Bridging the Gap – Maputo's newest Monument

Lawrence Greene
Sectional Head – North Link
Maputo Bridge and Link Roads Project
GAUFF GmbH & Co Engineering KG
lgreene@gauff.net

BACKGROUND

Mozambique, situated on the east coast of southern Africa, is endowed with rich natural resources, fertile soils and an Indian Ocean coastline of more than 2 800 km. Due to these assets, and the recent discovery of natural gas in the north, Mozambique is considered to have one of the largest untapped development potentials in the world. Unfortunately, despite impressive economic growth in recent years, the country's progress in sustainable economic development is moving at a snail's pace.

One of the major hurdles holding back development is the lack of a well-developed transportation network between the capital city, Maputo, and the south of the country. In addition to this, a trade route connecting Maputo to Kwazulu-Natal in South Africa has been identified as a precursor for continued economic development. The creation of this southern development corridor forms part of Mozambique's National Development Master Plan, which emphasises the setting up of infrastructure to support economic development and tourism. This will result in new employment opportunities and further economic growth, and will empower the southern region of the Maputo Province. To support these initiatives, it was decided to construct the Maputo Bridge and its accompanying link roads.

MONUMENTAL DIMENSIONS

Once completed, the Maputo Bridge will be the longest suspension bridge in

Overview showing the positioning of the Maputo Bridge and its accompanying link roads

Reinforced concrete post-tensioned T-beam – south approach

Close-up of the T-beam

Balanced cantilever reinforced concrete box girder – north approach

Africa, with a main span of 680 m and a combined bridge length of just over 3 km. It is considered the most important project in the south of Mozambique since Mozambique's independence. Construction started in 2014.

The total project value is $725 million, including the north and south links, which consist of 184 km of roads and multiple highway bridges. The north link will connect Maputo's major arterials to the main bridge and the south link will connect Maputo to the KZN border, Kosi Bay and the seaside tourist town, Ponta do Ouro. The design and execution are being carried out by the China Road & Bridge Corporation (CRBC), based on FIDIC's Silver Book EPC (engineering, procurement and construction) contract.

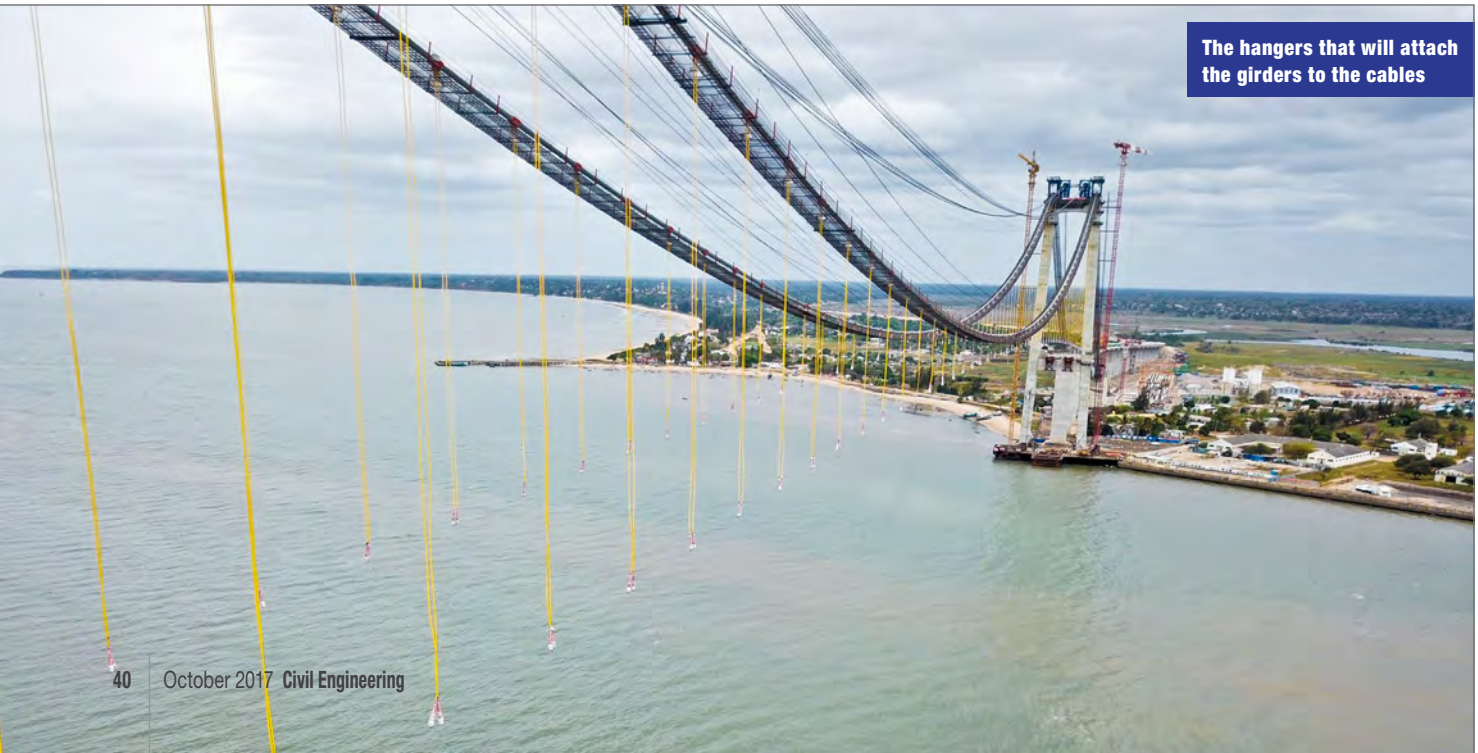
GAUFF Engineering, a German consulting engineering firm, was appointed to oversee quality control and verify the design against the Eurocode. Through the institution of a QMP (quality management plan), specifically developed by GAUFF for this project, all aspects of quality and construction are controlled and supervised. This is highly important to the employer, EDMS (Empresa de Desenvolvimento Maputo Sul), a development corporation set up by the Mozambican government to oversee the project and the future management of the infrastructure.

The 57 massive box girders for the main span arriving from China on 27 September 2017 (the main span across the bay will have a clearance of 60 m, allowing the largest of ships to pass under)

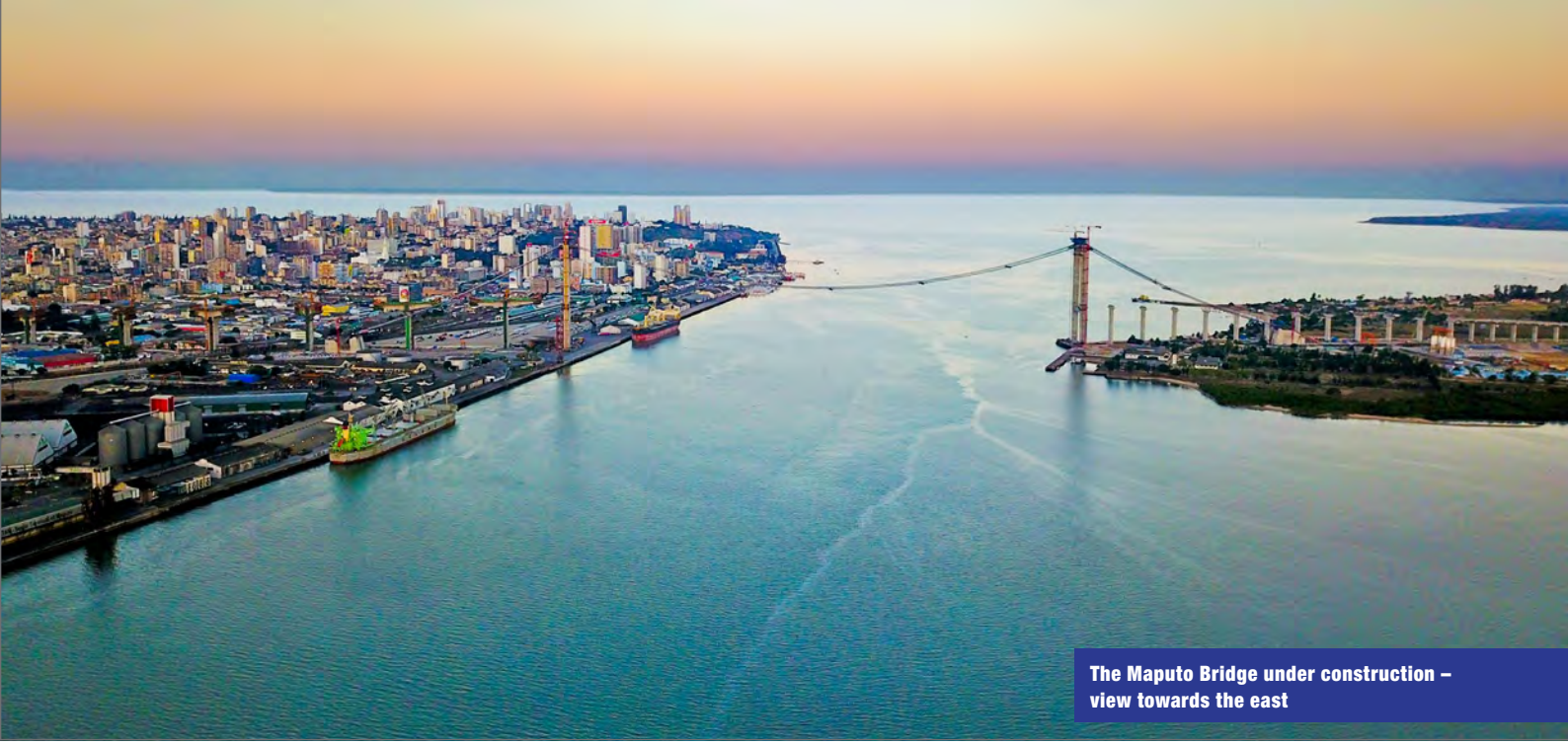
The girders will be lifted off the ship, rotated into place and attached by hangers to two 0.509 m diameter galvanised 91-strand cables; each segment will then be connected to the next, and specialist-welded into place

What makes the Maputo Bridge project truly remarkable is the fact that it comprises three different bridge types – an RC (reinforced concrete) post-tensioned T-beam south approach, a balanced cantilever RC box girder north approach and a suspended steel box girder main span across the bay, guaranteeing a clearance of 60 m, so the largest of ships can pass under, thereby insuring the future of a port that will become one of Africa's busiest.

With a design speed of 80 km/h, the north and south approach bridges will be built utilising two different design and construction methods, due to local constraints. In the north, the approach bridge will be a balanced cantilever construction of approximately 1 km in length, rising up towards the main bridge with a gentle S-curve in plan. The southern approach bridge will



The hangers that will attach the girders to the cables



The Maputo Bridge under construction – view towards the east

be built using prefabricated post-tensioned T-beams to form a total length of 1.234 m.

The approach bridges connect on each side to the single-span double-hinged suspension bridge made up of 57 steel box girders. The steel girders are manufactured in China with a GAUFF engineer placed on assignment to monitor all production works. Each girder is 3 m deep and 25.6 m wide, with a segment length of 12 m as standard. There is a central segment of 13 m and two end girder segments of 8.65 m. Each of the segments can weigh up to 150.6 t and will be attached to the main cable with hangers ranging from 73 m in length at the pylons to 3 m at the midspan.

The steel girders will be lifted off the ship by a specialised crane, rotated into place and attached by hangers to two 0.509 m diameter galvanised 91-strand

North approach under construction

South approach showing the massive anchor block

The south anchor block before visible construction

cables. Each segment will then be connected to the next, and specialist-welded in place.

Both cable ends are attached to the 'splay saddle buttresses' which are anchored into two massive anchor blocks on either side of the bay. These will in effect hold up the entire main span of the bridge. What makes them truly unique is their sheer size, necessitated by the poor geological conditions and the high water table. With a diameter of 50 m and an excavated depth of 37.5 m they are currently some of the largest anchor blocks being constructed in the world. Containing chambers of sand and concrete, the south anchor block will eventually weigh an impressive 170 000 t.

The cables will then extend from anchor block to anchor block, over the top of two portal frame pylons positioned on both sides of the bay. The south bank (Katembe) pylon has a final height of 136 m and the one on the north bank (Maputo) 135 m. An interesting aspect of the pylon design is the fact that each leg is inclined at 2° towards the centre line of the bridge for added stability. Additional to this, each pylon has 24 piles with a diameter of 2.2 m, which reach depths of 105 m (south) and 95 m (north), due to poor geological conditions, making the combined structure truly massive. In total 331 piles were constructed for the main bridge and its approaches, averaging a depth of 50 m.

THE CONCRETE

Keeping the highest quality in mind, compressive strength concrete cubes are manufactured for 7, 28, 90 and even 365-day compressive strength tests for every element cast, and slump testing is done at regular intervals to confirm workability. Mandated durability testing is also done to SANS specifications continually.

Another truly unique aspect of the concrete on this project was the substitution of up to 40% of the cement with fly ash or pulverised fuel ash (PFA). This not only offered immediate cost savings, but also long-term benefits. The PFA, produced by Ulula fly ash and delivered from South Africa, results in the concrete having an extremely high level of durability, a fact which was confirmed by the University of Cape Town's Concrete Materials & Structural Integrity Unit (COMSIRU) which tested samples cored from the bottom slab of the anchorage. These samples reached durability levels never

The south anchor block under construction

The south bank pylon has a final height of 136 m

The concrete mix used for the Maputo Bridge project has an extremely high level of durability, as confirmed through tests done by the University of Cape Town's Concrete Materials & Structural Integrity Unit

seen at the laboratory before. Producing sustainable concrete, and most importantly, a sustainable project, is particularly important to the CRBC and the client. Reduction of its carbon footprint by reducing CO_2 emissions is part of the company's mix-design philosophy, and, through the use of PFA as an extender, it has resulted in dramatically lowering the cementitious CO_2 emissions of the concrete from an estimated 352.5 kg CO_2/t to 229.5 kg CO_2/t – a reduction of 35%.

CURRENT STATUS

The calculations to Chinese standards and their verification against the Eurocodes were completed in June 2016, alongside the production of piles and diaphragm walls. The anchorages for the main cables of the bridge are now complete and the main pylons have reached their final height. The main cables have been laid and are now being prepared for the steel box girders. In the coming months the steel box girders will be erected and welded in place. At the same time the construction of the highly demanding balanced cantilever post-tensioned north approach bridge will continue, and the last of the 45 m T-beams will be manufactured and placed in the south.

Handover of the new Maputo Bridge to the Mozambique nation is currently scheduled to take place in 2018, forever changing the skyline of Maputo and setting the bar high for future African mega infrastructure projects. ☐