Mvoti River Pipe Bridge Crossing Project

FINALIST – Technical Excellence Category

KEY PLAYERS

Client
Umgeni Water

Main consultant
Bosch Stemele (Pty) Ltd

Main sub-consultant
BKS (Pty) Ltd

Main contractor
Icon Construction (Pty) Ltd

Main sub-contractor
Impact Engineering

Pipe riggers busy with on-site jointing on the Mvoti River Pipe Bridge

OVERVIEW

The Mvoti River Pipe Bridge Crossing is an important component of the Umgeni Water North Coast Bulk Water Supply Project. The strategic bulk conveyance system between Ballito and KwaDukuza, comprising large diameter steel pipelines, is necessary to ensure security of supply by meeting the present and projected future water demand requirements in the North Coast area of KwaZulu-Natal.

The North Coast Bulk Water Pipeline starts from the Avondale Reservoir in Ballito, traverses through and along several housing developments, farms and major roads, and crosses the Umhlali, Etete and Mvoti Rivers until it terminates at the Mvoti Balancing Reservoir in KwaDukuza.

The Pipe Bridge crossing is located over the Mvoti River in Groutville, alongside the existing R103 road bridge between Umhlali and Stanger.

DESCRIPTION OF THE PROJECT

The Mvoti River Pipe Bridge Crossing Project comprises a 280 m long, 800 mm diameter steel pipe supported by a 220 m long steel lattice-type bridge, in turn supported on existing abandoned concrete abutments and an existing unreinforced concrete central pier which were extended using reinforced concrete.

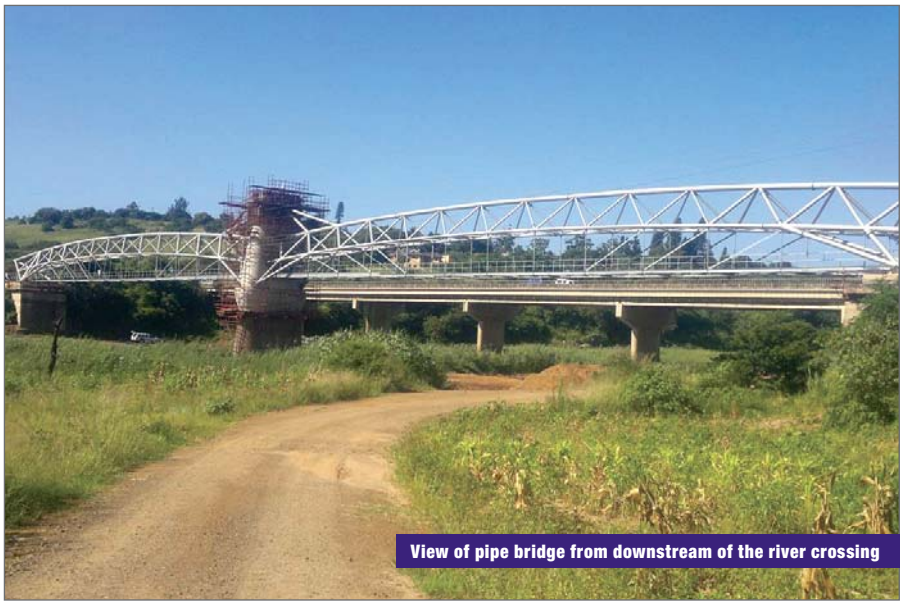
It includes below-ground reinforced concrete anchor walls which contain the forces generated as a result of the transition from the buried to the above-ground pipe installation, pipe thrust walls, and a system of pipe bearings and bridge bearings.

Other salient features of the project include a maintenance walkway along the bridge, and allowance for the installation of a second 800 mm diameter pipeline at a later stage.

SPECIAL DESIGN AND CONSTRUCTION CONSIDERATIONS

One of the key decisions during the preliminary design stage was to consider the various options for the piped river crossing, which included a sub-surface river bed installation, installing on the existing R103 road bridge, and on a steel

Lifting the south bridge span into position



View of pipe bridge from downstream of the river crossing

View of pipe bellow to allow for longitudinal movement

pipe bridge supported on the old abandoned road bridge pier and abutments. The latter was determined to be the most feasible option taking into consideration various criteria such as costs, operations and maintenance, future demands and environmental impacts.

The Mvoti River Pipe Bridge consists of two main spans fabricated from tubular steel sections in a trapezoidal arch configuration. Each girder spans a distance of 79.46 m, is 3.5 m wide and 4 m high. A lower bridge deck, which supports the bulk water pipeline, is suspended from the main bridge girders with tubular hangers at 6 m centres. All loads are taken to ground through the existing concrete abutments and central pier which previously supported a steel road bridge that was decommissioned. The existing abutments and pier were modified to suit the new bridge steelwork.

Both main spans were fully preassembled, surveyed and welded in the contractor's workshops to ensure fitment on site. The girders were then dismantled in approximately 20 m segments and shot-blasted and painted in the contractor's in-house painting facility.

Transporting the girder segments to site was undertaken with eight abnormal loads, the longest being 24 m.

The truss segments were then spliced together on the flood plain before being lifted in two lifts per span, into their final position over the river. The various segments were held and lifted into position using one 90-ton and two 200-ton mobile cranes. The two bridge sections were then finally bolted together in the air and secured on bearings at the abutment. Connections at the central pier were site-welded onto cast-in plates.

As each bridge span was erected on separate days, the first bridge span needed to be supported by a temporary erection tower in the river bed to minimise any eccentric loads on the central pier while waiting for the other span to be erected.

Close cooperation between engineering and construction teams was crucial for the successful completion of this complicated construction project.

Unseasonable winter and well above average spring rains resulted in high river levels, which created huge challenges for access of materials and equipment during construction.

The old existing concrete abutments and piers date back to 1921 and, following

investigations, were found to be completely unreinforced. The central pier and abutments were modified and extended in height using an elaborate layout of dowels and reinforced concrete.

Detailing of the steelwork and the profiling of the ends of the circular hollow sections and connections were complex. The steelwork was detailed using the contractor's in-house StuCad 3D Modelling Software and shop drawings produced to facilitate fabrication.

The above-ground section of the steel pipeline is subjected to variations in pipeline and temperature and the significant effects thereof were taken into account in the design. Stainless steel bellows (pipe movement joints) were installed on the pipe at each of the abutments. The supports located on the bridge were positioned approximately six metres apart. These are subjected to movement of both the pipeline and the steel structure, and as such the final installation thereof had to take this into account, as well as the "Poisson" effects when the pipeline would be pressurised with water. Movement bearings and an uplift bearing are located at each pipe support.

PROJECT SCOPE

The scope of the project comprised the following:

- Supply, fabrication and erection of the double-arched steel bridge structure spanning 220 m across the Mvoti River, supported on the existing old road bridge central pier and abutments
- Extension of the existing central concrete pier and end abutments by 13.5 m vertically
- Construction of temporary works, including access roads and working platforms, river diversion and a temporary support for erection of the first bridge span
- Installation of 220 m of above-ground and 60 m of buried steel pipeline (800 mm nominal diameter)
- Supply and installation of expansion and contraction pipe bellows
- Construction of concrete in-situ plinths, anchor walls and thrust blocks on the north and south banks
- Supply and installation of the bridge bearings, pipe support bearings
- Sheet piling, dowelling and anchor bolts
- Air valve installations
- Cathodic protection requirements
- Environmental management and rehabilitation.

ENVIRONMENTAL CONSIDERATIONS

The Mvoti Pipe Bridge Crossing project traverses an environmentally sensitive river and wetland area.

Based on the Environmental Impact Assessment and the Environmental Record of Decision, Umgeni Water's Scientific Services Division prepared a comprehensive Environmental Management Plan specifically for the implementation of this project.

The contracts were closely monitored during construction for compliance with the requirements of the Environmental Management Plan. Specific emphasis was placed on the rehabilitation of areas along the pipeline route affected by construction activities.

The use of the existing concrete supports of an abandoned road bridge

reduced the impact on the environment, whilst also minimising costs.

Steel's ability to be recycled also provided good motivation in terms of environmental sustainability. Steelwork could also be pre-fabricated off-site, which minimised the impact on the environmentally sensitive area.

SOCIO-ECONOMIC BENEFITS AND OPPORTUNITIES

Construction of the Mvoti River crossing will result in several short- and long-term benefits for the region, including:

- that it is of strategic importance in significantly increasing the capacity and improving the security and reliability of water supply in the upper North Coast supply area, extending from Ballito in the south to Groutville and KwaDukuza in the north,
- that the implementation of the project has made allowance for much needed future developments in the supply area, and has unblocked one of the key infrastructure constraints for new developments, and
- that the pipe was designed to accommodate a future bulk pipeline and to operate bi-directionally, from the Hazelmere Dam in the south in the short term, and from the future Tugela River supply in the north in the medium to long term.

View of pipe bridge from adjacent road bridge

COMPLETION AND COST

The project was completed within budget at a cost of R 22.3 million, although later than originally programmed, mainly due to inclement weather conditions and associated high river levels during construction.

Source:
http://www.saice.org.za/downloads/monthly_publications/2012/2012-Civil_Engineering-December.pdf