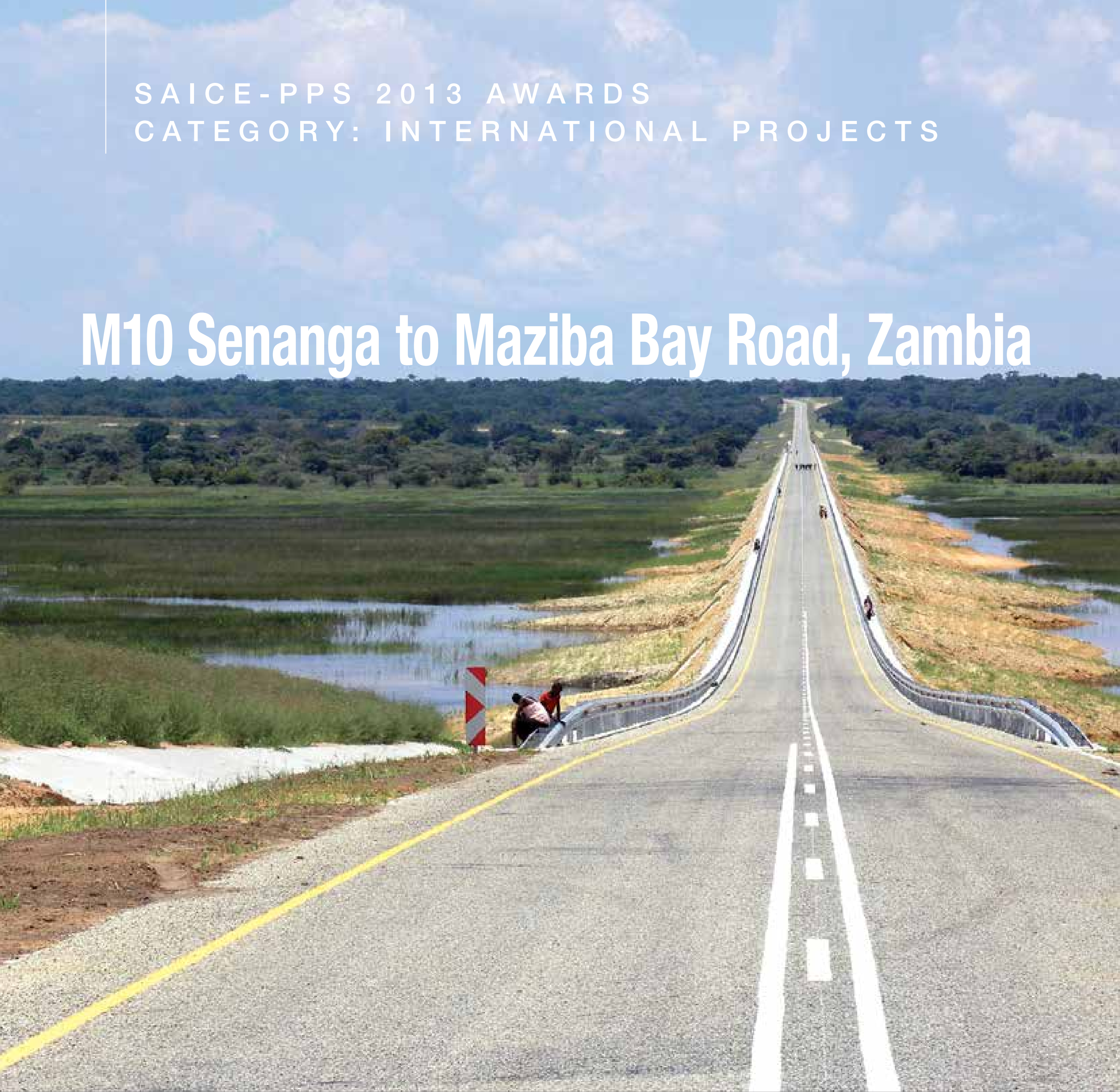
SAICE-PPS 2013 AWARDS
CATEGORY: INTERNATIONAL PROJECTS

M10 Senanga to Maziba Bay Road, Zambia



WINNER
International Projects Category

KEY PLAYERS

Client
Zambian Road Development Agency
Professional team
UWP Consulting
Main contractor
China New Era International Engineering Corporation

OVERVIEW

In June 2010, UWP Consulting was appointed by the Zambian Road Development Agency to design and supervise construction for an 81 km stretch of road on the M10, along a new alignment down the eastern bank of the Zambezi River from Senanga to Maziba Bay in western Zambia. The new alignment avoids the flood plain which the old gravel road traversed. During the rainy season this old road became unusable and dug-out canoes were the only means of transport to cross the rivers.

The road was built in difficult sandy terrain and crosses fourteen large streams and rivers which flow across the route into the Zambezi River. Several of these rivers have flood plains where the water backs up from the Zambezi during the rainy season, the largest being the Lui River. The road also crosses the Zambezi near Maziba over a new 200 m long concrete arch bridge to join the continuation of the M10 southwards along the western bank of the Zambezi down to Sesheke.

The difficult terrain resulted in the construction of reinforced sand embankments, instead of unaffordable long bridges.

Additional camps and preplanning/stockpiling of construction materials at strategic locations enabled construction

A section of the new M10 Senanga to Maziba Bay Road in Zambia: the completed road across the Lui River flood plain

Lui River temporary crossing during the rainy season

Flood plain embankment designed to be above maximum likely flood levels; note culverts

to continue during the rainy season where the flood plain became inaccessible.

UNUSUAL CONSTRUCTION METHODS

Due to the width of the flood plains, particularly the Lui (1 500 m) and the Kakenge (500 m), and the large flood volumes dispersed across the full width of the flood plains (Lui: 1 500 m^3/sec, Kakenge: 550 m^3/sec), it was not economically feasible to construct large bridges across the full width of the flood plains. Embankments with large box culverts placed at the natural low point flow positions provided a solution for this to enable the crossing of the flood plains.

The box culverts were standardised at 4.2 m wide (an economical span to balance concrete thickness and reinforcing requirements), and standard opening heights of either 2.4 m or 4.2 m were used to save on shuttering costs.

They were designed as closed cell rectangular culverts with the floor slabs cast integrally with the walls and deck slabs to ensure that the culverts would not become structurally compromised if any settlement of the embankment fills occurred across the variable ground conditions.

Further precautions included the construction of a rock-fill foundation layer under each culvert floor slab. The adoption of this embankment method also required the construction of large fills reinforced with geofabric and then clad with hand-packed stone rip-rap to prevent erosion in the unlikely event that the embankments were ever over-topped.

The fills were constructed to a height of 1 m above the calculated and/or known maximum flood heights to prevent over-topping and constructed on a 0% grade so that, in the event that they are over-topped, the water flow would be thin laminar flow as opposed to concentrated flow at low spots, which would cause erosion and embankment failure.

The rock cladding also provides protection for the geofabric which would otherwise be exposed. The fills were stabilised with geofabric embedded well into the fill both to restrain the sand at the steep 1:1 slope, and to prevent slip circles and collapse of the embankments occurring as they become saturated during the rainy season.

All fills were constructed using non-cohesive Aeolian sand as no other construction materials were available in the area. In order to minimise fill volumes on these high fills (due to budgetary constraints), the fill slopes were increased to 1:1 as opposed to the more usual 1:6 when using non-cohesive sand for fill material.

Road pavement layers

As there were no natural gravel materials on the eastern bank of the Zambezi River, crushed stone had to be used to construct the sub-base and the base layers. In order to save costs and avoid unnecessary wastage of this expensive and hard-to-come-by material, the contractor elected to place the crushed stone layers with a paver instead of using conventional road construction methods.

In addition to greatly reducing the cost of the project, this unusual construction method also provided many job opportunities in a very poor rural community.

DESIGN CONSIDERATIONS

The design process also had to take into consideration the fact that the awarded tender sum was far too low to complete the work, and that the new design therefore had to be as economical as possible. Cost savings were made by paying special attention to minimising the earthworks quantities as far as possible. This was achieved by carefully fine-tuning each of the 81 km of the vertical alignment and by standardising the sizing of the 80 box culvert openings.

Special consideration had to be given to programming the work, too, particularly the design of the 80 large box culvert openings, as no construction work could take place in any of the larger flood plains during the rainy seasons between December and May.

The road pavement design

The road pavement had to be designed around the fact that there was no natural gravel in the area available within 100 km of the work area. The natural bedrock found in the area was overlain by 30 m to 50 m of fine grained Aeolian sand.

The solution was to construct the fills and the road subgrade layer from in situ sand and then to construct the sub-base and base layers using graded crushed stone material.

Due to environmental concerns, it was not possible to quarry rock on the banks of the Zambezi River. As a result, two quarries were opened on the banks of the smaller tributaries in areas where the rivers had exposed the quartzite sandstone bedrock. These quarries had to be carefully managed, taking into account the environmental constraints of working on river banks. This was an economical method, although not always easy, especially as the sand was non-plastic and non-cohesive.

CHALLENGES

General challenges

The management of the planning and technical design was severely constrained by the fact that the employer had appointed the contractor, using an estimated schedule of quantities, before the design consultant was appointed. By the time UWP was appointed to commence the design and environmental impact assessment, the contractor was already fully established on site and ready to commence work.

Environmental challenges

Part of the road passes through a National Forest Area where the impact of the road had to be minimised.

Due to the sandy conditions, additional measures were required to prevent erosion of the side drains and culvert outlets.

Additional care was also required to ensure that the geometric alignment of the new road blended in with the terrain as best as possible. The visually intrusive embankment crossings were clad with sandstone, and the bottom edges of the fill slopes were softened by backfilling with sand and topsoil, allowing the natural riverbed vegetation to regrow up the sides of the embankments.

CONCLUSION

Despite the difficulties of working in areas which are under water for half the year, the embankments and culverts constructed across the flood plains and the various smaller rivers and streams were completed successfully.

The road, which passes through previously inaccessible territory on the eastern bank of the Zambezi (the existing road is on the western bank), now provides all-weather access between Mongu, the capital of western Zambia, and Livingstone/Kazangula, thereby providing access to approximately 20 villages and several local schools. Local residents can now easily reach Senanga, the nearest large town with a hospital, as well as local government administration offices. The project was completed within budget and three months ahead of schedule – a commendable achievement given the very remote location of the project more than 700 km from Lusaka. □

Winner: the M10 Senanga to Maziba Bay Road – UWP's Sybrandt van Wyk (left) accepting the award from SAICE President Peter Kleynhans