Global Coastal Challenges

Coastal case studies, contracts and news – *DPC*'s ten-page review kicks off with a roundup of projects that include a fish-friendly breakwater in the US and a brand-new port in the middle of nowhere…

Well, 'nowhere' as it applies to southeast Madagascar, since the region's about as remote as you can find on the island – but it has one huge economic redeeming feature and that's vast amounts of ilmenite (titanium dioxide), a vital ingredient in paint.

In turn, that's attracted **Rio Tinto** and its 80%/20% venture with the Madagascan government, **QIT Madagascar Minerals** (QMM), which is developing a mineral sands mining project in what is the largest investment in the island's history.

In order to ship the ilmenite, as well as to import/export other vital commodities, QMM's had to build the $145M deepwater Port d'Ehoala from scratch. It's a project that includes a 600m-long breakwater, a multi-use quay, dredging, land reclamation and a groyne – and US-based engineering consultancy **Baird & Associates** won the planning, design and construction management contract.

Remote And Rough

"The project site's challenging in terms of the environmental conditions, as well as issues inherent in working in a remote region," said Baird's Dave Anglin. "The wave climate's severe and bi-modal in nature, with intermittent easterly seas superimposed over persistent southerly swells – Hs = 2m to 3m is typical. In addition, storm waves in excess of Hs = 8m are possible during a tropical cyclone."

That wave climate dictated the requirement for a substantial breakwater to provide protection to the port. In addition, rapid advancement of breakwater construction was critical to the overall project schedule, as protection was required to facilitate dredging, land reclamation and quay construction. And the client was also looking to ship the first batch of ilmenite in March 2009 with port completion later in the year.

"Alternative breakwater design concepts were evaluated during the preliminary design phase," Dave continued, "including a conventional breakwater with single-layer concrete armour units (nominally 16m^3) and a berm breakwater armoured with quarried stone (up to 20 tonnes)."

Estimated construction costs were similar for both concepts – around $20M – but the objectives of the evaluation were to define key issues/uncertainties associated with the two concepts, such as:

- *Concrete armour units* – ability to achieve required placement grid/density in persistent swells and the risk of breakage during their placement
- *Armour stone berm* – ability to produce sufficient quantity and quality of large armour stone.

Subsequent analyses, including 2D model tests and extensive quarry investigations, led to the selection of the berm concept. Additional analyses were undertaken to assess single-class and multi-class berm breakwater designs, with the latter identified as a more efficient approach. Extensive 3D model tests were undertaken to develop, refine and optimise the breakwater design, along with further tests with an interim cross-section in order to assess the risk of damage during construction.

And Today

The port project was bid early 2006, with the contract awarded to **Daiho** of Japan in October that year. After an extended period for mobilisation and quarry start-up, breakwater construction began in June 2007.

The core and interim armour were advanced to the roundhead location by October 2007, followed by progressive construction of the full cross-section, including simultaneous operations in work zones along the breakwater.

And as *DPC* went to press, the breakwater was substantially complete,

Safe Haven

An environmentally sustainable sheltered harbour that will encourage visits by leisure craft and boost tourism

That's the *Caladh Mór* project on Inis Meaín, Ireland, that was opened by community minister Éamon Ó Cuiv and natural resources minister Eamon Ryan in November.

Home to just 200 people, Inis Meaín is the middle of the three Aran Islands and the €14M project included removal of about 34,000m^3 of limestone to form a sheltered basin to a depth of 3m Chart Datum.

A precast concrete caisson pier was constructed and protected with 9.6-tonne *Xbloc* concrete armour units – increasing the island's berthing capacity – and a 125m-long offshore breakwater will provide shelter.

***Caladh Mór* under construction**

RPS Consulting Engineers managed the project, including design, administration and onsite supervison.

More info at www.ndp.ie

with the structure being capped off with crest armour.

Meanwhile...

...in the middle of the Atlantic, Baird was working on another breakwater, this time a rehabilitation job at Praia da Vitória on Ilha Terceira in the Azores – now nearing completion after six years of phased construction.

The rubble-mound breakwater, built in 1961 at the north end of Praia Bay on Terceira's east coast, protects the harbour and its navigable waters, but it's directly exposed to easterly Atlantic waves and has been extensively damaged.

Praia Harbour's relatively protected compared to the island's northwest coast, but still experiences severe storms

How it looked in late 2008

Work under way on Port d'Ehoala in September 2008

PDB completed ahead of schedule

with significant wave heights at the breakwater reaching approximately 4m to 5m every one or two years – and approaching 8m once every 100 years. And a detailed assessment of the site wave climate formed an essential part of the development of a long-term solution, actions including:

♦ Acquisition of long-term commercial hindcast data (1958 to 2000) for a location near the island of Terceira

♦ Deployment of a wave measurement pressure gauge in 16m depth in front of the breakwater in November 2004 – measurements continue as you read this

♦ Completion of an Atlantic Ocean wave hindcast from 1995 to 2005 over the period of design development and wave monitoring. Comparing the several years of overlap between the bought-in commercial hindcast data and the in-house hindcast, it was found that the predicted wave conditions were very similar.

Design Challenges

Development of a more permanent design solution for Praia was initiated in 2004 and posed significant challenges, including:

1). Limited funding – rehabilitation of the structure had to run over several years because of lack of cash, necessitating a phased approach

2). The breakwater's condition – long-term degradation over its entire length

3). Stabilisation – of any repair section within the damaged structure.

A hybrid *Core-Loc* and armour stone structure was selected as the preferred option, developed out of physical model testing. The cross-section consists of a 20m (minimum) to 30m-wide berm of armour stone at the toe of the Core-Loc armour layer.

Nearly There

The berm's constructed of 5-tonne to 18-tonne stone along the trunk, 10-tonne to 22-tonne stone at the head and will have a crest elevation of +3m (MLW). A narrow (10m-wide) berm is proposed in front of the northernmost tetrapod section of the structure, while the upper portion's protected with 32-tonne Core-Loc units to a crest elevation of +9.3m.

"This project's demonstrated an effective approach to the repair of a severely damaged rubble-mound breakwater," said a Baird spokesman. "In most cases, repair can be significantly more challenging than construction of a new breakwater!"

Coming To A Coast Near You!

Launched at the end of 2003, first used on a 2004 shore protection project in Indonesia, with the first breakwater project at Ireland's Port Oriel in 2005 – Xbloc goes from strength to strength

A single-layer concrete armour unit developed by Dutch firm **Delta Marine Consultants,** Xbloc's been used in five completed projects in four continents and three projects are currently in progress.

Xbloc's strengths are its high hydraulic stability, robustness and cost savings compared with other armour due to reduced concrete use and faster placement – either by hydraulic excavator or by crawler crane. Typical placement rates in the completed projects have been between eight and 40 units per hour.

Work to improve performance continues, DMC opening a new wave flume test facility in Utrecht where two-dimensional physical model tests can be carried out. The flume's equipped with an innovative piston-type wave generator that can generate random and irregular waves up to 30cm and absorbs waves that are reflected by the tested structure. And in July 2008 the first project-related model tests were carried out, investigating both a vertical wall shore protection system and Xbloc shore protection in Panama City.

An interesting trend over the past five years has been development from small projects in 2004 and 2005 – 1,000 to 6,000m³ of concrete – to last year's larger projects of 25,000 to 30,000m³. It looks set to continue in 2009 – a >100,000m³ project will be constructed soon.

More info at www.dmc.nl

Modelling in Utrecht

Halting The Drift

It's estimated that about 80% of coastal erosion within the State of Florida is directly attributable to coastal inlets, including ports...

Which is why Governor Charlie Crist signed the *Inlet Management Bill* into law in the middle of last year that not only affects Florida, but also highlights a critical concern regarding ports throughout the US, writes Dr Michael Jenkins, coastal engineering team leader with Florida-based **Applied Technology and Management**.

Ports interrupt the natural littoral drift of sand from updrift to downdrift beaches – and, as the law states: 'the legislature finds it is in the public interest to replicate the natural drift of sand which is interrupted or altered by inlets'.

While some major deepwater commercial ports are exempt, the law does require that ports demonstrate 'reasonable effort to place beach-quality sand from construction and maintenance dredge and port development projects on adjacent eroding beaches'.

It's good news for contractors, as the measures advocated include:

- Construction of fixed bypassing facilities to pump sand hydraulically from updrift to downdrift beaches
- Use of small dredgers and settling basins for the same ends, and
- Dredging of offshore sand as beach nourishment material in order to make up for the volume of sand lost at the updrift inlets.

Fixed inlet bypassing plant at Palm Beach's Lake Worth Inlet

Florida has a well-established coastal management programme that includes dedicated funding for restoration projects. This new legislation provides additional direction by specifically dedicating funds to studies of coastal inlets and construction projects to address downdrift erosion.

The full Inlet Management Bill can be found at www.fsbpa.com/documents/CS-HB%201427%20Enrolled.pdf – or you can reach the author by email at Mjenkins@appliedtm.com

Back Home

... for something completely different at WE Energies' power plant in Port Washington, Wisconsin, US, where Baird designed a fish-friendly 273m 'porous dyke breakwater'.

As a condition of the federal and state permits required for conversion of the plant from coal-fired to gas, WE Energies had to implement measures that would reduce entrainment and entrapment of fish in the cooling water intake system. They conducted studies to weigh the advantages and disadvantages of various cooling water intake options – among them, several deepwater intakes, fine-screened intakes... and the porous dyke breakwater (PDB) concept that was eventually deemed the most cost-effective. Advantages included the fact that it could be constructed nearshore in relatively shallow water, thus limiting the amount of stone needed.

How It Works

A PDB allows the flow of cooling water while at the same time serving as a barrier to fry and adult fish. WE Energies' studies determined that while the dyke would contain voids thought to be a safe haven for small fish, they'd be able to swim against the current generated by the cooling water's through-flow and would not enter deeply into, or pass through, the dyke.

And there was a bonus. While the PDB's main objective is to keep fish out of the intake system, it will also serve as a barrier to large masses of floating *cladophora* (algae) that have plagued the power plant on numerous occasions when it was drawn into the intake and clogged the trash rack and intake screens. That resulted in a total shut down, cutting power generation and causing significant revenue losses.

The PDB's expected to divert the large masses of algae past the intake. And while it may clog portions of the dyke, that's been taken into account: greater than 50% of the dyke's porosity can be lost before the inner water level drops to a point at which the plant intake system can no longer function. In any case, wave action in the upper metre or so of the water column will quickly break down any clinging algae.

And There's More

As its name suggests, the PDB is also a breakwater – wave agitation within the basin it encompasses has been significantly reduced. A calm wave environment places less stress on the intake pumps, which would otherwise chase the more widely varying intake pressures caused by wave action.

"Project highlights included a study to determine whether or not fish would enter a structure having openings or voids of a given size," said a Baird spokesman, "plus physical modelling in the Canadian National Research Council's Ottawa laboratories to test different porous dyke stone gradations and cross-sections in an effort to determine that resulting flow rates and pressure losses would meet the plant's requirements."

The contractor was US-based **Durocher Marine**, the PDB cost $3,285,000 and was completed ahead of schedule and under budget in September 2008.

More info at www.baird.com

Getting Up To Speed

Royal Haskoning's won the environmental consultancy and support contract for construction of the UK's Sheringham Shoal wind farm

Once complete, the installation, off the coast of Norfolk, eastern England, will cover 35km², have 88 turbines and is expected to produce around 1.1TWh of electricity – enough to power over 200,000 homes.

Royal Haskoning provided multi-disciplinary consultancy services, advice and technical input throughout the environmental impact assessment (EIA) and consenting phases for both the onshore and offshore elements – and will now oversee development, implementation, reporting and dissemination of effective mitigation and monitoring plans.

More info at www.royalhaskoning.com