Liverpool WwTW

United Utilities keeping the Mersey clean with the AMP5 upgrade project

Following on from the Liverpool WwTW AMP5 Main Works Upgrade article featured in UK Water Projects 2012, Wellington Dock has been fully prepared for construction of the sequence batch reactor (SBR) plant which is now underway. The project is part of the £3.6 billion being invested by United Utilities in AMP5 across the North West to improve water quality and the environment by 2015. By upgrading the existing works and constructing a sequence batch reactor, the treated water leaving the new plant will be cleaner and greener helping the continued rejuvenation of the River Mersey and ensuring it meets strict European Standards for water quality.

SBR gallery with lower cells nearing completion (May 2013) - Courtesy of GCA JV

Undertakings

GCA JV, a joint venture between GallifordTry, Costain and Atkins working in partnership with United Utilities, was appointed as main contractor for the following works:

- BAFF refurbishment works.
- Silt removal.
- Dock closure and infill.
- Construction and commissioning of the:
  - SBR plant.
  - SBR feed pumping station.
  - Blower building.
- Inlet works modifications and sludge thickening building.
- Maintenance works to existing WwTW.
- Environmental Permitting Regulations (EPR): Flare stack replacement.

In addition to the above engineering, construction and refurbishment activities, the programme also includes a Habitats Directive driven quality project to provide a new outfall extension pipe into the Mersey Estuary. This falls outside the GCA JV contract.

BIM (Building Information Modelling) has been used extensively on the project, helping to realise benefits during the design and early construction phases, with further benefits in the commissioning, aftercare and long term operational and maintenance phase anticipated.

Sand infill

Before construction could begin, 31,000m^3 of silt was removed from the base of the Victorian dock. This was undertaken by WD Mersey, a trailing suction hopper dredger operated by Westminster Dredging.

Once the silt removal had been completed the dock gates were closed and a concrete filled sheet pile cofferdam was installed across the entrance to form a permanent water tight seal. Wellington Dock was then filled with over 206,000m^3 of sand reclaimed by dredger from the nearby Morecambe Bay. A floating/sunken temporary feed pipe system was laid from a connection point within the River Mersey, over Sandon Half Tide Dock bed through to a pipework distribution system within Wellington Dock, negating the need for access through the dock system by boat.

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This removed the restriction in vessel size created by the dock system and enabled 24-hour continuous operation for Westminster Dredging to pump sand and seawater solution down an 800m pipeline, via a spreader pontoon, into the dock filling an area of 29,000m^2 to a depth of 8m. The sand was then dewatered and the water pumped back into the Mersey Estuary.

Following this, the surface was compacted hydraulically and then mechanically using earth moving equipment. The entire operation took just 20 days, well ahead of programme. The innovative method of sand infill saved 25,000 vehicle movements dramatically reducing the carbon footprint of the works and avoided major disruption to the city traffic system and neighbours.

Foundation construction

To promote sustainability the 42,000t of imported stone required for the 800mm thick permanent piling mat was made up from reclaimed aggregate, enabling piling subcontractor Bachy Soletanche to install over 860 (No.) continuous flight augered (CFA) piles of 900mm diameters to an average depth of 15m. The piles, which are socketed up to 5.5m in the underlying sandstone provided the foundations for the new SBR.

The efficient compaction of the sand reduced the quantity of stone needed for the piling mat, and the ease with which it could be dewatered helped simplify the piling process. The CFA piling was initially engineered for cased piles however by close collaboration between main contractor, piling subcontractor and client engineering, the project team agreed to use uncased piles to improve efficiency in the sandstone and used compressed air to loosen the rock.

The piles were then installed flush with the top of the piling mat without continuous reinforcement negating the need for pile capping, removing significant health and safety risk and expediting follow on activities. The piles were installed on a 5m grid, lining up where required directly beneath the corresponding column of the SBR structure.

SBR construction

Construction of the Sequence Batch Reactor (SBR) commenced in September 2012 around 12 months after dredging commenced. The new facility is a 16 (No.) cell, dual level SBR with a footprint of 165m x 110m standing 21m high. Up to 5,743l/s of water can pass through the SBR each day during the stages of secondary treatment. Each cell measures 40m x 49.5m with 6.5m water depth with a 9m wide pipework gallery down the centre of the structure.

The 750mm thick base of the SBR was formed in 20 pours, each requiring approximately 600m^3 of concrete. Over 50,000m^3 of concrete and 10,000 tonnes of reinforcement will be required to complete the SBR structure. Reusable formwork was employed to again promote sustainability and the use of off-site manufactured precast concrete element has been maximised.

The SBR is being constructed using in situ concrete, based on a network of slender 500mm and 600mm square columns and 600mm thick wall panels. The concreting process has been simplified as much as possible by using system formwork for the repetitive structural elements. Consequently, this has significantly reduced the need for scaffolding. Workers use mobile elevating work platforms (MEWPs) to minimise the risks of working at height.

Although the SBR structure is predominantly in situ concrete, maximum use has been made of precast concrete throughout the design and construction process. When evaluating the use of precast elements GCA JV have considered its potential to:

- Improve the aspects of health and safety through simpler installation and minimising working at height.

CFA piling in full swing. The 900mm diameter piles are all installed on a 5m grid and constructed to finished level in one operation. 9,000m^3 of pile arisings were retained on site for future reuse (July 2012) - Courtesy of GCA JV

- Remove the time risks, through building off line and reducing the amount of potentially 'time critical' activities.
- Reduce interface issues with other work activities, safe method of work.
- Improve the intrinsic constraints associated with providing temporary propping and curing related to in situ concrete.
- Provide significant costs benefits.
- Provide significant time savings on the activities.
- Precast Install during nightshift, removing interface with the day shift and improving safety performance.

The main areas where precast sections are utilised are:

- Internal baffle walls.
- Outlet channel cover slabs.
- High level walkways.
- Ring beams (supporting SBR process covers).
- Additional upper precast slabs (instead of GRP from walkway to cover beams).
- Retaining walls within the dock.
- Pump station support beams and slabs.
- High level distribution chamber support walls/legs.

All precast elements will be manufactured off site and delivered to site to suit the installation schedule. Due to the restrictive nature of the site, a 'just in time' delivery schedule will be implemented. The size of individual units will depend upon delivery and installation restrictions which in turn will be dependent upon crane capacities and radius lifts.

SBR feed pumping station construction

Intercepted flows from the existing Sandon Works will be pumped into the new SBR via a new pumping station situated at the western end of Wellington Dock. CFA piles for the structure were initially driven in October 2012 and then a cofferdam (45m x 16m x 4.5m deep) was installed in order to construct the lower RC substructure. The piles were broken down to the correct levels as excavation works advanced.

Value Engineering utilising the BIM system to provide visualisation for all stakeholders enabled the cofferdam to be removed after construction and backfilling of the dry and wet wells, thereby ensuring earliest completion of the substructure overall. Approximately 5,000m^3 of concrete will be required to complete this substantial structure.

It is envisaged that the mechanical fit out of the building will be carried out prior to erection of the steel framed superstructure in order to realise programme savings and to allow earliest unhindered construction of the adjacent SBR distribution chambers.

SBR blower building

A steel framed building will be constructed within Wellington Dock immediately east of the SBR. This structure will house the new aeration blowers and associated electrical equipment. The structure has been designed to sit on engineered fill material and hence remove the need to carry out costly piling works.

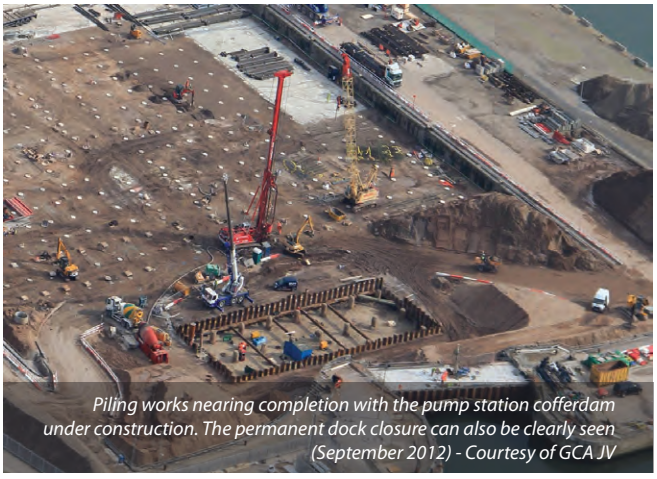
The building footprint is currently 48m x 14m and will include a mezzanine floor in order to house all the MCCs. A complex erection sequence of the structure will be undertaken, taking into consideration the large 1.2m diameter blower pipework which will penetrate the building at various locations; again utilising BIM to provide time based 3D visualisation.

Sludge thickening building

An engineering decision was taken to construct a new 'off line' sludge plant as opposed to extending the existing sludge building currently servicing the Sandon works. Although this will increase the direct construction costs, it is anticipated that

Grading out the completed sandfill to Wellington Dock prior to installation of piling mat (June 2012) - Courtesy of GCA JV

Spreader Pontoon placing dredged sandfill (May 2012) Courtesy of GCA JV

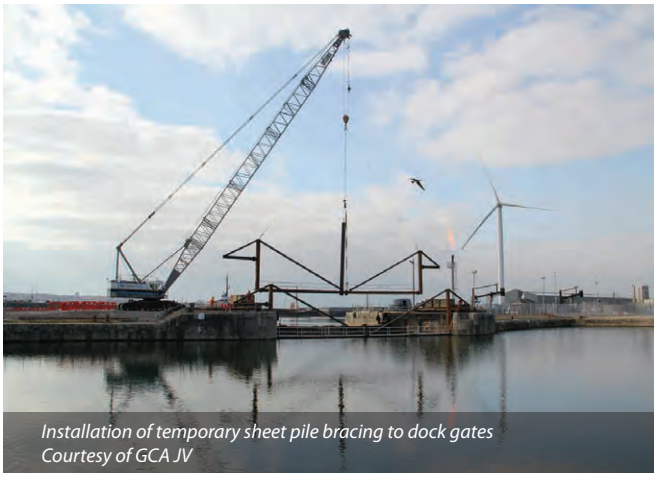


Piling works nearing completion with the pump station cofferdam under construction. The permanent dock closure can also be clearly seen (September 2012) - Courtesy of GCA JV

Aerial view (February 2013) - Courtesy of GCA JV

Clay-board void former being installed to construct the central SBR expansion joint (June 2013) - Courtesy of GCA JV

Liverpool WwTW: Aerial view (June 2013) Courtesy of GCA JV



Installation of temporary sheet pile bracing to dock gates Courtesy of GCA JV

Outfall pipeline in the Mersey followings its long journey from Norway (May 2013). Actual installation late August 2013 - Courtesy of GCA JV

by greatly minimising the required interfaces an overall time and cost benefit to the programme will be realised.

The new structure is located on the North Dockside and consists of a piled foundation supporting RC cantilevered ground beams and concrete base slab. Before works could commence the area had to be cleared of existing redundant foundations and extensive service diversions carried out.

The steel framed and cladded building erection will need to be phased to allow placement of the various poly dosing and potable water tanks and other associated equipment such as the overhead travelling crane beam prior to roof construction. The facility contains:

- 3 (No.) SBR secondary sludge drum thickeners.
- 3 (No.) primary sludge drum thickeners servicing the existing plant sludge production.
- 2 (No.) poly dosing plants servicing the two sludge types.
- Ancillary pumps.
- MCCs and integrated control system.

This facility is sized to accommodate projected sludge production at Liverpool which once thickened will be pumped to the digesters to produce gas for the existing CHP engines.

Maintenance works to existing WwTW

As part of the 'X' works at Liverpool, GCA JV are carrying out extensive refurbishment work on the existing Sandon Dock Treatment works including:

- BAFF plant remedial works to maintain treatment capability whilst the SBR is constructed.
- Refurbishment of the primary settlement tanks.
- Up rated PST scum collection systems.
- Replacement of storm tank scrapers.
- SCADA systems upgrade.
- Refurbishment and optimisation of the existing 3 (No.) odour plants.
- Upgrade to HV power infrastructure from 10MVA to 15MVA to meet new demand.
- Refurbishment of the inlet works pumps, including replacing 8 (No.) pumps.

Environmental Permitting Regulations (EPR)

A new flare stack complete with new control panel is to be installed to replace the existing unit. This new flare stack is to be compliant with *LFTGN 05 – Guidance for Monitoring Enclosed Landfill Gas Flares*.

The new flare condensate will have to be managed requiring a new pumping station and surface channel drain to be installed. The new pumping station will be contained within an existing chamber and the discharge pipeline returned through the existing west service gallery to the existing site drainage wet well.

River outfall extension

The Liverpool Habitats Outfall project is part of the Liverpool WwTW AMP5 Upgrade programme but outside the scope of the main contractor's construction and maintenance activities. The project is necessary to deliver an extension to the existing outfall from Liverpool WwTW by March 2015 in order to comply with the EU Habitats Directive.

The outfall extension pipe arrived safely on 1 May 2013 having been towed by tug-boat over 750 miles to Canada Dock from Norway, a journey that took around eight days.

The current outfall arrangement discharges the treated wastewater at the edge of the River Mersey which results in a visible plume with

the final effluent tending to hug the bank of the river as it flows away from the treatment works. The 2.1m diameter extension will take the discharge further out into the Mersey by approximately 285m. This will help to improve dilution of the discharged effluent and enhance the river habitat.

Building information management

GCA's pioneering approach on this flagship project for United Utilities, has been to deliver a 3D model to act as a 'single point of truth' is the core of the design process. It has promoted a culture in which the project team have been able to explore alternative concepts, conduct value engineering and optimise designs. It has enabled collaboration and integration between designers, constructors, process partners, supply chain and client in a far more efficient way than ever before, leading to improved cost effective coordination, buildability, operability and maintainablility.

The use of BIM, with discipline specific applications feeding into the model, providing an informed work environment to support the design and documentation process has resulted in a reduction in errors helping to deliver the project on time and, according to current estimates, under budget.

Navisworks Freedom is available on every design and construction engineer's desktop and the 3D model is updated on a daily basis to enable them to navigate to their own particular area of interest, to facilitate HAZOPS and Access Lifting and Maintenance (ALM) reviews, and to give the construction team a BIM model to 'rehearse' construction, coordinate work and plan safe systems of working.

A BIM station is also available in the common area of the site offices, where site personnel can navigate around the model to their designated work areas to check for safety concerns, access routes etc, or to simply orientate themselves within the structures and ongoing construction areas.

Client operatives also visit the station regularly to view a facility which will not be handed over to them for at least another 12 to 18 months, leading to feedback from them, further aiding the design process. The model is also being utilised by the SHE department as an aid with inductions, tool box talks and risk assessments.

Safety is a major issue both for GCA and United Utilities and to date over 900,000 manhours have been completed without a reportable accident. For every 100,000 accident-free hours UU and GCA donate £1,000 to charities nominated by the workforce. To date over £9,000 has been donated to Liverpool based charities on this project alone.

The main model is made up of over 140 smaller ones including process vendor and supplier models, managed in a common data environment. The main model is then updated and issued to the design engineers who check for clash detection and other design issues.

The model is the focal point of weekly design and construction review meetings involving all key stakeholders including the client and process vendor. Areas of interest can quickly be navigated to and deliberated on, to a satisfactory conclusion. Images are taken from the model and incorporated into the minutes, which are then published on the business collaboration tool.

The use of BIM and 3D modelling has enabled us to enhance the construction programme for the feed pumping station by providing a 4D timeline, demonstrating each construction activity complete with a Gantt chart which could be downloaded as an Excel spreadsheet. Downloading the original data from Primavera, the exercise of building the model in a granular fashion based on each individual activity, highlighted a number of errors in the programme which we were then able to rectify. Having proven its effectiveness on a smaller structure, 4D timelining was then applied with equal success to the SBR.

Each of the lower SBR cells contain 68 (No.) RC columns at 9.7m in height on a 5m grid (February 2013) - Courtesy of GCA JV


Primary tank scraper - Courtesy of GCA JV


SBR structure preform scaffold - Courtesy of GCA JV


Piling for sludge building (February 2013) - Courtesy of GCA JV


Storm tank bridge - Courtesy of GCA JV

Although GCA JV issue traditional 2D drawings i.e., plans and sections as detailed design deliverables for the project, these are not done in isolation. Instead they are cut from the model itself, and annotated accordingly, saving both time and money. This has an added benefit in that the plans and sections are live when the model is amended to produce the 2D drawings, meaning that only annotation and dimension revision are required. This has led to direct cost savings by having to employ fewer draughtsmen across all disciplines.

Sub-contractors for structural and secondary steelwork, electrical and mechanical elements of the project have also bought into the BIM strategy. The model is sent to the contractors which they can then view through Navisworks Freedom, enabling them to isolate their own areas of interest or to view them in context with the complete model. They can take any required measurements and colour code items already covered enabling them to price far more accurately than could be done traditionally with plans and sections. Contractor models can then replace design intent in the main model for clash detection etc.

Heritage

To conserve the historic setting of the dock, features were included in the project as appropriate for a World Heritage buffer zone. The SBR was positioned to provide a visual gap between the dock perimeter wall and future development to the south of the site. The fill within the dock was kept below the quay wall and will be finished in green slate chippings to give an impression of a 'water surface'.

Dock furniture and the exposed quay wall are being protected during construction and will be refurbished on completion. Historic paved surfaces will be incorporated in the final site layout and replica dock gates will be installed in the perimeter wall.

Conclusions

The overall solution package that included refurbishment work on the Sandon Dock plant as well as adding new secondary treatment as a replacement for the existing treatment process, resulted in a £200m upgrade that includes:

- £44m of improvements on the existing site.
- £11m for a new outfall.
- £145m to infill Wellington Dock and build the new SBR.

The long term partnership arrangement between GCA JV and United Utilities formed for this project in May 2010 has helped develop the options and to value manage costs out of the project as much as possible, with the result that the scheme is targeting some significant savings against the original forecasts.

The collaboration between the partners has also helped to influence and maintain the excellent safety performance together with the development of safety innovations such as a dedicated loading bay, a first aid/medical room and traffic management initiatives.

Attention has also been paid to the sustainability and carbon footprint of the project using reusable and recycled materials wherever possible.

The first of the process equipment arrived on site in June 2013 ready for the project team to carry out installation and commissioning throughout 2014. The entire scheme is set to be fully operational by April 2016.

The renewed and extended wastewater treatment plant will deliver increased reliability of performance with reduced operating costs and so continue the improvement of the River Mersey environment.

The editor and publishers wish to thank United Utilities and GCA JV for preparing the above article for publication.

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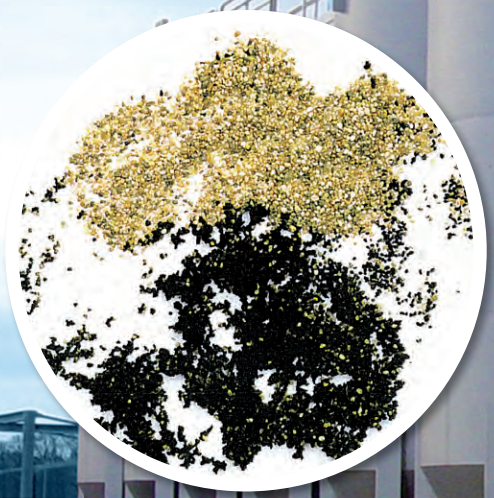

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