

Getting the foundations right

Christian Niemietz, FCBC Senior Engineer- Caissons, gives an update on the on-going works to install the new bridge's vitally important steel foundation caissons.

Since our last edition, there has been significant progress on the positioning and installation of the three enormous steel caissons which will help form the foundations of the new bridge. Here, I want to give an update on the progress being made in positioning the caissons on the seabed and the processes which still have to be carried out before the bridge's towers can start to rise.

The positioning of all three caissons is a significant milestone for the project and provides the first real evidence of the new bridge taking shape. The largest of the caissons is 30 metres in height by 30 metres in diameter (roughly the size of an eight storey building) and weighs a massive 1,200 tonnes. They are amongst the largest steel caissons ever sunk to the seabed anywhere in the world. Here is a summary of the various operations involved:

Lowering. June and July saw the caissons being lifted off a semi-submersible transportation barge (with the help of a floating shearleg crane specially designed for the operation) and taken to their final location. Once in position, each caisson was lowered to the seabed using the latest GPS technology to ensure placement within a very tight 250mm tolerance. Water was then pumped into the double-skinned cavity wall sections as ballast to increase the weight and help further sink the caissons into the sedimentary alluvium and glacial till overlying the bedrock. At the time of writing, 3,300 cubic metres of concrete are being

poured into the cavities, displacing the water and increasing the weight in order to sink the caissons further down into the clay and glacial till levels of the seabed.

Excavation. The lowering operation is aided by excavations taking place inside the caissons. Using floating cranes with grabs (each capable of lifting ten tonnes of material in every scoop), a total of 46,000 cubic metres of excavated material will be removed (from all three caissons) and taken to one of two designated areas of deep water further downstream in the Firth of Forth where it is returned to the seabed. As they descend, the caissons are constantly monitored to ensure they go down vertically, any tilt being corrected by careful ballasting and excavation.

Jet grouting & temporary caissons. The caissons will be sunk to a depth where they are held stable by the friction and firmness of the soil they are being forced through. Next, a grouting seal will be formed at the bottom of the caisson walls to create a strong seal between the caissons and the sloping bedrock which prevents sea water and sediment seeping back in. Meanwhile, temporary caissons are installed on top of each caisson, keeping the surface of the structures above sea-level.

Concrete & de-watering. Once excavations are complete and the rock surface is cleaned of all debris using an air-lift suction device, up to 18,000 cubic metres of concrete will be poured into each caisson – in a non-stop, 24/7 operation lasting two



North Tower caisson excavation underway.

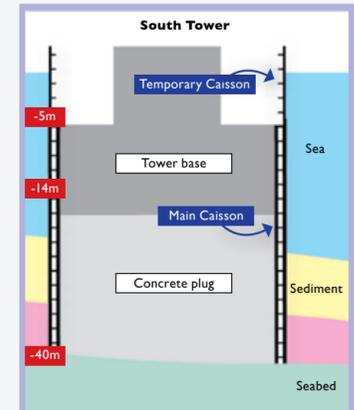
weeks each – up to a depth of 26 metres to form a “plug”. At this point, all sea water will be pumped out of the caisson to allow the 14 metre high, reinforced concrete tower foundation base to be formed on top of the marine foundation (the “plug”) in dry conditions. At this point, work can start on the 210 metre high towers themselves.

So far, progress has been smooth and on schedule. The main issues which could cause problems would be hitting large boulders embedded in the alluvium and glacial till levels of the seabed – or encountering unforeseen fissures in the rock surface. Whilst these are not expected, close liaison with the project's engineering geologists will ensure the minimum of disruption should they occur (see Q&A article on page 6).

All work on the caissons is scheduled to be completed by the end of 2012.



One of the temporary caissons being lifted towards its destination on top of the South Tower permanent caisson.



The bedrock of success

The foundations currently being constructed will bear the weight of the new bridge. But it is the rock structure beneath the waters of the Forth which will support the foundations. Jenny Symons is an Engineering Geologist with the Forth Crossing Design Joint Venture, FCBC's design partners.

Q What is your role on the Forth Replacement Crossing project?

A I am essentially a “rock inspector”. My job is to analyse the rock uncovered by the construction activity both on the seabed and on-shore and compare the results against the many ground investigations carried out prior to construction works starting. This is important since, clearly, the new bridge is being built on rock and we need an accurate, detailed picture of the shape and strength of the rock formations which will support the foundations for the bridge's towers and piers – in fact, the entire weight of the bridge.

Q So, what types of rock is the new bridge being built on?

A The bedrock beneath the waters of the Forth is made up of a series of multi-layered – or ‘interbedded’ – sedimentary rock strata (layers) including sandstone, limestone, mudstone and siltstone. These rocks were formed during a geological time period known as the Carboniferous Period and are up to 360 million years old. The layers of sedimentary rock are interrupted in many places by another type of rock called dolerite. This is an igneous rock which is associated with volcanic activity that occurred in this part of Scotland millions of years ago. The molten dolerite was originally forced upwards from the bowels of the earth and squeezed in between the layers of sedimentary rock. You can see the dolerite rock exposed in the walls of the cutting on the Fife side of the existing A90.

Beamer Rock in the middle of the Forth is made of dolerite. The geological structure of the area is marked by a series of faults associated with tectonic plate movements which have caused the rock strata to be offset and tilted away from horizontal. The bedrock is topped by a layer, over 20 metres thick in places, of superficial material including alluvium (soft, sandy clay or silt containing gravel and shells, deposited by historic flood events),

glacial till (stiff clay with sand, gravel and occasional cobbles and boulders, deposited by melting glacial ice), and fluvio-glacial material (sands and gravels in glacial till that has been moved and re-deposited by rivers). Together, this material is called sediment.

Q What are the main challenges on a job like this?

A Working out at sea – and beneath the water – is never easy. The excavation process, which creates a space on the sea bed for the tower and pier foundations is carried out underwater and so the machine operators are essentially working “blind”, relying on what their instruments tell them (about the depth to rock etc.) rather than what they can actually see. The divers carrying out inspections on the seabed are further restricted by tidal and weather conditions. They carry CCTV cameras which send pictures up to the surface for people like me to view. Before we can pour in concrete to start constructing the foundations, the rock surface must be “clean” – ie. free of sediment, loose rocks and other material.

Q What gives you most satisfaction?

A That's easy. Every day on this job we are having it confirmed that the ground model or “geological map” we drew up on the basis of our detailed ground investigations is, in fact, extremely accurate. The design of the bridge was greatly influenced by these geological investigations and encountering no surprises means that the construction of the bridge can proceed with a minimum of re-design being necessary, if any at all. This, in turn, minimises any delays in the construction programme. It is good to know that we got it right and that all the effort and time spent on the ground investigations were well worth it.

Forth Replacement Crossing project update

August 2012



Artist's impression of the new bridge.

Looking north: all three foundation caissons in line with Beamer Rock for the first time.

Contacting the FRC team

There are a number of ways you can contact us to ask questions, provide comments, make a complaint or find out more about the Forth Replacement Crossing project:

Call the dedicated 24 hour Project Hotline **0800 078 6910**

Email the team enquiries@forthereplacementcrossing.info

Log on to the project website at www.forthereplacementcrossing.info

Or drop into the **Contact & Education Centre** c/o Forth Bridge Administration Office, South Queensferry, West Lothian, EH30 9SF

Opening times
Mon–Fri: 0900–1730, Sat: 1000–1600



Project Directors' update

An overview of progress to date on the Forth Replacement Crossing. **Page 2**

M9 Junction 1a and Fife ITS

Latest reports from the works to improve direct road access to the new bridge for north and southbound traffic. **Page 3**

Technical focus

The operation to position the foundation caissons is in full swing. Find out more about what's involved. **Page 5**



Foundations and road connections move ahead on schedule

We are already over 20% of the way through building what will become one of the most famous and significant bridges in the world. All elements of the Forth Replacement Crossing project have made good progress during the past quarter and we remain firmly on schedule.

On the roads front, local residents and road users will have seen the progress being made on the works to upgrade Junction 1a of the M9 near Kirkliston and install Intelligent Transport System gantries on the M90 in Fife. Both contracts are progressing well and are on schedule to complete according to plan (see articles on page 3). At all times, the aim has been to minimise disruption to the travelling public and we thank drivers for their continuing understanding and patience which has helped us meet this aim.

Turning to the Principal Contract, the construction of the new bridge and the immediate connecting roads continue apace. Most notably, the operation to position all three foundation caissons on the seabed out on the Forth has been successfully carried out. The excavations on Beamer Rock are complete, allowing the steel sheetpile cofferdam to be erected which provides a dry environment in which

the foundations of the bridge's Central Tower can be constructed. All this activity means that, for the first time, we now have clear physical evidence out on the water of the precise route the new bridge will take (see front cover).

The caissons are one of the most vital elements in the whole bridge project. Over the next few months, we will undertake the operation to excavate and sink them to bedrock level and then fill them with concrete ready for the start of work on the three towers early in 2013. (See 'Technical Focus' on page 6 for more information on the progress being made on the caisson installation.)

Every one of us working on the Forth Replacement Crossing project is keenly aware of how globally important this location is for bridges. We even had the Olympic Flame making an appearance in June as it made its way round the country ahead of the start of the Games in London. Proof of what a famous place this is for bridges...



Carlo Germani and David Climie in front of the Project Office mural showing the new bridge.



Famous cyclist, Mark Beaumont, carrying the Olympic Flame across the Forth Road Bridge in June.

David Climie
Transport Scotland
Project Director

Carlo Germani
FCBC
Project Director



M9 Overton Road bridge.



Junction 1a in September 2011 prior to works commencing.



July 2012: the alignment of the new connection to M9 westbound.

M9 Junction 1a takes shape

Progress on the construction of the M9 Junction 1a upgrade has been marked over the past few months with a number of major structures being erected on schedule right across the site. The alignment of the new slip roads and road widening is now clearly visible on the ground, with associated earthworks, drainage, barriers and road construction progressing rapidly.

The Sisk Road Bridge (SRB) works involve the construction of one new and two widened bridges to create the new junction layout, as follows:

- The new M9 overbridge across the M9 motorway which will carry traffic travelling towards the Forth Crossing from the M8 and Edinburgh City Bypass;
- The Newmains Road bridge which is being extensively widened to carry traffic from both directions of the M9 to the Forth Crossing and vice versa; and
- The Overton Road bridge which will provide widening of the M9 for the two new west facing slip roads to and from the M9.

With the impact on the travelling public at the forefront of SRB's approach to the works, the contractors have opted to widen existing bridges where possible in order to minimise the disturbance to existing traffic flows. This is especially true where additional lanes have been created by adding onto the existing bridges as opposed to constructing entirely new ones.

As the various structures come closer to completion, the temporary sheet piles supporting the existing road construction will be extracted and traffic will then run across the new bridges so that works in the central reserve can be completed.

The main M9 overbridge is now at an advanced stage with piling works, bridge abutments and piers in place.

During two 'rolling road blocks' in June and July, 12 girders, each weighing 27 tonnes and 22m in length, were lifted into position using a 500 tonne crane. The final six girders were lifted into place, connected and welded in early August. This allows the deck reinforcement and concreting works to be completed and the new bridge to be opened to traffic later in the year. The design of this new structure mirrors the existing overbridge as much as possible so as to create an aesthetically pleasing family of structures. With the same paint colour being used on the existing and the new, this will give the appearance of two new structures over the motorway.

Work is also progressing well on the installation and commissioning of 17 ITS gantries, of which 4 are already in place on the M9 Spur.

Major works to upgrade the M9 carriageway are due to be undertaken as part of this contract in September/October and these will be fully publicised to inform road users in due course.

SRB would like to thank all road users for their understanding during these essential works and in particular those affected by the complete closure of Overton Road since January 2012.

The M9 Junction 1a upgrade is well on target to be completed by Spring 2013.

Fife ITS nears completion

Major elements associated with the Fife Intelligent Transport System (ITS) contract were completed in July on key stretches from Admiralty Junction 1 to Halbeath Junction 3 on the M90 and the A823 (M) at Pitreavie. Despite the wet weather and various construction challenges (for example, mine consolidation works), GRAHAM Construction have made excellent progress and are now finalising plans for the phased erection of the gantry superstructures.

The motorway re-surfacing works were finished ahead of schedule and, by minimising contra-flows and lane closures on the M90, the impact on motorists was kept to a minimum. In addition, the new southbound bus lane has been constructed and is due to become operational when the sign gantries have been erected and the associated electronic messaging and lane control systems have been fully tested and commissioned. Hard-standing areas (for maintenance purposes), gantry bases and the steelwork support legs have all been constructed ready for the gantry installations.

Gantries are being fitted-out and variable message signs (VMS) are currently undergoing preliminary testing within the GRAHAM site compound in Inverkeithing. From here, the gantries will be transported and erected on the 18 dedicated sites along the route. These signs will improve road safety through applied lane control and variable speed limits as well as displaying a range of information for drivers.

Focus on the completion of key project



M90 in Fife.



Positioning of ITS gantry supports at M90 Junction 2 (Masterton).

elements, together with strategic planning for the phased erection of the gantries, resulted in the removal of all traffic management, 40mph speed limits and average speed cameras on the northbound M90 on 22nd July 2012 and on the southbound M90 on 6th August. Minor snagging works were carried out on the M90 Southbound, A823 (M) and A92 in July and August. In order to further minimise disturbance, the transportation and erection of the gantry superstructures will

be undertaken during scheduled night-time lane/road closures which generally utilise 'rolling road blocks' – limited closures of approximately 30 minutes' duration. This work is being done in full agreement with the Forth Replacement Crossing Traffic Management Working Group.

All the gantries are scheduled to be erected by the end of September 2012 with the ITS facilities and bus lane becoming operational shortly after, as scheduled.

A year of working with local communities



Aidan Douds and Steve Stewart of BLEW receive a cheque from FCBC's Ewen Macdonell and Derek Chambers to help with the charity's work with young people in the local area.



Hard at work at North Queensferry Primary School.



Pupils from local schools enjoying a "Construct the Bridge" exercise.



Site visit for Echline Primary pupils.



FCBC staff visit Echline Primary School during European Union Week.



Strathclyde University engineering students on-site.



Construction quiz at Park Road Primary School, Rosyth.

The Community Liaison team is marking its first year of working with local residents, schools, universities, clubs, voluntary groups and the public in general.

From Primary One pupils in local schools through the full age spectrum, we have been met with huge interest and enthusiasm for the project. We predict that interest levels will increase further as the bridge continues to take shape out on the water in the months ahead.

Recently, we were delighted to meet a local veteran (if he'll excuse the expression!) of the fantastic Forth Road Bridge construction project back in the 1950s and '60s. He is watching our progress on the new bridge with keen interest and a knowledgeable eye. We plan to invite a group of other such 'veterans' on-site in the coming months for a briefing on the Forth Replacement Crossing and to hear first-hand some of their experiences from 50 years ago.

We already have a rapidly filling diary of scheduled visits and events for the year ahead, many of which will take place in the new Contact & Education Centre which is due to open in by the end of the year. On the left is a selection of photographs, taken over the past twelve months, a year that has been exciting, challenging and rewarding.

Keeping the community informed

As the works ramp up from now on, the need to keep the community informed of our activities becomes even more important. Facilities such as the Forth Replacement Crossing website and the Contact and Education Centre will prove invaluable sources of information, backing up the more focussed flyers which we distribute around our closest neighbours, along with day-to-day contacts with individuals.

For the best up-to-date information, please keep an eye on the project website or drop into the temporary Contact and Education Centre which is open six days a week (directions and contact details on the back page).

www.forthreplacementcrossing.info