KZN pedestrian bridge a first in Africa

The Mkomaas River Pedestrian Bridge is the only prestressed concrete ribbon bridge in Africa. Its main span of 150 m equals the world record for this type of bridge. The bridge was constructed from concrete elements suspended from cables tensioned between abutments, which were then stressed along the length of the bridge by tensioning a second set of cables placed in ducts through the elements. Compression stresses induced in this way compensate for tensile stresses resulting from live loads on the structure. The project earned a commendation in the category Technical Excellence

MKOMAAS RIVER PEDESTRIAN BRIDGE

Commendation: Submitted by Pietermaritzburg Branch in the category Technical Excellence

KEY PLAYERS

Client KwaZulu-Natal Province, Department of Transport
Consulting engineer Jeffares & Green
Main contractor Sakhisizwe subcontracted to Somerset Oaks Trading 19
Subcontractors Esor (ground anchors); Infraset (pre-cast concrete elements)

IN AUGUST 2004 THE MAYOR of Sisonke District Municipality wrote to the KwaZulu-Natal MEC for Transport requesting assistance to overcome the difficulties posed by a swelling Mkomaas River in the wet season to children crossing the river to and from school.

Jeffares & Green were subsequently appointed for the design and construction monitoring of a pedestrian bridge over the river at the site.

Because of environmental and construction constraints, the consulting engineer favoured the concept of a single long-span bridge over the river. A single long-span bridge would not impede the flow of the river and escaped classification as an activity requiring authorisation in terms of the Environmental Conservation Act of 1989. Therefore there would be no delay awaiting a record of decision from the KZN Department of Agriculture and Environmental Affairs.

OTHER CONSIDERATIONS

The Mkomaas River is known to be fast flowing and to experience flash floods. As construction of the bridge would require several months to complete, it was inevitable that some of the work would be carried out in the rainy season. The river's potential for flooding also influenced the choice of a single-span bridge.

Owing to reduced construction time, the designers considered the use of precast concrete elements advantageous as several tasks could overlap. For instance, the deck panels could be manufactured before the abutments were in place. The use of precast panels also reduced the concrete work required on site under difficult circumstances.

Prestressed concrete ribbon bridges have found favour with some designers in Europe, Asia and North America, but as far as could be ascertained, this method of bridge construction had not previously been used on the African continent.

The following construction sequence is typical of this type of bridge:

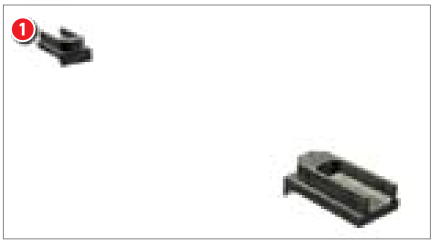
- The abutments are built and anchored back to rock on either side of the river (figures 1 and 2)
- Main bearer cables are placed and stressed between the two abutments (figure 3)
- Precast concrete elements are manufactured and suspended from the cables and slid across the river to their respective positions along the length of the bridge (figure 4)
- The precast deck elements are joined by lapping reinforcement and placing in situ concrete, thereby turning the deck into a continuous ribbon (figure 5)
- Longitudinal post-tension cables are placed along the length of the bridge in ducts inside the elements and tensioned in order to provide sufficient compression stresses to compensate for live load-induced tensile stresses (figure 6)
- Handrails and other finishings are installed before the bridge is commissioned (figure 7)

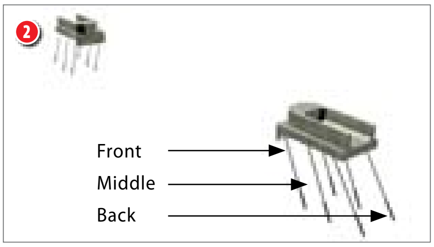
Other long-span alternatives considered included suspension bridges, which are often used for pedestrian bridges, pipe bridges and other light structures in South Africa. However, the client had previously experienced problems with people refusing to make use of such bridges, as they tend to resonate under live loads. The introduction of stabilisers to dampen the resonance proved only moderately successful. The towers of suspension bridges also tend to have a negative impact on rural landscapes.

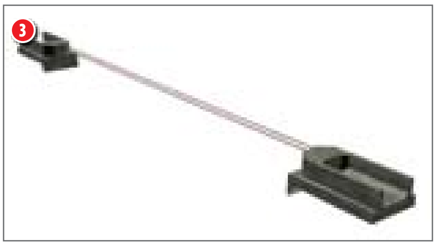
A prestressed ribbon bridge was determined to be a more viable option in terms of design requirements, cost effectiveness and time constraints.

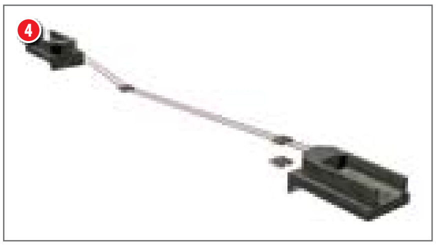
DESIGN

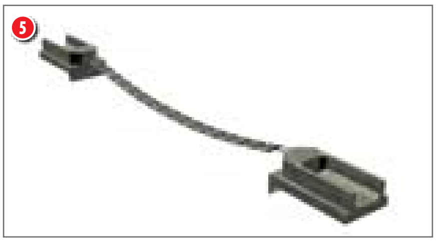
Conventional software packages are unable to analyse catenary-type structures with their large deflections, as these packages are based on the assumption that plane sections remain plane and deflections are



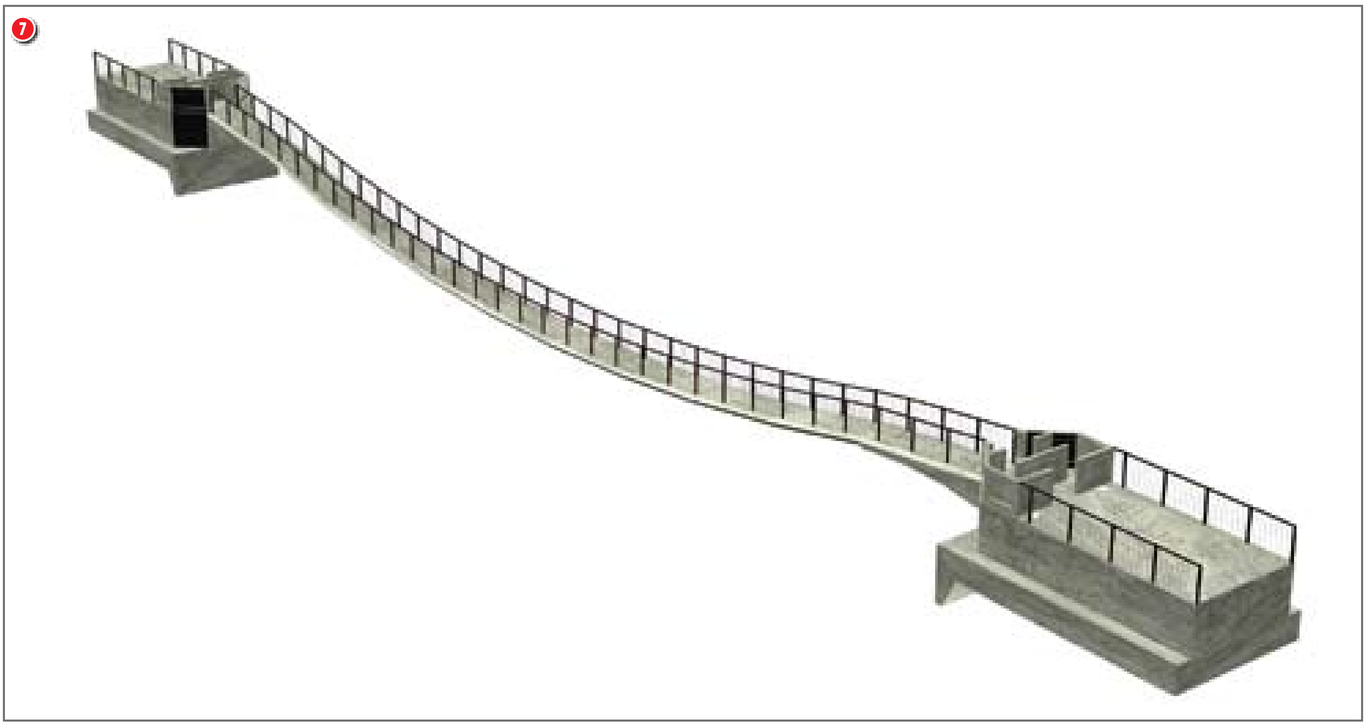








1 Cast abutments
2 Add rock anchors
3 Tension bearer cables
4 Add precast deck elements
5 Add in situ concrete
6 Post-tension
7 Final product.



small in relation to actual dimensions. Therefore the design was based upon first principles done on self-generated spreadsheets. Subsequently the Institute of Civil Engineering at the University of Stellenbosch was commissioned to conduct finite element analysis on the bridge by using a sophisticated finite element structural analysis package. Results obtained from this analysis confirmed those of the self-generated spreadsheets.

The CSIR's Dr Adam Goliger was employed to advise on anticipated wind loadings. His study was based on a computer-generated model, water tunnel tests and an extensive review of literature pertaining to wind loading on similar bridges. His report concluded that wind was unlikely to play a significant role in the lifespan of the bridge.

The maximum horizontal force that could be applied to each of the abutments under working loads is in the order of 10 MN, which meant that the abutments had to be securely anchored. As competent rock (charnockite with a compressive strength of approximately 50 MPa) was encountered on site, rock anchors were used.

The Mechanical Engineering School at the University of KwaZulu-Natal was commissioned to monitor the loads experienced by the rock anchors, with an option to re-stress if necessary. However, it turned out that the anchors behaved very similarly to the initial calculations and no further work was deemed necessary.

CONSTRUCTION

Remarkably, the contract for the construction of the Mkomaas River Pedestrian Bridge was won by a contractor who had never built a bridge before. The bulk of the labour force was recruited from the local community. Work commenced in November 2005 and was completed in April 2007. Difficulties were encountered in installing rock anchors through a 4 m deep boulder layer on the south abutment, but once that was completed the work went ahead without a major incident.

Deck elements were precast in Pietermaritzburg and transported to site.

8 The final product in use
9 Deck soffit at sunrise

10 & 11 Launching of precast deck units

The launching rate of these deck elements exceeded the designers' best expectations, as up to 24 elements were launched in a single day, making the launching of the 93 deck elements no more than a five-day operation.

The most significant quantities for this bridge were 190 m^3 of concrete, 37 t of steel reinforcement, 2 500 MN-m prestressing tendons and 31,5 MN prestressing anchorages.

The tendered price for the works was R3,73 million, which was well within the client's initial estimate of R5,0 million.

CONCLUDING REMARKS

The Mkomaas River Bridge is a humble structure in so far as its walkway is also its main structural member. It spans the river without props, piers, stabilisers or towers that could detract from the rural landscape in which it was built.

The design was sensitive to the many challenges faced by a contractor building a bridge over a large river in a remote area of KwaZulu-Natal. It specified the use of precast concrete deck elements, which reduced the amount of construction required on site, thereby alleviating some of the burden on the contractor, who was able to produce a quality product under difficult circumstances. The use of a single-span prestressed ribbon bridge also did not require the contractor to work inside a river notorious for its flash floods.

The extensive use of concrete elements ensures that this bridge will serve its purpose virtually maintenance free for many years. □