Forth Replacement Crossing
World’s largest underwater concrete pour

The background
The new Forth Replacement Crossing, a cable-stayed bridge known as the Queensferry Crossing, is Scotland’s largest infrastructure project in a generation. Due to be delivered by the end of 2016, it will feature three 210-metre high towers from which cables will suspend the road deck.

The £790m bridge is being designed and built by Forth Crossing Bridge Constructors (FCBC), a consortium comprising Hochtief Solution, American Bridge International, Dragados and Morrison Construction, for client the Scottish Government. In September 2013, the project set a new world record for the world’s largest continuous underwater concrete pour during tower foundation works.

The challenge
The main challenges in such a large non-stop process were logistical: ensuring a constant supply of raw materials to the batching plant and the use of established batching procedures ensured that the right quality of concrete was produced.

The operation to infill the tower caissons with underwater concrete was the subject of detailed planning for many months.

On completion, the pour caissons were emptied of water, cleaned and prepared for the next stage of construction – the creation of reinforced structural concrete foundations that will support the three 210m-high towers.
Our solution
FCBC worked extensively with BASF to design and deliver a mix capable of being specification compliant whilst providing high strength, consistent workability, long retention times and high flow characteristics. Two admixtures from BASF played a significant role in achieving all of FCBC's desired properties and logistical requirements.

Modern polycarboxylic ether (PCE) polymer based superplasticizers permit a previously unachievable level of concrete performance tailoring that allow truly bespoke solutions to be supplied. The challenges posed by the project resulted in the development of MasterGlenium SKY 903, engineered to allow high levels of water reduction and extended workability retention, without sacrificing early strength development performance or having any negative effect on the construction program.

Preliminary laboratory work identified that incorporating a modern generation set retarder (MasterSet R 200) gave further confidence and concrete uniformity, enhancing placing and finishing operations.

The south tower underwater concrete plug involved a continuous 15-day operation with concrete being poured into a mass foundation 24 hours a day. After batching, the concrete was delivered by a continuous flow of 8m³ loads to the quayside and pumped onto purpose-built bespoke barges, each capable of carrying a total of 72m³, with six static 12m³ concrete mixers on deck. The barges were transported by tugs to the caissons in the middle of the Forth Estuary.

The concrete was then pumped from the barges into the foundation caissons through a special floating tremie pipe. At this stage, the consistency of the concrete achieved both the specification and the placing method requirements. Following numerous trials it was decided to produce the concrete with a Slump/Flow workability of F6, so that the concrete 'flowed' approximately 20 metres under hydrostatic pressure and settled correctly, with any trapped air driven up to the surface as the concrete rose.

In planning the pour, FCBC had to consider possible delays such as weather and breakdowns; a set retarder (MasterSet R 200) was used to provide extended retention times in excess of 12 hours. As the concrete level rose, the seawater inside the caisson was displaced.

Benefits to the customer
The carefully designed mix and logistical preparation by FCBC and BASF supported the delivery of more than 30,000 cubic metres of underwater concrete to the three caissons.

The largest single pour for the South Tower foundation, resulted in 16,869 m³ of concrete being produced and delivered without any delays or returned concrete

Projects facts at a glance
- The South caisson alone involved more than 2,100 truck mixer deliveries and 250 barge trips.
- Solution developed through working closely with contractor.
- Each complete barge cycle took up to four hours.
- Non-stop process, 24 hours a day, over 15 days which, at its peak, involved up to 100 people.

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