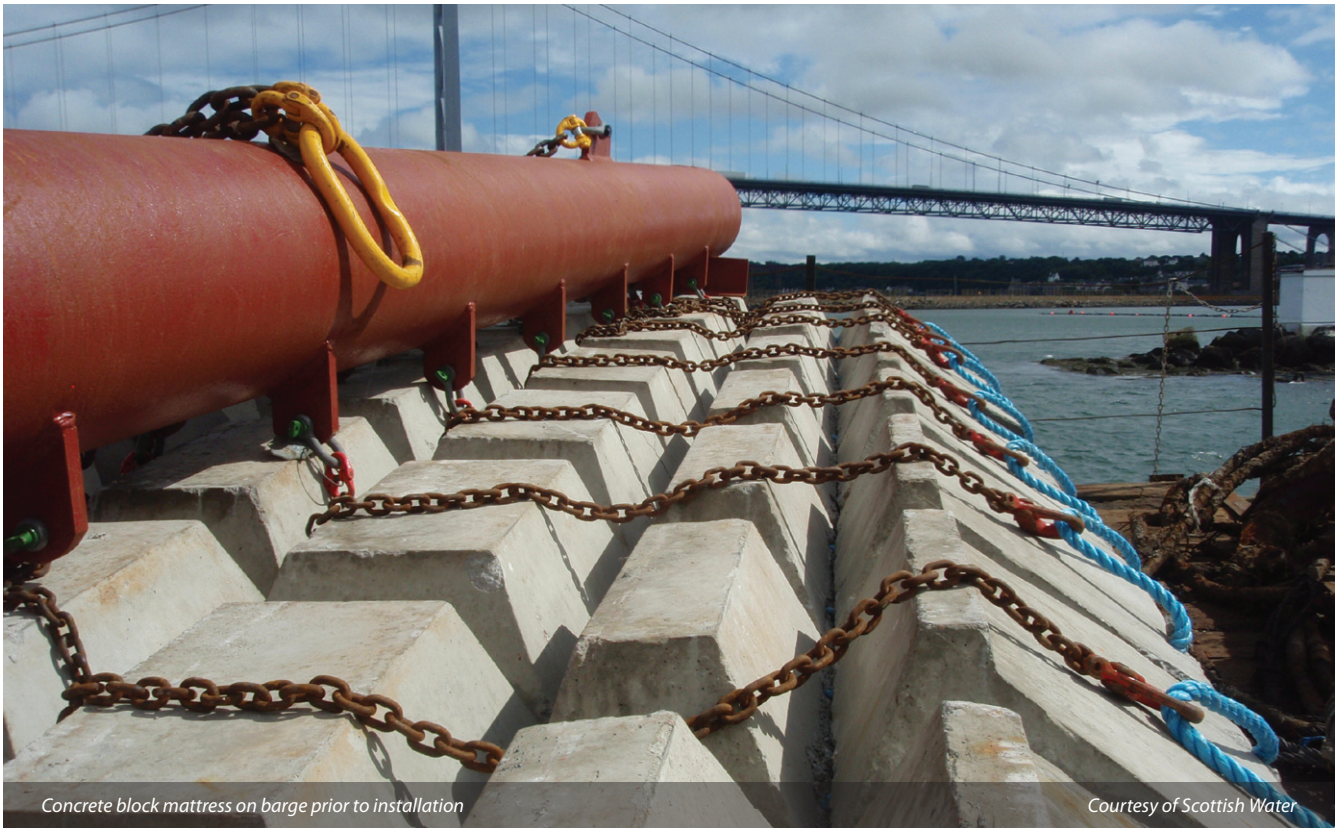
Forth Replacement Crossing

relocation of the Port Edgar long sea outfall

by Marcus Black B.Eng (Hons) C.Eng MICE

As part of their Forth Replacement Crossing project, Transport Scotland requested that Scottish Water relocate their infrastructure outwith the construction area for the new Forth Road bridge pier, to mitigate the potential for damage during construction. Scottish Water approached Grontmij in late 2009 to assist in the investigation, and undertake the detailed design of a replacement long sea outfall for the existing headworks at Port Edgar, South Queensferry.



Concrete block mattress on barge prior to installation *Courtesy of Scottish Water*

At an early meeting, Transport Scotland indicated their desire that all works should be completed by the end of December 2010, to tie in with the bridge construction programme. This milestone necessitated design completion by the end of December 2009, with a construction site start planned for summer 2010.

Scottish Water acted as client for the design and construction works. The scope of the project was fixed to require a *'like for like replacement of the existing pipeline, and to ensure no impact on flow, or detriment to the Port Edgar Marina'.*

Background

The existing headworks and long sea outfall at Port Edgar were constructed in the early 1990s. Through implementation of the Urban Wastewater Treatment Regulations, Scottish Water later constructed a new wastewater treatment works outwith the town, transferring flows from Port Edgar.

Design investigations & development

Prior to undertaking the design of the replacement outfall, Grontmij undertook substantial investigations to determine and review the original design parameters. Through review of existing records, discussions with Scottish Water and former employees of Lothian Regional Council who had been engaged in the original outfall's construction supervision, the following was determined:

- The pipe material was a high specification armoured pipeline.
- During construction, the installation of the pipeline diffuser proved onerous, due to the depth of installation, strong currents and low visibility for divers.

Investigation by the design team indicated that the supply cost of the armoured pipeline was estimated to be in excess of £1 million. In addition, due to the specialist nature of the pipe material, there were a limited number of vessels available which could undertake the installation works. With respect to the diffuser end, the limitations imposed on dive times at the working depth and the information obtained on the previous construction works, indicated that health and safety would play a significant part in the development of the design to mitigate risks to construction operatives.

Further investigations were carried out with Scottish Water to understand the reasons behind the original material selection, however these proved inconclusive. Text books which contained sections on the original installation and individual recollections were at times conflicting.

The design team later determined that a combination of the original method of installation (reel barge), which induces high tensile forces, and the relatively untested nature of HDPE pipelines in the early 1990s, were the most likely reasons for their selection. As such, it was considered that a replacement pipeline constructed from HDPE would yield significant costs savings, and leave the installation methodology open, thereby reducing the risk of lack of availability of installation vessels.

Single pipe solution

Following review of the existing twin pipeline and diffuser arrangement and, with health and safety at the forefront, the design team reviewed the pipeline hydraulics and proposed a single pipe solution, as this would result in minimal diving requirements, and in improved buildability.

From a review of bathymetric survey information, beyond 400m from the shoreline the ground profile drops substantially, from MLWS at -2.15m AOD to the discharge point at -30m AOD. At the discharge point the profile remains relatively steep, however the design incorporated a localised rock platform to flatten this section and elevate the diffuser above the seabed, thereby reducing the risk of sediment deposition.

The result of the change to the single pipe solution, and removal of the complex diffuser arrangement, led to a reduced need for potentially dangerous diving operations, and thereby substantially mitigated health and safety risks during construction.

Following agreement from key Scottish Water stakeholders to the single pipe option, the design progressed with the following key activities being carried out:

- Geotechnical desk study utilising historical data and data obtained from the bridge investigation works.
- Hydrodynamic modelling to prove no detriment in water quality.
- Pipeline hydraulics. An existing hydraulic profile was not available, therefore the system design was undertaken to match an assessment made of existing system losses.
- Calculation of wave forces in the intertidal zone to consider suitable pipeline protection.
- Development of the pipeline profile and backfill specification.

Undertakings

The tender design was completed in December 2009 and, following approval of cost estimates by Scottish Water and Transport Scotland, the contract was awarded to Farrans Construction in spring 2010. Farrans engaged Grontmij to undertake finalisation of the detail design. Through the incorporation of early Value Engineering, Farrans identified further potential costs savings and programme efficiencies through the use of concrete mattress protection below the intertidal zone, and optimisation of excavations and backfill.

Construction works progressed through the summer, with the pipeline being installed using conventional lay barge techniques. The works was undertaken by AMC Subsea, a subcontractor experienced in outfall construction, and completion was achieved on programme in September 2010.

Despite the challenging design and construction programme, the project highlighted the benefits of developing a thorough understanding of the historical context, and the development of the existing works, which when allied with appropriate Value Engineering and scope challenge, can produce substantial cost savings.

The Editor & Publishers wish to thank Marcus Black, Technical Manager with Grontmij, for preparing the above article for publication.

Installation of concrete block mattress to pipeline below MLWS *Courtesy of Scottish Water*