Creating the curves for Dublin's new bridge

Spencer Dock Bridge spans the Royal Canal and links Dublin city centre to the north docklands redevelopment area. The bridge has two lanes of vehicle traffic, two LUAS tram lines and pedestrians walkways. It consists of a two-span post-tensioned deck 40m in length, which is unique in terms of its geometrically undulating soffit forming a doubly curved surface.

Alastair Seaton, Cordek, Slinfold, UK

The bridge, designed by Future Systems, now Amanda Levete Architects, and engineered by Arup, resembles the shape of a manta ray fish with the asymmetric-shaped wings cantilevering out from the centre of the bridge deck.

Amanda Levete says that the proportions of the bridge are unusual and the office saw it as an opportunity to consider it as a piece of landscape design. The soft geometry and asymmetry of the bridge creates a piece of infrastructure that resolves the tension between form and function.

Alan Dempsey, project leader and consultant for Amanda Levete Architects, says that the company wanted to create a sculptural work that would integrate the surrounding infrastructure with Linear Park, designed by the French landscape architect Agence Ter. The architect also wanted to introduce "some kind of civic aspect" into the project by adding the bridge's viewing decks, which create potential meeting places for pedestrians.

The €6.8 million Spencer Dock Bridge has been funded by the Dublin Docklands Development Authority and the Rail Procurement Agency. The main contractor for the project is Laing O'Rourke.

The concrete bridge deck varies in depth from 600mm in the middle of each span to in excess of 3m at the two central columns.

Cordek was approached at the pre-tender stage by the architect to discuss possible methods for manufacturing the formwork for the bridge deck and parapets. The complexity of the design resulted in a finished form that could only be defined with a 3D digital model. The first exercise was to produce a scale model of the bridge. This not only gave the architects and the client the opportunity to see the design in three dimensions but it also proved an invaluable tool to demonstrate to the potential contractors the complexity of the project. The scale model was machined by Cordek out of high-density expanded polystyrene block using their latest CADCAM controlled five-axis router.

The bridge has been constructed from an innovative combination of in-situ and precast reinforced concrete. The formwork for the sculpturally formed bridge soffit was milled from high-density expanded polystyrene directly from a 3D parametric model and this provided a high degree of control over the complex geometry.

(Photos: Cordek Ltd.)

Figure 1: Original scale model of the bridge.

The most complex formwork for the project was required for the casting of the concrete parapet units. These precast elements were curved in plan and elevation and varied in cross-section along the length of the bridge.

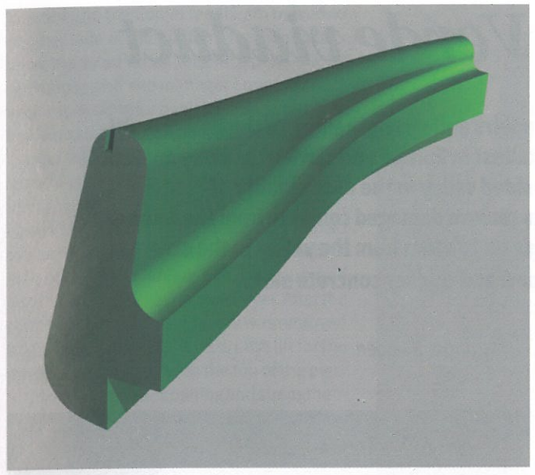
Cordek worked closely with Creagh Concrete Products to develop a formwork solution to ensure that the precast units could be accurately cast to the required dimensions and to achieve the quality of finish.

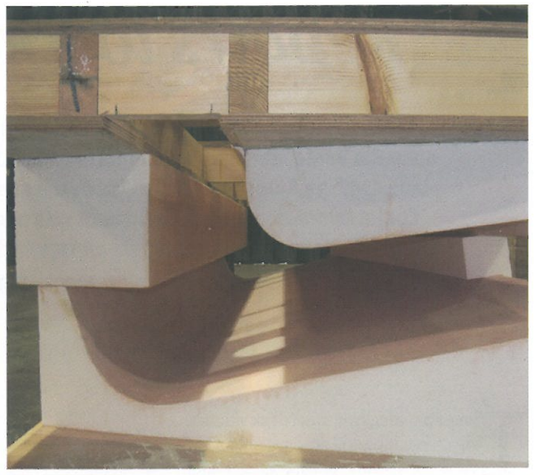
Casting the units on end was one option but this was considered to be impractical because of the complex curvature and the heavily skewed ends of the units which would make the compaction of the concrete almost impossible. Self-compacting concrete could not be used because a colour match with the rest of the concrete deck was required. The solution was to cast the units on their backs and to introduce the concrete through the reinforcement that mated with the in-situ concrete deck.

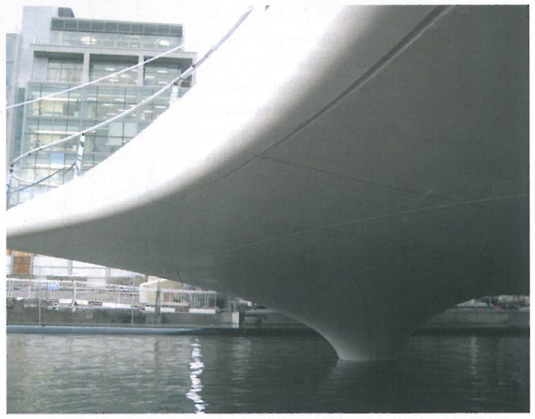
The moulds were manufactured in five parts to avoid the presence of joints on any of the visible surfaces. One joint was concealed in the lighting recess at the top of the parapet, another was hidden at the interface of the deck. The double curvature inner and outer mould pieces were created using a timber and plywood frame onto which was laminated an expanded polystyrene block. This block was routed to the exact profile required on one of Cordek's five-axis routers using the 3D digital file produced by the architect.

The profiled expanded polystyrene was then coated with an epoxy resin and fibreglass reinforcement mat which provided a smooth but tough surface which would not only easily debond from the concrete but would also provide an excellent finish. The two end profiles of the units were machined from 25mm-thick MDF board and included a 5mm chamfer which varied in cross-section around the perimeter. The fifth component of the mould was a flexible rubber insert which followed the complex geometry of the lighting recess.

Cordek produced a sample mould with which Creagh experimented to achieve the optimum angle at which to cast the unit. Several trial pours were necessary to minimise the blow holes in the finished concrete surface.







To enable the accurate fabrication of the stainless steel reinforcement for the constantly changing profile of the parapets, 2D cross-sectional drawings, at 150mm centres, were extracted from the 3D model. The prefabricated cage was then placed in the mould. Timber supports and external tie bolts were used to clamp the mould shut. The concrete included a high percentage of ground-granulated blast-furnace slag (GGBS) with admixtures to ensure a highly flowable mix with a low water/cement ratio. The concrete was placed through the opening in the mould where the reinforcement projected for the in-situ connection to the bridge deck. The moulds were placed on a vibrating table and subjected to a small amount of external vibration.

After several hours the top section of the mould was removed and the top surface (inner side of bridge) was examined and if necessary float-finished to ensure there were no 'blow holes'. The units were wrapped in polythene to aid curing. Due to the high percentage of GGBS it was necessary to leave the units in the moulds for a minimum of 36 hours before sufficient strength was achieved for lifting. Cast-in lifting eyes were hidden within the lighting recess. When stripped the units were inspected and placed in individual cradles for transport.

Bill Gray on behalf of Creagh Concrete comments, "We were very impressed with the accuracy and finish of the moulds from Cordek and believe that this could only practically have been achieved using digital machining techniques."

"It has been most rewarding to work with Amanda Levete Architects, Arup and Creagh Concrete on this interesting and demanding project," says Rodney White, Cordek's managing director. ■

Figure 2 top left: 3D model of a parapet unit.

Figure 3 top right: Inner and outer mould pieces.

Figure 4 above left: Fixing of stainless steel reinforcement.

Figure 5 above centre: Bridge structurally complete.

Figure 6 above: Precast parapet units blend in with in-situ deck construction.