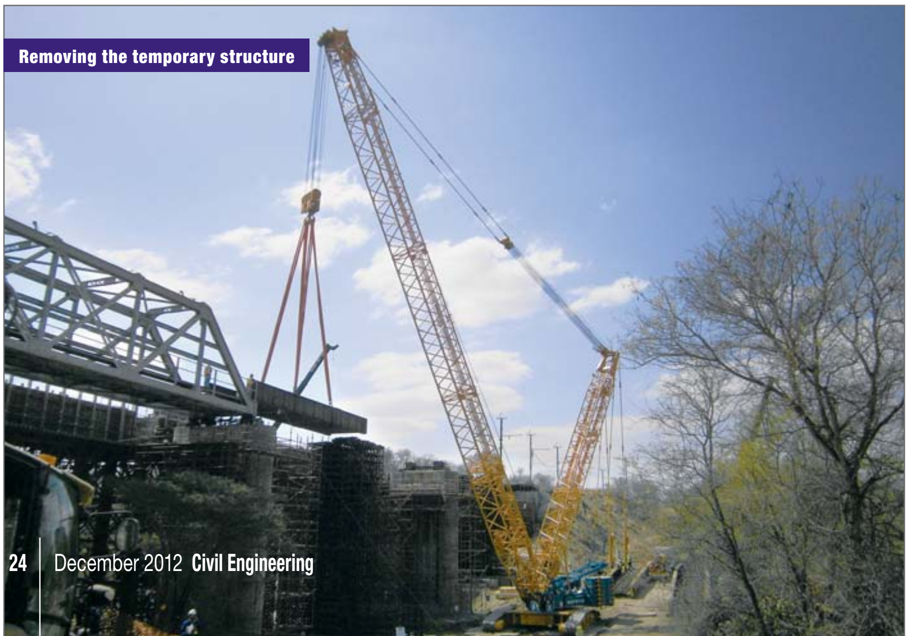
The original Brakspruit Bridge was constructed in 1962, and consisted of three 100-foot span steel trusses supported on reinforced concrete wall-type piers and abutments. On 20 September 2010 a freight train, consisting of 80 wagons, derailed whilst travelling over the bridge. The last 18 wagons crashed into the truss structure, demolishing two spans and damaging the third. Transnet faced serious financial losses whilst the line was out of operation and it was therefore imperative for them to restore the train service as a matter of extreme urgency. Goba was appointed to design a temporary structure to restore the line as soon as possible and to then proceed with design, documentation and construction supervision of a permanent replacement structure.

TEMPORARY STRUCTURE

Transnet Freight Rail (TFR) mobilised their in-house construction team to clear the site and erect the temporary support structure. The truss at the southern end of the structure was salvaged and pulled back into position. The two remaining spans had to be reconstructed with material that was immediately available to TFR, including 1.27 m deep plate girders

Temporary bridge in service

Construction of the new deck



Removing the temporary structure

approximately 16.7 m long and space frame steel cribs fabricated from 50 x 50 angles.

It was necessary to construct two temporary piers to support the plate girders. Existing mass concrete foundations, located midway between the existing piers and abutments, which had been used for the erection of the original trusses, were modified to accommodate the two temporary supports. These supports were up to 15 m high and were constructed from the space frame steel cribs. Nearly 800 cribs, which were 1.83 m long, 0.61 m high and 0.61 m wide, were stacked in an alternating pattern and connected with clamps and stitch welds. Additional bracing angles were welded onto the cribs to increase the rigidity of the towers. A pair of high-strength concrete brick pedestals, braced together with angles, were constructed on top of the existing concrete piers and abutment to support the temporary deck.

The temporary deck was constructed from the available plate girders and spanned from the existing concrete piers and abutment to the new support towers. Transverse steel beams connected the girders together and supported the sleepers and track.

The temporary structure was completed in just five weeks and the line was then returned to service. Speed restrictions were put in place to limit the dynamic forces on the structure. It was also considered prudent to monitor the performance of the temporary structure. A remote monitoring system consisting of GSM modems, a data logger and multiplexer, together with eight high-gain tilt meters were installed. The tilt meters had a measuring resolution of 0.005 arc degrees and a repeatability of 0.01 arc degrees, and were positioned on top of the temporary towers, concrete pedestals and plate girders. The monitoring system provided results that correlated closely with the anticipated deflections.

Whilst completion of the temporary structure was an important milestone the structure was by nature not that robust and was susceptible to flood damage. To mitigate the risks it was necessary to construct a permanent replacement as soon as possible. The floods in Hoedspruit in January 2012 proved that this was indeed a prudent decision.

REPLACEMENT STRUCTURE

Initially a new bridge was proposed on a new alignment adjacent to the existing structure. This bridge would be a continuous three-span cast in-situ beam and slab deck. The substructure would consist of wall-type piers and spill through abutments. A benefit of this scheme would be that the major part of the work could be carried out while the line remained operational, with a short period required to carry out the tie-ins at either end. However, the extensive rail realignment work and the scarcity of suitable fill material for the new approach embankments meant that this scheme was relatively expensive and would require a long construction period.

Goba, using their extensive experience in bridge launching, then developed an alternate scheme which had numerous advantages. This scheme had two sequential construction periods. During the first construction period the existing bridge substructure would be modified and strengthened whilst still in use. At the same time a new prestressed concrete deck would be cast on staging adjacent to the temporary bridge. During the second construction period (a scheduled three-week maintenance shut of the line), the temporary structure could be removed and the new deck could be launched sideways into position. With only minor rail tie-in work required the scheme offered both cost and programme advantages and was approved by Transnet.

Stefanutti Stocks were awarded the contract for the new bridge, and work commenced on site in April 2011. The most unusual part of the site establishment was the construction of an electrified game fence, as the Brakspruit site is located within a 'Big 5' game reserve area which forms part of the greater Kruger National Park.

Moving the deck

The completed Brakspruit Bridge

The new structural arrangement required the support points on the substructure to be lowered to maintain the track geometry. This imposed eccentric loading on the piers and abutments, and strengthening measures were therefore necessary. It was also found that the existing structure had insufficient resistance to the full traction load specified in the SATS Bridge Code. Strengthening measures to the abutments comprised a 1 m thickening of the wall, together with the installation of six no 350 kN permanent ground anchors to each abutment. A temporary shotcrete and soil nail wall, up to 6 m high, was required to provide working space whilst working on the abutment wall. The surface of the existing wall was sandblasted before the installation of dowel bars to provide composite action between the existing and the new concrete.

The existing piers had a dumbbell shape in cross section. To carry the new loads it was necessary to increase the thickness of the narrow part of the pier and to construct corbels near the top of the pier to support the new deck. Work was carried out on the piers in a similar manner to the abutments, with sandblasting followed by the installation of dowel bars and then casting of the concrete thickenings. High-strength prestressing bars were used to prestress the corbels. All the modification and strengthening of the substructure was done whilst the temporary structure was open to normal rail traffic.

In section the deck was 6 m wide and comprised 2.2 m deep edge beams connected by a 0.3 m thick slab. The deck was designed as simply-supported for the three spans, with link slabs over the piers to eliminate the need for expansion joints. Due to the limitations of concrete supply the deck was cast in three stages. After the concrete had attained a strength of 35 MPa each span of the deck was prestressed with 108 strands to a force of 21 MN.

A major part of the work required on site was the temporary work necessary to support the new prestressed concrete deck and to form a slide path onto the strengthened substructure. Temporary foundations comprised large quantities of soilcrete fill within the river channel, together with the installation of micro piles through boulder formations near the abutments. A system of high-load props and steel girders was preferred to a conventional staging layout, as it was less susceptible to damage from floods. The slide path was formed from a 35 mm thick polished steel plate on top of a pair of large steel beams.

At the start of the occupation period the rail infrastructure was removed from the temporary bridge before the plate girders and cribs were dismantled. The single remaining span of the original truss bridge was also removed. This required the establishment of a 650 t crawler crane which was the largest single cost to the project. Once the temporary structure had been removed the new deck could be moved into position. The deck was supported on elastomeric bearing pads with a PTFE sliding surface which slid over the polished steel plate. The entire 100 m long and 6 m wide deck weighing nearly 1 700 tons, was moved by synchronising six 95 t hollow plunger cylinder jacks which pulled on 36 mm diameter high-strength steel bars. The maximum force required to move the bridge was 135 tons. After the deck had been moved into position, it was raised slightly to remove the slide beams and install the permanent pot bearings. The ballast, sleepers, track and electrical infrastructure were installed by TFR as soon as the deck was in place.

CONCLUSION

Difficulties during construction, including the remoteness of the site, the steel industry strike at the time and the complexity of the temporary work, hampered progress. These obstacles were, however, overcome through a combination of teamwork and dedication to the task. Particular emphasis was paid to health, safety and environmental issues during construction and the team successfully completed more than 130 000 hours without any lost time injuries. The successful completion of the project within budget and by the required completion date was due to the team's ability to overcome the challenges involved in an unusual and technically challenging project. ◻

Highly Commended: the Brakspruit Bridge team seen here with SAICE president Martin van Veelen at the awards function