Gainsborough Frontages Flood Alleviation Scheme

innovative approach to the continual management of flood risk by extending the life of existing assets

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Gainsborough is situated on the eastern bank of the lower tidal reach of the River Trent, approximately 43km upstream of the confluence with the River Humber. The town is currently protected by nearly 4km of flood defences in the form of sheet pile walls, mass gravity walls and earth embankments. This pattern has arisen from the pressures on space along the river from commerce and development. Gainsborough is particularly vulnerable to flooding due to the meeting of tidal and fluvial floodwaters, and the low-lying nature of the town and buildings that are located close to the river bank. Following a series of condition surveys and studies, it was reported that section of defence had failed and was in urgent need of replacement.

Completed Strengthening works *Courtesy of Atkins Ltd*

Project overview

After a detailed condition assessment coupled with numerical analysis the project team came up with a strategy to re-use many of the existing flood defences including large areas of sheet piles, most of which were originally thought to be at the end of their design life. The work had revealed a significant and unacceptable risk of failure of some sections of the existing flood defences if urgent remedial works were not undertaken.

Combined with new construction flood defence schemes in the '90s, it was decided that the remaining defences in Gainsborough warranted a standalone improvement scheme. Construction works started in June 2006, and the reinforcement works to provide the increased protection were completed by May 2010, with all works completed by September 2010.

The implemented solutions have improved the condition of the town's defences and reduced annual flood risk to over 2,600 properties (of which 2,322 are residential) from the 1 in 70 annual chance event to defend against a 1 in 200 annual chance event - and remove the town from the flood risk register.

Integrated project team

The works were designed and delivered by an integrated project team. The core team was drawn from Environment Agency framework partners, which facilitated the development of the integrated approach. The core team was supported by selected specialist contractors as the key design and construction elements were developed and delivered.

Project development

Using the entire project team, and incorporating the end user and specialist contractors alongside the designer, initial outline designs and budgets were developed to identify options for improving the defences. Options for managing flood risk were identified and risks attached to each of the options discussed. The consequences of any failure of the walls and defences were then reviewed to ensure that acceptable solutions were chosen. This work enabled the team to deem appropriate a monitoring regime to identify further deterioration of the condition of the existing mass gravity wall defences. If deterioration was identified, a programme of improvement or replacement works would be developed at that time. This approach deferred the need for a capital replacement scheme for these assets.

Flooding at Gainsborough – December 2000 *Courtesy of Atkins Ltd*

However, the consequences of further deterioration - and possible failure – of the earth embankments and anchored sheet pile walls were deemed unacceptable and so a scheme of remedial works to extend the life of these assets was developed.

Improvement works

The main improvement works required by the preferred option were:

- Replacement of 50m of failed mass gravity floodwall with a new anchored steel sheet pile retaining wall and flood defence.
- Installation of a plastic sheet pile seepage cut-off to increase the stability of 1.7km of existing earth embankments.
- Raising 550m of earth embankment to increase the standard of flood protection from a 1 in 70 to a 1 in 200 annual chance event.
- Installation of 441 ground anchors and associated steelwork to strengthen 730m of hard defences to reduce the risk of failure.

Risk management

The nature of the works at Gainsborough meant that there are a significant number of risks to manage. Primary concerns were:

- Working with existing riverside retaining structures with only a limited knowledge of their condition.
- The expectation that existing structures could only take limited additional loading during construction.
- Many of the working areas are constrained by existing properties and structures.
- The Trent is tidal and subject to a large range of river levels and poses the risk of both fluvial and tidal floods.

Innovation

In delivering the scheme, the focus was on maximising value whilst ensuring the delivered works were sustainable in both design and construction. The very nature of delivering the works encouraged innovative ideas from the team for both permanent and temporary works, and all the while striving for value and sustainable solutions.

The use of plastic piles to strengthen the existing earth embankments provided an alternative to widening of the embankments and minimised the amount of imported material required. This use of plastic piles was a first for the Environment Agency – and Gainsborough has subsequently been used as an example site for other schemes.

Additionally, during the construction stage, the design of earthworks for raising the defence levels was adjusted to enable the use of surplus excavated material obtained from the creation of a pond elsewhere on the scheme. This avoided disposal costs and the need to import new material.

The use of ground anchors to strengthen the existing steel sheet pile walls to extend the life of the assets rather than constructing completely new walls proved sustainable as well as innovative: reuse of the existing flood defences created clear carbon benefits, providing a saving of approximately 1,100t of carbon for hard defences alone compared with the provision of a new steel sheet pile wall.

An innovative approach was key to developing a method for the installation of the ground anchors in the working environment of a tidal river, which was achieved with drilling platforms hung from the existing walls. To enable the drilling of the anchors to be undertaken during all tide levels (and thus prevent pollution and increase productivity), the temporary works included extension tubes from the anchor heads on the existing piles to reach above the predicted high tide levels.

The development of the temporary works was achieved through using the designer's ground and structural modelling to assess

Plastic Pile Installation *Courtesy of Atkins Ltd*

Ground Anchor Strengthening Works *Courtesy of Atkins Ltd*

the strength of the existing flood defences, the sub-contractor's previous experience with ground anchors and the main contractor's temporary works expertise and their abilities to control safe systems of work.

The need to build temporary cofferdams in the river was avoided through the use of bespoke temporary working platforms. A small number of platforms were developed that could easily and rapidly be moved to each anchor location to improve operational efficiency; between these, the team was able to cater for the full range of wall types and alignments of the existing frontages.

The main constraint to implementing the chosen option of strengthening the existing frontages was working over a fast flowing tidal river with a tidal range of 4.5m. During the early stages of construction - prior to commencing the river works - the team implemented a method of detailed tide and river level monitoring. This information was used by the construction planner to identify efficient working windows for the in-river works.

Continued monitoring throughout the construction phase facilitated the effective programming of resources and gave the team a better understanding of how the river responded to tides and to fluvial flow. This enabled productivity to be maximised and the main strengthening works to be completed ahead of programme and at a reduced cost.

Ground Anchor Installation *Courtesy of Atkins Ltd*

Tidal monitoring information demonstrated that to implement the original design, proposals would require significant temporary works in the form of cofferdams in the river. This would increase the scheme costs by around £3 million and take it above the approved budget. More importantly, the use of cofferdams would generate increased health and safety risks. An alternative would have been to revert to a traditional new build – but that would have lost the sustainable benefits of reusing the existing assets.

The team made additional savings through the efficient use of materials. The original fendering design required bespoke fenders at each location; 630 fenders in total, due to different lengths required to fit the varying shape of the existing frontages. With additional survey information on the sheet pile geometry, the team revisited the fendering design to develop a simplified solution, which could be used consistently throughout the scheme. This reduced the number of different fender sizes required and improved the efficiency of fabrication and installation.

A further review of the requirement for fenders to afford protection to the anchor heads from accidental impacts generated a significant change in the project team's understanding of the system. The result was to reduce the fender requirement at each anchor from two to one, decreasing the total number of fenders by 300.

For waling beam installation, to ensure an even load distribution between the new beams and the existing sheet piles, the design required a packing material. The original design was based on the use of prefabricated steel packers. Due to the varying shapes, position and alignments of the existing piles, each packer was potentially unique requiring bespoke manufacture.

During construction, an investigation into alternative solutions was undertaken. This identified grout and epoxy resin bags as a viable cost effective alternative, a technology borrowed from bridge engineering. The solution provides savings and reductions in installation time, material cost and carbon cost as well as a reduction in health and safety risks compared to the original proposal.

Summary

The Gainsborough flood alleviation scheme was a large complex project that used an innovative approach to the continual management of flood risk by extending the life of existing assets. An integrated team adopting a risk-based approach was the key to this success.

Close communication with the client was fundamental to success, which, through the development of trust and transfer of knowledge and understanding, facilitated a risk-based approach to design development and decision making.

Overcoming problems and risks jointly as an integrated team resulted in better solutions being identified quickly while also avoiding unnecessary and abortive costs. A rigorous culture of challenge to any proposed changes and risk mitigation options was also developed to ensure value for money throughout the design and construction of the scheme.

The nature of the works meant that there were a wide range of risks to manage. By developing an integrated team with the appropriate skills and approach, the scheme has been able to successfully manage risks, identify opportunities to improve the value of the works, and work successfully within the community to deliver the works safely.

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