PROGRESSIVE APPROACH

Movable scaffolding systems are being used to build the long, high viaducts for a highway bridge in the north of Portugal. **Helena Russell** reports

Close to the Portuguese city of Vila Real, a new landmark is being constructed over the River Corgo. The new cable-stayed bridge and its impressive approach viaducts is gradually taking shape and will offer improved links between Porto and the Spanish border when it opens next year.

The new bridge, which crosses the river valley near Vila Real, is formed of three different sections: the main cable-stayed crossing of the river, and two lengthy approach viaducts to the east and the west.

Once complete, the Corgo Viaduct will form part of the 120km-long Transmontana highway which links the Portuguese city of Vila Real with the Spanish border near the city of Bragança. Consortium CAETXXI is responsible for the design and construction of the highway, and will operate and maintain it for a concession period of 30 years.

The project also includes rehabilitation and modernisation of 56km of the existing road, between the cities of Amarante and Vila Real, as well as near Bragança. Work began in September 2009 and is due for completion at the end of this year. As CAETXXI project director Luis Noguiero explains, the Portuguese/Spanish concessionaire is led by Portuguese contractor Sociedade de Construções Soares da Costa which has a 50% share, with the remaining 50% split equally between Spanish contractor FCC Construcción and Portuguese contractor Ramalho Rosa Cobetar which is also part of FCC.

The total length of the bridge is approximately 2.8km which is made up of 42 spans and can be divided into three distinct parts; the west viaduct, which has a total length of 855m made up of 17 spans, the east viaduct, which has a total length of 1,167m and 22 spans, and the central cable-stayed bridge which crosses the Corgo River and has three spans with a total length of 768m.

The river runs through a steep-sided, rocky gorge at the site of the bridge, which posed something of an obstacle for construction of the main span. On the other hand, the presence of a large outcrop of rock on one side of the river offered an obvious foundation for one of the main span towers and in effect dictated the alignment of the crossing. The main cable-stayed span is 300m long and its towers rise to 130m height, with masts of 63m. Spans on the east and west viaducts are typically 60m long. Piers and deck alike are made of concrete, both on the approach viaducts and on the cable-stayed river crossing.

When *Bd&e* visited the bridge earlier this year, the main deck construction was under way with formwork carriages being used to erect it in the balanced cantilever construction method. The cable-stayed bridge has a prestressed concrete deck which is 28m wide and is formed of a box girder 10m wide by 3.5m deep, with additional cantilever slabs on each side, which are supported by precast concrete struts connected to the bottom edge of the box girder. Inside the deck, steel ties transfer the internal forces from the webs to the axle of the girder. Both the deck and the 63m high towers use C50/60 concrete.

The topography of the steeply-sloping site means that the majority of the concrete box girder deck is 100m or more above the ground level. CAETXXI chose to construct the central box girders of the approach viaducts using movable scaffolding systems to build it span by span, with an eye to optimising work progress against cost. Separate sets of movable formwork are then used to follow up with construction of the cantilever slabs with the precast props in place, to bring the deck to its full width.

The height of the structure and local access conditions meant that the use of MSS equipment, which can operate independently and relocate to each span without the need for additional equipment, was a key one. This procedure also dictated that construction of each viaduct had to begin at the abutment and move progressively towards the cable-stayed bridge, one span at a time. All equipment, materials and so on is delivered by truck along the newly-built bridge structure, with the main challenge for the contractors being the final process of dismantling the MSS equipment at the end of the viaduct.

Two different sets of MSS equipment are being used on the project. Construction of the 22-span east viaduct which is 1.1km long is being carried out using an underslung system from specialist manufacturer Berd, which incorporates the company's organic prestressing system or OPS. On the west viaduct an overhead system owned by FCC is being used to build the 17 spans of the viaduct, which is 855m long.

As *Bd&e* went to press, Berd had built 20 of the 22 spans with the final two due to be finished by the end of May. Progress on the west viaduct was slower, says Noguiero, because the first nine spans are on a curve of radius 700m and the transverse dimensions vary. Consequently each of the west spans was taking around three weeks to build compared with the 11 day cycle that Berd was achieving on the east viaduct.

CAETXXI contracted the work directly to Berd, preferring to take advantage of the company's rental scheme rather than investing directly in the equipment. Berd vice president of sales and marketing Diogo Mouro explains that the location of the bridge and the height of the deck also make it susceptible to high winds, which the designers also had to take account of. "We had to accept the climatic conditions, which include gusts of up to 150km/h," he says.

The technology that makes Berd's MSS special is the 'organic prestressing' system that is designed to control deflections during concrete pouring. A series of tendons that run below the deck along its full span length are adjusted automatically by the computer-controlled jacks during construction to maintain the formwork at the correct level. This system is so effective, says Mouro, that at the end of pouring the 60m-long span, the deflection is only about a millimetre. Sensors on the frame of the MSS detect movements in real time, and this information is fed back to the computerised control system which automatically instructs the jacks to either lengthen or shorten the tendons and adjust the position of the MSS accordingly. As well as enabling very tight control of the deflections of the finished structure, the OPS technology also means that the equipment itself is lighter than in traditional systems.

Noguiero says that his team is very happy with the equipment and the service they have received from the technical staff at Berd. "They have been the ideal partner for the completion of this project," he says. "They were very successful in achieving the objectives of the short schedule for each span - 11 calendar days - with the complex tasks and the high safety requirements involved."

Once the equipment has been positioned on a new span and prepared for construction, the deck is built in three phases, the first two of which are carried out by the MSS. The base slab and side walls of the box girder are cast first, with the top slab poured separately in a second phase.

The MSS is then moved forward to the subsequent span with the follow-up works to build the cantilever wings being carried out using a separate movable formwork system casting longitudinal sections of about 12-15m at a time. This process lags some way behind the box girder construction, not being part of the critical path, and at time of writing had reached about halfway along the east viaduct.

With the height of the deck preventing crane access from the ground, the four gantry cranes built into the MSS are invaluable for moving tools, equipment and materials around at deck level. They can service the full length of the span.

Decideing how the MSS will be dismantled and removed was a complex procedure, and one which was still being refined by Berd in March. Since this time, and with the operation set to start in only a month or so, the process has been finalised.

With the MSS on its bracket supports, all elements which do not form part of the structural support system of the equipment will be removed, such as the launching nose modules, the formwork, transverse structures and the rear ring. Once that phase is complete, two large cranes of 250t and 350t capacity will be used to lift the main girders onto the top of the concrete bridge deck. The girders will then be dismantled into pieces suitable for transportation