

Figure 1

1.0 INTRODUCTION

1.1 Foynes Port

Foynes Port has traditionally been a commercial port to all sea-going vessels wishing to service the west coast of Ireland. Over the past twenty-five years the port has grown such that in the early nineties, Foynes Harbour Trustees recognised the need to develop a modern deepwater facility capable of handling vessels up to Panamax size.

Over that time the port was used both for export of goods such as frozen meat, bagged sugar, milk powder, and ore materials – barytes, lead and zinc concentrate – and for import of bulk goods such as coal, animal feed, fertilisers, general cargo, molasses and oil products.

The berthage available consisted primarily of the East and West Jetties. The existing West Jetty, 106 metres long, handled vessels up to 22,000 DWT, but was limited in its load carrying capacity, as it was maintained dredged to a level of -10.15m OD (Poolbeg). The East Jetty, 296 metres long, was capable of handling vessels up to 35,000 DWT, which was maintained dredged to a level of -11.3m OD, i.e. below Mean Low Water Springs.

The bulk liquids berth consists of two dolphins linked to the shore, and was constructed in 1992. This available berthage also included 140 metres of

shallower berthage at the West Quay, which could handle vessels up to 6,000 DWT at suitable tides.

1.2 New Deepwater Facility

Foynes Harbour Trustees, recognising the need to progress the development of the port, made application in 1993 under the National Development Plan to the Department of the Marine and Natural Resources to carry out works to extend the handling capability of the port by construction of new jetty facility, dredging, and provision of port related infrastructure. These proposals were subsequently incorporated in the commercial seaports measure of the EU Operational Programme for Transport 1994-1999.

The steady growth in port traffic from typical 660,000 tonnes handled in 1983 to 1,275,000 tonnes handled in 1993 indicated the need for the development. A pre-feasibility study was commissioned in 1995 by Foynes Harbour Trustees to determine the optimisation of the proposed development. This study formed the basis of the new work incorporating the deepwater facility.

1.3 History

Foynes Harbour, having a good sheltered location from heavy seas and

ground swell, has been an important harbour for many years.

The earliest harbour works of importance were begun in 1846 with the construction of a masonry wharf 83 metres long and 12 metres wide in the location now known as the West Quay.

The cost of these works was essentially funded by Lord Monteagle whose family has long been associated with Foynes.

The Foynes Harbour Trustees were formed in 1890 and they immediately constructed a short timber jetty on greenheart piles running from the end of the masonry pier. This timber structure was later removed in 1934 to make way for the new West Jetty.

A spur from the foreshore at the eastern end was constructed in 1915. It was 46 metres long and 5.5 metres wide and consisted of cast in-situ concrete beam and slab placed over precast piles and precast concrete walls. This structure remains in place today in good working order.

The West Jetty structure was constructed in 1936 to service vessels up to 8,000 tonnes displacement and 7.6 metres draught. This was a concrete structure founded on precast concrete piles driven to firm stratum in groups, with cylindrical heads filled with in-situ concrete at the top of the pile extending through a splayed concrete pile cap to in-situ flat slab concrete deck.

This structure was upgraded as part of the new works.

Further berthing facilities were provided in 1968 when the first element of the existing East Jetty, 144 metres long, together with concrete access viaduct was provided, followed by an extension of 155 metres in 1984 to complete this jetty. The dolphin system to enable import of oil and chemicals was completed in 1992.

Under the Harbours Act 1996, Foynes Harbour Trustees was replaced by Foynes Port Company in March 1997. The extent of the jurisdiction of the port was determined and this enabled an overview to be taken on the capital works programme relating to future marine infrastructure.

2.0 DESIGN APPROACH

2.1 Pre-Feasibility Study

The pre-feasibility study commissioned by Foynes Harbour Trustees in 1995 was carried out by H R Wallingford Limited. It addressed four main aspects:

- Alternative jetty layouts, forms of construction and costs
- Analysis of trade and berth occupancy to assess future demand for berthage
- Desk studies on navigation and requirements for navigation channels and turning areas
- Examination of siltation risks based on desk studies and field measurements

(i) It was confirmed that the proposed layout suggested by the port was feasible from an engineering point of view. Ideally filling should be right up to the back of the quay to maximise access but ground conditions subsequently precluded full implementation of this. Alternative structural forms were examined.

Sheet pile quays were impractical because of the presence of unsuitable ground (soft silts overlying boulder clay and rock).

Serious consideration was given to gravity structures – block-work walls and caissons – but it was concluded that the unevenness of the underlying strata, plus the need to remove soft silty material to provide adequate foundations made them impractical. Sites for construction and launching caissons were also not available conveniently.

An open piled deck was therefore selected supported on tubular steel piles. A standard design loading of 25 kN per

square metre was initially considered. However, port experience on the East Jetty with the flexibility for crane loading given by a higher design capacity of 75 kN per square metre meant that this eventually prevailed.

(ii) The berth occupancy studies showed that the East Jetty was the most heavily used facility and that, if trade forecasts were correct, additional berthage in addition to the proposed extension of the West jetty would be required within the time frame 2001 to 2005. These predictions of pressure for additional berthage are already being confirmed in practice.

(iii) The navigation study concluded that the size of the navigation channel and turning circle were below PIANC recommended standards. In particular, the constraint at Barneen Point would require attention by dredging and land removal. The study also concluded that navigation aids should be improved in the port and in the East Channel so that vessels leaving the port could use them.

(iv) Siltation in the port was shown predominantly to be caused by the ebb tide through the harbour and it was concluded that the new berth at the West Jetty would have some increase on the maintenance dredging commitment. Flow and siltation modelling studies were recommended for the port and its approaches.

2.2 Project Planning

Based on the pre-feasibility study, Michael Punch & Partners initiated a preliminary design review of the proposal for the new development in consultation with Foynes Harbour Trustee Management in 1995. Studies of the scope of the works required to bring the project to completion were undertaken and decision made as to the sequence and the extent of the works.

Decisions were taken as follows:

- Set up a flow model of the port and carry out siltation monitoring prior to completing navigation to determine the best option for new approach to the upgraded berths.
- Carry out the jetty construction works as a single contract including any ancillary works such as installation of new navigation lights, landing stages for small craft using the port, and provision of support buildings.

- Complete the works with a separate dredging contract.

2.3 Navigation Studies

Following receipt of tender submissions from a number of hydraulic specialists, in 1996, H R Wallingford Limited were commissioned by Foynes Harbour Trustees to carry out Navigation Studies of the port approaches and within the inner port area so as to fine tune the proposals for the new West Jetty and the associated capital dredging works. As well as setting up a port model, a number of real-time simulations were carried out at H R Wallingford's premises in UK using the H R Mardyn simulator. Foynes Harbour Trustees pilots participated in simulation exercises to ensure that they were satisfied with the results.

The results of these studies were used to:

- (a) Assess the projected rates of siltation arising within the Harbour.
- (b) Determine the optimum dimensions for vessel manoeuvrability in respect of both daylight and night time navigation.
- (c) Establish the new approach channel to the port and thereby determine the extent of dredging necessary to achieve these defined areas.
- (d) Confirm the appropriateness of navigational aids, particularly at night.

Conscious of the need to set up the port model correctly and to determine the optimum manoeuvres, significant time was allowed to carry out the fieldwork and subsequent analysis prior to issue of report. The results obtained were then used to determine the extent of the Capital Dredging Works to conclusion.

2.4 Jetty Design Concept

An integrated Design Team approach was adopted from an early stage of the project design. Together with Michael Punch & Partners as Team Leaders, H R Wallingford Limited specialist marine consultants advised on the fundamental design elements, and Healy Kelly & Partners Chartered Quantity Surveyors were retained as quantity surveyors.

Conceptual design on the new jetty commenced in 1995. Initially a view had to be taken on the existing West Jetty and in particular its further design life.

A desktop study of old drawings and site data in the possession of Foynes Harbour Trustees was carried out. Preliminary calculations were made on the adequacy of the structure and a view taken on its load carrying capacity. In this instance the Paper on the “New Deep-Water Jetty at Foynes, Co Limerick” by H A Delap and T A Simington published in 1938 by the Institution of Engineers of Ireland was most helpful.

The clients brief called for extension of the existing West Jetty eastwards for a distance of 164 metres and an upgrading of the existing jetty. With respect to the existing structure, it was considered that a load test on single pile unit be carried out to verify load carrying capacity. After some investigation, it was agreed that such check would be too onerous and would require significant opening up and destruction of existing structure.

A design decision was taken to ignore the structural support provided by the existing West Jetty in any new scheme. It was therefore decided to pile through the existing deck and to cast a new in-situ flat slab supported as a temporary works measure off the existing deck but designed to span onto the new piles.

It was also decided to include ancillary works such as provision of two new landing stages for small craft on the mainland in lieu of the existing landing stage being made obsolete by the new construction. This work also included provision of new landing stage at Foynes Island.

The jetty is designed to take a 35,000 DWT bulk carrier vessel fully laden or a partly laden vessel of 45,000 DWT. The jetty length of 270 metres is such that it can accommodate both a 35,000 DWT vessel and a 22,000 DWT vessel simultaneously.

2.5 Dredging

The design approach to the scope of the dredging works was determined by the requirements of Foynes Port Company to provide deepwater berthing for larger vessels at all stages of the tide. In particular, the design dredge levels to – 12.0 m OD in the berths and to – 8.1 m OD elsewhere in the inner port area were requested at an early stage.

Studies were carried out on the approaches to the berths and on turning circles within the inner port area, and the limit of the dredge was determined. This dredge limit was then verified or modified as appropriate when the real time simulation studies were carried out.

2.6 Operational Issues

Arising from the signing off of the design criteria, the following operational issues were determined:

- The port is capable of handling vessels up to Panamax size partly laden subject to dimensional checks on vessel.
- The limit of size of vessel is so determined by the ability to swing the vessel within the inner port area.

- The maximum size of vessel which can be handled following the completion of the development is:

Length	204 m
Beam	29 m
Working draught	10.5 m

The live load capacity of the new jetty is 75 kN per sq metre. This provides for operation of large mobile cranes at any position on the new jetty.

3.0 PRELIMINARY DESIGN

3.1 Overall Design Considerations

The new West Jetty structure is designed as two independent structures. One structure forms the extension to the east while the other occupies the area of the old West Jetty. This is primarily due to the difference in site conditions between the two elements, as work over water and work from a solid platform require different design approaches. Another important reason for the incorporation of independent structures with separate construction phases, is the client’s requirement to have use of as much of the available quayside facilities as possible during construction. The works were therefore set out on a phased basis to enable partial hand-over to take place midway through the contract.

The phase 3 element of the new West Jetty is a marginal quay structure and occupies the western 106 metres of the new jetty, while the remaining 164 metres is offshore and accessed from the west by the marginal quay and from the east by a new concrete viaduct.

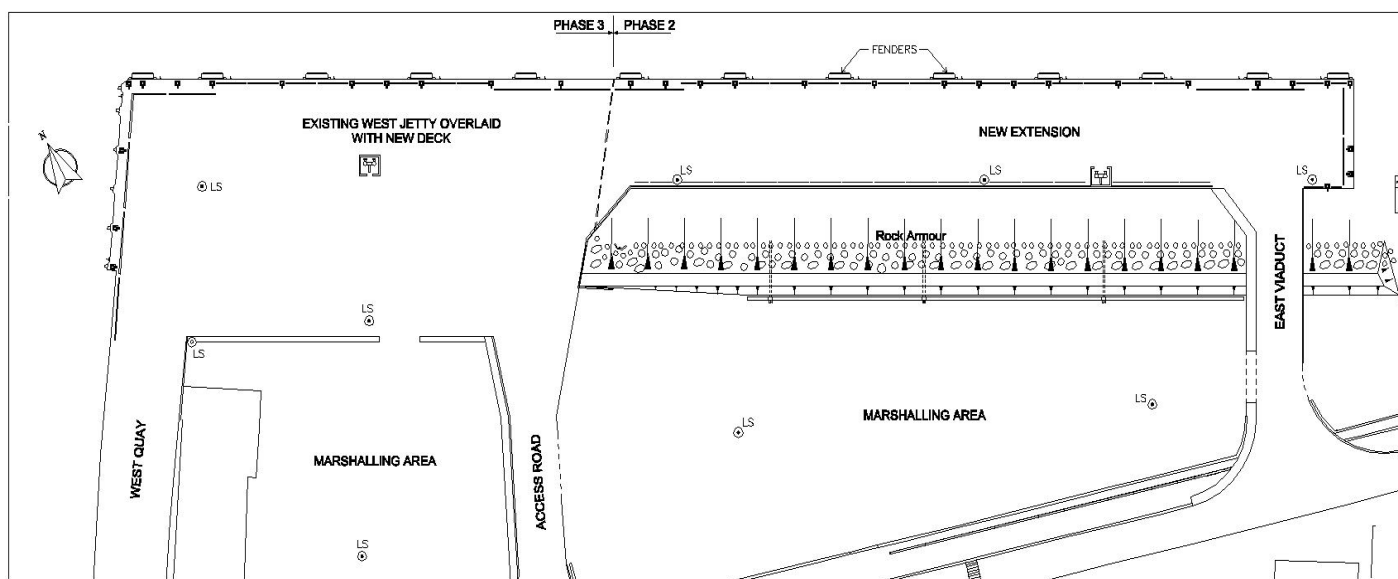


Figure 2

The phase 2 jetty extension is given lateral support at the west end by a group of raking piles. The extension is given lateral support at the east end from raking piles on the land-ward end of the concrete viaduct. The jetty deck spans horizontally between these two strong points to resist any applied horizontal lateral loads. The phase 3 jetty upgrading is given lateral support along the central 70 percent of its length also by raking piles. Applied horizontal longitudinal loads are resisted through portal action of all 102 no. piles in phase 2 and 69 no. piles in phase 3.

3.2 Load Conditions

As discussed in item 2.1 above, the design loading for the deck was established as a characteristic imposed blanket loading of 75 kN per Sq metre. This loading relates to the deck area nearest the berth for a distance of approximately 18 metres from the berth.

The open tidal basin at the rear of the existing West Jetty was designed to be filled with a structural deck, which has a characteristic imposed load capacity of 35 kN per Sq metre. The access viaduct at the eastern end of the new extension also has a characteristic imposed load capacity of 35 kN per Sq metre. The horizontal characteristic berthing load on the structure is 2000 kN when transferred through the fender system, and characteristic bollard loads are 1000 kN.

3.3 Preliminary Design – Layout and Sizes

The structure is designed to maximise the use of precast concrete elements to provide a permanent shutter and working platform for insitu works while minimising the amount of temporary works over water.

The structure of the extension at the West Jetty is designed as a composite concrete three-span deck spanning continuously between support beams running longitudinally along the length of the extension. The beams are at 6.39 metre centres. The concrete deck is 550mm thick consisting of 200mm solid precast pre-stressed concrete slabs topped with 350mm of insitu reinforced concrete. The entire deck is at a gradient of 1:100 for drainage.

The support beams are also designed as a composition of precast and insitu concrete and span between piles driven at 7.62 metre centres along the line of the beams. This dimensional grid was determined by the spacing of existing piles at the old West Jetty. The precast beams are 1500mm wide

and 850 mm high and span from pile to pile. In situ pile caps connect the beams and transfer the loads to the pile. The full slab depth of 550mm over the beams is incorporated in the composite design of the beams. The piles are 1067mm outside diameter, with a wall thickness of 25mm.

The access viaduct to the eastern end of the extension, and the old west basin infill slab are also of composite concrete construction.

4.0 PROJECT PLANNING

4.1 Planning Permission and EIS

Planning permission was sought from Limerick County Council in mid 1996 for the development works proposed. The application was accompanied by an EIS.

The scope of the EIS included detailed examination of the environmental effects arising during the construction period. Sediment analysis that had heretofore been carried out for previous dredging works, were reviewed and used as a baseline for input into EIS. Observations were made by third parties during the planning period.

Planning permission for the works was issued in January 1997 with 7 no. conditions attaching.

4.2 Foreshore Lease

Prior to the submission of application for Foreshore Lease for the Jetty Works, detailed discussions were held with the Department of the Marine and Natural Resources. The lease was duly issued in December 1997 prior to the main works proceeding.

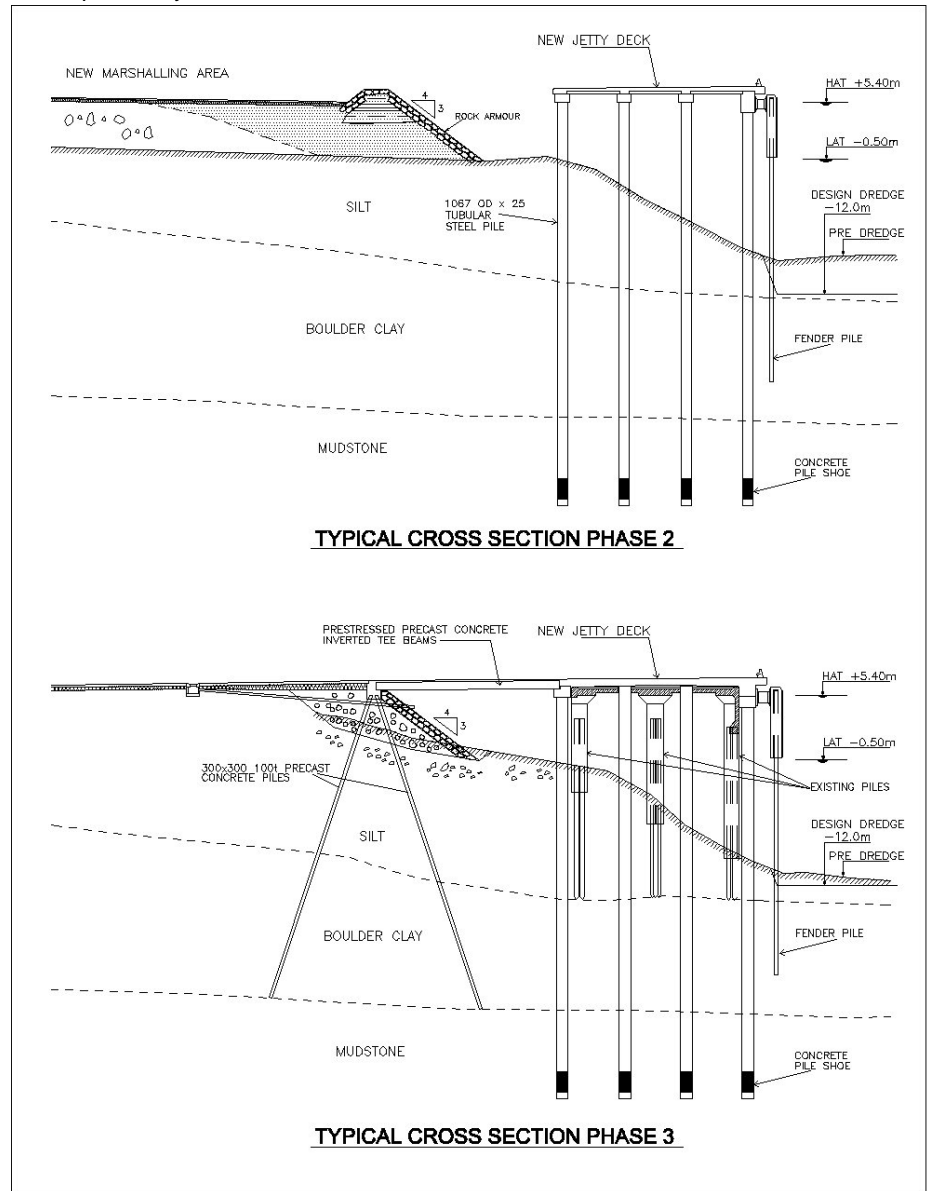


Figure 3

PROGRAMME

Activity	1998												1999												2000	
	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	
Jetty																										
Mobilisation	■	■																								
Phase 1																										
Landing Stage			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Phase 2 - Piling																										
Pile Tests			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Tubular Pile Driving			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Fender Pile Driving																										
Deck Construction																										
Precasting of deck beams & slabs			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Installation of precast deck			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Installation of precast T beams																										
In situ topping over precast																										
Phase 3 - Piling																										
Pile tests			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Tubular Pile Driving																										
Concrete Pile Driving																										
Fender Pile Driving																										
Deck Construction																										
Precasting of deck beams																										
Installation of precast T beams																										
In situ topping over precast																										
In situ slab over original deck																										
General Jetty items																										
Fill and rock armouring																										
Precast / in situ concrete fenders																										
Ancillary Works																										
Dredging																										
Mobilisation																										
Trailer suction dredger																										
Rock drilling and blasting																										
Backhoe dredging																										
Ancillary works																										

Figure 4

4.3 Site Investigation

Simultaneous with the detail design work, a site investigation contract was put in place over the period June to September 1996.

The investigation consisted of shell-and-auger and rotary core test holes using NQ (Samples of 57mm diameter) and HQ (Samples of 64mm diameter) rigs from floating pontoons, and a PQ rig (giving 87mm samples) working from the existing jetty deck. Core samples were difficult to obtain, as recovery was poor arising from poor quality rock.

It was confirmed at an early stage that the site covers a geological fault zone, so extra trial borings were made to determine the extent of the anomaly. This fault was in the form of a buried valley in the area midway along the phase 2 jetty extension. A sand deposit was found at depth in this valley. The general pattern of the stratum recorded was silt, overlying clays with boulders on to a very poor mudstone rock.

The investigation also revealed that the piles to the existing West Jetty were founded on boulder clay at the east end, and not on rock as thought at the time of driving these piles.

The interpretative report and corings taken were reviewed in detail by the design team prior to issue of tender documents. Also the tendering contractors were invited to examine the samples on site.

4.4 Tendering for Jetty

The tendering process was to comply fully with Council Regulations (EEC) 2082 / 93 and 2083 / 93. It was decided that the method of procurement of the project was to invite applications from contractors for inclusion in a tendering short list. A contractor pre-qualification notice was published in the OJEC in May 1997.

A total of twelve applications were received from which seven contractors were selected and issued with full tender documents on 2nd July 1997. Tenders were received from each of the contractors on 1st September 1997. After reporting to Foynes Port Company following the opening of tenders, a reduced scope of works was determined and a decision was taken in December 1997 to award the jetty works contract to Ascon Limited.

4.5 Jetty Contract

The contract commenced on 2nd February 1998. Whilst the contract duration called up in the tender documents specified a contract duration of 82 weeks, the contractor's programme stated a 52 week completion. The construction programme over-ran by 7 weeks from a time very early in the contract, due to difficulties encountered in piling in April and May 1998. The contractor, however, continued working

to the contractual programme and substantially completed the contract with this 7 week over-run. Some extra works were incorporated in the contract at the conclusion of the works, which extended the contractors duration on site. The contractor demobilised from site for the main works in September 1999.

5 DETAIL DESIGN & CONSTRUCTION

5.1 Jetty Pile Design

The agreed design approach for the founding of the tubular piles was to provide open ended tubular piles driven to the firm fluvio-glacial till (boulder clay) or sedimentary mudstone rock. Such piles perform and are designed to reach their working capacity by forming a plug within the shell core when driven through boulder clays. The appropriate schedule of pile lengths was drawn up on the basis of penetration into the boulder clay (6 x pile diameter) in accordance with the API code.

5.2 Pre-Compression Load Testing of Piles

A number of pre-compression pile load tests were carried out prior to driving the permanent phase 2 and phase 3 tubular piles. The design load requirement for the new

construction is 75 kN per Sq metre which generates a working pile load of 550 tonnes. It was found during the tests that the boulder clay could not sustain this load and the full test load was not attained. Further investigation of the boulder clay revealed the presence of the geological fault such that the deposits were of a much coarser nature than originally determined during the initial site investigation.

After review of the information from the test piles and the further investigation, a decision was taken to provide concrete plugs in the toe of the pile so as to enhance the load carrying capacity of each pile. The piling was then carried out in a satisfactory manner and no undue difficulties were found in obtaining the necessary pile set. The weak sedimentary nature of the mudstone bedrock (UCS below 5000 kN per Sq metre) meant that the piles were, in some cases, driven beyond their

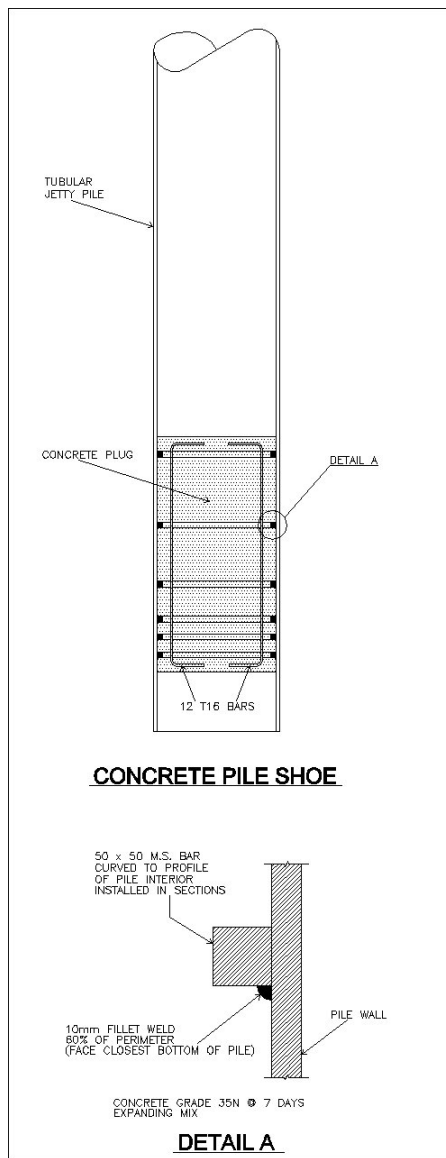


Figure 5

design length which necessitated an extension and re-driving of the pile to obtain the required design pile set.

5.3 Pile Types

The tubular piles for the support of the jetty deck are 1067mm outside diameter 25mm thick. There is a corrosion allowance on the wall thickness - without cathodic protection or protective coatings - for a design period of 50 years. This corrosion allowance is based on British Steel recommended corrosion allowances for a marine environment. The grades of steel used are API grade X60 / X65, which satisfy the requirements of BS10025 grade S355 GP (Grade 50).

At the toe of many of these piles a closed-ended shoe was fitted. A method of transferring the large driving forces from the shoe to the steel wall of the pile in a suitable manner needed to be devised. The method used was to insert a plug of concrete within the bottom 2500mm of the pile prior to pitching.

In order to transfer the loads from the concrete plug to the wall of the pile, mild steel shear connectors in the form of 50mm square bars were welded to the inside wall of the pile prior to installation of permanent shutters. The cavity was then filled with the concrete mix incorporating admixture to reduce shrinkage of the concrete. This helped to give an intimate bond between the face of the concrete and the wall of the pile, improving the shear capacity of the shoe within the pile.

Non Destructive Testing of pile material was carried out using radiographic and ultrasonic methods before sign-off of pile fabrication welds carried out both on-site and in the fabrication works in Middlesbrough.

Precast concrete piles 350mm square in section were driven at a rake of 1:3 at the bank-seat on phase 3 of the work to support the bank-seat and stabilise the phase 3 deck under lateral loads. No tension is developed in these piles under lateral loading due to the weight of the deck overhead.

356 x 406 634 kg/m steel H piles were driven for the fenders in the main berths and in the return berths on the western side of the jetty. These piles were designed as cantilevers from the underlying stratum. Independent specialist verification of the agreed pile size was provided by the contractor for the fender piles.

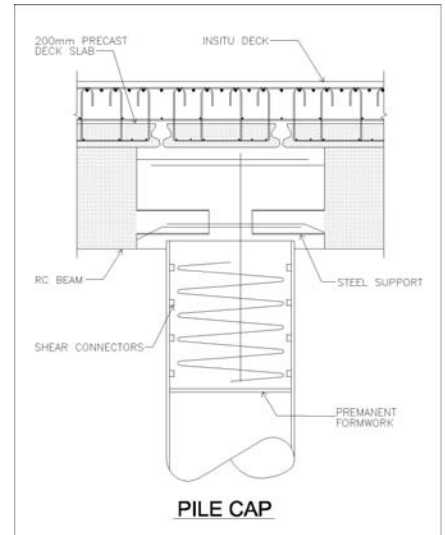


Figure 6

5.4 Piling

The large tubular piles were driven by Delmag D55 and Delmag D62 diesel piling hammers. These were operated on a flying leader from a 150 tonne tracked mobile crane located on the shore or from a large floating barge, the 'Marlin', equipped with fixed leader. This barge is 60 metres in length and 23 metres in width and was also used to position the first precast concrete beams. The 'Ascon 5' barge was also used in the latter stages of the project.

Based on the test driving monitored during the pile tests, the tubular piles were driven to a set of 35 blows for 50mm. This set was generally achieved in a single set-up. However, some piles had to be re-driven after a period, in order to verify the set.

5.5 Pile Caps

At each pile head, a method of transferring the large forces from the concrete to the steel wall of the pile in a suitable manner needed to be devised. The method used was to create a plug of concrete within the pile for the top 1250mm. A permanent shutter was slung from the rim of the pile.

In order to transfer the loads from the concrete plug to the wall of the pile, mild steel shear connectors in the form of 25mm square bars were welded to the inside wall of the pile above the permanent shutter. This gave the edges of the concrete plug sufficient bearing area to transmit the loads safely and uniformly to the wall of the pile and down to the bearing stratum. This element of the pile cap was usually cast only when the upper element between the precast beams was also ready for casting.

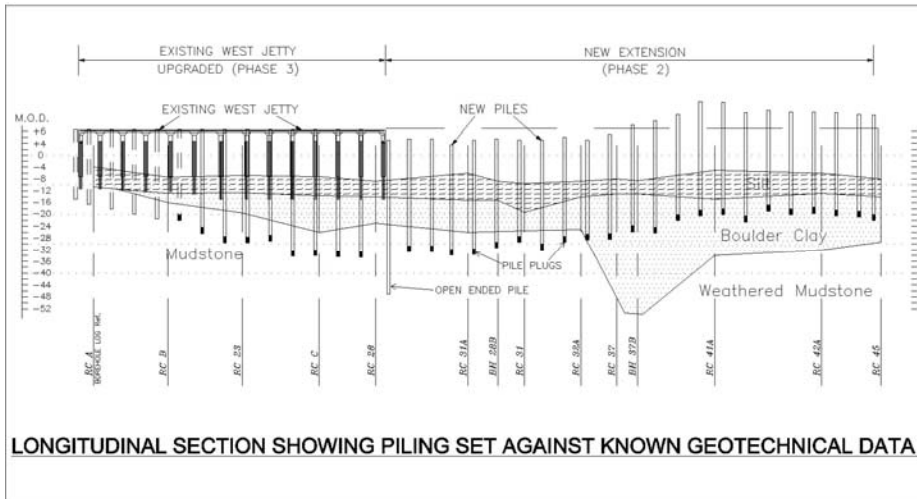


Figure 7

In some cases, where the pile heads were out of position, increasing the pile cap dimensions to encompass the pile head accommodated the piles.

5.6 Precast Beams – Phase 2

The deck spans between reinforced concrete beams. The beams were precast on site in a precast yard set up by the contractor within 200 metres of their final position. The beam dimensions were 1500mm wide and 850mm deep, so chosen to facilitate tolerances in the pile locations after driving.

The grade of concrete used was 42.5N20 with minimum cover to reinforcement of 65mm. This design complies with Table 3.4 of IS 326, Part 1. The two critical design criteria were ultimate limit strength and crack widths. The maximum crack width under full imposed loading is 0.29mm.

The beams were cast to fit between the pile heads and had two steel beams extending from each end to allow the beam to be rested on the top of the pile when cut-off to the required level. The concrete beams had the ends and top surface treated to expose the aggregate

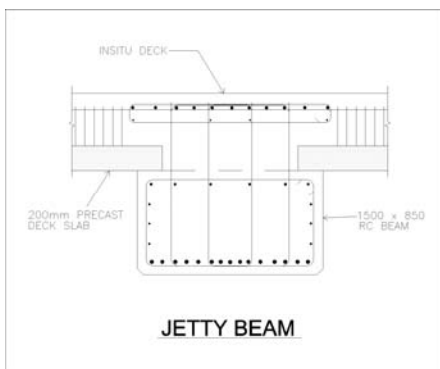


Figure 8

and give the beam a good bond with the insitu concrete, which would later be cast over it.

The steel beams extending from the ends of the concrete beams were required to carry only the weight of the beams alone in the temporary condition. Before the precast deck slabs could be placed on the beams, the upper portion of the pile cap was poured between the ends of two opposing beams over a single pile. The reinforcement projecting from each beam would lap with the corresponding reinforcement from the other and, when cast, the pile cap would form a continuous beam running the length of the jetty extension.

Vertical reinforcement projected from the top of the beams to tie into corresponding reinforcement that would later be placed within the insitu slab. In this way the down-stand beam acted compositely with the slab and utilised the full depth of the beam/slab combination to minimise the effect of bending moment on crack widths and ultimate limit state design.

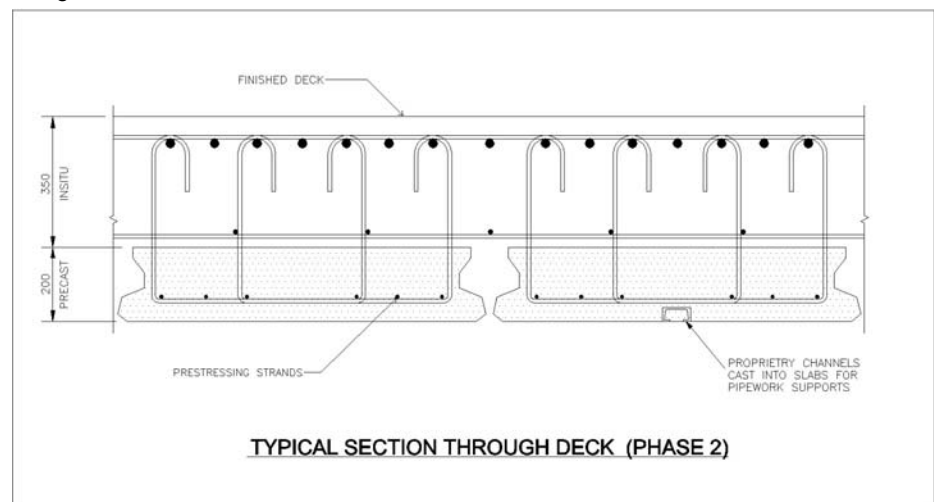


Figure 9

Further beams were installed parallel to the span of the deck slabs at 22.86 metre centres for the purpose of stiffening the deck as a whole when the deck slab is under lateral loading and spanning horizontally as a deep beam between the strong points at either end.

5.7 Insitu Beams

Some beams located on the grid-line nearest the berth could not be constructed in precast concrete due to their larger size. This size is due to the presence of large fenders at 22.86 metre centres along the berth, offset ship-ward of the cope-line by approximately 1300mm. The soffit level of these beams is 1100mm below that of the precast beams on either side. As a result these beams were constructed in insitu concrete. This work necessitated a substantial amount of temporary works, much of which was below high water, and thus accessible only for several hours each day.

5.8 Deck Slabs – Phase 2

With the beams cast in position over the piles, the precast deck slabs were lowered into position on the beams. The precast deck slabs were fabricated off-site by Banagher Concrete at their works in Co. Offaly. The grade of concrete used was 60N20 with minimum cover to reinforcement of 50mm.

The precast slabs were solid slabs 5250mm in length, were 200mm in thickness and were pre-stressed using 12 no. cables of 12.9mm diameter superstrand giving a total pre-stressing force of 1674kN per slab. Reinforcement extended from the top of the slabs in the form of T10 open links. These links were used to tie to the reinforcement at the top



Figure 10

of the composite slab in the insitu concrete topping.

The width of the bearing shelf provided on the precast beams on each side was 180mm. Over the 200mm precast deck slabs, a concrete topping of 350mm was poured to complete the deck construction. The grade of concrete used was 42.5N20 with minimum cover to reinforcement of 65mm.

The precast deck slabs are designed to support the weight of the wet concrete topping in the temporary construction condition. The composite section is then available to resist imposed loading. Such analysis must take into account, however, the stresses already locked into the precast member under loading from wet concrete.

5.9 Bank-seat Beams

The bank-seats are reinforced concrete beams poured in situ on the foreshore to provide a line of support for a series of parallel T-beams which span from the foreshore onto a corresponding line of support on the outer suspended structure, called the jetty-seat.

The bank-seats are located on phase 2 at the eastern viaduct and also on phase 3 on the basin in-fill deck behind the area of high strength jetty deck.

In each case the bank-seat forms a strong point for stabilising the jetty as a whole against lateral loads such as berthing or mooring loads.

In phase 2, the bank-seat sits on 8 no. 473mm outside diameter steel tubular

piles. The piles are raked at a pitch of 1:3 to provide lateral stability. The raking piles are augmented by a down-stand reinforced concrete skirt, which runs the full length of the bank-seat beam and resists lateral movement of the jetty through the build-up of passive pressure with the surrounding soil. The weight of the TY7 bridge beams that span onto the bank-seat ensures that even under abnormal berthing forces, the piles remain firmly bedded into the shallow rock.

In phase 3, the bank-seat is supported on a line of raking precast piles. The weight of the TY7 bridge beams ensures that no tension develops in the piles even under abnormal berthing forces.

5.10 TY7 Precast Bridge Beams

The TY7 precast bridge beams were fabricated off-site by Banagher Concrete at their works in Co. Offaly. The grade of concrete used was 60N20 with minimum cover to reinforcement of 50mm.

TY7 bridge beams are precast prestressed inverted T beams normally used for bridge spans. They are used in this project to allow heavy vehicular movements to and from the main jetty deck. The T beams used were up to 17.5 metres in length and were pre-stressed using 35 no. cables of 12.9mm diameter superstrand giving a total pre-stressing force of 4882.5kN per beam. The individual beams were 750mm wide and 750mm high overall.

28no. beams are located on phase 2 at the eastern viaduct and 94no. on phase 3 on the basin in-fill deck behind the area of high strength jetty deck. The T beams are used for bridging the long spans necessary to reach the jetty from the foreshore, minimising the need for intermediate supports.

As discussed, the TY7 beams also serve to provide lateral stability to the structure as a whole under conditions of lateral loading, through their ability to transfer the lateral loads from the point of application of the load at the berth, back to the raking piles at the rear. The jetty-seat beam connection with the TY7 beams is designed as a continuous connection. The connection was designed to resist the high bending moments attracted from such a long span under imposed loading.

The TY7 beams are placed side by side, with each additional beam adding 750mm to the width of the composite slab. The beams are constructed with openings at corresponding centres along their length to facilitate the threading of reinforcement through the beams to be encased in the insitu topping and tie the entire slab together. The overall depth of the composite slab is 850mm.

The holes nearest the ends of the T beams are placed such that they align with each other within the reinforcement cage of the bank-seat and jetty-seat, improving the robustness of the structure.

5.11 Flat slab – Phase 3

The presence of an original deck over much of the phase 3 area provided the opportunity to save costs by utilising the original deck where possible for use as a permanent shutter to the new concrete deck.

It was decided to use a flat slab design where the interference with the

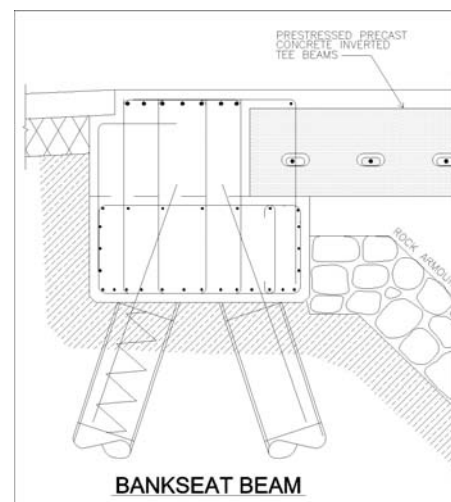


Figure 11

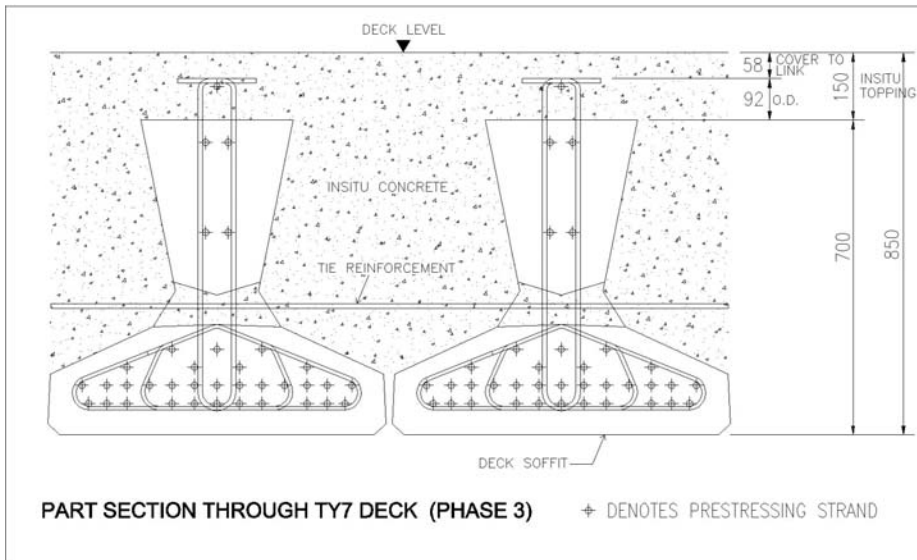


Figure 12

original deck structure would be limited to the locations of piled supports spaced at a 7.62 metre by 5.6 metre grid.

Due to the uneven surface of the original deck, and the gradient applied across the new deck for drainage purposes, the thickness of the flat slab varies from 400mm to 650mm. The loading on the flat slab was such that it necessitated the use of substantial shear links at pile head locations.

5.12 Fenders

The fender system is required to prevent damage to the berthing vessel and the jetty structure. It does this initially by presenting a large surface area for contact with the ship. This serves to limit the pressure exerted on the hull during berthing to 30 tonnes per Sq metre. The fender panel size adopted to achieve this was 6.7 metres high, 4.75 metres wide, and 1.0 metre deep. This size was determined to an extent by reference to existing fenders within the port, which have been operating successfully for many years.

Secondly, the berthing energy of the vessel is absorbed and channelled away from the point of contact in a controlled manner through the use of rubber cell fenders located between the fender panel and the jetty deck.

Initially, it was thought that drop cantilever facing panels with energy absorbing cell fenders behind would be acceptable. However, taking into account previous port experience, it was eventually decided that the robustness of having the fender panels supported directly on fender piles would be desirable.

The configuration eventually adopted is shown in section in figure 14 and involves each fender having a facing panel of concrete with rubbing facing strips of very low friction ultra high molecular weight polyethylene (UHMW – Pe).

Each 6.7 metre by 4.75 metre panel is supported on three no. heavy-duty (634 kg/m length) Universal Column steel H section piles which also absorb some of the energy on vessel impact. The piles are driven to a depth that enables them to be restrained against bending at their toe and to support their self-weight and the weight of the concrete fender panel. However the founding levels are significantly higher than for the main steel

tubular piles.

Each panel is braced against the deck by two 1200mm-diameter cell fenders that compress on vessel impact to absorb the energy of the vessel. The rubber cell fenders can compress to within 60% of their uncompressed length, and apply a gradually increasing load of up to 200 tonnes to the jetty deck, under berthing conditions. The energy capable of being absorbed by each fender panel is 85 tonne metres. The cell fenders were manufactured in Korea by Kum Nam Chemicals Inc.

Despite the presence of low friction facing on the fender panels, a friction load may develop at the contact face between the fender panel and the berthing vessel, and must be considered in the design of the fenders. If the berthing vessel has a component of velocity parallel to the line of the quay, the fender panel in contact with the hull is, to a certain extent, pulled in the same direction. To limit the deflection of the concrete panel, it is surrounded by concrete thrust blocks, which resist further panel movement. The nominal at-rest gap between the concrete panel and the thrust blocks on either side is 75mm.

The fender panel consisted of the bottom portion of the panel, which was precast on the foreshore, and the upper portions, which were insitu.

The precast portion incorporated three hollow shafts running the full height of the unit to allow it to be lifted into position over the three vertically driven H piles.

The precast panel was secured in



Figure 13

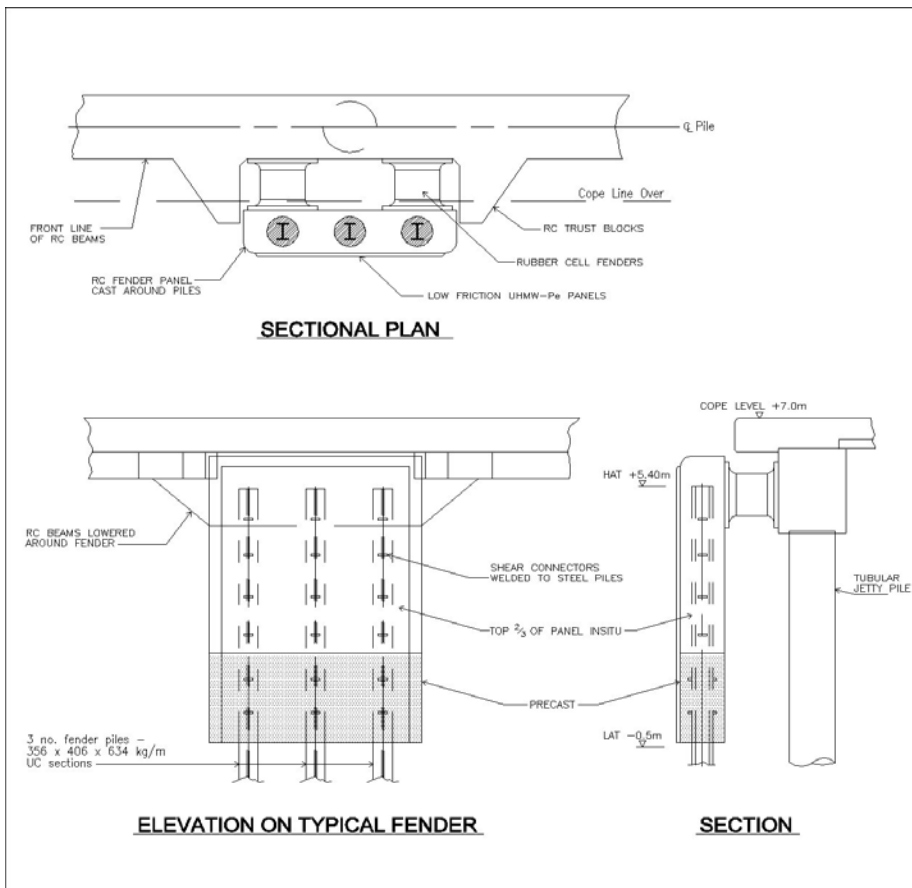


Figure 14

position by filling the space between the fender piles and the inner face of the hollow shafts with insitu concrete. Mild steel shear connectors in the form of square bars were welded to the fender piles to allow the transfer of load from the precast panel to the fender pile. The shear connectors were designed to carry the load from the second lift of insitu concrete. Further shear connectors were welded to the pile prior to pouring insitu concrete, to distribute the load in the long term.

The very low friction ultra high molecular weight polyethylene facing panels were fixed to the concrete fender by proprietary anchors cast into the concrete at 410mm centres. The facings were fitted with chamfered edges to minimise the likelihood of vessels removing the panels.

The two 1200mm diameter energy absorbing cell fenders were similarly fixed to the concrete elements using proprietary anchors cast into the concrete, using a template to ensure proper alignment.

5.13 Quarry Fill / Rock Armour

The quarry run limestone rock-fill for the project was sourced within the port lands approximately 1 kilometre from the site. Rock armour material was also sourced from this location and used to protect the foreshore behind the West Jetty and at the eastern and western landing stages.

5.14 Bollards

32no. 100 tonne twin bitt 'D' base one-piece cast iron Bean bollards Type 11-10-A-40 are fitted to the West Jetty for the mooring of vessels. They are fixed to the deck of the West Jetty via an arrangement of cast-in grade 8.8 bolts, 7no. 64mm diameter and 2 no. 28mm diameter.

5.15 Water main / Fire main

Separate water main and fire main are provided on the West Jetty. The water main is located under the jetty deck close to the berth where it is primarily used as vessel supply. The fire main is located further back under the jetty deck. Both systems comprise of closed loop

supply networks connected to existing port systems.

The water main is 100mm diameter and fire main is 150mm diameter. Both supplies are provided under the jetty deck through ductile iron pipes, which are cement lined and bitumen dipped with spigot and socket connections.

5.16 Oil pipeline

The West Jetty incorporates a facility for loading heavy fuel oil from suitable vessels for the benefit of a port operator. To maximise the flexibility of the use of the West Jetty, there are two loading stations provided, located approximately 50 metres from each end of the jetty.

Due to the viscous nature of the liquid using the pipeline, it is heated prior to loading to reduce its viscosity. As the required temperature may be as high as 80 degrees Celsius, it was necessary to incorporate a number of expansion joints within the pipeline. These expansion joints were designed to allow the use of a 'pigging' process, without risk of snagging of the rubber 'pig' within the line.

5.17 ESB Substation / Lighting

The West Jetty is automatically illuminated in the hours of darkness by 8 no. galvanised steel lighting masts, each with an assembly of high powered lamps attached to the top and directed to give a uniform level of illumination throughout the working areas. The average level of illumination achieved on the jetty deck is 50 Lux. The lighting masts are protected from damage by vehicular traffic by large concrete bases, which rise 2 metres above ground level.

A new electricity sub station built in the vicinity of the West Jetty under the contract services the lighting masts. This sub station has capacity to be upgraded in the future to service the growing needs of the port and its users.

5.18 Landing Stages

Three no. floating landing stages for small craft were installed under the jetty contract. Each landing stage comprises of an articulated assembly of 2no. galvanised steel frames, each with 3 glass reinforced (GRC) floats which are filled with expanded polystyrene. The floating stages are located in position on plan by 2no. or 4 no. vertical piles 406mm in diameter which guide the landing stages vertical movement with the change of tide.

The design of the landing stages is complicated by the large tidal variation found on the west coast of Ireland where

the range at spring tides is nearly 6 metres. To maintain safe access for the users of the landing stage it was necessary to incorporate an articulated gangway of 17 metres in length, fixed to the foreshore at one end and resting on the landing stage at the other, to limit the gradient of the gangway at low water.

5.19 Other Ancillary Works

In addition to the items already mentioned, further ancillary works were carried out in the vicinity of the West Jetty. 3 no. access roads to the West Jetty were constructed. The east and central approaches are constructed of 200mm concrete slab, while the west approach is asphalt. The West Jetty has numerous items of steelwork furniture comprising of safety ladders, traffic safety barriers, low level safety kerbs and traffic signs. The works also included refurbishment of an existing stone wall along the harbour road for the full length of the phase 2 jetty extension.

6 Dredging Works

In parallel with the construction of the new West Jetty, the important element of development within the port has been the improvements made to the bathymetric profile of the inner harbour area and approaches through the recent dredging programme. Under this dredging programme, approximately 390,000 cubic metres of material was dredged from the harbour.

6.1 Tendering for Dredging

In a process similar to the jetty contract, and under the EU directives for co-ordination of procurement procedures, invitations for pre-qualification were published in OJEC in January 1999 and ten responses were received.

Tender documents for the dredging project were issued to seven tenderers on 5th July 1999 and were returned on 23rd August 1999.

Following a review of tenders, discussions took place with the lowest tenderer, Irish Dredging Company Ltd, and a contract was later awarded on 12th November 1999.

The determination of dredging quantities for both tender and contract management was primarily carried out using Hypack and Microstation software packages.

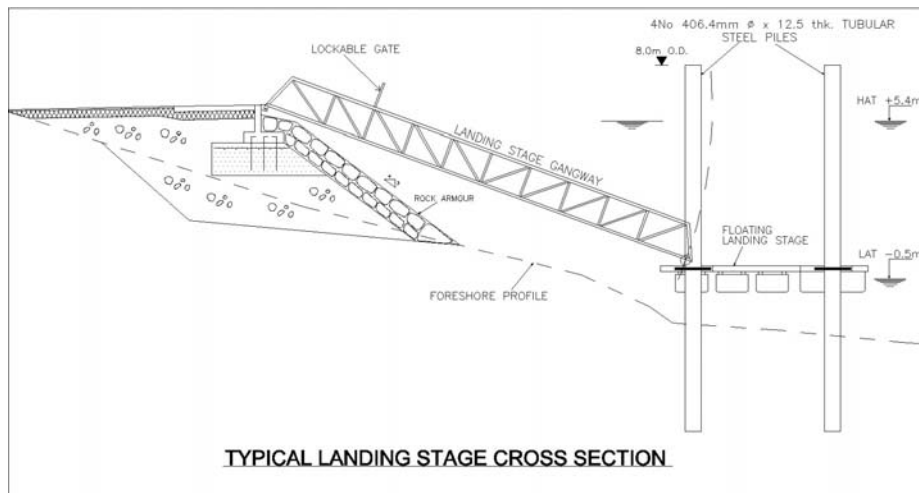


Figure 15

6.2 Dumping Permit

Under the Dumping at Sea Act 1996, a dumping permit is required from the Department of the Marine and Natural Resources prior to dumping of any material into the sea off the Irish coastline. Among the details shown on this permit are the quantity of material to be dumped, the material composition, the dump location, and details of vessels to be used.

Application was made in April 1999 to the Department of the Marine and Natural Resources for permit to dump dredge spoil at two specific locations, with further updated information provided once the contractor was appointed.

As part of the consultation process prior to issue of permit, the Department of the Marine and Natural Resources consults with the Natural Monuments and Historic Properties Service of DUCHAS (The Heritage Service). The services' Maritime Archaeological Unit has stated that all proposed dredging and dumping sites must undergo archaeological assessment. Initially, a geophysical survey of the relevant areas was carried out using a side scan sonar and magnetometer. Field records were analysed and the geophysical data received. Areas of anomalies were noted, and these specific locations were further site checked by diver using an experienced marine archaeology company with diving experience. In all, seven locations identified by DUCHAS were examined. No artefacts, features or deposits of archaeological interest were observed, but each location was verified.

A detailed report was issued to the Maritime Archaeological unit of DUCHAS. During the course of the dredging works, archaeologists carried out monitoring of the dredged material to confirm the pre-contract findings.

As part of the investigation of the dumpsites, a photographic record and report of the immediate foreshore opposite the sites was carried out. A shoreline survey examined the site of former fish weirs on the shore and verified that the disposal of material would not have a deleterious effect on the shoreline. After due consultation with various third parties by the Department of the Marine and Natural Resources, a permit to dump spoil was issued in November 1999.

As the permit expired at the year-end, a new application for permit into the year 2000 was sought and granted. The permit was duly amended to expire on 29th February 2000. Dredging after this date was not allowed due to the movement of specified fish species within the Estuary. The species are listed under annex II of the EU Habitats Directive and are also designated a Red Data Book species for Ireland. These species migrate from the sea to fresh water to breed during the period March to June. Whilst this cut-off was very onerous in terms of delivery of the completed contract, the contractor made every effort to ensure that the dredging element was completed satisfactorily within the timeframe.

6.3 Foreshore Licence

Application was made in April 1999 to the Department of the Marine and Natural Resources for a Foreshore Licence for the dredging works under the Foreshore Act 1933. After due review of the application and issue of appropriate notices to interested parties such as Shannon Estuary Port, The Commissioners of Irish Lights, Marine Survey Office of the Department of the Marine and Natural Resources, and the

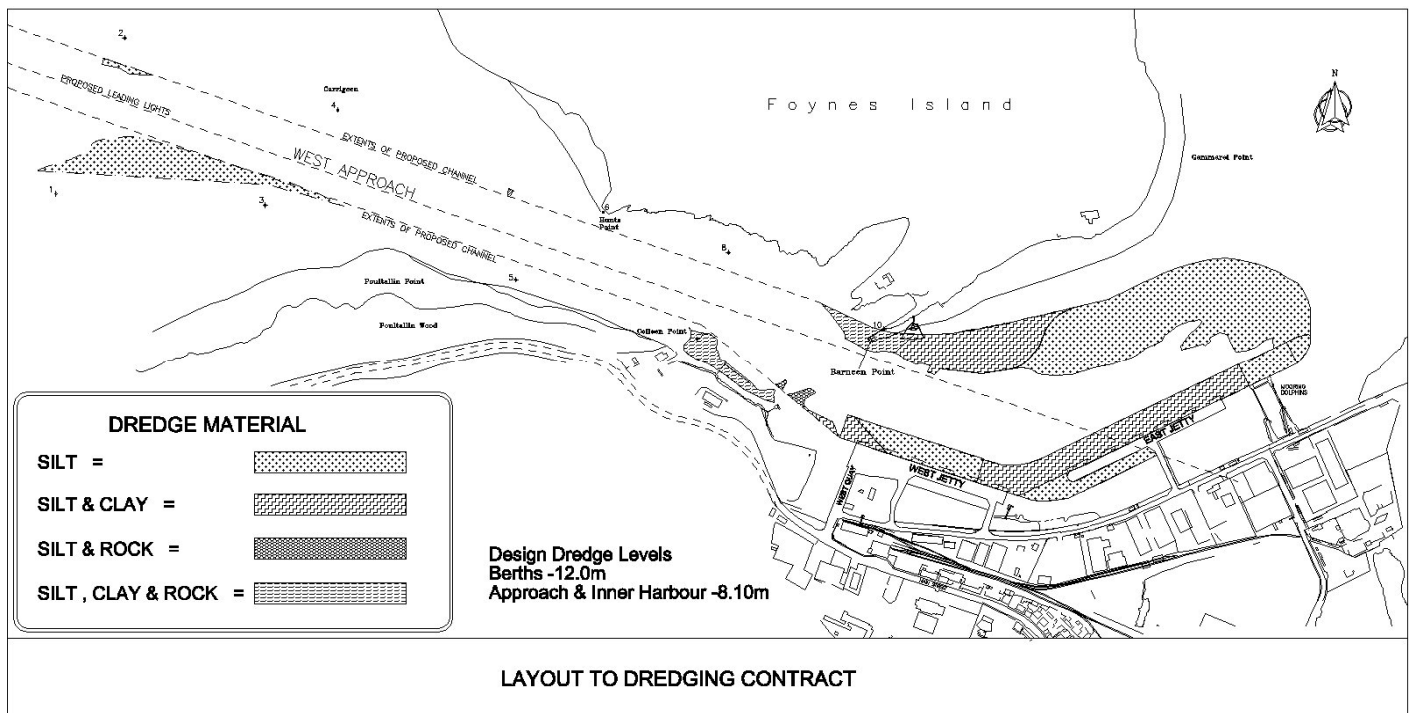


Figure 16

British Admiralty Hydrographer, a Foreshore Licence was issued in November 1999.

6.4 Maintenance Dredging

An ongoing sediment transport regime at Foynes requires that the inner harbour areas be dredged at regular intervals to restore the depth of water to allow safe vessel movements into and around the port area. This dredging process is usually required on an annual basis.

An amount approximating to 100,000 cubic metres of material was dredged from the harbour under maintenance dredging. This is comprised entirely of silt material.

6.5 Capital Dredging

In parallel with the construction of the West Jetty, it was necessary to make improvements to the bathymetric profile of the channel approaches and inner harbour area. The berths on the West Jetty and East Jetty were originally maintained with a bed level of -10.15m OD and -11.3m OD respectively. In order to accommodate the vessels now being used in the port, it was necessary to deepen the berths on both jetties to -12.0m OD. This level is required to allow the largest vessels to remain afloat in the berths at all stages of the tide.

In addition to dredging of the berths, it was required that all areas designated for vessel movement in the port area be dredged to remove all material above a level of -8.1m OD. This level is required

to allow the largest vessels to enter and leave the berthing areas during high tide and to ensure safe turning manoeuvres. Following the results of the navigation study carried out by H R Wallingford, it was determined that an outcrop of rock encroaching on the shipping channel from the Foynes Island side should be partially removed and reduced to the design level of -8.1m OD.

Approximately 390,000 cubic metres of material was dredged from the harbour under capital works dredging. This comprised of 330,000 cubic metres was silt, 40,000 cubic metres of boulder clay, and 20,000 cubic metres of rock.

6.6 Dump Areas

There are two dump areas associated with the dredging works. The primary dumpsite is located in the middle of the Shannon Estuary under the jurisdiction of Shannon Estuary Ports approximately 2 km downstream of Foynes Port and is 800 metres x 250 metres in size, with an average depth of water of 36 metres below datum. This dump area is used for the deposition of dredged silt and clay material.

The secondary dump area is located just offshore of the southern bank of the Shannon Estuary within Foynes Port jurisdiction, and is 100 metres x 75 metres in size, with an average depth of water of 8 metres below datum. This dump area is used for the deposition of dredged rock. It is envisaged that this rock can be reused in its present position

for a future port-related development within the jurisdiction.

6.7 Silt Dredging

The majority of the silt material was dredged using a trailer suction hopper dredger, the 'WD Medway II'. This is a type of vessel that is designed specifically for the task of removing soft to firm overburden from the riverbed. This vessel is 19 metres in width and has the ability to load a hopper contained within its structure, of 3,700 cubic metre capacity, by means of a centrifugal pump attached to an articulated arm whilst the vessel is moving ahead.

At the bottom of the articulated arm is a drag-head that, on this vessel, is equipped with a jet system to loosen firm material from the river bed for removal by the pumps. This vessel has a powerful bow thruster that provides a high degree of manoeuvrability. Unloading is by means of a bottom-discharge arrangement over the designated dumping area in deep water.

During the works, the trailer suction dredger rate-of-dredge was of the order of 15000 cubic metres per day over a 24-hour work period. The dredger is fitted with a DGPS system for accurate positioning at all times.

6.8 Dredging with a Hydraulic Backhoe Dredger

The backhoe dredger 'Koura II' was used to dredge hard boulder clay material and loose rock as well as areas of silt not



Figure 17

removed by the 'WD Medway II' trailer suction dredger. The 'Koura II' is a dedicated marine dredger consisting of a heavy duty hydraulic base machine with an extended boom, dipper and bucket arrangement, all on a rotating base fixed to a floating pontoon. The pontoon is fitted with a number of 'spuds', which are hydraulically operated legs that may be raised and lowered to allow the pontoon to sit with positive bearing on overburden while dredging. The backhoe has a working reach in excess of 12 metres.

When the material is excavated with the backhoe, it is then loaded into a barge for dumping. In this contract, the barge was a split hopper barge called the 'M.V.A.'. Unloading of the M.V.A., like the 'WD Medway II', is by means of a bottom-discharge arrangement over a designated dumping area in deep water. The working capacity of the backhoe is 600 cubic metres per 4 hours necessary to fill the bottom dump barge.

6.9 Rock Dredging

Approximately 20,000 cubic metres of rock was dredged from the harbour. The bulk of this material was located at Barneen Point on Foynes Island. From pre-contract investigation, the UCS of the rock was determined to be of the order of 75 MN per Sq metre. The rock was resistant to removal by backhoe and required pre-treatment before it could be excavated.

The pre-treatment consisted of drilling and blasting, to fracture the rock

sufficiently to allow excavation by the backhoe dredger. This operation was carried out independently of other dredging operations using a specialised pontoon with 3no. on-board drilling rigs. Before the pontoon could locate over the area, the rock above low water level was removed in the traditional manner using a track mounted drilling rig.

The outline procedure for blasting of rock was as follows:

- 1 A drilling pattern was set up on a 2.5 metre by 3 metre grid.
- 2 At each location, the outer casing was lowered to the riverbed, through any soft material and collared into the rock.

- 3 The rock was drilled out with inner drill rods to the required depth.
- 4 The holes were charged with up to 130 kg of Frangex explosive.
- 5 The outer casing was lifted to retrieve the initiating line.
- 6 The hole was stemmed to confine the blast.
- 7 The drill rig was moved and the process repeated until sufficient charges were placed for efficient detonation of the explosives. A detonator delay of 20ms was used between blasts.

Using the pontoon at Barneen Point, a total of 755 holes were probed with the outer casing, of which 352 were subsequently drilled and blasted. A total number of 67 blasts were carried out using 4641 kg of explosive over a period of approximately 17 days. Using the land based equipment, a total of 7 blasts were carried out using 596 kg of explosive.

7 Cost Summary

A summary of the costs arising on the project is as follows:

Preliminary investigation	IR£ 150,000
Jetty Works	IR£ 7,100,000
Dredging Works	IR£ 2,000,000
Navigation Studies	IR£ 100,000
Charges	IR£ <u>350,000</u>
	IR£ 9,700,000

All works were instructed following competitive tendering in compliance with EU procedures. Throughout the works, cost control was monitored by the Design Team and cost reviews made on a monthly basis.

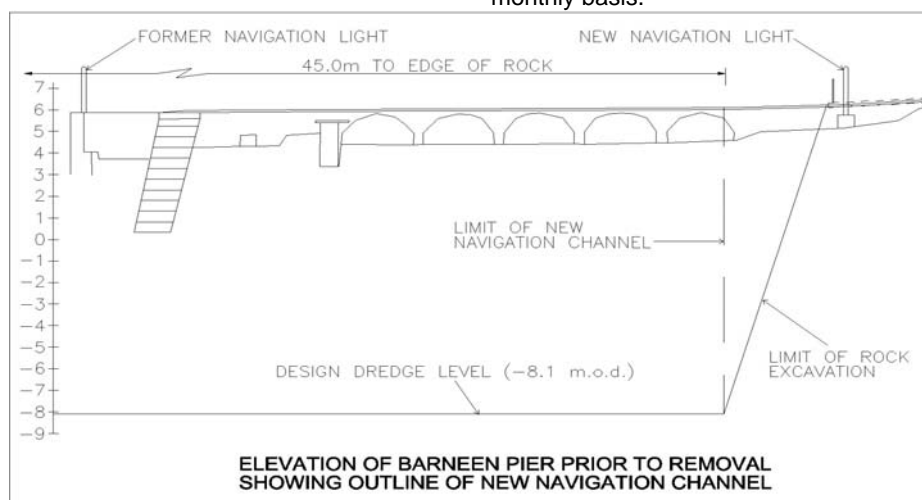


Figure 18

8 Project Quantities

The leading quantities on the capital works are as follows:

Piling			
1067 diameter	5,701	Lin m	
356x406 UC	1,184	Lin m	
350x350 concrete	1,288	Lin m	
Reinforced Concrete			
Insitu concrete	6,953	Cu m	
Pre-stressed concrete slabs	2,454	Sq m	
Pre-stressed TY7 beams	2,074	Lin m	
Reinforcement			
Insitu concrete	1,122	tonne	
Crushed Stone Filling	18,704	Cu m	
Asphalt Surfacing	11,603	Sq m	
Dredging			
Silt	330,000	Cu m	
Clay	40,000	Cu m	
Rock	20,000	Cu m	

9 Acknowledgements

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Employer

Foynes Port Company

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Healy Kelly & Partners

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Hydrographic Surveys Ltd

Resident Engineers
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Contractors for West Jetty

Main Civil Contractors
Ascon Limited

Precast Concrete Suppliers
Banagher Concrete

Steelwork Suppliers
Foynes Engineering

Ground Investigations
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Resident Engineers for Dredging

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Main Dredging Contractors
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