

Bridge

DESIGN & ENGINEERING

UP TO SPEED
HK LINK ROAD PICKS UP PACE

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Aerial view of the site, with construction progressing from the top left of the picture

WAY TO GO

With the third of six phases now complete, construction of a new viaduct in Belgium is making good progress. **Helena Russell** reports

Contractors in Belgium building a new highway link close to the city of Bruges have chosen a semi-integral bridge for the project's main structure. When the A11 link is completed, which is currently scheduled for summer 2017, it will provide a new connection making it easier for traffic to travel between the east and west sides of Zeebrugge harbour.

Belgium's terrain demands very few elevated bridges and in fact even this bridge, which crosses the Boudewijn Canal at a height of some 16m, still requires a lifting span. But with its elevated structure the vast majority of barges will be able to pass through without raising the span, minimising the interruptions to highway traffic.

The viaduct is part of a 12km-long highway scheme which includes some 80 structures; it is 1,050m long on the west side of the canal and 250m on the east side, with a 160m-long movable span over the canal, and it will carry eastbound and westbound traffic on two separate bridge structures.

The highway link is being built on a design-build-maintain basis by joint venture contractor Via Brugge, whose members are DG Infra, Inframan, Ondernemingen Jan De Nul, Algemene Aannemingen Van Laere, Aswebo, Aclagro and Franki Construct.

As Via Brugge senior project manager for civils works Ivan Van Wassenhove explains, the joint venture contractor took the decision to try and design as much of the

structure as possible using integral bridge design principles, in order to reduce its future maintenance. Under the terms of the contract, Via Brugge is required to maintain the highway for 20 years after completion, and in addition to this, there must be no major maintenance intervention needed within the subsequent five years after the bridge is handed back to the Flemish highway authority.

At first glance, the work on site seems rather complex for what outwardly appears a very straightforward structure. The end spans are being cast in situ on a forest of formwork towers, but the majority of the twin viaduct is being built using a movable scaffolding system from Berd which by the end of the construction contract, will have been dismantled and reassembled six times.

A more traditional approach for building this size of viaduct with spans of just 35m length, would have been to use standard scaffolding and formwork to cast them, agrees Van Wassenhove. But ground conditions on site would have required large temporary foundations for the scaffolding, and this would have been expensive. The second reason for choosing Berd's MSS, he says, is the Organic Prestressing System, which enables the size – and hence weight – of the permanent deck to be minimised.

Initially the intention was to use an overhead version of the gantry, but once the decision was taken to make the bridge fully integral, this had to be revised to an underslung gantry. Van Wassenhove recalls, "Because the deck and piers of the permanent bridge have a monolithic connection, it would have been very difficult to make room on the pier tops for the bearings, so we went with an underslung version."

However this does prevent the system from being used on the spans that cross the railway, and on the lower spans, where traditional solutions are being used.

The use of the MSS – and the multiple dismantling and reassembly – is largely due to the contractor's decision to build an integral bridge. The two structures are each being built in two separate halves which are then prestressed away from one another before the closure pour is cast at the middle and the prestressing is released. This will prevent the moments in the slender, cast in situ piers from



The underslung gantry on the piers, with its organic prestressing system deployed

becoming too high over time with the predicted concrete creep.

First stage was to build the west end of the northern viaduct, starting at the lowest end and rising towards the centre of the structure. Second phase saw construction of the west end of the southern viaduct, over the corresponding length. For phase three, which has just been completed this month, the MSS moved to the east end of the northern viaduct and worked back towards the centre, then for the fourth phase it will carry out the same manoeuvre on the southern viaduct. Phases five and six relate to construction of the shorter lengths of viaduct on the other side of the canal.

But despite the complexity it creates on site, Van Wassenhove is confident that this is the right way to go in the context of the contract – he estimates that anything up to 30% of maintenance costs can be saved by eliminating the need to carry out regular maintenance of bearings and joints, as well as their periodic replacement.

The design of the bridge was proposed as an alternative to the reference design proposed by the client, the Flemish Public Works Authority, as part of the tender process. “We could have adopted and priced this design, we could have proposed an alternative, or we could have done a mix of the two,” he explains. The alignment of the bridge was fixed, so the main difference is that it is an integral bridge. “It costs a bit more to build it,” he says, “but this is more than offset by the saving in maintenance.”

Consultant Schlaich Bergermann & Partners is the bridge designer, and structural engineer Tilo Behrmann explains that the viaducts are built as semi-integral structures with the bridge deck connected monolithically to the substructure at as many piers as possible. Several design features were adopted to maximise the integral length and minimise the number of bearings and associated future maintenance requirements, he says.

The aim was to reduce design actions due to imposed deformations caused by creep and shrinkage and temperature changes. Piers are slender ‘wall’-type columns, with low stiffness against imposed deformations in the longitudinal bridge direction.

At the extreme ends, the piers are 2.5m wide and 500mm thick, compared to 2.5m wide and 800mm thick in the centre. The smaller cross-sectional area is compensated by

using higher strength concrete for the most slender columns.

The design of columns and foundations uses pre-deformation of the pier columns in order to compensate the long-term effects of creep and shrinkage and reduce the overall design actions of the substructure. The pre-deformation is applied as part of the construction sequence by pulling the partially-completed frame structures back towards a temporary fixed point located at either end of the bridge.

Each viaduct consists of 22 pairs of columns, of which 18 have a monolithic connection to the deck. The last two piers on each end have bearings. The pull-back operation takes place at each end of each viaduct once four spans – around 140m of deck – have been built. The first operation at the west end of the northern viaduct took place in February last year and a similar operation at the east end was carried out last November; on the southern viaduct the west end was pulled back in July last year and the final operation will take place at the eastern end later this year.

The process involves the installation of two diagonal cables at the end of the viaduct; each cable consists of 19 prestressing strands and they are connected between anchors on the pile cap and on the top of the deck above the adjacent pier. Ducts were cast in the concrete deck section to allow the cables to pass through and be connected to temporary concrete blocks on the top of the deck. To achieve the longitudinal movement of a few centimetres, a total force of around 1,500kN or 750kN per cable was required.

The movable scaffolding system being used on the site is an underslung version with three girders, as Berd operations manager David Moreiras explains. It is an unusual arrangement resulting from the size of the deck units – they are 35m long and vary in width from 14m to 17m – and other operational restrictions. All three of the girders on the MSS incorporate Berd’s Organic Prestressing System which prestresses the girders as the concrete is poured into the forms, and enables the deformation of the span to be very carefully controlled.

Construction with the MSS began in December 2014, when it started work on the northern viaduct moving from the east end of the bridge towards the west. After building 11 spans the MSS was dismantled and moved back to the eastern end of the bridge, where it carried out the same manoeuvre to construct the southern, twin viaduct.

For the 35m-long spans that make up the majority of the viaduct, the construction process takes around eight days; the 25m-long spans at the end of the structure may be shorter, but they are more complex and hence take two days longer to build. “We had planned for the construction to take ten days per span,” recalls Van Wassenhove, “but we quickly got that down to eight in practice.” Not only do spans take less time to cure due to the reduced concrete volumes, but the equipment needs fewer people to operate it. The second day after the concrete is poured, the formwork is struck and the machinery can be moved forward to the next span, a process that takes three or four hours. The 84m-long girders are then moved forward – the middle girder moving first and the other two following on.

Another aspect of the construction that is unusual on this particular project – and the one which has prompted the need for three girders rather than the usual two – is that the slender, permanent piers were designed only to take the permanent loads; the MSS is not permitted to use them for support. As a result, temporary support piers have had to be built between the permanent piers. The central girder is smaller than the two outer girders, being 0.8m wide rather than 1.2m.

“It’s a very small machine but it’s very complex,” says Moreiras. The ‘nose’ and ‘tail’ are designed so that they can be folded in, a manoeuvre that will be necessary at the end spans so that construction of the viaduct does not interfere with that of the lifting bridge over the canal, which is being built separately.

The bridge deck is a full concrete section, an unusual solution which is also prompted by the minimum-maintenance requirement. Piers are high-strength concrete and precasting had originally been considered because of the poor ground conditions, reveals Van Wassenhove. Subsequently this was dismissed as it would have introduced too much risk in the schedule in terms of erecting the piers. Construction work started in autumn 2014 and is currently on schedule for completion in June 2017 ■