Castletownbere Harbour Development
Some Aspects of the Design

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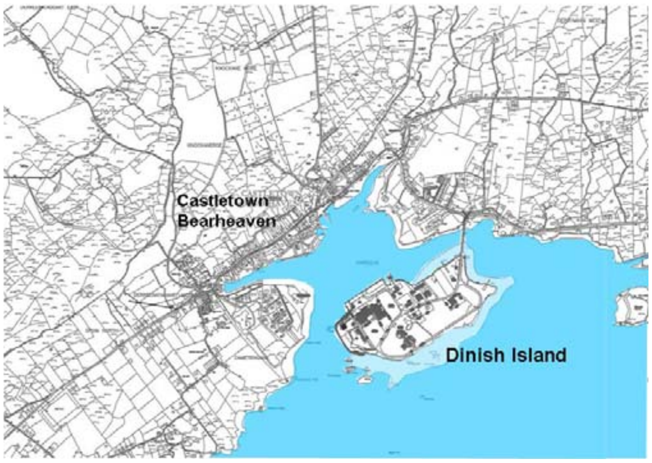
Synopsis

Castletownbere Fishery Harbour Development comprises the construction of 214m of new quayworks, dredged berthing pocket to -10.2m (OD), and extensive other capital dredging works. The dredging includes the removal of significant quantities of contaminated sediments. The paper describes selected aspects of the design of the project, and the approach to their construction.

Castletownbere Harbour Development

Overview

Castletownbere Fishery Harbour in West Cork, on the northern side of Bantry Bay is one of Ireland's major fishing ports, with landings of up to 745 tonnes per month. The harbour is located between the town on the mainland, and Dinish Island which is owned by the Department of Agriculture Fisheries and Food, and is the location for a number of fish processors and other marine industries. The island is linked to the mainland by a short bridge.



Location Plan

The commercial activity in the port is shared between the quays on the mainland, where Bord Iascaigh Mhara are located, and where the old fish auction hall is established, and the Quay on Dinish Island, where the ice plant and synchrolift are located.

The project was initiated in 2000 by the decision of what was then the Department of Communications Marine and Natural Resources, to extend the existing quay on Dinish Island, provide a dredged berthing pocket and to construct a new fish auction hall.

Mott MacDonald and Jacobs Engineering (then E.G. Pettit & Company and Babtie respectively), were appointed to advise on the project, Mott MacDonald as Project Manager and designer of the buildings, and Jacobs as designer of the marine works.

The scope of the project at that time comprised an extension to the length of the existing reinforced concrete wharf of some 115 metres, the dredging of a berthing pocket to -10.2m (OD), and the construction of an auction hall for the sale and distribution of whitefish landed at the port.

It became evident during the development of the project that the requirements of the fishing industry were developing extremely rapidly. Following consideration of several schemes for the auction hall including special facilities for electronic web based auctions, it was concluded that to construct a new auction hall was inappropriate, and that better value would be obtained by investing in the replacement of the existing reinforced concrete wharf, and more extensive dredging.

The final outcome of the Preliminary Report stage was a recommendation to replace the existing wharf, which was reaching the end of its design life and to construct a new quay giving a total length of 214m with a dredged depth at the berthing face of -10.2m (OD). Some additional dredging was also included to remove a hazard in the approach channel known as the Perch rock.

The project is currently under construction, with both the dredging and the extension to the quay complete with the new quay in use. Work is in progress on the replacement of the wharf with piling complete and assembly of the precast deck in progress.

On completion of the civil engineering works, there are plans to build a new harbour office overlooking the entrance channel to provide facilities for the Harbourmaster and the Sea Fishery Officers.

The engineering work associated with the project is extensive and at times complex and innovative, and this paper describes some of the issues that have arisen.

Site Investigations

As is normal for a major civil engineering project, extensive geotechnical investigations were carried out. It was known from previous investigations that the level of rock was highly variable over the site area, and was outcropping on the adjacent shoreline. Of particular interest however was the overburden, consisting of soft sediments, clays, some peat and very dense gravels.

Due to the historic use of tin based antifouling on fishing boats, and probably exacerbated by the proximity of the boatyard and synchrolift, significant concentrations of tributyl tin (TBT) were found in the upper layers of the soft sediments. This particular form of antifouling has been banned from small craft and fishing boats for some time, but its legacy remains.

Through impact and erosion, small particles of antifouling will detach from the hulls of boats over time, and settle on the sea bed. There they form an attachment to fine soil particles, particularly silts, and remain there for a considerable period. The presence of TBT in the sediments is usually monitored by observing the damage to the benthic ecology, in particular the mutations to certain types of shellfish.

The consequence of this for the dredging operations is significant. Disturbance of the silt using conventional dredging methods, will put the material into suspension and allow tidal currents to disperse it over a wide area with the potential to cause environmental damage. In addition, since the material is particularly toxic to marine life, it obviously cannot be disposed of by dumping at sea as is normal in dredging work for non-hazardous dredge spoil.

To quantify the extent of the contaminated silt and to design an approach for its removal, we obtained and tested samples from different depths over the area in which dredging was planned, as well as more generally within the harbour.
The sampling was carried out so that the samples at each depth were effectively undisturbed or ‘uncontaminated’ by the layers above or below them, so that the depth to which the TBT was present could be established.

It was found that TBT was generally present in the surface layer at levels well in excess of the 0.1mg/kg regarded as a minimum intervention level. The contamination extended to greater depths in certain locations, but without a particular pattern. The findings of the contamination sampling are summarised on Fig. 1, which shows the different levels of contamination with depth and throughout the harbour footprint.

One of the challenges in dealing with TBT is the absence of a quick in-situ test for its presence. This means that a dredging contractor cannot be certain whether the contaminant is present in the material at the time of dredging. Consequently it was necessary to devise a method of ensuring that all of the contaminated material was removed, but without mixing it un-necessarily with clean material.

Following consultation with the Marine Institute, as the Licensing Authority for marine environmental issues, it was agreed that the most appropriate approach from an environmental perspective was to

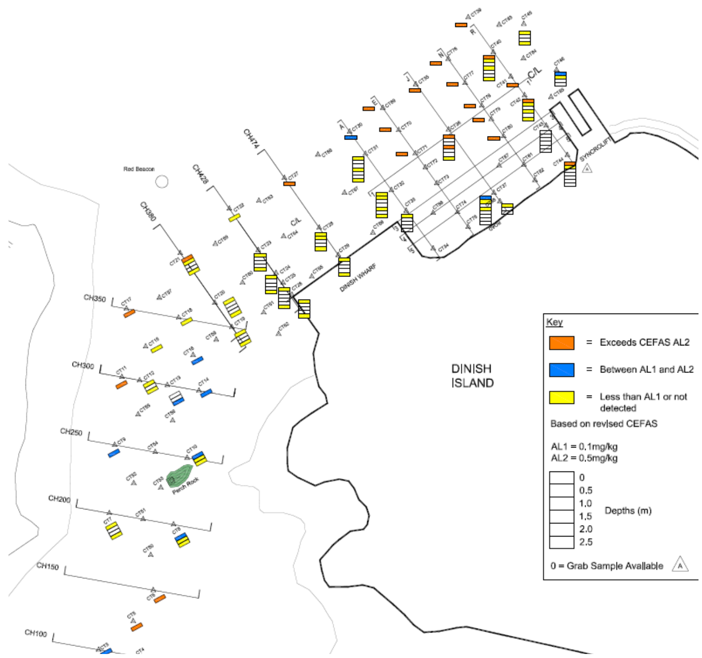


Fig. 1

over dredge the contaminated silt to ensure that all of the contaminated material was removed.
In this context, the consequences of leaving the material in-situ would be the continued degradation of the quality of the eco-system in the harbour, which was already seriously damaged.

As noted above, disposal of the material is only possible on land, and due to the presence of the tin compound, the material is designated ‘hazardous’ although it is not considered particularly toxic to terrestrial life. Consequently the options for disposal are limited. The general absence of hazardous waste disposal facilities in Ireland, and the substantial volume of material concerned require a careful assessment of the methods to avoid a cost that would make the project non-viable.

Procurement of the dredging contract

In order to establish the practicality of handling the material, and also to manage its disposal, we consulted with a number of specialist dredging companies, particularly with a view to establishing whether treatment processes were viable, and if there were any potential uses following treatment.

It emerged that while dredging equipment to remove the material in a controlled fashion was reasonably readily available, there were widely different approaches to the treatment and disposal. It was also evident that the technology used to deal with the arisings from dredging the major European waterways such as the Rhine was well developed. As a result, we adopted a design and build strategy to procure the dredging contract to allow the tenderers to develop their own proposals for the removal and disposal of the contaminated material.

This approach created some additional issues to be addressed, in that the treatment processes were likely to require pilot studies to validate their effectiveness on the in-situ materials, and the Statutory Permissions for the processing and disposal of the waste materials would be dependant on which proposal was accepted and on the outcome of any pilot studies. It would also be necessary to quantify the extent of the contamination as precisely as possible to minimize the premium cost of its removal.

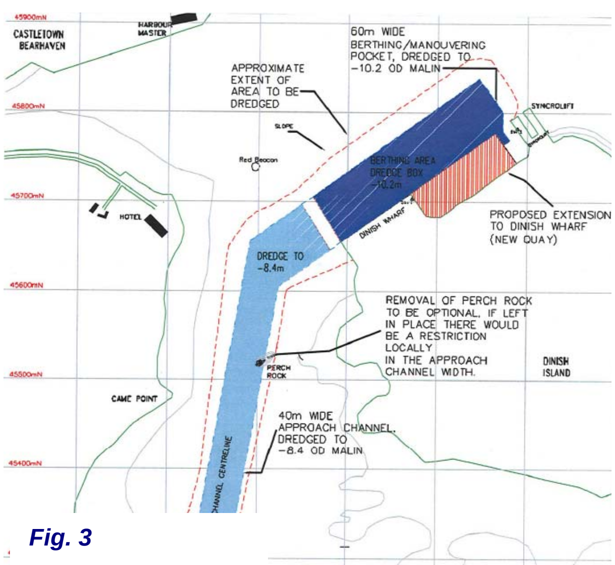


Fig. 3

Accordingly the Contract was structured to provide an initial phase in which the Contractor would carry out further sampling of the sediments, and run whatever pilot process trials were needed to validate the treatment. In parallel, the Contractor would obtain the various Statutory Permissions for the waste operation and disposal.

In this context, we note that Planning Permission and a Foreshore Licence had already been obtained for the permanent works and a Dumping at Sea Licence for suitable material was available.

It should be noted that while the TBT contaminated silts represented a significant part of the contract, the remaining dredging works included 12,500 m^3 of rock, and 62,000 m^3 of clean glacial deposits, mostly clays and gravels.
Continuing with the spirit of the design and build approach, the contract included provision for value engineering, with the benefits to be shared between the Contractor and Employer. This ultimately gave rise to the successful recovery of sufficient fill material to re-claim a substantial area of the foreshore, for example.

Dredging Contract

Following Pre-qualification and Tendering, EDI, the joint venture between Land and Water Remediation Ltd and DEC Environmental Contractors, was appointed.

During the first phase of the contract, extensive sampling of the sediment was carried out by vibrocoring which established the horizontal and vertical profile of the contamination. Consultation with the Marine Institute concluded in agreement to remove 750mm depth of material from areas where surface contamination was present, and greater depths in locations identified as hot spots by the survey.

The strategy proposed for the contaminated material was to dredge it using a sealed bucket to minimize the disturbance under water, and to bring it ashore on Dinish Island to a storage lagoon.

Reclamation of foreshore excavated rocks

The material would be accumulated there, and the water leaching from it would be recovered and treated before disposal back to the sea. Silts were separated from sands and gravels to minimise the volume of contaminated material to be disposed of. The silt was then mixed with cement to stabilize it for transport, further reducing the free water. Once sufficient material had been accumulated, the stabilized silt was shipped from the site to Germany to a licenced disposal site where it would be further treated by the operator before final disposal or re-use.

This methodology allowed the costs to be defined with considerable confidence in advance, and the reduction in commercial and environmental risk was perceived as beneficial to all parties.

The process was subsequently operated under a Waste Permit issued by Cork County Council, with disposal requiring a Trans-Frontier Shipment Licence.

In addition to the dredging required by the quayworks, additional areas of the harbour were also dredged to avail of the opportunity to remove as much of the TBT contaminated material as possible while the appropriate equipment was on site.

Environmental Monitoring

Prior to construction, a dispersion study was carried out to model the potential movement of sediments disturbed by the dredging and the dumping activities. The presence of shellfish farming in the general area was a particular concern, and although the modeling suggested that there was little risk of interference, a turbidity monitoring programme was put in place during the dredging activity. Protocols were established to allow for the temporary suspension of work should excessive turbidity arise.

The lagoon for the holding and treatment of the silt was lined with an HDPE membrane, and soil samples from beneath this were chemically tested before and after construction to verify that there had been no escape of leachate.

Quayworks

There are two separate quays that make up the fishing harbour upgrade. The first quay is a new mass concrete structure of length 102m with a concrete suspended slab behind the quay. The second quay is a replacement for what was an existing concrete wharf. The new mass concrete quay wall was constructed first. That quay is to the east of the original wharf at Dinish Island (refer to Fig. 2) and will connect into the Dinish Wharf replacement structure, which is currently under construction, to provide a continuous upgraded berth of over 214m.

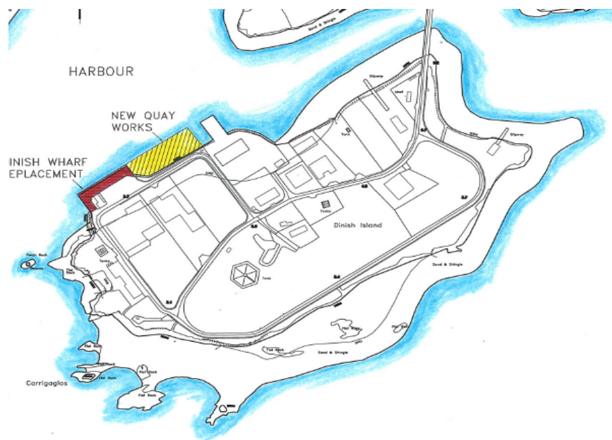


Fig. 2

The completion of the new mass concrete quay allowed the fishing fleet to move onto the new quay from the old Dinish Wharf. The old wharf was then demolished.

Each of the two quay structures has different design and construction aspects, some of these are discussed below.

New Mass Concrete Quay Wall

The Client, DAFF, had expressed a preference for a concrete wall to form the new quay at Castletownbere. A mass concrete wall was selected as the solution and it is designed as a gravity structure resting on the excavated rock bed of the harbour which was formed as part of the advanced dredging contract.

The mass concrete wall is a robust and durable design solution for the new quay and has a minimum design life of 60 years.

The base of the mass concrete wall measures 7m in width. The back face of the wall is stepped so that its width reduces to 5m just above low water and reduces further immediately below cope level. At that point, just below deck level, the rear shoulder of the wall acts as a bearing ledge for a suspended reinforced concrete deck slab behind the new quay.

The suspended concrete deck slab is supported by precast piles and provides a working platform to transfer fish ashore. The overall height of the new mass concrete quay wall is 13.4m. The water depth at Low Water (MLWS) is 8.5m therefore a fishing vessel of draught 7.5m can be accommodated for that tide, allowing a 1.0m under keel clearance.

Mass concrete wall under construction

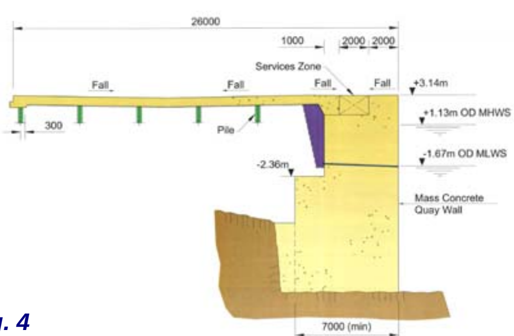


Fig. 4

A cross section through the mass concrete wall and suspended reinforced concrete slab is shown on Fig. 4. The wall has a series of weep holes allowing drainage of the soils behind the wall to control hydrostatic pressure as the tide falls. A drainage trench of granular material is provided immediately behind the wall.

The wall is designed as a gravity structure, and resists sliding and overturning by its weight and base friction over the prepared rock base. There are localised areas of reinforced concrete blocks cast integrally with the wall, these provide anchorage bases for mooring bollards.
Controlling concrete cracking during construction of the mass concrete wall was a design and construction challenge. A cement replacement mix was selected to assist in controlling difficulties with heat of hydration during curing. The wall was to be cast in sections typically measuring 7m in length. Before commencement of construction, the contractor, CIL, proposed a change in the wall by introducing concrete pedestals which were poured in advance of the main sections of mass concrete. These pedestals were full height, but narrow enough to be formed with a single box shutter of manageable weight. Once complete, longer infill panels were poured between the mass concrete pedestals by clamping full height shutters front and back and sealing against the seabed using bagwork. All pours, pedestals and infills, were poured in single continuous pours to almost the full height of the quay.

A services trench is provided immediately behind the wall cope with ducts cast into the concrete works for lighting cables and other services. Water,fuel and power services are provided to berthed fishing vessels.

The suspended slab behind the quay wall is typically 600mm thick and is supported on precast concrete piles. Although back fill has been placed behind the quay wall, the suspended slab is piled to prevent excessive settlement.

The suspended slab is designed for a superimposed loading of 40 kN/m^2.

Dinish Wharf Replacement

The second new quay at Castletownbere is the replacement Dinish Wharf. The existing reinforced concrete wharf was reaching the end of its design life with evidence of wear and tear and significant concrete deterioration. There was evidence of chloride attack on the primary supporting beams to the wharf deck. The existing wharf was therefore demolished and is being replaced by a new structure. The demolition of Dinish Wharf followed immediately after completion of the adjacent mass concrete quay.

The form of structure developed for Dinish Wharf replacement was a suspended reinforced concrete slab supported on steel cased reinforced concrete piles. This form of structure was selected as it matched the features of the ground make up beneath the existing wharf and it was a solution that was compatible with the required construction sequence (a continuation of the mass concrete wall solution would have required significant excavation behind the berth, or, extensive temporary works and it would have been an expensive option as the rock head was deeper in this area).

Photograph of old Dinish lWharf showing evidence of wear and tear on the front face of the structure

A cross section through the new Wharf is shown on Fig. 5. In plan, the wharf is "L" shaped as at its western limit a return section was required for 44m. This was a feature of the original structure. The cased concrete piles feature steel casings of 800 and 900mm diameter, wall thickness 10mm and 13mm. The steel casings are essentially sacrificial in that the reinforced concrete internal pile is designed to carry the full dead and imposed loads. The casings were sunk to the required depth by vibrating and pushing and rotating the casings and augering out the internal material when required. A reinforcing cage was then inserted down the cleaned out casing and grade 50 concrete tremied into the casings.

The contractor requested that the upper sections of the replacement wharf be modified from a cast in-situ design to a pre-cast design. Fig. 5 shows the final solution with precast concrete elements forming the upper sections of the structure.

Precast "doughnut" units were placed on top of the piles to act as landing points for precast concrete units. The doughnuts provide for some tolerance in the as-constructed position of the pile head in relation to the planned location of the pre-cast units. There are different types of precast units that make up the wharf. Solid precast planks form the front face of the wall providing a berthing face. The precast planks have a shear key detail as shown on Fig. 5 to aid structural continuity between the lower

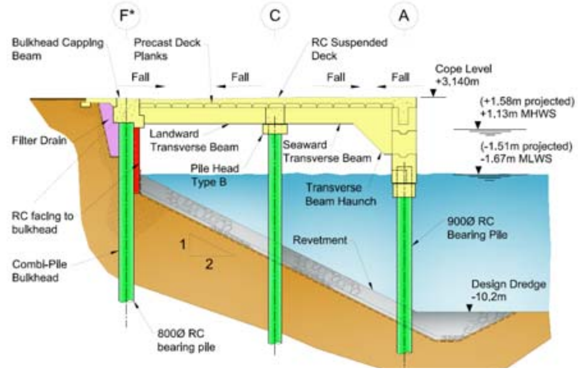


Fig. 5

and upper planks. The front wall acts predominantly as a one-way spanning slab, spanning between the main transverse beams. It is designed to transmit berthing loads to the main transverse beams in the jetty deck and to the upper deck slab. In-situ reinforced concrete stitches were cast above the piles to join the planks together and to form a homogeneous front wall.

Deep reinforced concrete beams (transverse beams) run transversely from the front wall into the wharf deck. These are large precast "U" sections which allowed a steel reinforcement cage to be placed into the units once the precast trough units were placed. In-situ concrete was then pumped into the "U" sections to complete their construction.

The transverse beams feature a wedge shaped drop in their front section that significantly stiffens the beams as they join into the front wall (refer to Fig. 5). The purpose of that detail is to provide a strong load path for berthing loads imposed on the front wall and to carry these loads by direct thrust into the main section of the wharf structure. It was important for the design that the transverse beams were very stiff elements so that berthing loads were carried by a direct thrust via the transverse beam and distributed into the deck. This structural action limited deflections of the wharf deck under berthing loads and made sure that bending moments imposed on the front row of cased precast piles were minimised.

The upper deck slab is constructed by pre-cast planks spanning between the transverse beams. The precast planks have reinforcement placed on their upper layer with an in-situ slab then cast to provide a homogeneous structural element. The replacement Dinish Wharf structure is designed to carry a Super Imposed load of 40kN/m^2.

It was necessary to install a bulkhead wall behind the wharf to retain soil during demolition and wharf replacement. The bulkhead was also necessary to retain support to the existing ice plant structure that was to remain in place and in use during the construction phase. The bulkhead wall consists of a steel combi-piled structure strengthened by rock anchors that run diagonally downwards from the concrete cope beam of the bulkhead into rock behind the works. King piles in the bulkhead are either 914mm diameter, 16mm wall thickness or 1067 mm diameter, 19.1mm wall thickness. 2 sheet piles are clutched between the king piles. The larger king piles were used in the area around the Ice Plant as a stiffer retaining wall was required there to limit soil movement beneath the plant. The bulkhead wall height varies between 12.6m and 17.4m. The rock anchors were a contractor design element, they featured a double corrosion protection system and had an anchor capacity ranging between 95 and 100 Tonnes. The steel combi piled bulkhead is faced with a protective concrete facing.

Services, similar to those detailed into the adjacent mass concrete wall are provided on the new wharf.

Dinish wharf replacement at early stage of construction. Precast doughnuts are shown fixed to the cased precast piles

Common Deck Features Both Quays

Both the new quay and the Dinish Wharf replacement structure feature similar drainage, services and mooring arrangements at deck level. Drainage falls are set at deck level leading water into the drainage system. A number of gate valves are featured giving access to the drainage system for flushing. Fish product debris can easily clog the drainage system and a means of flushing the system is essential.

Mooring bollards are provided at regular intervals along each quay, either side of the safety ladders (2 No bollards every 13m, approximately, 30 Tonne capacity).

In combination, the mass concrete quay wall and the replacement Dinish Wharf provide a total berthing length of 266m and a new working area of 6848 sq.m (0.7 hectares).

Conclusion

The project has had a long gestation, but will shortly be complete, creating a new commercial fishing port which can receive the large vessels now forming the core of the business. The older quays on the mainland will continue to serve the smaller inshore craft and are expected to form the basis for the leisure sector in due course.

Project Team

Client:
Department of Agriculture Fisheries and Food
Lead Consultant and Project Manager:
MottMacDonald Ireland
Marine Engineering Consultant:
Jacobs Engineering
Dredging Contractor:
EDI
Main Civil Works Contractor:
Carillion Irishenco

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