The Hull Tidal Surge Barrier refurbishment project

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SYNOPSIS The Hull Tidal Surge Barrier project is a £10M refurbishment of the most important flood risk management asset in the Environment Agency's Yorkshire & North East Region. To put the importance of the barrier into context, without it a high surge tide would result in damages to Hull in excess of £230M with the flooding of 17,000 homes.

PROJECT BACKGROUND

The barrier was built in 1980 and its operating mechanism, which lifts and pivots the 30m span x 10.7m deep x 212T gate in an "up-and-over" motion similar to a garage door, was suffering from wear and tear with the gate itself was suffering from corrosion. There was a significant risk that the barrier could fail to operate when needed and it required a total overhaul.

Figure 1 Gate in Part - Lowered Vertical Position

PROJECT PROGRAMME

To avoid exposing Hull to an unacceptable flood risk the barrier can only be taken out of operation for very limited periods when the risk of a high tidal level is decreased (summer tidal window). The programme was extremely tight and, to ensure that the works were completed within this summer tidal window, they were split over two years.

Virtually any slippage in the programme meant that works would not be completed in the designated summer tidal window and consequently completion would be delayed by at least a full year. The project also provided a significant contribution towards the CSR (2008-2011) outcome measure (OM2) target and without it the Environment Agency could fail to achieve the required national target.

PROCUREMENT STRATEGY

To deliver this complex, high risk project it was clear from the outset that an innovative procurement strategy was required and a specialist team had to be brought together to deliver it.

The first task was to translate the outline design ‘concept’ provided in the Environment Agency’s Project Appraisal Report (PAR) into a detailed design and construction specification ready for the tender process. This included a complex finite element analysis of the existing towers to ensure they were structurally capable of carrying the loads imparted by the new machinery.

Due to the very complicated and specialist nature of the project, expressions of interest were sought from the wider European market via an OJEU notice. A rigorous evaluation of all interested parties resulted in a shortlist of seven companies who were considered most capable of carrying out this work.

A design, build and maintain contract was developed using the New Engineering Contract (NEC) and a greater degree of control was gained by introducing particular constraints that removed any contractual circumstances that may incur a programme delay. A bespoke tender document was produced to include individually drafted Z clauses not normally used in Agency contracts with incentives for the Contractor to complete on time. This included provisions for bonus on completion of particular stages by key dates and liquidated damages against any delay. Any bonus earned also acted as an ‘accumulator’ in that if any subsequent key date was not met all bonuses previously earned were lost.

The seven tenderers were only asked to price the design stage as it was considered more appropriate to build up a price for the fabrication and installation element after the complex design was complete. This effectively removed the risk of a company ‘buying’ the work to win the contract then subsequently being paid actual costs for works done and disputing variations between the outline and final designs.

Received tenders were evaluated against a detailed quality price matrix prepared to ensure quality and certainty of outcome were more paramount than price.

PROJECT MANAGEMENT TEAM

The Environment Agency NCPMS (National Capital Programme Management System) managed the project in close consultation with the Environment Agency Area ASM (Asset Systems Management) and MEICA (Mechanical Electrical Instrumentation Control Automation), with Halcrow Group Ltd and Kenneth Grubb Associates Ltd providing specialist contractual, structural and M&E support. To complete the project team the successful tenderer, Qualter Hall, a Yorkshire contractor with proven ability to deliver similar complex mechanical and electrical projects to quality specifications and critical time-scales, was appointed in April 2008.

DESIGN AND DEVELOPMENT

The developed design comprises a new ultra reliable electro-hydraulic system with multiple levels of redundancy not previously provided to ensure the barrier can be lowered under any conditions. For instance, if the hydraulic system fails in one of the towers, then the barrier can be operated from the other tower. If the mains electrical supply is lost, there is an on-site generator, then 24V back up systems. The barrier can now even be lowered under gravity, or on its braking system. The chances of not being able to operate the barrier when required are now extremely low.

A number of critical components had a lead time of up to 54 weeks from order to delivery. If one of these was damaged, stolen or even dropped whilst being installed it could mean the very real possibility of not having an operable barrier for over a year. This risk was not acceptable and to mitigate it was decided to purchase a spare for all such critical parts.

This was one of several key decisions to be made along the way that later in the programme proved to be invaluable. During the factory testing problems were encountered with the gearbox settings. The ability to forensically investigate the spare and hence avoid dismantling the machine under test avoided delaying the programme. Had the spare not been available a minimum of one year would have been lost.

During the design all components were detailed within ‘Solidworks’, a 3D computer graphics package which allowed the tolerance and fit of all components to be checked. It was also used to check the overall fit within the actual plant rooms at the top of the tidal barrier’s two towers which are more than 30m above ground. To facilitate this a conventional survey of the plant rooms and a laser scan of the inside of each was carried out, which resulted in the production a 3D model accurate to within 5mm.

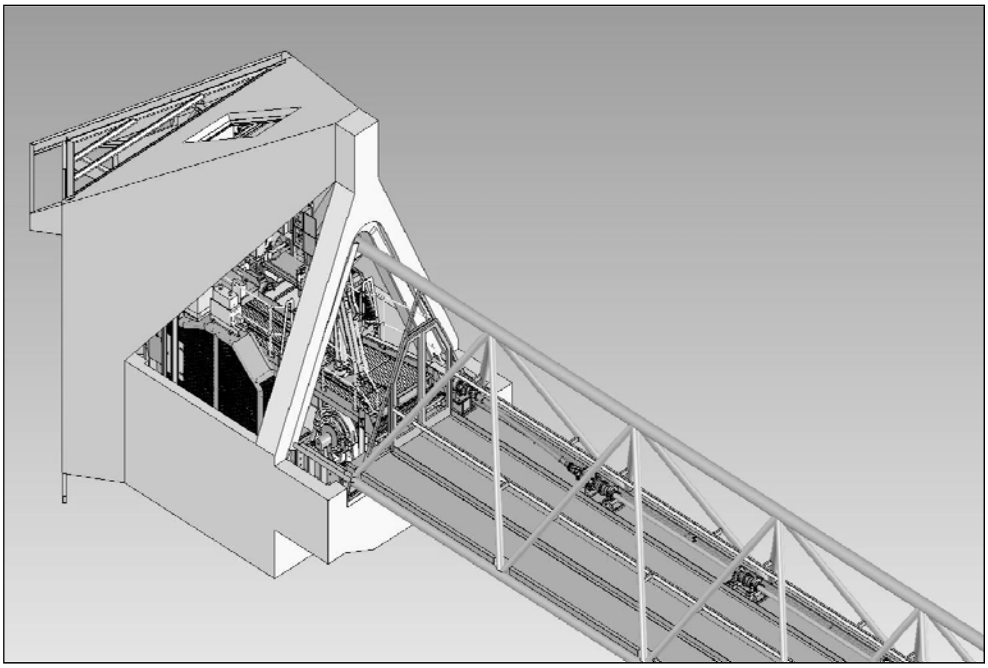

Figure 2 Part view of the 3D Model of the proposed installation design

ENABLING AND SIMULATED INSTALLATION WORKS

During the enabling works in 2009, which included refurbishment of the gate, wheelboxes, and wheels, the gate was fully encapsulated for grit blasting and repainting. Even though work was being carried out in a period when the risk of a high tidal level was very low, the encapsulation was able to be quickly removed to enable the gate to be lowered if necessary. Similarly a spare wheelbox was fully refurbished and individually exchanged with one on the gate so the ‘down time’ was limited to brief periods during very low tidal levels. The removed wheelbox was then refurbished and the process repeated until all were complete.

Once the design had been approved and the components delivered, extensive factory acceptance testing of the operating mechanism was carried out, including all mechanical, electrical and hydraulic systems, to check the functionality of the equipment before installation. Checks included computer simulations by specialists at both Bath and Newcastle Universities.

The full machine was built into a life size replica of the barrier machinery rooms within the Qualter Hall factory. Part of the factory roof was removed to enable components to be lowered in by crane and fed through the windows of the replica exactly as they would be on site

This included use of an innovative ‘C’ hook which was specially designed to facilitate safe lifting and placing of the heavy, large, and irregularly shaped components into the working space.

Figure 3 Works assembly of the New Hoist within the Tower Mock up

This process replicated and proved installation methods to be employed on site and tested the fitters ability to install the machine in the restricted working space. Test weights were also linked up to the mechanism to replicate part of the loads produced by the tidal barrier's gate.

SITE INSTALLATION WORKS

Whilst the factory acceptance testing was ongoing, a new control building to house control panels was constructed on the east bank. This required planning permission and building regulations approval, and working times were restricted by Natural England due to concerns on any impact on over-wintering birds. 2009 was also one of the coldest winters for a decade and in order to meet the programme the building was encapsulated in a large heated tent so that construction work could progress.

The main lift pins on which the gate hangs were damaged and needed replacing, but the 1980 design did not include any provision for removing them or their bearings. An innovative design was required to enable their replacement whilst maintaining an operational gate and, in consultation with the harbour master, navigational requirements. This was provided by fabricating and installing new hanging points on the gate before adjusting and connecting the chains and rigging links to them, enabling the gate to be lifted and lowered sufficiently to maintain navigation. The old pins were subsequently machined out and replaced with more robust ones of a higher specification before the operation was reversed to leave the gate hanging on its new lifting pins and bearings.

When it came to the main works in 2010, during which the barrier would be out of operation, the contractor was only allowed to take possession of the site after the last high tide in April and an operable barrier had to be available by the next expected high tide in June. The construction period between these potential high tides was challengingly short. In 2010 this period was only 43 days, and the site programme had to include 24 hours shift working, 7 days a week, to ensure the key dates were met.

The work was programmed on an hour-by-hour basis, building in contingency to enable the team to cope with any slippage. Qualter Hall had staff on site throughout the process, and their factory staff were also available to offer any additional support that might be needed.

Before progressing to site for the 2010 main works, the Environment Agency Director of Operations and the Chief Executive had to be convinced that all risks had been identified and eliminated or sufficiently mitigated before granting permission to proceed. To gain this consent, in addition to the risk reduction and mitigation measures already outlined, the following specific tasks were undertaken:

- A statistical analysis of the probability of storm surge, based on all known storm surges since records began, to show that the chance of a storm surge occurring in the 43 days the barrier was due to be inoperable was 1 in 24 million.
- A comprehensive contingency plan to further mitigate any flood risk.

The picture below shows the C hook lifting in the bedplate. This was the first component to be installed once all the original machinery had been dismantled and removed. Meticulous planning was required to ensure components were delivered in the correct sequence and on time.

To enable the barrier to be lowered under gravity, one site challenge was to remove some of the large cast iron counterweights which weigh some seven tonnes each and are located within the counterweight well. To break the counterweight down into pieces which could be removed through a small aperture some 30m above ground level involved ‘stitch drilling’ the slabs with specialist drilling machinery which enabled them to be split. This work was in a confined space, was a critical path activity, and prevented other works above it from being carried out due to the health and safety issues. This activity proved to be particularly difficult due to the hardness of the cast iron material.

Figure 4 Lift operation using C hook

Installation was successfully completed two days before the 43 day deadline. This was an incredible achievement given the complexity of the task in hand. Following the completion of installation, further acceptance testing was carried out on site to check all functions before the subsequent training of the Environment Agency's operational and maintenance staff. Additional works not specifically required to make the barrier operable, such as security fencing and office and mess room refurbishment, have been carried out on an ongoing basis. The contract also includes a three-year maintenance programme.

This project has proven incredibly challenging and has taken exceptional levels of preparation, design, engineering, manufacturing, project management, and organisation to reduce the risk of delays or unsuccessful installation. Integrated team working across various organisations and disciplines, and the extraordinary and innovative measures taken, have been key to the successful delivery of this crucial project.