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# ESC PROJECT CASE STUDIES

## BOOK I (2000-2013)

Global Foundations, Steel Structures, Flood Mitigation, Ports, Retaining Walls and Retention Projects

# About ESC

Further to simply supplying products we at ESC take a different approach to piling which is tailored to the customers' requirements. ESC believes that just supplying a product is insufficient and we strive to provide a level of support that is beyond customer expectations. This support ranges from general advice on the Client's options to full engineering support and design. ESC has amongst its divisions expertise in marine equipment, corrosion, trench safety and structural steel fabrication.

ESC products are produced & designed in accordance with the latest international standards as well as ISO 9001 Quality Management Systems. Other specific standards depending on the client's needs can be applied on request.

ESC has designed and supplied its products to projects in every continent of the world, including Antarctica. In the last decade, ESC has successfully diversified into structural steel fabrication, synthetic sheet piling, cathodic protection, mooring bollards and marine fender systems to provide complete engineered solutions.

## COMPANY CERTIFICATION

ESC products are produced & designed in accordance with the latest international standards 9001:2015, ISO 14001:2015, OHSAS 18001:2007 certifications for both supply, design and installation scopes related to sheet piling and piling related products.

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## About ESC

Across the globe, the ESC Group of Companies now consists of the following registered enterprises:

- ESC Al Sharafi Steel LLC, UAE
- ESC Al Sharafi General Contracting LLC, UAE
- ESC Steel Engineering Sdn Bhd, Malaysia
- Acerlum ESC SAPI de CV, Mexico
- ESC Nigeria Ltd., Nigeria
- ESC Steel Philippines Inc., Philippines
- ESC-Beregstal Jsc, Russia
- ESC Steel LLC, USA
- PT ESC Steel, Indonesia

And partners,

- Cimtronic Design & Engineering, Argentina
- Europile B.V., Netherlands
- Mageba Ukraine LLC, Ukraine
- Bulkplus Integrated Limited, Nigeria

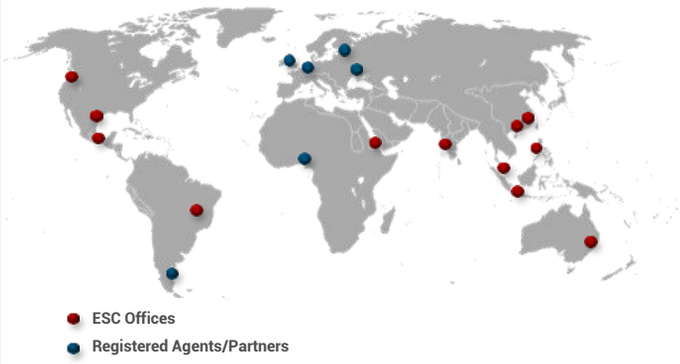
The ESC Group has manufacturing plants located in China and the United Arab Emirates.

The ESC Group is also represented by agents of our own officers across Asia, Europe, North & South America, India, Africa and the Pacitic.

The ESC Case Study Booklet aims to highlight and explain the more technical components of some older and more recent jobs that ESC has completed.

*ESC serves the global market from a range of strategic locations. ESC Group operates with over 15 agent and ESC offices around the world. Highlighted on the left are the representative offices for the steel structures division.*

## Global Locations



# ESC Project Case Studies Index


| PROJECT TITLE | LOCATION | PAGE |
|---|---|---|
| Al Jeer Fishing Harbour | Ras Al Khaimah, United Arab Emirates | 5 |
| Barrow Island Load-out Jetty | Western Australia | 9 |
| Bascule Highway Cofferdam | Adelaide, Australia | 13 |
| Baynoonah Sheet Pile Retention | Abu Dhabi, United Arab Emirates | 16 |
| BHP Gas Pipe Project | Illawara, New South Wales, Australia | 18 |
| Cruise Ship Docking Facility | Dominican Republic | 24 |
| Eurotank Terminal | Amsterdam, Netherlands | 31 |
| Jalan Duta, Kuala Lumpur Road Widening Project | Kuala Lumpur, Malaysia | 34 |
| Johor Bahru Convention Centre | Johor, Malaysia | 41 |
| Jubail Supply Base | Jubail Commercial Port, Saudi Arabia | 44 |
| Kaohsuing Port Combi Wall | Kaohsuing Port, Taiwan | 48 |
| Liquid Bulk Terminal Rubis | Rotterdam, Netherlands | 52 |
| Melaka River Beautification | Melaka, Malaysia | 55 |
| Modular Transport Beam System | Netherlands, United Kingdom | 61 |
| Ohau Channel Diversion | Roturua, New Zealand | 63 |
| Port Of Fujairah OT2 Phase 1 Project | Port of Fujairah, United Arab Emirates | 66 |
| Port Of Fujairah OT2 Phase 2 Project | Port of Fujairah, United Arab Emirates | 72 |
| Ras Al Khaimah Port | Ras Al Khaimah, United Arab Emirates | 80 |
| Sabah Oil & Gas Terminal (Sogt) | Kimanis, Sabah, Malaysia | 86 |
| South Breakwater Berths | Port of Fujairah, United Arab Emirates | 91 |
| Tankput 19 Vopak Terminal | Rotterdam, Netherlands | 96 |

# AL JEER FISHING HARBOUR

## QUAY WALL PROJECT

| | |
|---|---|
| **Project Name** | Al Jeer Fishing Harbour |
| **Project Owner** | Government of Ras Al Khaimah |
| **Consultant** | Gibb Ltd |
| **General Contractor** | Athena SA |
| **Project Location** | Ras Al Khaimah , United Arab Emirates |
| **Product** | Sheet Piles & Corrosion Protection Coating |
| **Total Tonnage** | 920 MT |
| **Year** | 2007 |

### INTRODUCTION

The Government of Ras Al Khaimah needed to improve their harbour and berthing facilities for the local fishing fleets. The decision was made to construct a shallow water quay wall in the Al Jeer Harbour. The requirement was for a permanent quay wall with a dredge depth of -8.0 for fishing vessels. Durability was for 50 years. All designs were to be as per the British Standards.

The Port Authorities considered several options, including suspended decks and concrete block walls, however due to economics and timing, ESC's sheet pile wall solution with tie rods won the contract.

ESC carried out the alternative design calculations on behalf of the Contractor (Athena SA) and submitted them for approval to the Client (RAK Government) and their Consultant (Gibb Ltd). All relevant drawings and engineering detailing was provided by ESC for this project. Once approval was received the manufacturing was carried out in the ESC factory for delivery to the site.

As always, ESC personnel were on site to assist Athena SA during the beginning of the installation process. Several recommendations were made regarding piling guides and handling processes. ESC provided efficient Dawson Lifting Shackles that helped increase the productivity of the installation, while ensuring maximum safety during the process.

INITIAL DEADMAN SHEET PILE WALL INSTALLATION BEGINS ON SITE

NOW THE MAIN WALL SHEET PILE INSTALLATION STARTS

# PROJECT DETAILS

## SOIL PROFILE

The existing seabed was between approximately -2.0 EL to +1.0 EL in the vicinity of the proposed wall. Subsequent filling activity has reclaimed the area to approximately +3.0 EL. Fill material is dense to very dense sandy gravel with cobbles and boulders.

The original seabed is a layer of medium dense to very dense silty sand, overlying a medium dense to very dense silty gravel layer with sandstone bands up to 8.0m thick.

Below the gravel layer are pockets of medium dense to dense sands, overlying a very dense sand layer with sandstone bands at approximately -13.0EL.

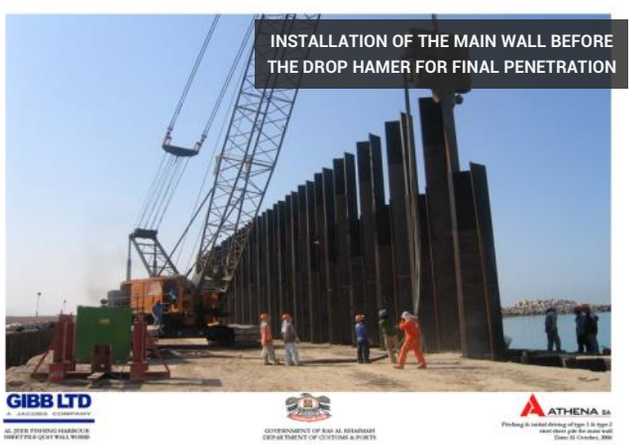
## STRUCTURAL SPECIFICATIONS FOR SHEET PILES

The specifications for the proposed Main Wall and the Anchor Wall piles are as follow:

| WALL TYPE | PILE TYPE | PILE LENGTH (m) | DESIGN STRESS ($N/mm^2$) | MAX. SECTION MODULUS ($cm^3/m$) |
|---|---|---|---|---|
| **Main Wall** | **ESC46A (6268)** | 10.5 | 355 | 4040 |
| **Anchor Wall** | **ESC18A** | 3.0 | 275 | 1800 |

The total sheet pile tonnage supplied was 920 tons. Pile shoes were fitted to all Main Wall piles due to the hard driving conditions.

The tie rods were supplied by Dextra Manufacturing under the guidance and design of ESC. The rods supplied were M47mm of steel grade 950/1050 at 3.0 metre centres in 15.0 metre lengths. Tie rods were wrapped in Denso tape prior to installation.




INSTALLATION OF THE MAIN WALL BEFORE THE DROP HAMER FOR FINAL PENETRATION

TIE ROD INSTALLATION IS UNDERWAY

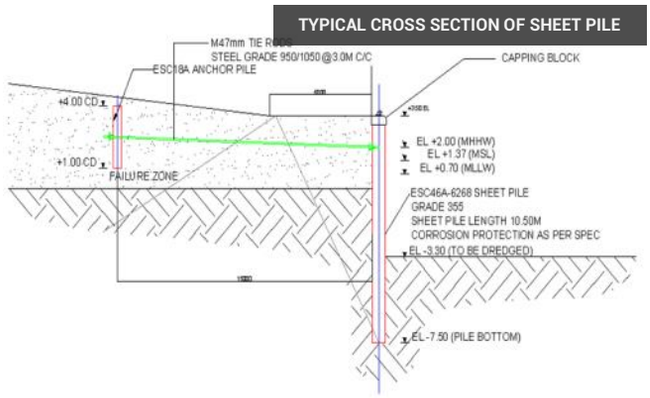
## COATING REQUIREMENTS

The specified coating for the sheet piles is for sand blasting to SA2.5 followed by 50 micron of primer and then 400 micron of coal tar epoxy paint. The coating is to be applied to the entire front surface and two metres of the back surface of the Main Wall piles only.

## INSTALLATION DETAILS

Installation was done by pitching the sheet piles in a piling frame and driving to refusal with an ICE 815 vibro hammer. Piles were then driven to the final required level using an IHC S90 hydraulic hammer, together with a pile helmet.

TYPICAL CROSS SECTION OF SHEET PILE



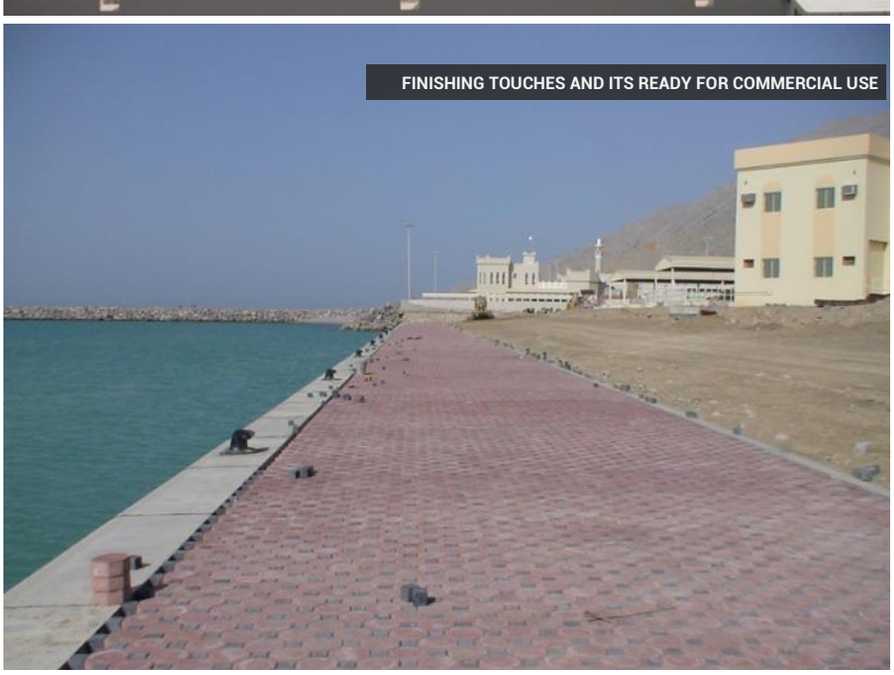
# STACKING

# ON-SITE INSTALLATION

# PROJECT COMPLETION

FINISHING COMPACTION WORKS BEGINS

READY FINAL COMPACTION CONTINUES NOW THAT ALL SHEET PILES AND TIE RODS ARE INSTALLED



FINISHING TOUCHES AND ITS READY FOR COMMERCIAL USE

# BARROW ISLAND LOAD-OUT JETTY

## MATERIAL OFFLOADING FACILITY PROJECT

| | |
|---|---|
| **Project Name** | Barrow Island Load-Out Jetty |
| **Project Owner** | Chevron Australia Pty Ltd |
| **General Contractor** | MMJV |
| **Project Location** | Western Australia |
| **Product** | LSAW & SSAW Tubular Piles |
| **Total Tonnage** | 1,100 MT |
| **Year** | 2010 |

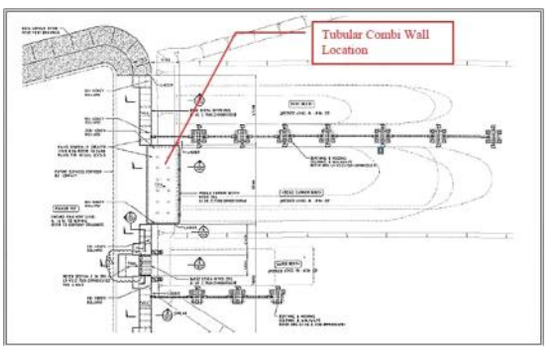
### INTRODUCTION

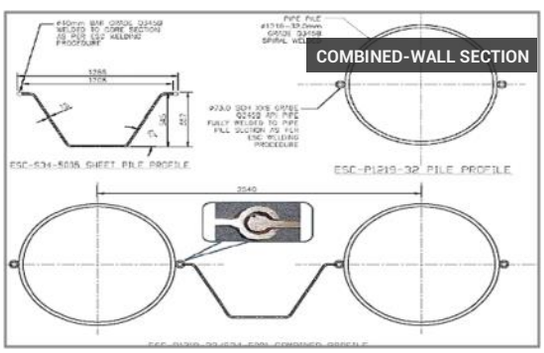
ESC delivered over 1,100 tons of combined wall system to MMJV for the prestigious Barrow Island LNG Plant Material Offloading Facility in Western Australia. ESC completed manufacture in both its China and Malaysia facilities. The King Pipe Pile design also contained structural fabrication scope for lifting lugs, tie rod brackets, shear connections and more.

ESC in Malaysia and China built the combi-wall system specially designed for the Barrow Island LNG Plant Material Offloading Facility (MOF). This is part of the massive Gorgon Project for Chevron Australia Pty Ltd. The MOF will facilitate the offloading of the materials and the components that will be used to construct a major LNG (Liquefied Natural Gas) processing facility on the island. The Gorgon gas fields, off the northwest coast of Western Australia (WA), contain about 40 trillion cubic feet of natural gas and this development currently represents the largest single project underway in the world.

ESC's client was MMJV which is a project specific joint venture created by the joining of Marine and Civil Construction Pty Ltd of Australia and Murray & Roberts Marine of South Africa.

The unique aspects of the project were dealt with by ESC through constant dialogue with MMJV and Chevron's Engineers Kellog Joint Venture (KBR, JGC, Hatch and Clough). Design evolution during the project construction required the manufacture from ESC to be very dynamic and able to facilitate change.



# FABRICATION OF PIPES & PILES

## ACTIVITIES

MANUFACTURING OF KING PIPE PILES

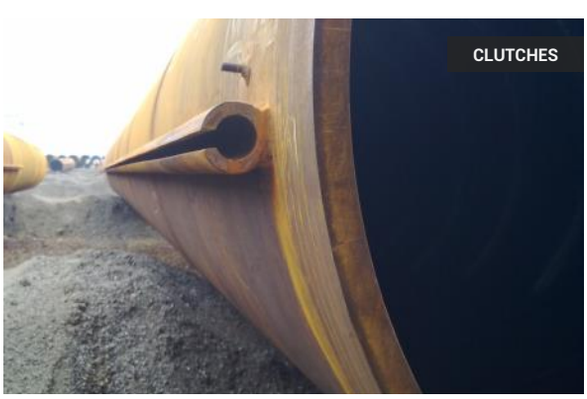
INFILL SHEET PILES

MANUFACTURING OF KING PIPE PILES

TIE ROD CONNECTION

SHEAR KEY

INSPECTION OF FABRICATED PIPES


CLUTCHES

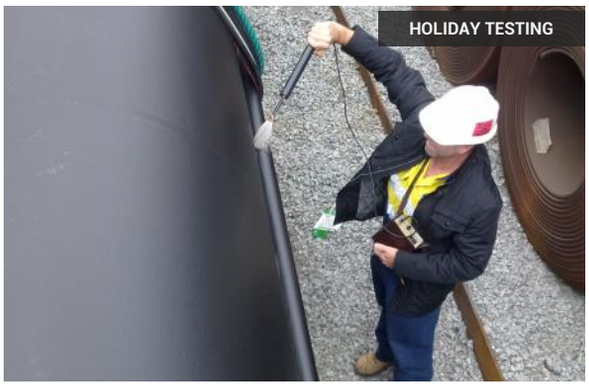
INSPECTION OF FABRICATED PIPES

# PAINTING OF PIPES

## ACTIVITIES

PIPES READY FOR PAINTING

PAINTING INSPECTION

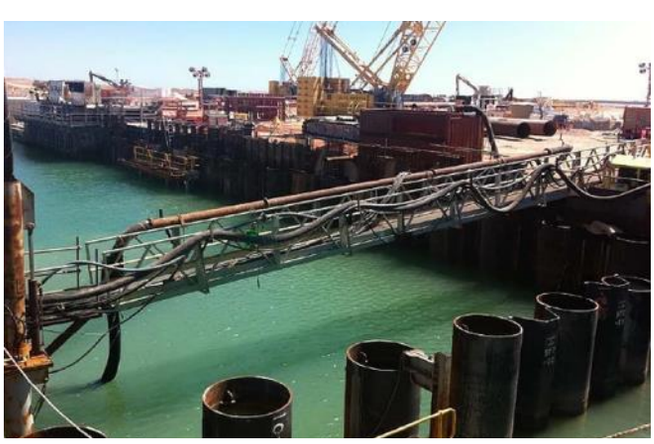

HOLIDAY TESTING

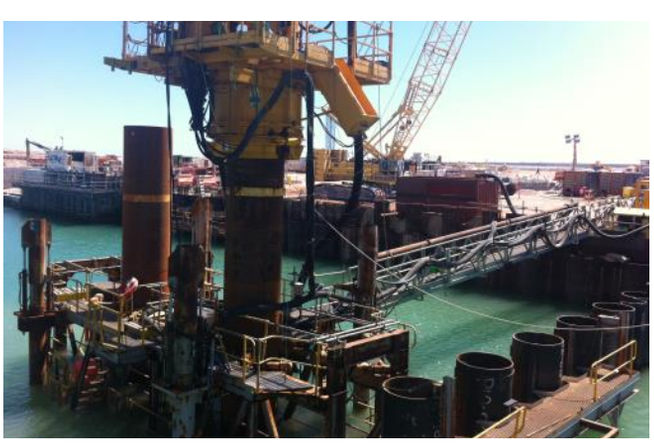
HOLIDAY TESTING

# PACKING & STACKING

# SHIP LOADING

# ON-SITE INSTALLATION

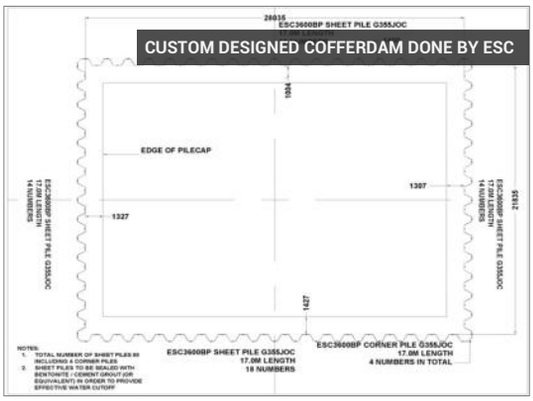




# BASCULE BRIDGE COFFERDAM, AUSTRALIA

## BRIDGE COFFERDAM PROJECT

| | |
|---|---|
| **Project Name** | Bascule Bridge Cofferdam |
| **Project Owner** | Adelaide Port River Expressway |
| **General Contractor** | Abigroup |
| **Project Location** | Adelaide, Australia |
| **Product** | Sheet Piles |
| **Total Tonnage** | 240 MT |
| **Year** | 2010 |




## INTRODUCTION

A four lane, high-level opening Road Bridge across the Port River was to be built. The 300m long bridge would consist of 8fixed spans as well as a single track, dual gauge, high level opening Rail Bridge approximately 1000m long with 37 fixed spans.

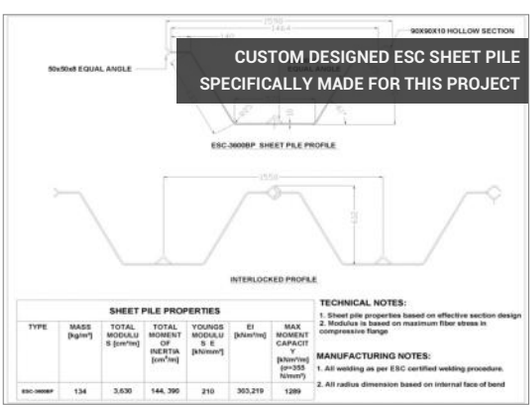
Abigroup who were building the Adelaide Port River Expressway needed a cofferdam that was able to be de-watered in order to allow the construction of the bridge piers. The previous option used by Abigroup was second hand AZ36 sheet piles. This option could not provide an adequate water proof area for the construction to proceed in a timely manner. So forced with substantial delays on the first cofferdam, Abigroup decided to use ESC for the second cofferdam.

ESC was approached to help them find a solution. As a result ESC designed a custom sheet pile and called it the ESC3600-BP. This sheet pile was a variation to the catalogue issued BP sheet piles. The BP sheet pile is designed with an open clutch suitable for post installation grout sealing. The BP pile is for de-watering works, groundwater cut-off walls and pollution control situations. This pile with its light weight, wide profile and minimal clutches also provides an attractive commercial proposition for retaining walls and other applications.

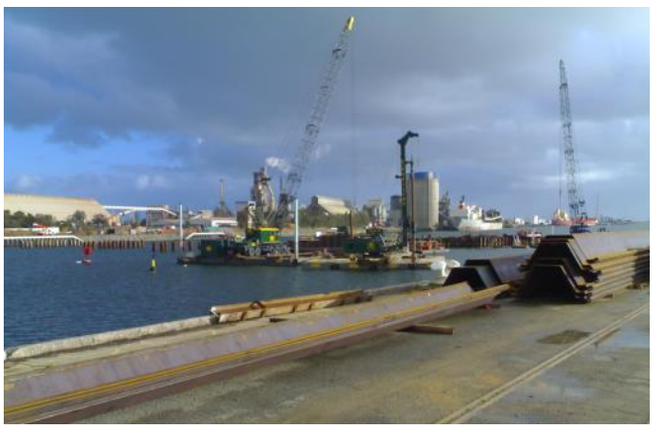
ESC delivered a better alternative to the originally specified AZ36 sheet piles for a cofferdam to allow the construction of the Bascule Bridge for the Adelaide Port River Expressway. Side-by-side, the ESC36BP provided a much drier cofferdam than the adjacent one constructed of AZ36 sheet piles. This was partially due to only containing less than half the number of interlocks and also the interlock design providing a excellent void which can more easily and effectively be filled with grouting for sealing.

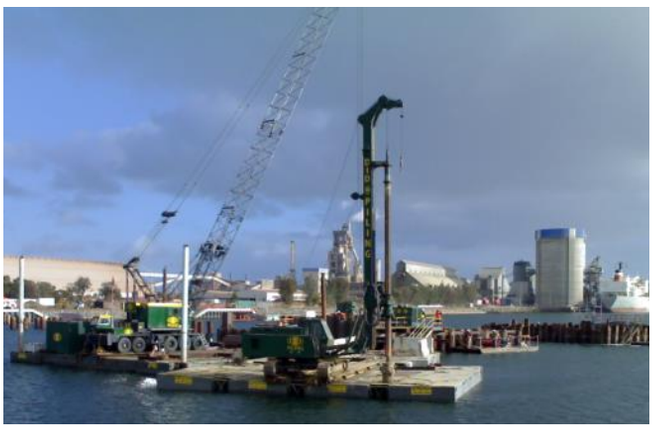
The BP sheet pile in this case had to be 17 metres long and hold out vast amounts of water with a 6 metre head whilst using only one layer of struts to ensure the project site could move ahead with minimal obstructions whilst maintaining the design and construction criteria required by the client.

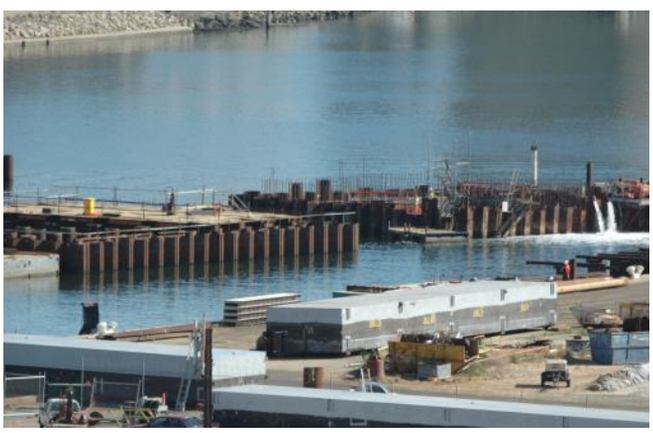
River depth was 10.0m, with 2-3m of soft silt material overlying a hard clay layer. Sheet piles were installed 2m into the hard layer to provide an effective cutoff for water seepage under the pile wall. The cofferdam was filled with gravel and then dewatered to depth of 6.0m below the mean water level. Post grouting was done with a non toxic cement grout mixture, which was critical as environmental considerations were paramount on the project as the harbour is home to a large dolphin population.



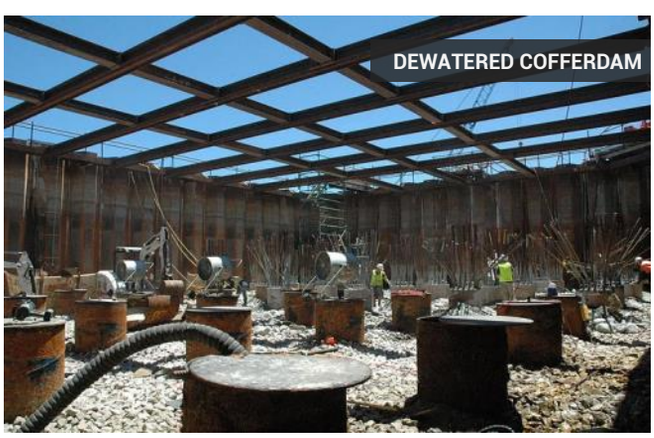
# ON-SITE INSTALLATION

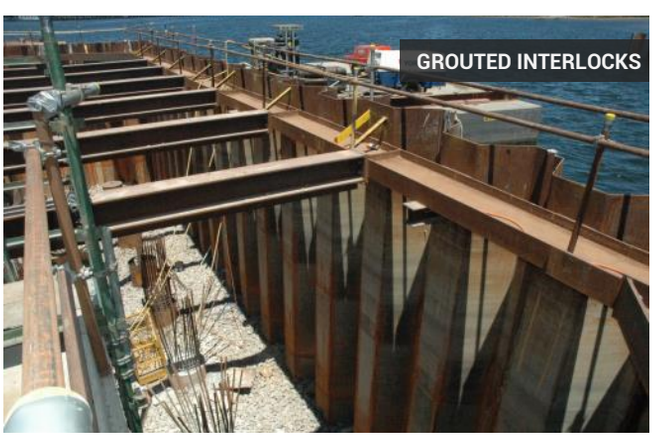




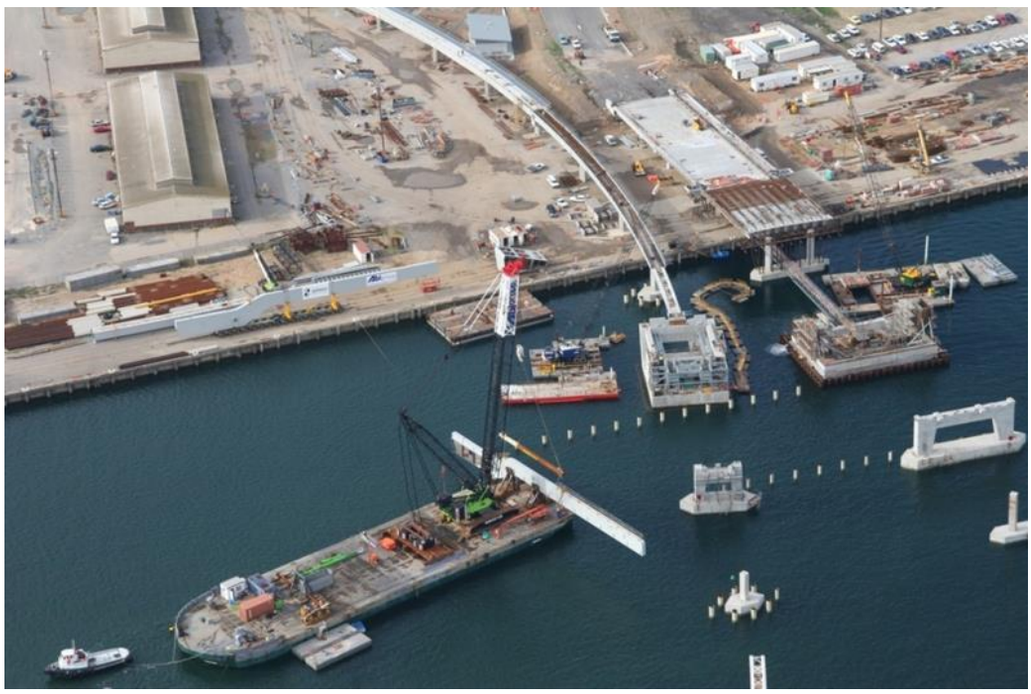


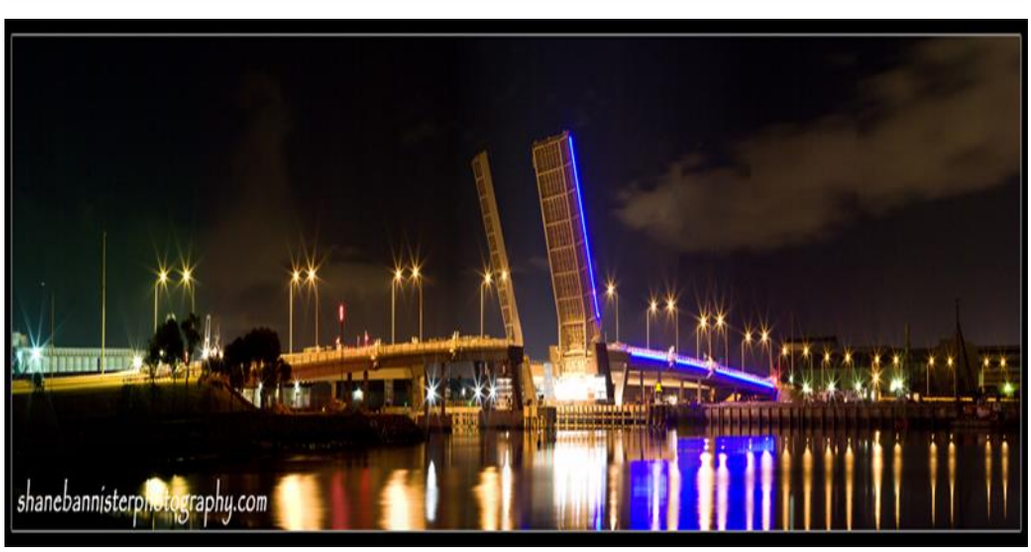
# DRY CONDITIONS INSIDE COFFERDAM



# PROJECT COMPLETED





# BAYNOONAH TUNNEL, UAE

## TUNNEL CONSTRUCTION PROJECT

| | |
|---|---|
| **Project Name** | Baynoonah Tunnel , UAE |
| **Main Contractor** | Abu Dhabi Department of Transport (DoT) |
| **Consultant** | Parsons |
| **Product** | Sheet Piles |
| **Total Tonnage** | 1,500 MT |
| **Year** | 2011 |

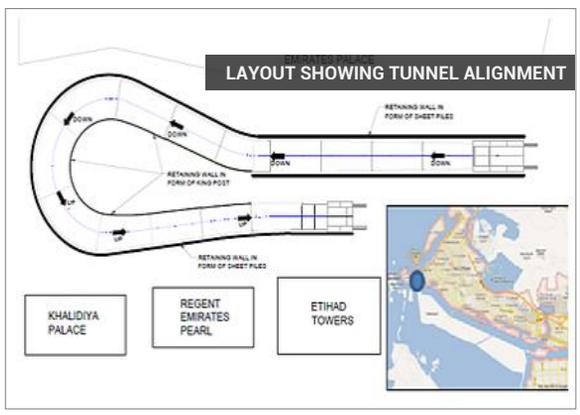
### INTRODUCTION

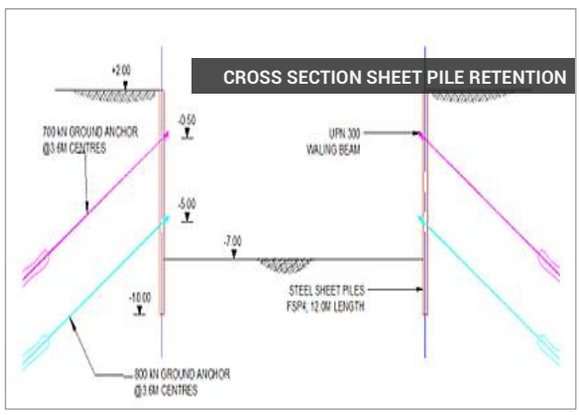
In the recent years, Abu Dhabi has witnessed huge growth in demand on construction and development due to constant increase in cities population and infrastructure demands. Abu Dhabi Department of Transport (DoT) is carrying out various road development works in Abu Dhabi and a strategic decision was made to construct a road tunnel, widen Baynoonah Street and also carry out various landscaping works on the Baynoonah Street, Al Ras Al Akhdar road and in front of the Emirates Palace. A U-shaped road tunnel 25m wide and extending to a depth of 10.5m, was proposed to be built on the Al Ras Al Akdar road. Due to the close proximity of the proposed tunnel to tall structures, a temporary retention system was proposed to be built to facilitate the tunnel construction.

ESC carried out the design calculations on behalf of the Main Contractor and submitted them for approval to the Client (Abu Dhabi Department of Transport) and their Consultant (Parsons). All designs were to be as per the British Standards.

In general, the overburden soils at site consisted of a 2m thick loose gravel fill followed by loose to medium dense silty sand to about 9m depth. This is followed by dense to very dense silty sand, until bed rock (Calcarenite) is encountered at 11m depth. However depth of bed rock varies consistently and is as shallow as 6m at some locations.

The original design was to build a secant pile wall. However, ESC managed to demonstrate to the client and the consultant that a sheet pile retention system is faster, cheaper and technically sound solution. The proposed embedded steel sheet pile solution was adopted. Large parts of the retaining wall needed to be supported by one



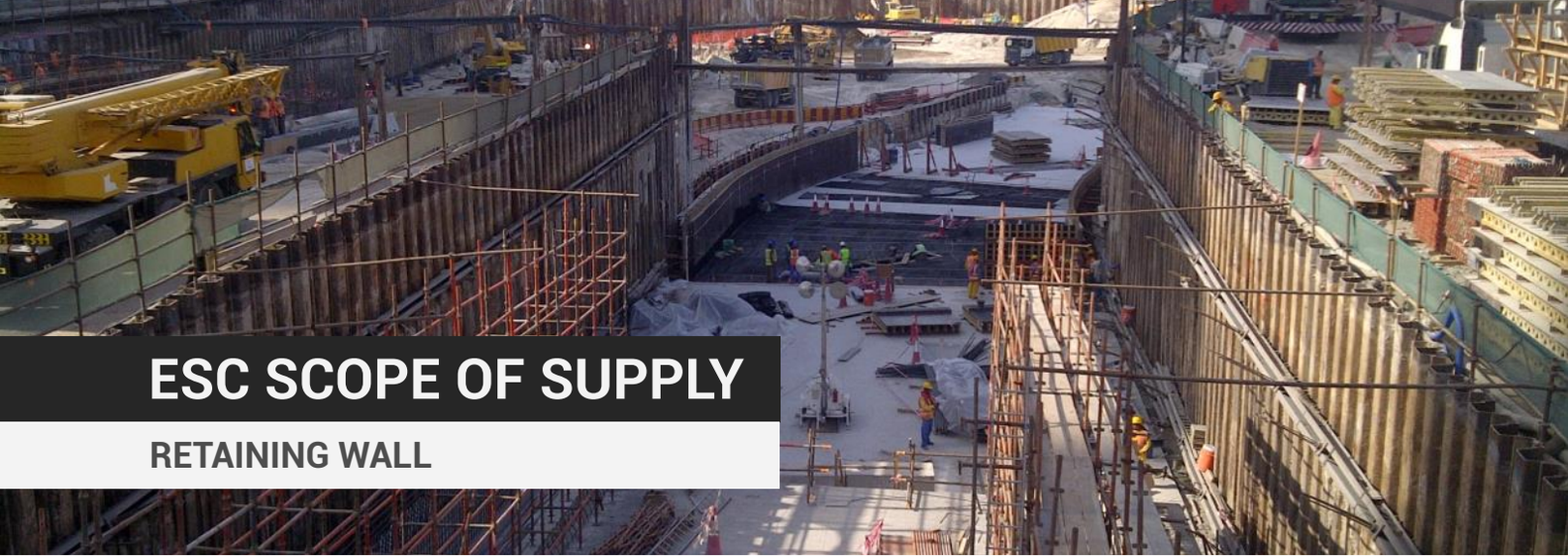




and/or two levels of ground anchors with a continuous waling beam.

Due to the sloping nature of the excavation, retaining wall conditions were constantly changing along the length of the wall. The analysis therefore had to be done incrementally, taking design cross sections for each section of the tunnel. Modeling was performed using an effective stress analysis based on BS8002, using the analysis software ReWaRD. The design of the sheet pile system was performed in accordance with the requirements of BS5950. Anchors were designed based on BS8081, which is a working load design standard.

Installation of the sheet piles was carried out by vibrating the sheet piles to required level with a vibro hammer mounted on a 50T crawler crane.

Due to the varying depth of hard stratum (depth of bed rock) pre-drilling was carried out to facilitate driving of sheet piles at some locations.



# ESC SCOPE OF SUPPLY

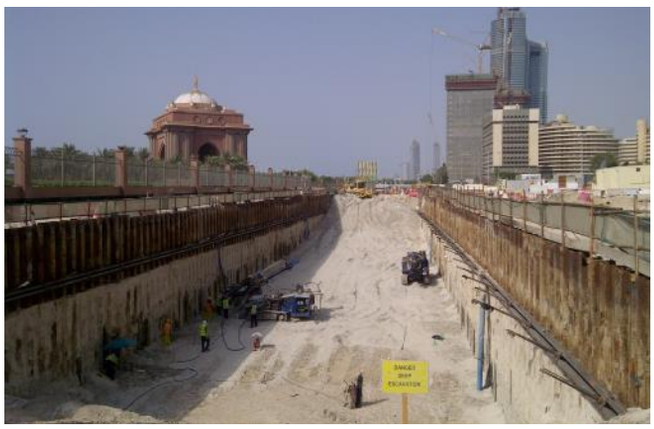
## RETAINING WALL

The total length of the temporary sheet pile retaining wall was 790m. Sheet piles of different configuration and length were used to suit the site conditions and the design requirements. The type of sheet piles installed included CR13-575, CR13-600, NSPIIIw and FSPIV with lengths varying between 9.5m and 15m, which correspond to a total tonnage of approximately 1,400T (1,463 nos).

Ground anchors were installed using a horizontal hydraulic drilling rig. The capacity and no. of levels of the ground anchors varied with the depth of excavation. A total of 311 anchors were installed with capacities ranging from 400kN (for shallow excavation) to 1,000kN (for deeper excavation, 10.5m depth).

Waling beams were installed to secure a continuous support of the Retaining Wall. For the Waling beam UPN 300 with a section modulus of 535 cm3/m was used with a total tonnage of approximately 94 T.

# ON-SITE INSTALLATION



# BHP GAS PIPE, AUSTRALIA

## GAS PIPE PROJECT

| | |
|---|---|
| **Project Name** | BHP Gas Pipe Project |
| **Client** | BHP |
| **Location** | Illawarra, New South Wales, Australia |
| **Product** | SSAW Pipes |
| **Total Tonnage** | 800 MT |
| **Year** | 2013 |

# ESC SCOPE OF SUPPLY

## SSAW PIPES

ESC was awarded the supply for BHP, Australia. The products for this project include galvanized spiral submerged arc welding pipe with groove.

The pipe was produced strictly in accordance with the Standard: API 5L PSL1, with Grade X42.

Pipe specification:

OD: 450NB, 600NB, 900NB.

Thickness: 8.7mm & 9.5mm.

Lengths: 1m, 5.9m, 6m.

Incoming raw material is strictly controlled: each raw material certificate is reviewed, coil dimension checked and steel retests are performed on each heat number for chemical composition and mechanical properties prior to commencement of the production process.

All inspection was carried out strictly in accordance with the approved Inspection and Test Plan

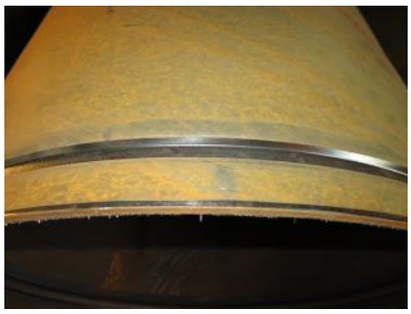
Radiographic Test

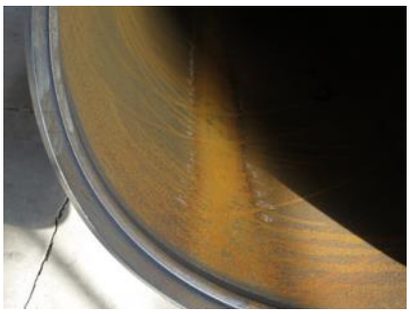
# SSAW PIPE FORMING

# GROOVING

Groove dimension followed requirements as stated in Victaulic AGS Roll Groove specification. Pipe dimension is rechecked / reconfirmed prior to commencement of galvanizing.

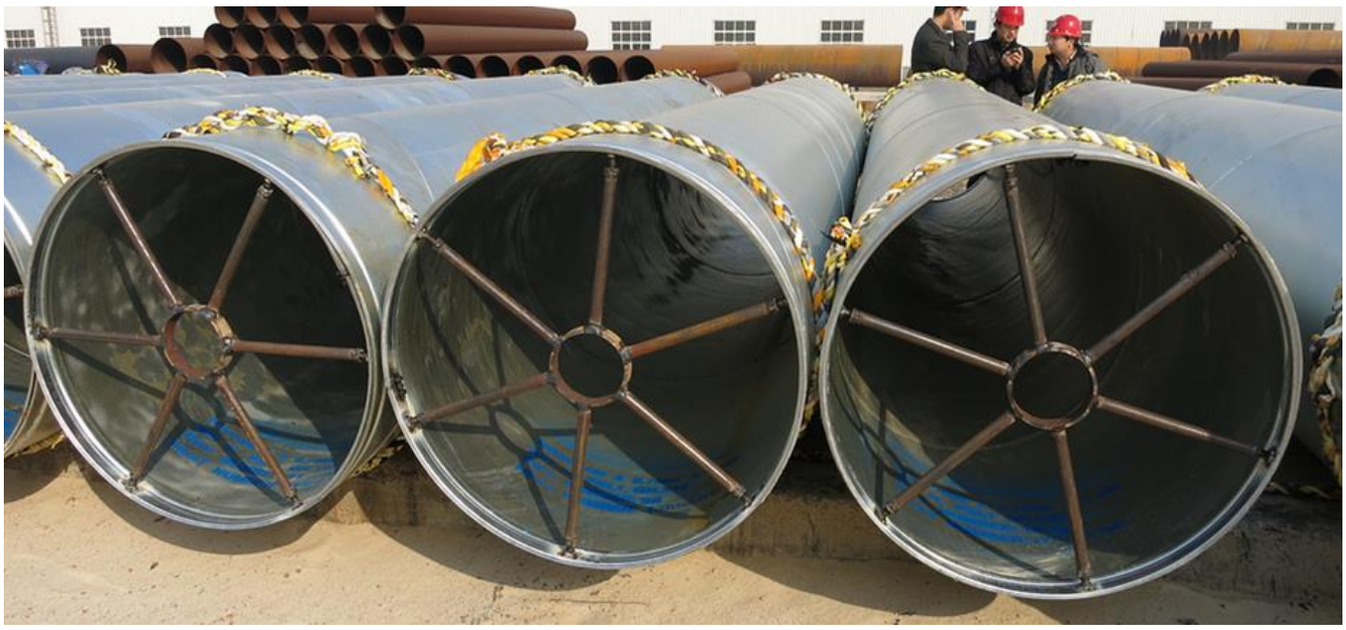
MARKING ON PIPE TO MAINTAIN TRACEABILITY

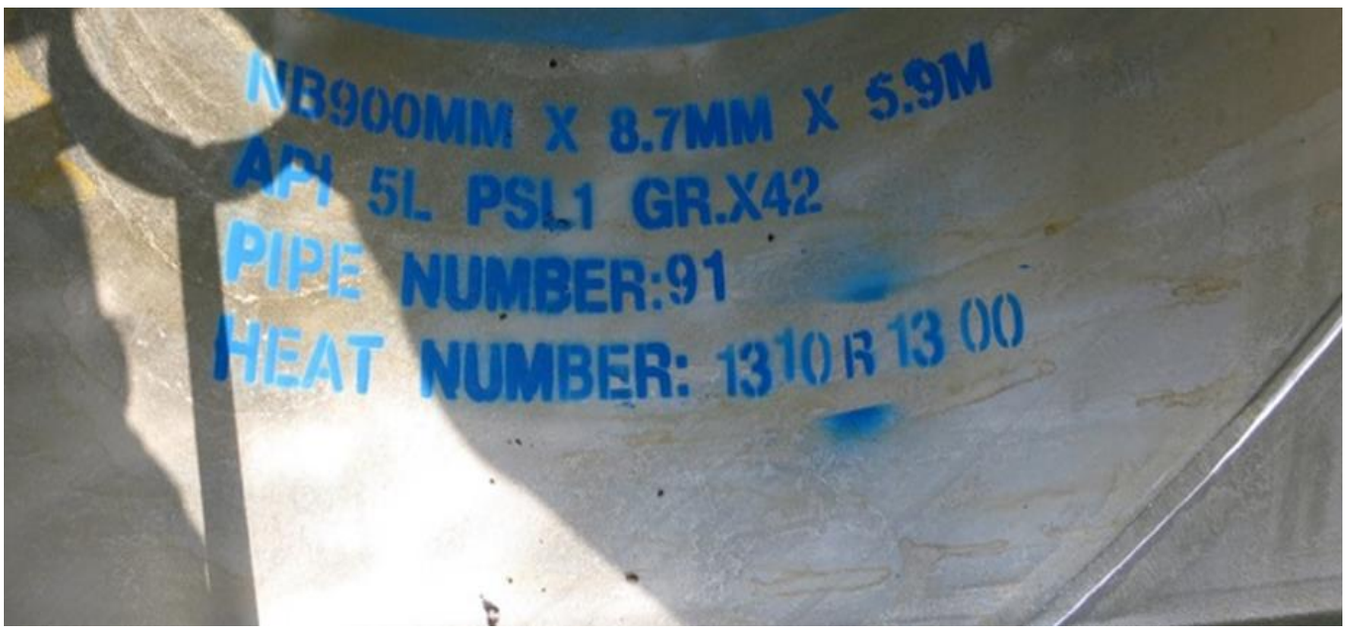




# GALVANIZING

Pipe galvanized with an average thickness of more than 85 micron.





# PACKING & HANDLING

Both ends welded with spider to prevent deformation.

# LOADING & DELIVERY

# LOADING & DELIVERY

# CRUISE SHIP DOCKING FACILITY

## SHIP DOCKING FACILITY PROJECT

| | |
|---|---|
| **Project Name** | Amber Cove, Dominican Republic |
| **Client** | Carnival Cruise Line |
| **Contractor** | Orion Marine Group |
| **Location** | Bahia De Maimon, Dominican Republic |
| **Product** | SSAW Pipe |
| **Total Tonnage** | 4,346 MT |

# ESC SCOPE OF SUPPLY

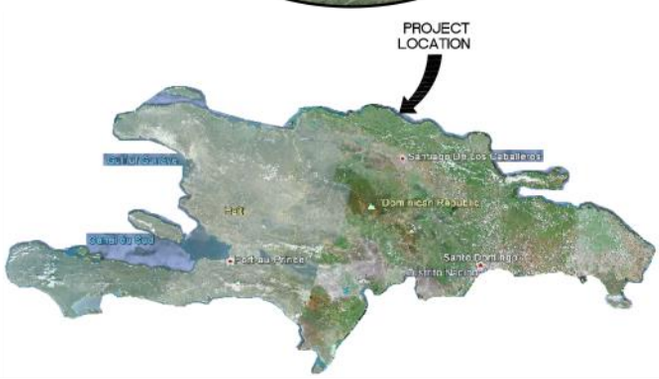
## SSAW PIPE

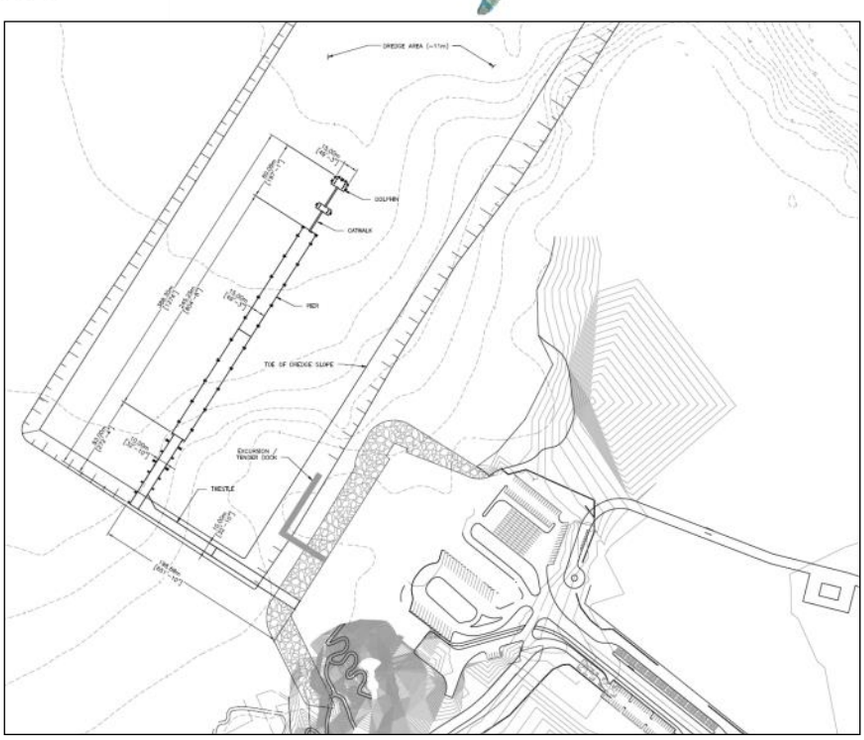
ESC was awarded the job to supply painted tubular pile for the construction of a cruise ship docking facility located in the Dominican Republic.

ESC supplied the required SSAW pipe with outside diameter range from 508mm ~ 1371.6mm at a thickness of 16mm. Length of pipe varies from a range of 31.396m ~ 54m.

The entire 4,346 tons of painted pipes were delivered to site within 90 days of order.

ESC coordinated with the contractor to ensure the vessel was able to directly unload to their barge at the project site to save time and cost.



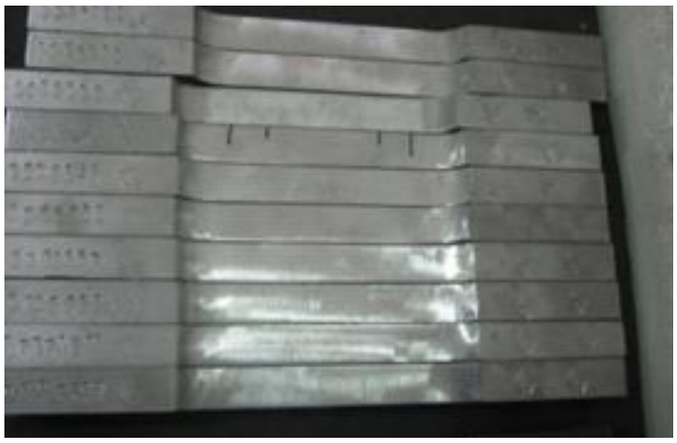



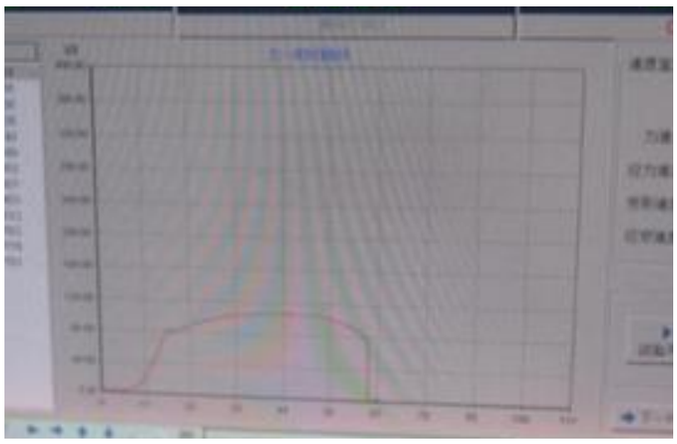
Overall site map.

# RAW MATERIAL INSPECTION

Raw material (hot rolled steel coil) for the project supplied in accordance with ASTM A1018 Gr50 at a thickness of 16mm.

The quality of the raw material is critical to ensure the final product meets the project specification. Thickness of each coil is inspected and the identity of the material shall be traceable with each coil.





Mechanical properties test and chemical composition analysis is carried out on each available heat number. Each test is performed with the witness from ABS (third party inspector).

Raw material must pass dimensional inspection, visual inspection, traceability inspection, mechanical properties test, and chemical composition analysis before the production process can be started.

# PIPE FORMING

Traceability: Stencil marking on the pipe inner surface once the pile is formed to ensure traceability is under control throughout the whole production process.

SSAW PIPE FORMING PROCESS WITH 100% ONLINE UT

NDE INSPECTION: MANUAL ULTRASONIC TEST

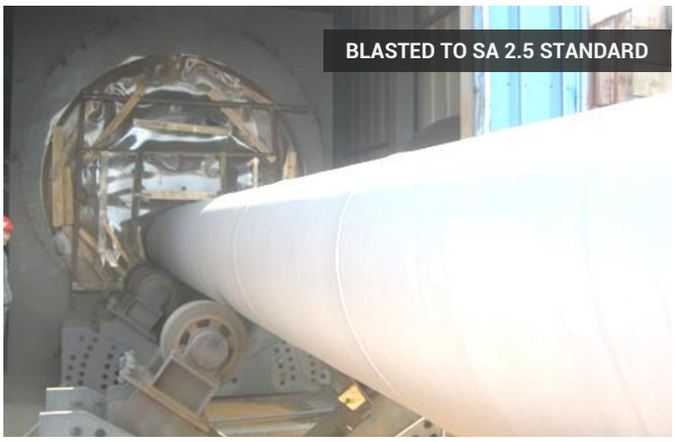
DIMENSIONAL INSPECTION

A third party inspector was present during the entire production process including all quality control processes, ABS (American Bureau of Shipping) was the third party inspector.

Quality Control: 100% visual inspection, online UT as well as manual UT performed on both spiral and plate end welds, 100% dimensional inspection including ovality, straightness, diameter, length, and squareness of pipe ends.

# SURFACE PREPARATION & PAINTING

AMBIENT CONDITION MEASUREMENT


BLASTED TO SA 2.5 STANDARD

BLASTED PIPE

PAINTED WITH BLACK COLOUR COAL TAR EPOXY PAINT WITH TOTAL DRY FILM THICKNESS OF 410µM

CHECK SUBSTRATE TEMPERATURE PRIOR TO EACH LAYER OF COATING

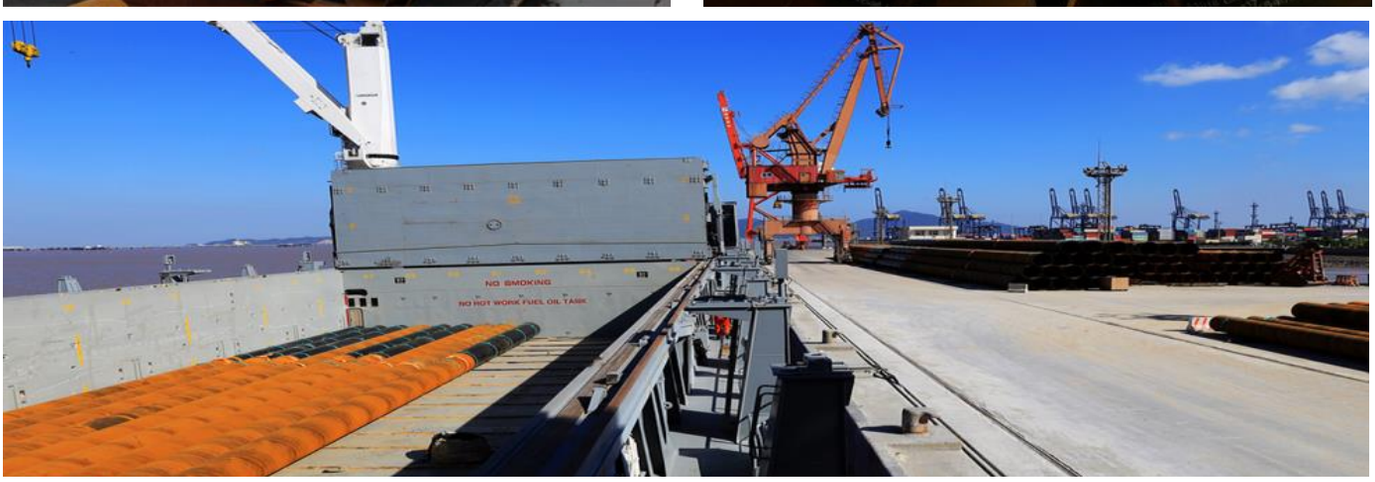
RANDOM SAMPLE ADHESION TEST

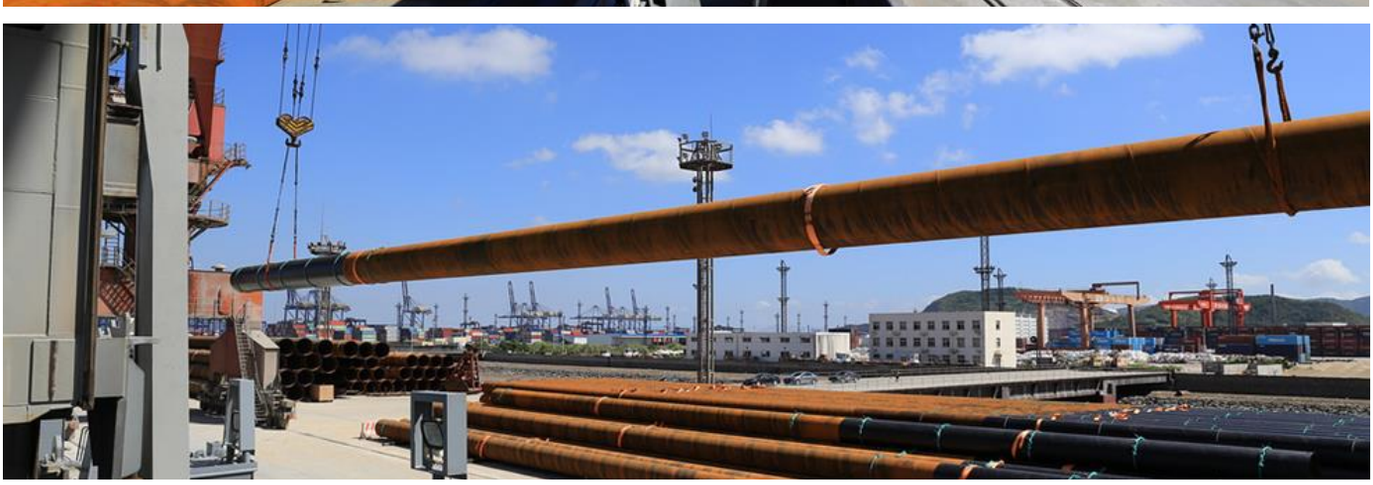
DFT INSPECTION IN ACCORDANCE WITH SSPC PA2

100% HOLIDAY TEST

# PACKING, STACKING & SHIP LOADING

PAINTED PIPE PACKING AND STACKING METHOD: PROTECT AGAINST DAMAGES TO THE PAINTED SURFACE.



# SHIP LOADING

## ARRIVAL AT DESTINATION

## DOMINICAN REPUBLIC CRUISE SHIP DOCKING FACILITY

# EUROTANK OIL TERMINAL

## OIL TERMINAL PROJECT

| | |
|---|---|
| **Project Name** | Tankput 19 Vopak Terminal |
| **Client** | Europile BV |
| **Main Subcontractor** | Geka Bouw B.V. |
| **Location** | Amsterdam, Netherlands |
| **Product** | Sheet Piles & Capping Beams |
| **Total Tonnage** | 550 MT |
| **Delivery Date** | March 2008 |

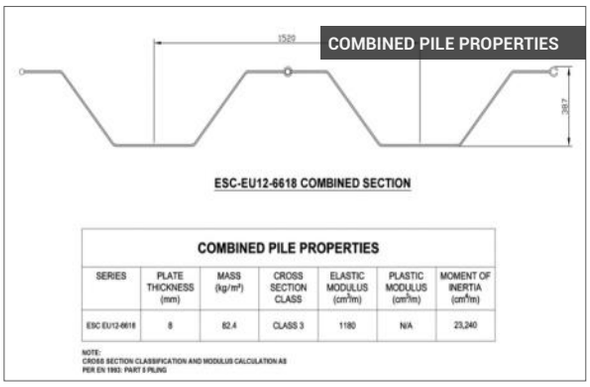
### INTRODUCTION

ESC quickly gained successive orders with Europile BV in the Netherlands with the EuroTank Terminal in Amsterdam, Netherlands.

Legislation required that they needed to have an impervious fire proof barrier put in place around the oil tanks. They had to have a perimeter that would withstand the possible scenario of a massive failure of the tanks and all the contents flowing out into the surrounding area. In addition, this liquid could well be on fire at the time so the perimeter had to cater for this potential issue as well.

After a long design discussion where various options were looked at by the Contractor and Client (like concrete and earth walls) is was decided to use sheet piles. The ESC sheet piles with their wide profile made an ideal selection due to their very limited clutches per metre of wall. The sealing of the clutch is at least half that of other sheet piles and this also means less risk of seepage for the Contractor.

Geka Bouw B.V. won the project with a sheet pile option supplied by ESC. ESC worked closely with Geka Bouw B.V. through its agent in Europe, Europile B.V.




COMBINED PILE PROPERTIES

| SERIES | PLATE THICKNESS (mm) | MASS (kg/m²) | CROSS SECTION CLASS | ELASTIC MODULUS (cm³/m) | PLASTIC MODULUS (cm³/m) | MOMENT OF INERTIA (cm⁴/m) |
|---|---|---|---|---|---|---|
| ESC EU12-6618 | 8 | 82.4 | CLASS 3 | 1180 | N/A | 23,240 |

NOTE:
CROSS SECTION CLASSIFICATION AND MODULUS CALCULATION AS PER EN 1993: PART 5 PILING

# ESC SCOPE OF SUPPLY

## SHEET PILES

Calculations were carried out by ESC in order to ensure that the stringent requirements of the Client (EuroTank B.V.) and the Contractor were met whilst at the same time the budget constraints needed to be adhered to.

All sheet piles were painted on the top 4.1 metres (both sides) with 375 microns of Jotamastic 87 black paint. The capping beams were completely coated using the same paint and thickness. All painting works were carried out in the ESC factory in China. During installation some paint discolouring and damage was noticed. Therefore, ESC/Europile put an extra layer of Jotun PU coating on top of the original Jotamastic coat to make sure that the grey colour kept its final RAL code for the design length.

Extra clutches were sent along with the shipment to ensure that if any special corners were needed to be turned or obstacles caused a variation in the driving line then Geka Bouw BV was able to perform the onsite fabrication without any delays to the project timetable. The Bill of Quantities for this project included:

- ESC-EU12 Sheet Piles of various lengths between 8-10m Grade Q345B (528 tons)
- Steel Capping Beam x 11.8m length Steel Grade Q235B (22 tons)

# CARGO LOADING

SHEET PILES INSPECTION

THE SPECIAL PACKAGING ALLOWED FOR FULL UTILISATION OF CONTAINER SPACE

SHEET PILES READY FOR SHIPPING

# ON-SITE INSTALLATION

# JALAN DUTA, KUALA LUMPUR ROAD WIDENING PROJECT

## RETAINING WALL PROJECT

| | |
|---|---|
| **Project Name** | Permanent Sheet Piling and Ground Anchor System Along Wall 4 and Wall 8 |
| **Client** | Jabatan Kerja Raya Malaysia and Ahmad Zaki Sdn Bhd |
| **Location** | Kuala Lumpur, Malaysia |
| **Product** | Retaining Wall and Ground Anchors |
| **Date** | May 2005 |

### INTRODUCTION

ESC Projects (M) Sdn. Bhd. (ESC's construction arm), carried out a project in Kuala Lumpur, Malaysia for the Jabatan Kerja Raya, Malaysia (Public Works Department of Malaysia) where ESC sheet piles were used in a permanent situation. This allowed for faster construction time, lower cost and an aesthetically pleasing finished product.

Wall 4 before construction.

# ESC SCOPE OF SUPPLY

## RETAINING WALL & GROUND ANCHORS

ESC's scope was to provide the design, supply and construction of the complete retaining wall and the associated ground anchors for the sections with greater exposure. The design is based on a permanent sheet pile system that is supported by permanent ground anchors at W4 and permanent cantilever wall system at W8. The objectives of the system were;

To stabilise the existing slope in the long term against slides and movement caused by the additional engineering loads (backfill) on top of it and the subsequent traffic flow.

The geotechnical analysis will determined the requirements of the sheet pile retaining wall and anchoring system. The parameters determined were:

1. Earth and groundwater pressures
2. Structural forces
3. Settlements and displacements

Standards used in this section are;

BS 8002: Code of practice for earth retaining structures

# PROJECT DETAILS

Soil parameters were obtained from the borelogs. For wall W4, the results from the Standard Penetration Test indicated that there was a hard impenetrable layer varying from 9.0m to 12.0m from top of the road finished level, where the Very Dense Sand and Hard Silt layers are found. Therefore, the required embedment for 9.0m piles should be achieved with the usage of high frequency vibro hammer and / or hydraulic drop hammer. Different values of Ø' were used for wall W8. This is due to the actual soil conditions on site are much higher than the conditions indicated in soil log. The existing slope with the range of 26.5˚ - 29.1˚ steepness could actually stand up stably by itself with the existing soil conditions, which means that the soil frictions on site must be sufficiently high. Moreover the available bore log was carried out 3 years ago about 20m away from wall W8.

An analysis of the entire retaining wall system was carried out using the ReWaRD Retaining Wall software.

In accordance with BS8002, the following considerations were made to the analysis of the retaining wall in order to comply with the limit state design requirements;

- Minimum over excavation of 0.5m
- Minimum surcharge of 10 kPa
- Use of design soil parameters, which are defined as the representative soil parameters divided by a mobilisation factor (M) of 1.2 (effective stress design).

During all analysis, active water tables were set conservatively at 1.2m depth on retained side and passive water tables at 0.5m depth on excavated side for wall W4. While wall W8, the active and passive water table were set at 6.0m below the finished road level, since wall W8 is located on top of an embankment.

In accordance with BS 8081 the anchor load design was done in compliance with working load design, therefore the representative soil parameters are used in the analysis of the required anchor loadings.

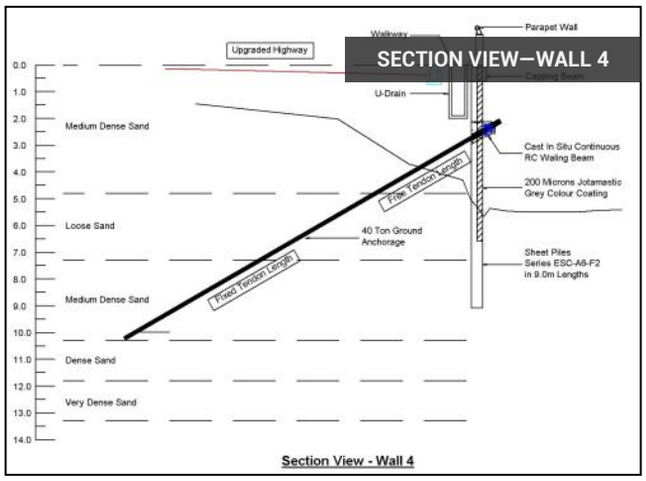
Due to the different soil conditions required to satisfy the different codes, two cases were analysed of the structure using the ReWaRD software;

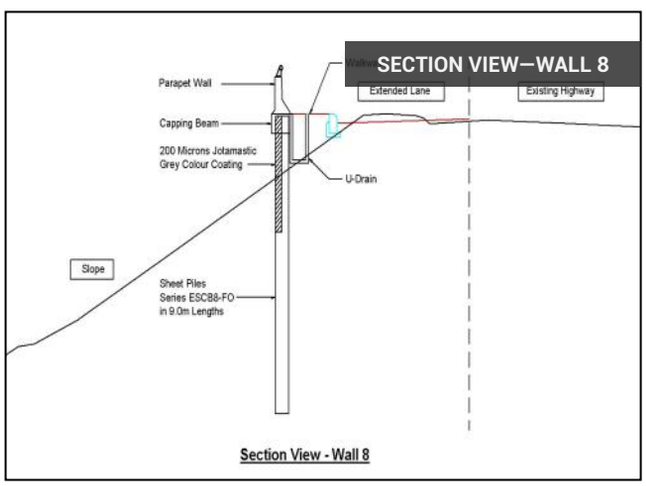
- SP case to determine sheet pile requirements (BS 8002)
- ANC case to determine anchor loadings (Eurocode – Serviceability)

While Wall W8 was analysed using the most critical case (Section on Ch 30.00), with the highest retained soil and steepest slope profile. And the largest factored bending moment recorded was 56.7kNm/m. Please refer to Appendix B for ReWaRD analysis results.

The retaining wall design will consist of two major components;

- Main Wall Sheet Piles




- Ground Anchor System

Standards used in this Section are;

BS 5950: Code of practice for structural use of steelwork in building

BS 8002: Code of practice for Earth retaining Structures

BS 8081: Code of practice for Ground Anchorages

BS 449: Specification for the use of structural steel in building

The moment capacity of the Main Wall is based on;

$$Mc = fy * Z \qquad \text{(eq. 3.3.1)}$$

Where;

Mc = ultimate design moment capacity

Z = section modulus

fy = material yield strength

= 180 N/mm2 for permanent piles

The ground anchors to be used are 400kN working load capacity anchors.

# PROJECT DETAILS

The preliminary designs for wall W4 were carried out based on the following sequences of works:-

i. Installation of the sheet piles.

ii. Backfill to the ground anchorage level at the back of sheet pile wall.

iii. Installation of ground anchors and RC waler

iv. Backfill to the finished road level

v. Construction of the capping beam.

And the preliminary designs for wall W8 were carried out based on the following sequences of works:-

i. Installation of the sheet piles.

ii. Backfill at the back of sheet pile wall up to the finished road level.

iii. Construction of the capping beam.

ESC Projects ( M) Sdn. Bhd provides the Client with complete solutions to their retaining wall needs. The experience gained in the last 10 years have allowed the company to provide basement, marine, retaining and many other sheet pile solutions to markets in Malaysia and overseas.

# BEFORE INSTALLATION

# ON-SITE INSTALLATION

# PROJECT COMPLETED

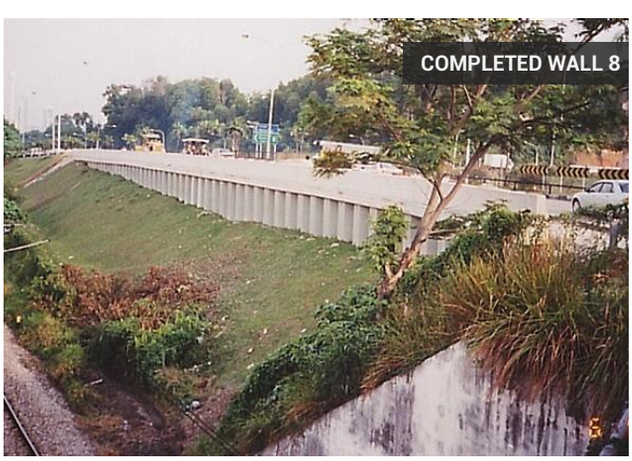
COMPLETED WALL 4

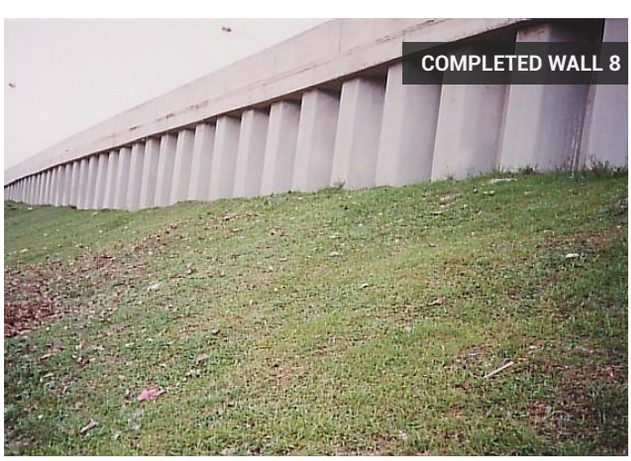
# PROJECT COMPLETED

# COMPLETED PROJECT

COMPLETED WALL 4

COMPLETED WALL 4


COMPLETED WALL 8


COMPLETED WALL 8

# JOHOR BAHRU CONVENTION CENTRE

## CONVENTION CENTRE PROJECT

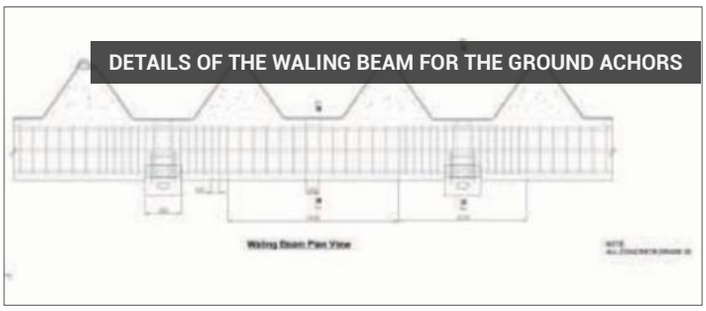
| | |
|---|---|
| **Project Name** | Johor Bahru Convention Centre |
| **Client** | Government of Johor |
| **Main Subcontractor** | Kumpulan SK Jaya Sdn Bhd |
| **Location** | Johor Bahru, Malaysia |
| **Product** | Sheet Piles and Ground Anchors |
| **Total Tonnage** | 408 MT |
| **Delivery Date** | 2005 |

### INTRODUCTION

Time was limited and the project had been given the prioriy by the Government of Johor. Subsequently, Kumpulan SK Jaya Sdn Bhd asked ESC to look at the best way to meet the time constraints and still work within the proposed budget.

The convention centre was to be built on the side of a hill next to the Puteri Pan Pacific Hotel. The excavation need only occur on three sides due to the nature of the site.

From the aspect of geotechnical analysis, the soil log showed existence of clayey materials ranging from firm to very stiff condition. A clay soil will only exhibit plasticity between certain limits of water content. If water content is lower than the plastic limit, the clay will be dry and crumbly. If the water content is greater than the liquid limit, the soil will behave almost like a liquid. This naturally poses a very challenging geotechnical situation for sheet piling and ground anchorage design consideration. Furthermore the pore water pressure and consolidation process during both short and long term for clayey soil also increases the difficulty in sheet pile moment capacity and deflection checking.

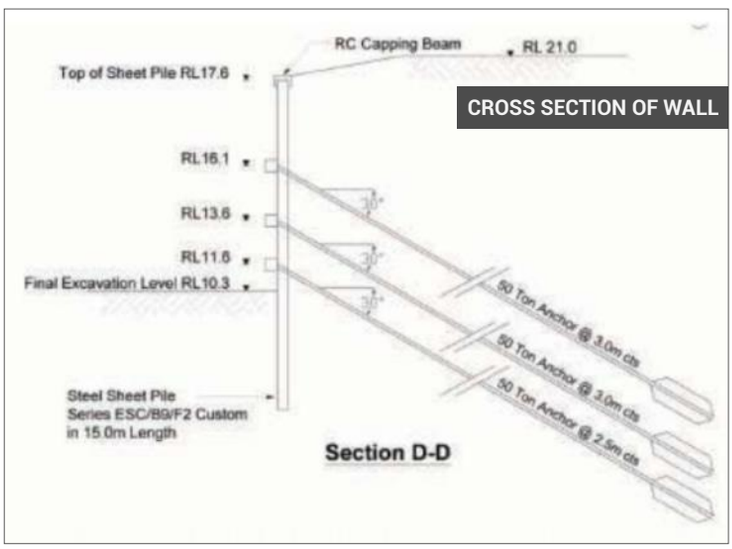



# ESC SCOPE OF SUPPLY

## SHEET PILES & GROUND ANCHORS

ESC suggested that the project use 15 metre sheet piles and permanent ground anchors as the best solution for the client's requirements. ESC won the selection and subsequently supplied 408 tons of ESC-B9-F2 custom sheet piles with a section modulus of 2,800cm$^3$/m along with 297 number of 400kN ground anchors. ESC also installed the sheet piles, ground anchors and carried out the necessary concrete works for the ground anchors waling beams.

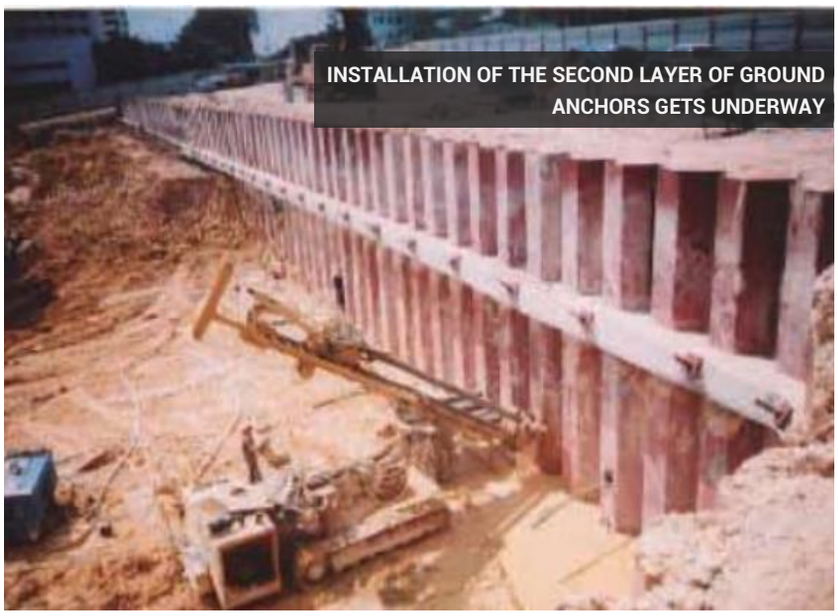
The ground anchors were incorporated into the floor slab during the basement construction and were left in place. All clutches of the sheet piles were welded after installation to provide the 100% water cut-off necessary in such parking structures.



# ON-SITE INSTALLATION

SHEET PILES WERE PITCHED AND DRIVEN TO REFUSAL USING A STANDARD VIBROHAMMER

AFTER INITIAL INSTALLATION WITH THE VIBROHAMMER A HYDRAULIC HAMMER WAS EMPLOYED TO DRIVE TO FINAL DEPTH



INSTALLATION OF THE SECOND LAYER OF GROUND ANCHORS GETS UNDERWAY

# PROJECT COMPLETION

GROUND FLOOR IS COMPLETED

COMPLETED WALL READY FOR USE

PHOTO AFTER 5 YEARS OF USE

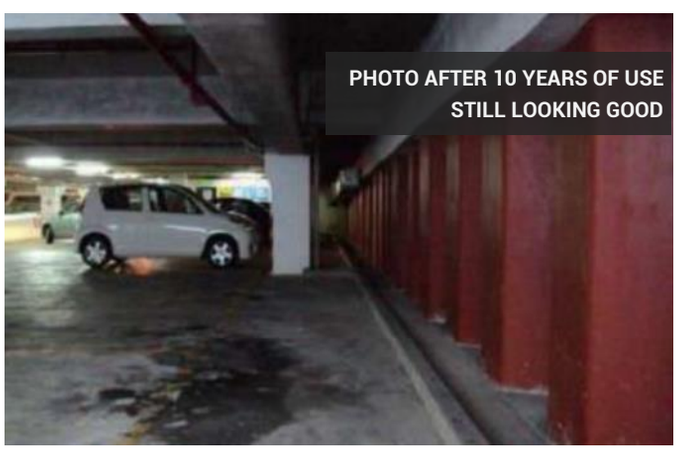


PHOTO AFTER 10 YEARS OF USE
STILL LOOKING GOOD

THE JOHOR CONVENTION CENTRE AFTER COMPLETION IN 2005

# JUBAIL SUPPLY BASE

## SHEET PILE WALL PROJECT

| | |
|---|---|
| **Project Name** | Jubail Supply Base Project |
| **Client** | Jubail Commercial Port |
| **Main Subcontractor** | Dialog E & C Sdn Bhd |
| **Location** | Jubail, Saudi Arabia |
| **Product** | H Piles, Sheet Piles & Tie Rods |
| **Total Tonnage** | 2,078 MT |
| **Delivery Date** | 2011 |

### INTRODUCTION

The Jubail Supply Base (JSB) is located within the Jubail Commercial Port limits utilizing a shallow water wharf adjacent to the Commercial Port, with a common approach channel. The JSB at 80km north of Damman City and airport, is strategically located within the international air and shipping routes on the Arabian Gulf and in close proximity to major oil/gas fields within the Arabian Gulf and petrochemical complexes onshore.

Dialog E&C Sdn Bhd needed the water depth to be increased from –3.5m CD to –6.0m CD in order to cater for offshore support vessels for the supply base. A new sheet pile wall would need to be installed in front of the old wall to cater for the new depth requirements. They to ESC and we provided a solution that combined shipments from ESC's factories in China and Malaysia.

The best solution was an H Pile combination wall with deadman sheet pile and tie rods linking both walls.

# ESC SCOPE OF SUPPLY

## H PILES, SHEET PILES & TIE RODS

The project tonnage was:

- ESC H90/40A-1 x 18m Q345B—1160 Tons
- ESC S9.5 x 18m Q345B—624 Tons (with pile shoes)
- ESC 22BP x 6m S355— 294 Tons
- Tie Rods—57.55mm diameter with rolled thread grade St 670/800 x 19m—20m; 1740 kN yield capacity; Fully galvanized.

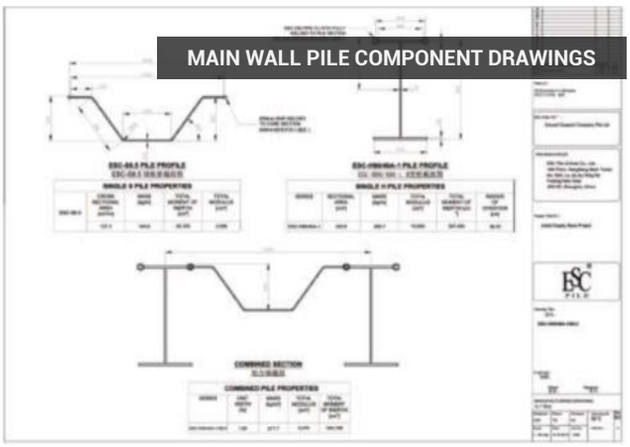
Waling beam (painted) size 305x305 (total 347 ton) with all necessary stiffener plates cut to size for fast and easy installation on site.

Based on soil investigation results, the wharf basin seabed was overlaid with a layer of very dense sand/cemented sandstone with thickness ranging from 0.5m-2m. Below the caprock, the subsoil statum comprised of medium dense sand and very stiff clay.

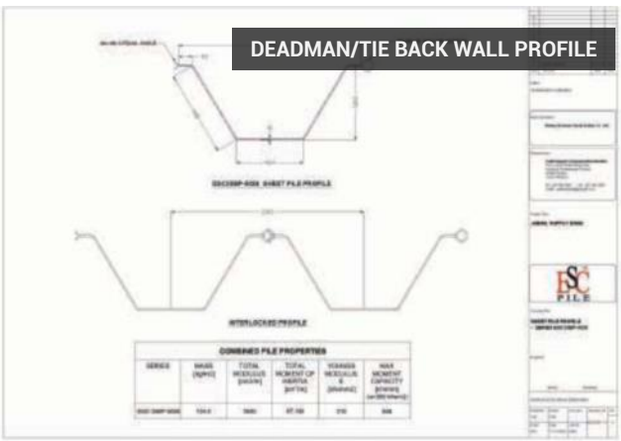
These soil conditions encouraged ESC to advise the client to carry out predrilling for the King(H) Piles and sheet piles to ensure full penetration and speed of installation. In addition, due to the hand driving conditions at the site ESC attached pile shoes on the infill S9.5 sheet pile.

The painting system and surface preparation of the H Piles and sheet piles including other accessories had to cater for the environment category of C5M as stated in BS EN ISO 12944 and ISO 9223. The coating comprised of two layers of epoxy mastic totalling 400 µm dry film thickness, Jotamastic 87 was used for this task. The surface preparation was sandblasted to SA 2.5 according to ISO 8501-1. All the sheet piles, tie rods, waling beam and other steel items were provided with these protective coatings.

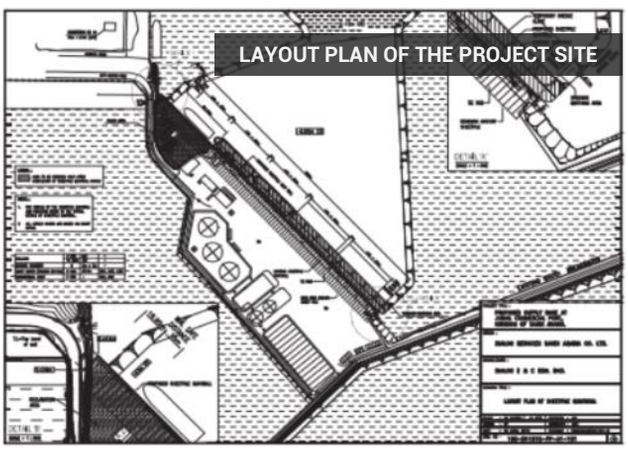
# PROJECT DETAILS



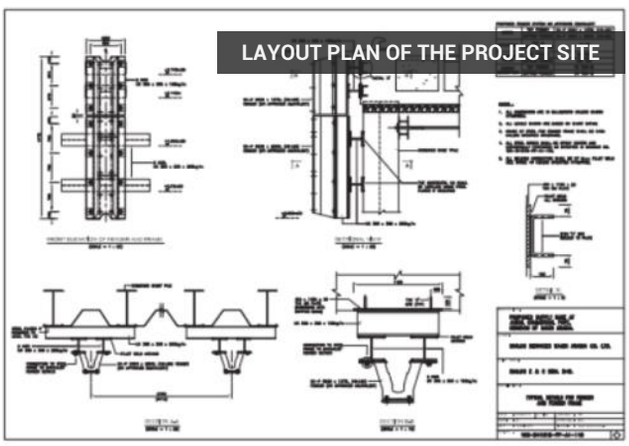
MAIN WALL PILE COMPONENT DRAWINGS



DEADMAN/TIE BACK WALL PROFILE



LAYOUT PLAN OF THE PROJECT SITE



LAYOUT PLAN OF THE PROJECT SITE

# PAINTING

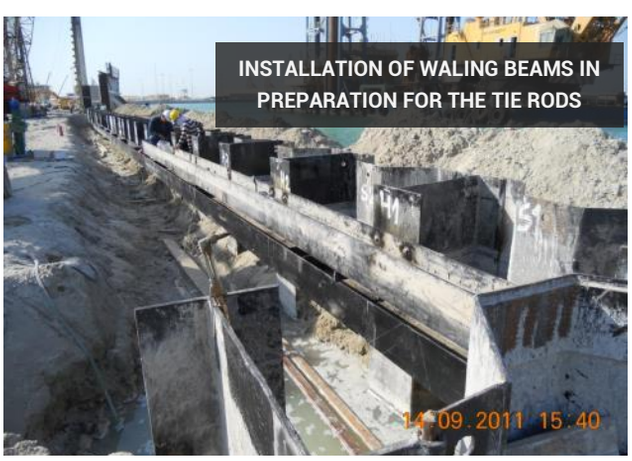
WALING BEAMS FOR THE TIE BACK SYSTEM BEING PAINTED IN ESC MALAYSIA'S FACTORY

# SHIP LOADING

# ON-SITE INSTALLATION

ONGOING INSTALLATION OF MAIN WALL

TIE ROD INSTALLATION BEGINS




INSTALLATION OF WALING BEAMS IN PREPARATION FOR THE TIE RODS

PARTIALLY COMPLETED SECTION OF THE WALL

# COMPLETED WALL

# KAOHSUING PORT COMBI WALL, TAIWAN

## COMBI WALL PROJECT

| | |
|---|---|
| **Project Name** | Kaohsuing Port Combi Wall, Taiwan |
| **Main Subcontractor** | Meng-Deng Construction Co. Ltd, of |
| **Location** | Kaohsuing, Taiwan |
| **Product** | Tubular Piles and Sheet Piles |
| **Total Tonnage** | 10,282 MT |
| **Delivery Date** | 2011 |

### INTRODUCTION

Meng-Deng Construction Co. Ltd, of Taiwan had a project for the Port expansion in Kaohsuing, Taiwan. The options they were given by the normal large sheet pile providers were just not cost effective enough for the budget and design constraints that the Port had.

ESC Pile Steel Trading (Shanghai) Co, Ltd looked at the best method for the contractor and the Kaohsuing Harbour Bureau, Ministry of Communications. After several discussions and design options ESC and Meng-Deng settled on the Tubular sheet pile combi wall.

The Existing structure was unable to take the larger size of the newer vessels as well as the required dredge depth for the larger vessels that were calling in Kaohsuing. The method approved was to install the main wall of the tube and sheet pile in front of the existing structure and then proceed with the removal of the old wall and installation of the rest of the system.

With Ports globally getting deeper and deeper in order to handle the post Panamax Container vessels and other newer and larger conventional vessels it is expected that more and more clients and Port owners will look to these solutions for their requirements.

# ESC SCOPE OF SUPPLY

## TUBULAR PILES & SHEET PILES

The unbeatable combination of ESC's design and sourcing allowed the contractor to manufacture the 1470mm diameter, 15mm thickness tubes in 31 metre lengths (approx. 8000 tons) in Taiwan. Then, we sourced 28, 19 and 13 metre sheet piles from Nippon Steel in Japan (2,282 tons of IIIw in SY390) and finally the 109 tons of specially made IIIw sheet pile clutches that are unique to ESC.

The project saved considerable time and money for the contractor and was a very successful first tubular combi wall application in Taiwan.

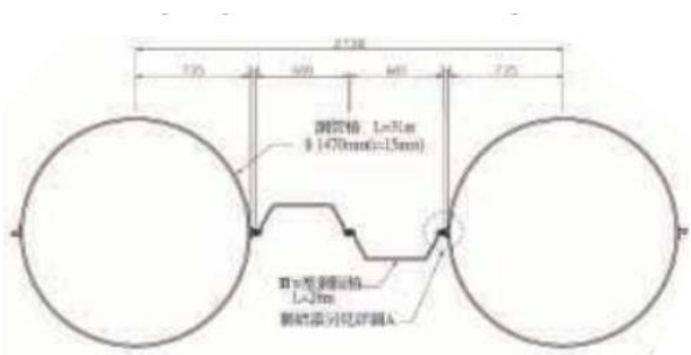


Figure 1 Plan view of the Combi wall profile

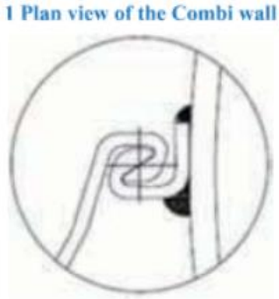
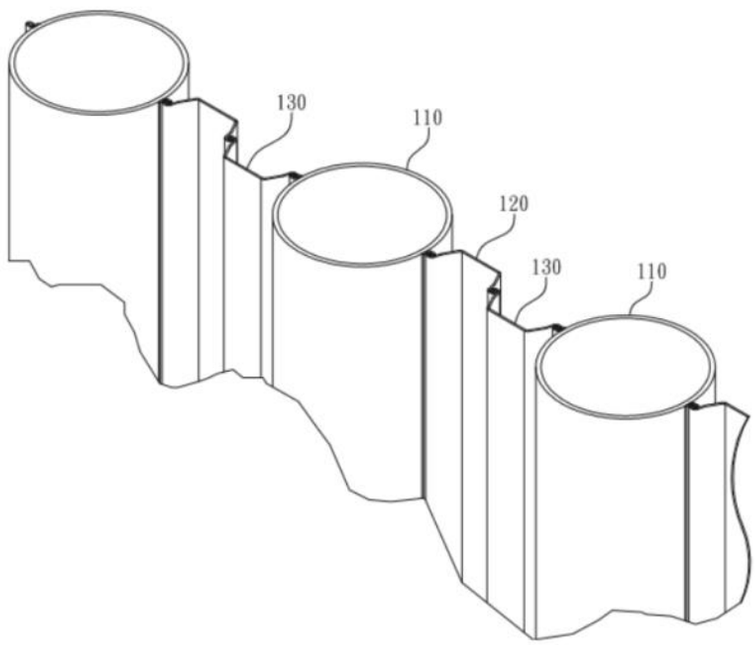


Figure 2 Clutch configuration detail

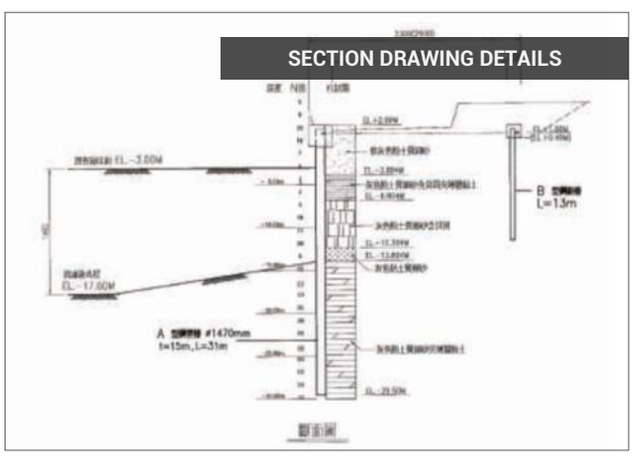
# PROJECT DETAILS

Here is the isometric drawing of the wall profile showing the two IIIw infill sheet piles in between the 1470mm tubes. This system is installed with the tubes or king piles first using a driving guide. Once the tubes are installed the guide is removed and the IIIw sheet piles installed between the spaces and slotted in using the special clutches attached to the tubular piles. Below, we can see the schematic drawing which allows for five tubular piles to be installed before the guide is removed. This guide is essential in the efficient installation of long marine sheet pile walls. Without it productivity is greatly reduced as well as the straightness and aesthetics of the final wall. As you can well imagine if you get the tubular piles out of alignment then it will be nearly impossible to install the infill sheet piles.

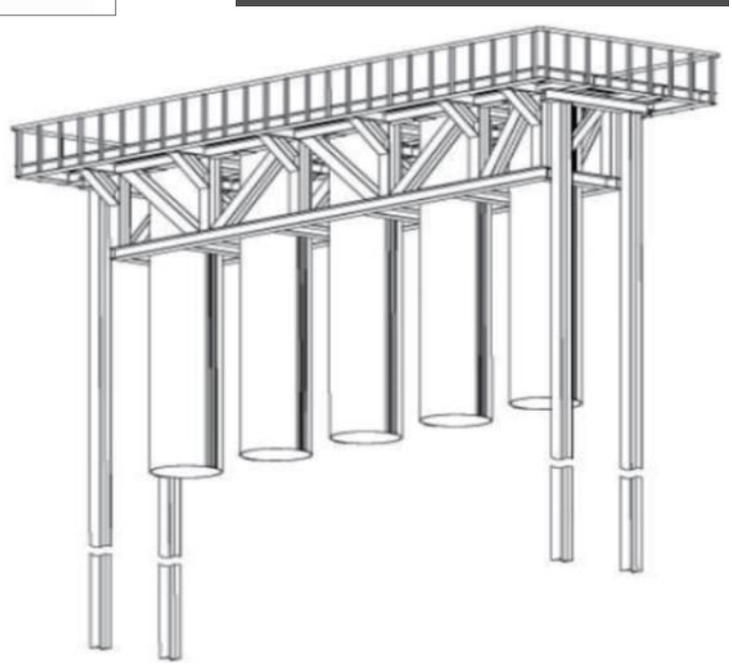
ISOMETRIC DETAIL OF THE MAIN WALL SYSTEM




SECTION DRAWING DETAILS




DRIVING GUIDE DESIGNED BY ESC

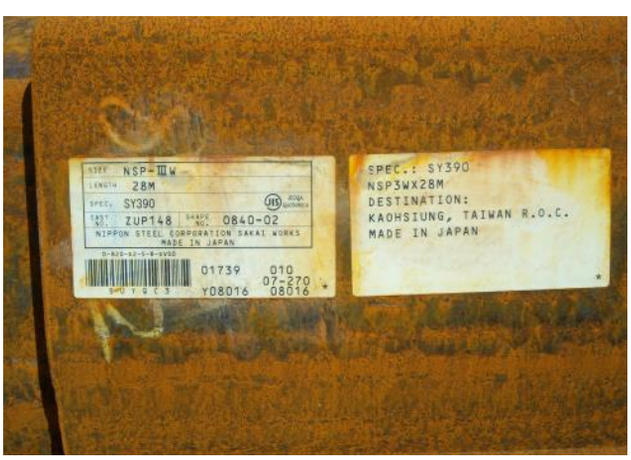


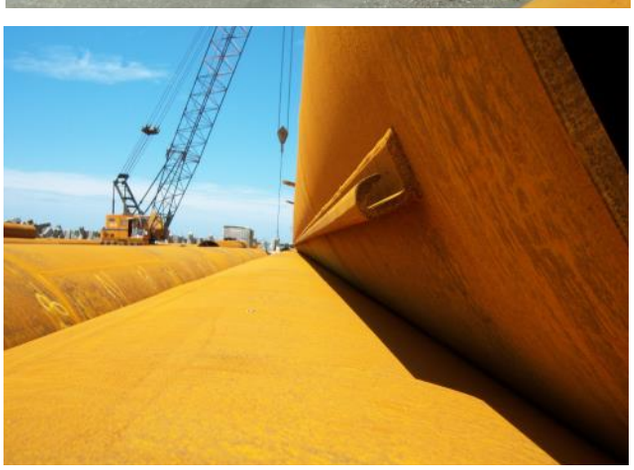
# PROJECT DETAILS

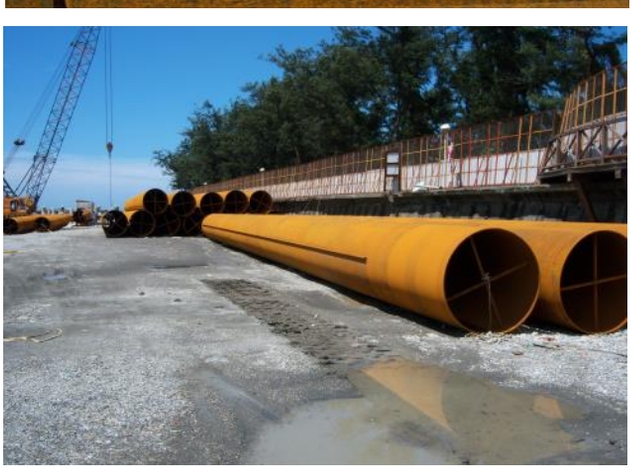
CLUTCH ON CLUTCH PROFILE

TUBULAR PILES WITH CLUTCHES

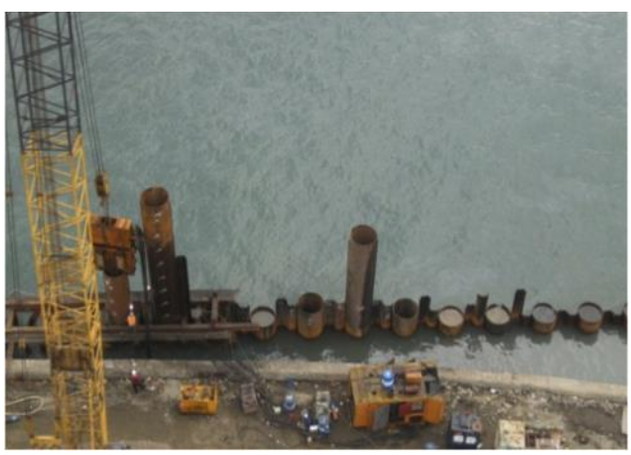
# DELIVERY TO SITE

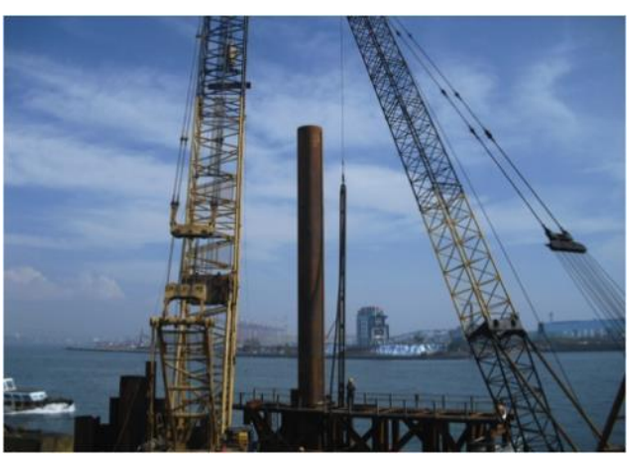


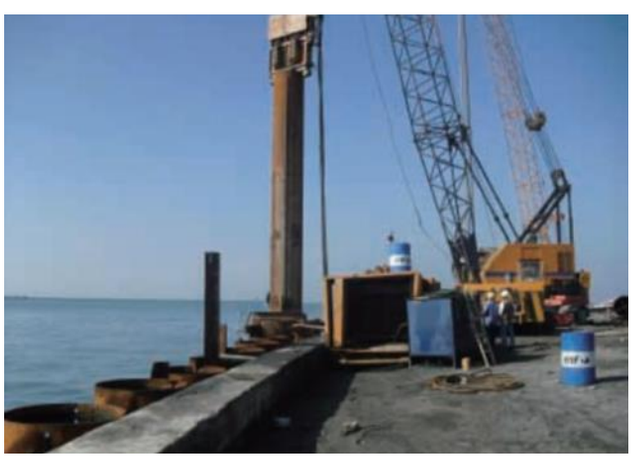



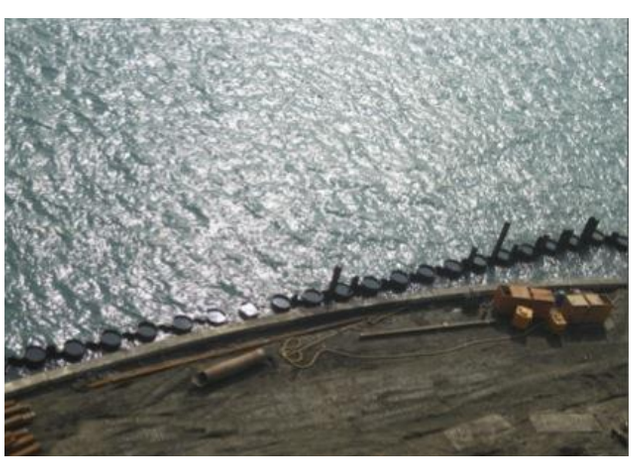


# ON-SITE INSTALLATION









# LIQUID BULK TERMINAL RUBIS

## TANK PROTECTION PROJECT

| | |
|---|---|
| **Project Name** | Liquid Bulk Terminal Rubis |
| **Main Subcontractor** | Geka Bouw B.V. |
| **Location** | Taiwan |
| **Product** | Sheet Piles |
| **Total Tonnage** | 283 MT |
| **Delivery Date** | March 2009 |

### INTRODUCTION

Europile BV in the Netherlands secured yet another Tank Protection Project, this time for the Rubis Tank Terminal in Rotterdam, Netherlands.

Legislation required that they needed to have an impervious fire proof barrier put in place around the oil tanks. They had to have a perimeter that would withstand the possible scenario of a massive failure of the tanks and all the contents flowing out into the surrounding area. In addition, this liquid could well be on fire at the time so the perimeter had to cater for this potential issue as well.

# ESC SCOPE OF SUPPLY

## SHEET PILES

The Bill of Quantities included:

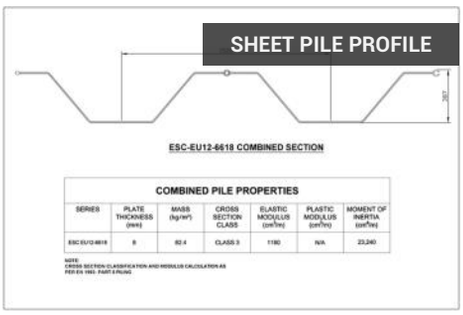
ESC-EU12 Steel Sheet Piles Grade Q345B in various lengths from 9.5m to 10.5m (252 tons)

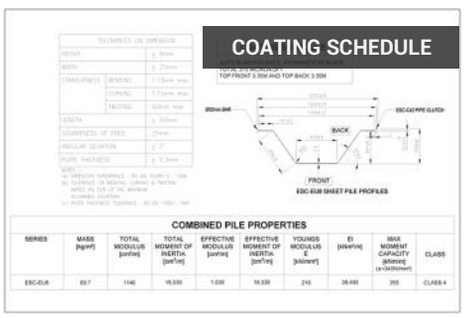
ESC-EU8 Steel Sheet Piles Grade Q345B in various lengths from 5.7m to 7.7m (31 tons)

Calculations were carried out by ESC in order to ensure that the stringent requirements of the Client and the Contractor were met whilst at the same time the budget constraints needed to be adhered to.

All EU12 sheet piles were painted on the top 3.35 metres on the front side and the top 4.0 metres on the back side with 375 microns of Jotamastic 87 black paint. The EU8 sheet piles were painted on the top 3.35 metres on the front side and the top 3.35 metres on the back side with 375 microns of Jotamastic 87 black paint All painting works were carried out in the ESC factory in China.

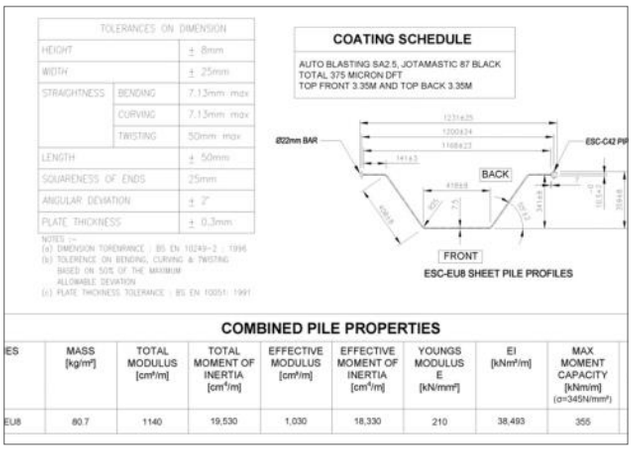
The ESC sheet piles with their wide profile made an ideal selection due to their very limited clutches per metre of wall. The sealing of the clutch is at least half that of other sheet piles and this also means less risk of seepage for the Contractor.



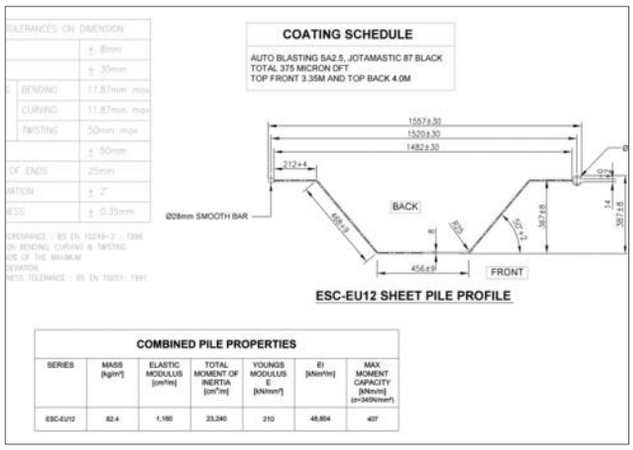

Extra clutches were sent along with the shipment to ensure that if any special corners were needed to be turned or obstacles caused a variation in the driving line then Geka Bouw BV was able to perform the onsite fabrication without any delays to the project timetable.

# PROJECT DETAILS




COMBINED PILE PROPERTIES

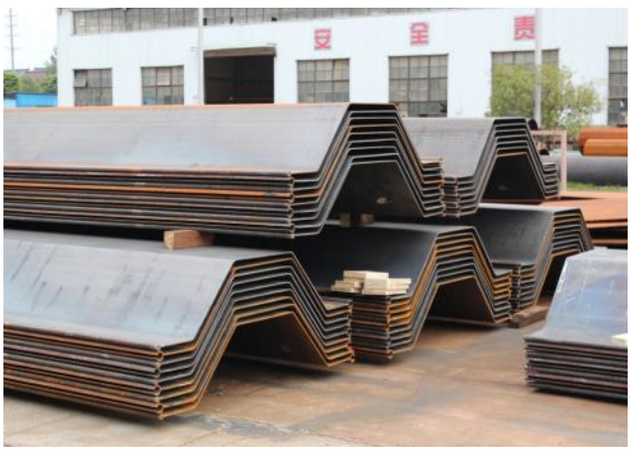
| ES | MASS [kg/m²] | TOTAL MODULUS [cm³/m] | TOTAL MOMENT OF INERTIA [cm⁴/m] | EFFECTIVE MODULUS [cm³/m] | EFFECTIVE MOMENT OF INERTIA [cm⁴/m] | YOUNGS MODULUS E [kN/mm²] | EI [kNm²/m] | MAX MOMENT CAPACITY [kNm/m] (σ=345N/mm²) |
|---|---|---|---|---|---|---|---|---|
| EU8 | 80.7 | 1140 | 19,530 | 1,030 | 18,330 | 210 | 38,493 | 355 |




COMBINED PILE PROPERTIES

| SERIES | MASS [kg/m²] | ELASTIC MODULUS [cm³/m] | TOTAL MOMENT OF INERTIA [cm⁴/m] | YOUNGS MODULUS E [kN/mm²] | EI [kNm²/m] | MAX MOMENT CAPACITY [kNm/m] (σ=345N/mm²) |
|---|---|---|---|---|---|---|
| ESC-EU12 | 82.4 | 1,180 | 23,240 | 210 | 48,804 | 407 |

# PACKING & DELIVERY TO SITE



# ON-SITE INSTALLATION

# CONCRETE FOUNDATIONS

# PROJECT COMPLETED

# MELAKA RIVER BEAUTIFICATION

## BEAUTIFICATION WORKS PROJECT

| | |
|---|---|
| **Project Name** | Melaka River Beautification |
| **Main Subcontractor** | Pesona Metro Sdn Bhd |
| **Consultant** | SMHB of Malaysia |
| **Location** | Melaka, Malaysia |
| **Product** | Sheet Piles |
| **Total Tonnage** | 3,000 MT |
| **Delivery Date** | 2005 |

### INTRODUCTION

Melaka is a very popular destination for Malaysian and foreign tourists alike. The history and beauty of the city was legendary. However, over the years there had been unauthorised building and unwanted dumping of waste into the Melaka River from residents and industries alike. The Government could not advertise and utilise the river as part of its promotion anymore.

It was decided to clean up the river and allow larger tourist boats to venture up the river as well as providing pedestrians with an unhindered walking access along the river's edge for more than 5km from the river mouth. This also ran hand in hand with a major clean up of the waste that was being dumped in the river and an education programme for the citizens and local industry. They knew it was no good making a new development if old habits turned it back into an eyesore and health risk and people didn't want to use it.

# ESC SCOPE OF SUPPLY

## SHEET PILES

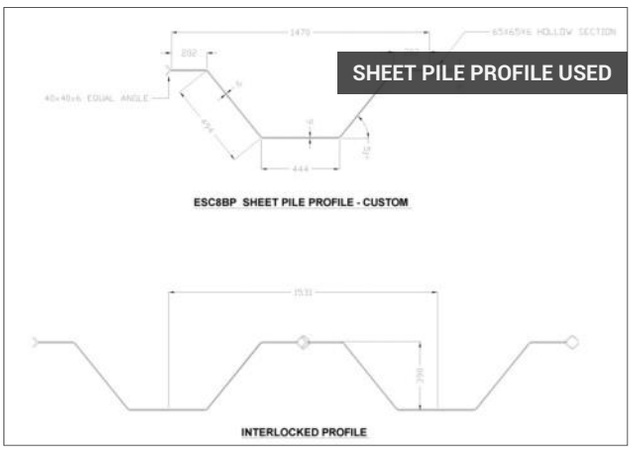
In 2005 Pesona Metro Sdn Bhd came to ESC asking for assistance in the designing, manufacturing and installation for a bold new plan to clean up the Melaka River and make it more conducive to tourists and local residents alike. The designs and the long term goal had to take into consideration a 50 year design life and the fact that the new sewage lines that were going hand in hand with the beautification could be accommodated within the scope of the structure if necessary. Piles were galvanised in some sections and painted in others according to the requirements.

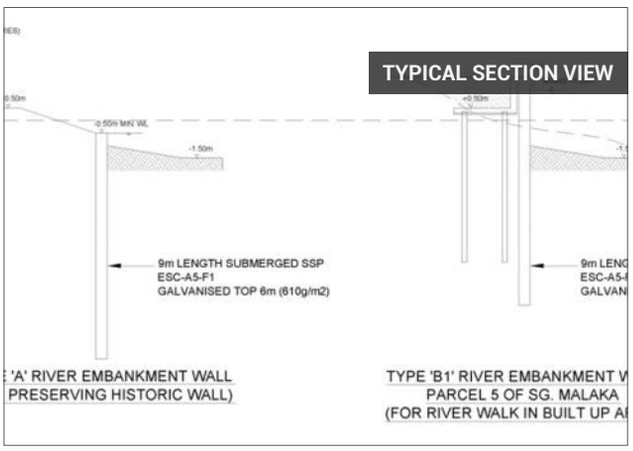
The Government of Melaka awarded the very prestigious project to Pesona Metro Sdn Bhd based on their combined experience and particular expertise that they brought to the table with ESC and Consultants SMHB of Malaysia. All parties worked very closely together for a period of more than 4 years from design stage right through to the implementation and completion stage. Sheet pile profiles varied from section to section along the many stages of the project.

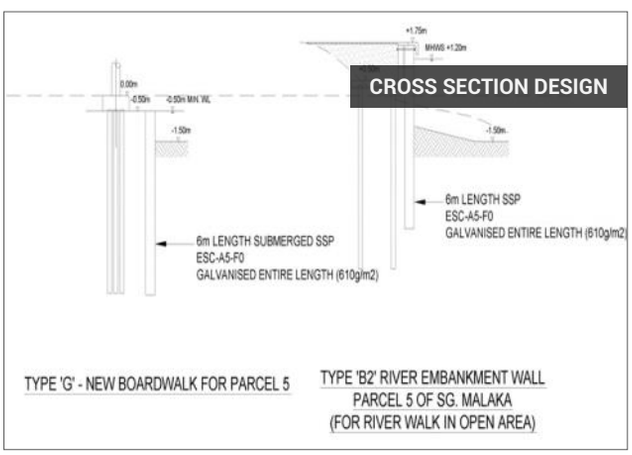
The sheet pile was designed strictly as an aesthetic river frontage in most of the sections as the walkways were predominately supported by reinforced concrete piles thus enabling the structure to require no loading to be taken by the sheet piling. More than 3,000 tons of sheet piles were used in the project over the 4 year period.

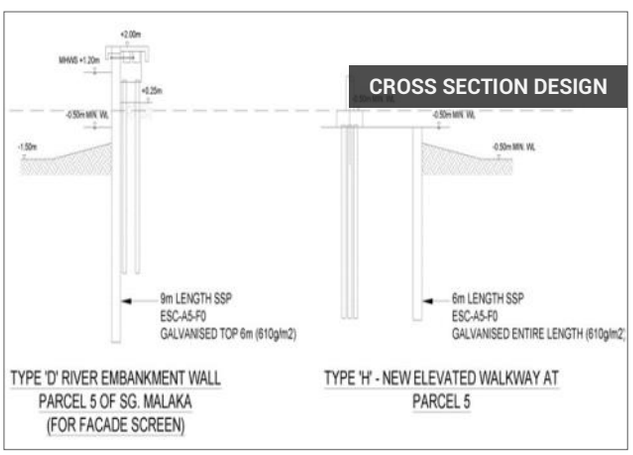
ESC's cost effective design and locally manufactured sheet piles were integral for securing the scope of work.

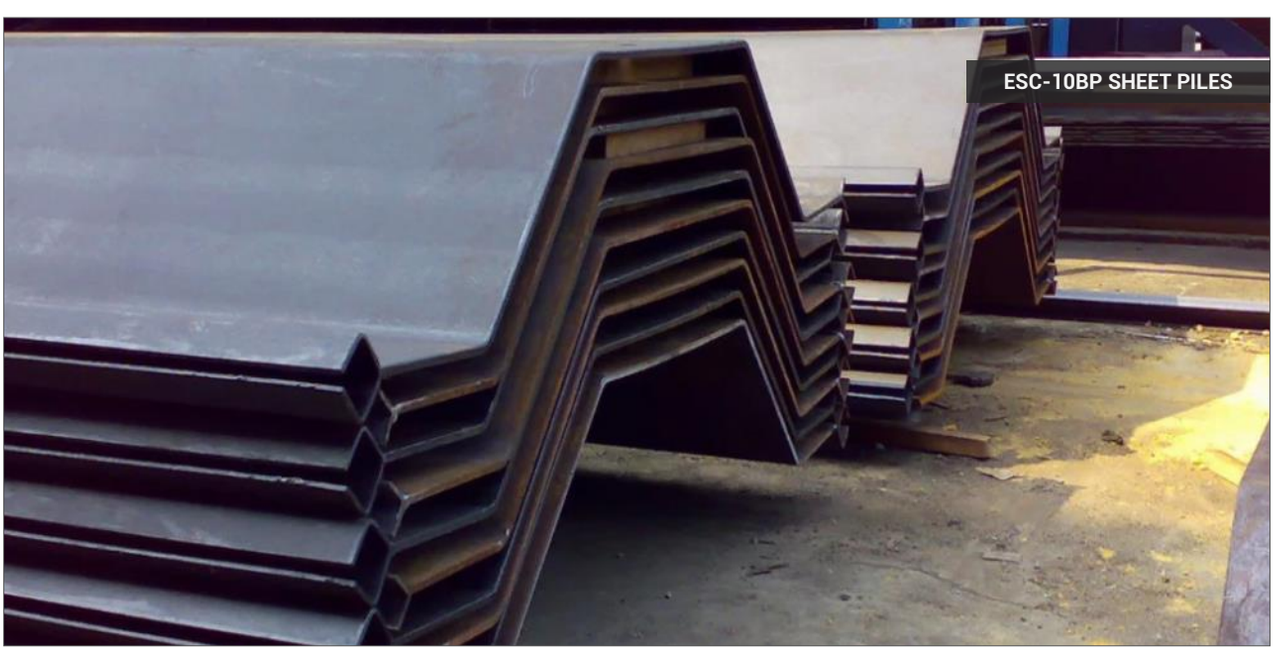
# PROJECT DETAILS



# MELAKA RIVER BEFORE & AFTER

# MELAKA RIVER BEFORE & AFTER

# PROJECT COMPLETED

# PROJECT COMPLETED

# MODULAR TRANSPORT BEAM SYSTEM

## MODULAR BEAM TRANSPORT PROJECT

| | |
|---|---|
| **Project Name** | Modular Beam Transport System |
| **Main Contractor** | ALE Heavylift BV |
| **Location** | Netherlands, United Kingdom |
| **Product** | Transport Beams |
| **Delivery Date** | July 2013 |

### INTRODUCTION

ESC was awarded the manufacture of an innovative heavy duty modular beam transport system with adjustable lengths, capable of carrying heavy assemblies for loadout such as container cranes, offshore towers. ESC carried out high precision, heavy duty fabrication.

There are 6 central beams with lugs on both ends and 4 end beams with lugs on one end only - to form a two sided 55 metre length platform that can be rolled along the ground.

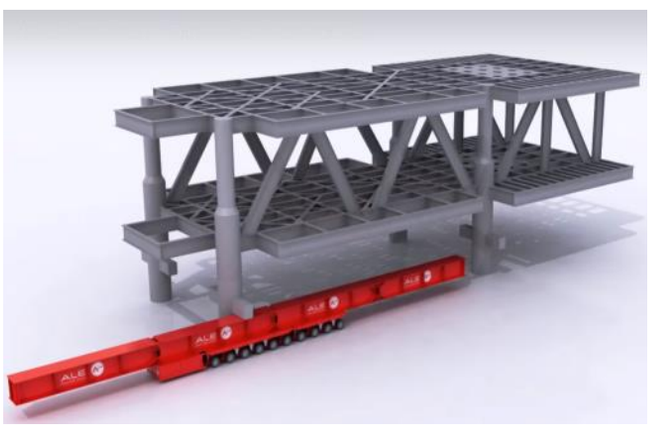
Each of these beams was 1.55 metres height, 1.6 metres width and 10.7 metres in length. The steel grade high tensile steel grade S355J2G3. A complex configuration of lug holes that had to align in different planes meant the finished tolerances were critical in acceptance by the client of the steel beams. Qualified and highly skilled welders completed challenging welds due to difficult access within the beam structure. The beams were trial fitted in several configurations to ensure they mate together with no issues.

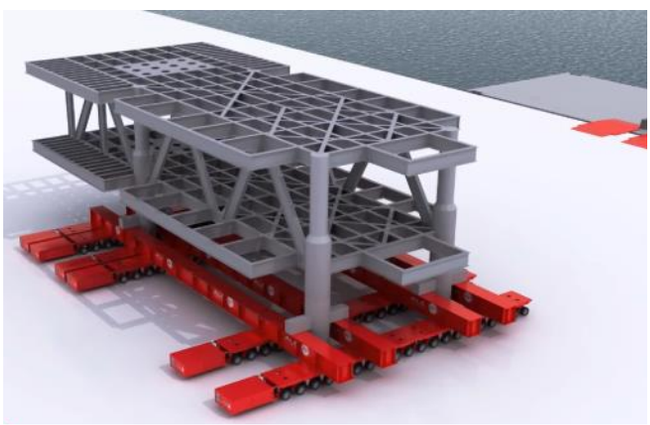
The project was successfully delivered in the United Kingdom in July 2013 and has since been reused for numerous heavy lifts.

# ESC SCOPE OF SUPPLY

## TRANSPORT BEAMS STRUCTURES

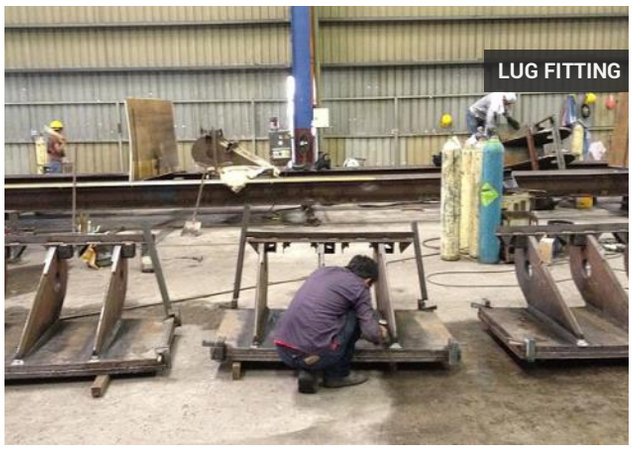
ESC's Malaysia facility was awarded the fabrication scope by globally respected heavy lifting and transport contractor ALE Heavylift BV based in the Netherlands in 2013 to produce 10 heavy transport beams, for a total of over 200 tons. These beams were to be utilised in a reusable platform for skidding large and heavy items for example, an oil platform on and off the sea.





Transport Beams Application Sample.

# PROJECT PHOTOS


LUG FITTING

LUG FITTING

DRILLING LUG HOLES

DRILLING LUG HOLES

COATING COMPLETED

HEAVY LIFTING BEAM ON LOW LOADER

HEAVY LIFTING BEAM ON LOW LOADER

# OHAU CHANNEL DIVERSION

## DIVERSION WALL PROJECT

| | |
|---|---|
| **Project Name** | Ohau Channel Diversion |
| **Main Subcontractor** | HEB Smithbridge Ltd |
| **Location** | Rotorua, New Zealand |
| **Product** | H Piles, Sheet Piles with Clutches |
| **Total Tonnage** | 2,637 MT |
| **Delivery Date** | January 2008 |

### INTRODUCTION

Environment Bay of Plenty was granted resource consent to build the diversion wall structure in Lake Rotoiti. The Diversion Wall is designed to stop water flowing from Lake Rotorua into the main body of Lake Rotoiti, instead diverting it down the Kaituna River via the Ohau Channel.

Most of Lake Rotoiti's problems are caused by nutrients flowing into it from Lake Rotorua. So the diversion wall will, over time, significantly improve the lake's water quality. The Ohau Channel Diversion Wall is located at the outlet of the Ohau Channel, which links Lake Rotorua and Lake Rotoiti. It is 1275 metres long and diverts the water from Lake Rotorua, with its higher nutrient levels, directly down the Kaituna River, preventing it from degrading Lake Rotoiti's water quality.

The wall cost just under $10 million to build and was funded by Environment Bay of Plenty and Central Government. It is expected to improve Lake Rotoiti's water quality in less than five years, with the support of lakeside sewerage reticulation projects.

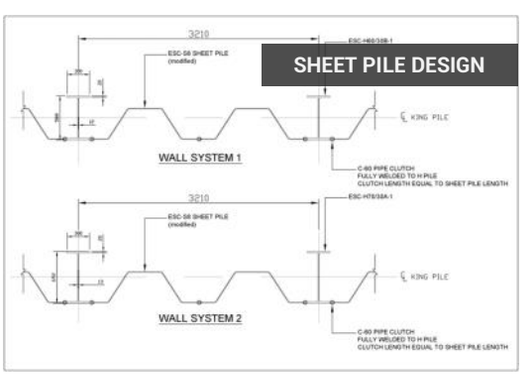
# ESC SCOPE OF SUPPLY

## H PILES & SHEET PILES with CLUTCHES

ESC worked very closely with the Contractor (HEB Smithbridge Ltd) to provide the most practical and economical solution for this prestigious project.

The materials were all manufactured in ESC's China factory and delivered over the course of 2007. ESC constructed a custom wall system which allowed for a king post at 3.2 metre centres and infill sheet piles (3 numbers). The design was a reconfiguration of the ESC H Pile Combination series wall. All designs and calculations were carried out by ESC.

In terms of engineering, the wall was unique in that the engineer required a guaranteed zero settlement, even with NZ's high seismic activity. The H pile wall solution was therefore employed because the H piles could be driven deep through the soft lakebed mud and down onto the bedrock. In some cases, this meant H piles over 50m in length, which had to be extended during driving until the required set was achieved.



# MATERIALS READY TO SHIP

The diversion wall is driven into Rotoiti's lake bed and rises to just above lake level. It is made of large, precast interlinking concrete and steel wall segments designed to last for at least 50 years. There is a cap on top of the wall to discourage people from walking on it, for safety reasons.

The final design of the structure was based on feedback from the public at various hui (Maori Assembly) and public meetings, as well as comments received on the questionnaires, and a number of technical studies. These studies include:

- Water quality modelling
- Sediment transport modelling
- Hydrodynamic modelling of the lake
- Geotechnical investigations
- Assessment of effects on downstream water quality in the Kaituna River and Maketu Estuary
- Landscape and visual assessment
- Cultural assessment
- Ecological assessment, including effects on fish and water birds

The wall will divert water currently flowing through the channel from Lake Rotorua into Lake Rotoiti, directly down the Kaituna River. Currently, about 40 percent of this water flows into the Kaituna River, mostly in summer. The rest of the year it flows mostly into Lake Rotoiti.

The diversion will prevent 180 tonnes of nitrogen and 15 tonnes of phosphorus entering the main body of Lake Rotoiti from Lake Rotorua each year through the Ohau Channel. The diversion is expected to improve Lake Rotoiti's water quality within five years, as research has shown that 70 per cent of the nutrients entering the lake come through the Ohau Channel. It is not expected to have any significant impact on Kaituna River quality.

A 5 knot/50 metre wide channel on the western side of the diversion wall allows boat access to/from Lake Rotoiti and the Ohau Channel. This channel is between the diversion wall and the red conical buoys. An exclusion zone between the red conical buoys and the lake edge protects birdlife.

The wall was part of a number of initiatives being used to help protect and restore the lakes - from structural interventions like the wall through to land use management practices to reduce nutrients leaching from farm land.

The effect of the wall is now being closely monitored to assess its success and whether wildlife is adversely affected by it or not, including a five-year fisheries monitoring programme.

# ON-SITE INSTALLATION

# PORT OF FUJAIRAH OT2, PHASE 1, UAE

## PORT CONSTRUCTION PROJECT

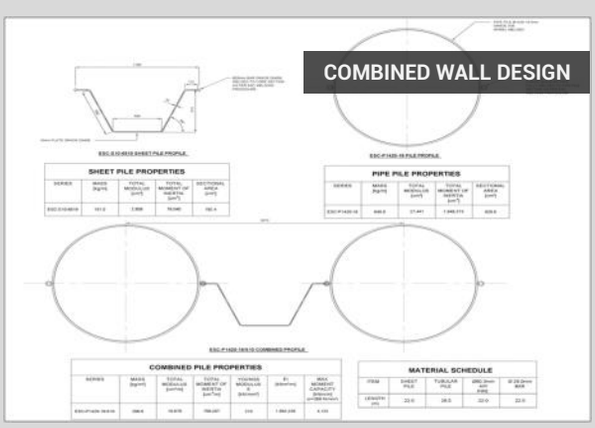
| | |
|---|---|
| **Project Name** | Port of Fujairah Oil Terminal 2, Phase 1 |
| **Client** | Port of Fujairah, UAE |
| **Main Contractor** | Athena SA |
| **Engineer** | MUC |
| **Location** | Port of Fujairah, United Arab Emirates |
| **Product** | Tubular Piles, Sheet Piles, Waling Beams, Tie Rods & Corrosion Protection |
| **Total Tonnage** | 17,000 MT |
| **Delivery Date** | November 2008 |

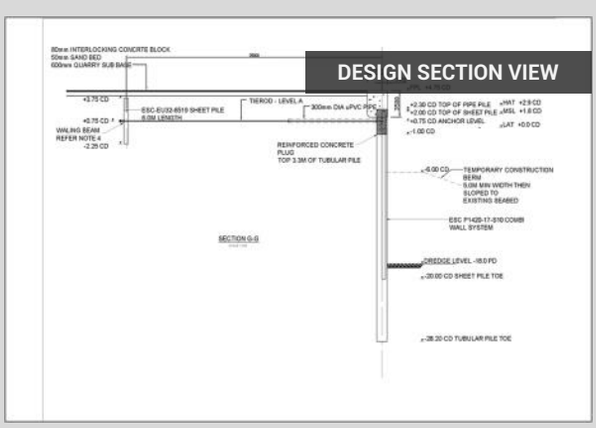
### INTRODUCTION

Athena SA and ESC proposed the ESC Combi-wall Tubular Pile system which eventually won the award from the Port of Fujairah and their Engineers MUC of the Netherlands. During the course of the design stage of the project ESC held site meetings in the UAE and visited MUC's geotechnical and structural team in Terheijden, Netherlands. ESC ensured that all facets required by the Client and their Engineers were able to be met.

The Port of Fujairah proposed a new quay wall for an oil terminal facility to be constructed to the north of the existing port facility. The name of this project is Fujairah OT2. The main purpose of this quay will be as a vessel loading facility for oil products.

The type of retaining wall used is a steel tubular pile wall with sheet pile infills, restrained by tie rods to a buried sheet pile anchor wall. This wall was backfilled with locally dredged material. In addition, in order to counter possible liquefaction issues there was significant removal of inadequate material and replacement with suitable rock material.



# ESC SCOPE OF SUPPLY

## TUBULAR PILES & SHEET PILES

ESC delivered over 17,000 tons of combined wall pipe piles, sheet piles, tie rods and waling beams for the quay wall constuction as part of the expansion works for the Port of Fujairah - a multi-prupose port on the Eastern seaboard of the United Arab Emirates, approximately 110 kilometres from the Straits of Hormuz.

ESC not only worked with the owners but the contractor Athena SA had constant site visits and communication from ESC both during the design stage and the implementation stage of the project. Designs of the wall system took into account the preferred method of construction detailed by Athena SA and were adapted accordingly whilst at the same time ensuring the stringent safety factors of the Clients Engineers were followed in terms of the seismic and structural conditions.

# PROJECT DETAILS

COMBINED WALL DESIGN

The design of the sheet pile wall was undertaken by ESC and detailed in a series of reports. The scope of the design covered by these series of reports was as follows;

- Evaluation of geological data and existing site conditions to determine a range of geotechnical parameters for use in the designs.
- Analysis of the retaining wall and restraint system given the geotechnical parameters, site requirements and loading considerations, including seismic design.
- Specification and design of necessary sheet pile and tie rod components to withstand the calculated geotechnical and imposed loads
- Evaluation of the corrosion conditions, and design of the sheet pile system components to accommodate these conditions, including specification of protective coatings.
- Various method statements required for specific tasks, including painting, bitumen sealing and clutch strength testing.

# SURFACE PREPARATION

## ACTIVITIES

SHEET PILES ON SITE READY FOR BLASTING & PAINTING

ON-SITE BLASTING OF PIPES

# PAINTING OF PIPES

PAINTING WORKS ARE UNDERWAY ON SITE

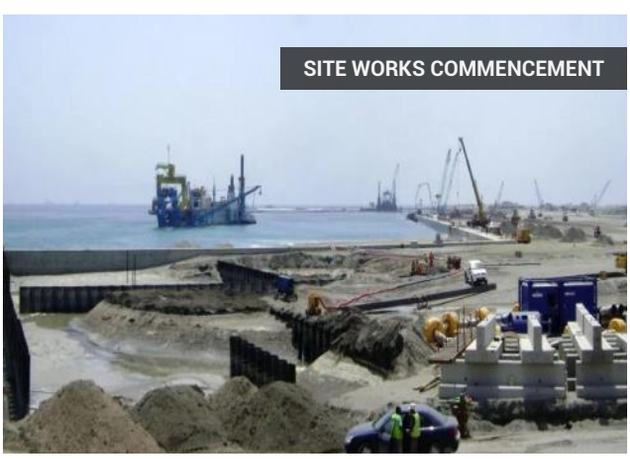
.

The specified coating for the sheet piles is for shot blasting to SA2.5 followed by 2 layers of 250 micron Jotamastic 87. The coating was applied to the top 22.3m of the front of the ESC Tubular Piles and the back 4m. The ESC Sheet Piles had the full 22m length both sides with paint applied. The ESC Anchor Piles had no coating.

# CARGO SHIPPING

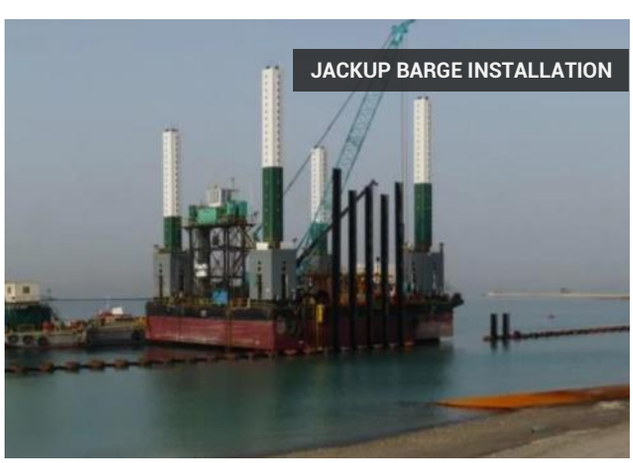
# ON-SITE INSTALLATION

CUSTOM DRIVING GUIDE FOR KING PILES


SITE WORKS COMMENCEMENT

TIE BACKS & REINFORCED CONCRETE

INFILL SHEET PILES DRIVING


JACKUP BARGE INSTALLATION

# PROJECT COMPLETED

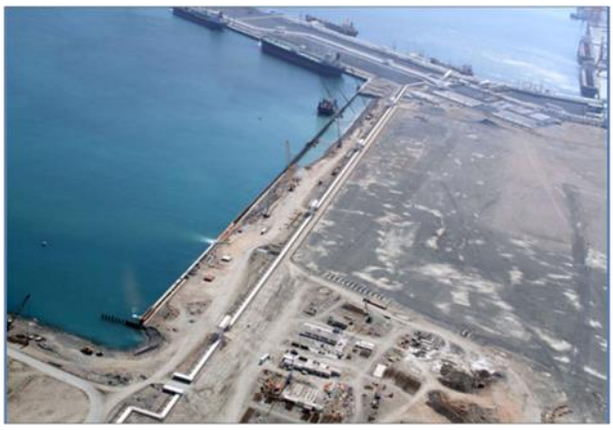
# PORT OF FUJAIRAH OT2, PHASE 2, UAE

## PORT CONSTRUCTION PROJECT

| | |
|---|---|
| **Project Name** | Port of Fujairah Oil Terminal 2, Phase 2 |
| **Main Subcontractor** | Athena SA |
| **Client** | Port of Fujairah, UAE |
| **Engineer** | MUC |
| **Location** | Fujairah, United Arab Emirates |
| **Product** | SSAW Pipes, H Beams and Sheet Piles |
| **Total Tonnage** | 8,445 MT |
| **Delivery Date** | 2013 |

### INTRODUCTION

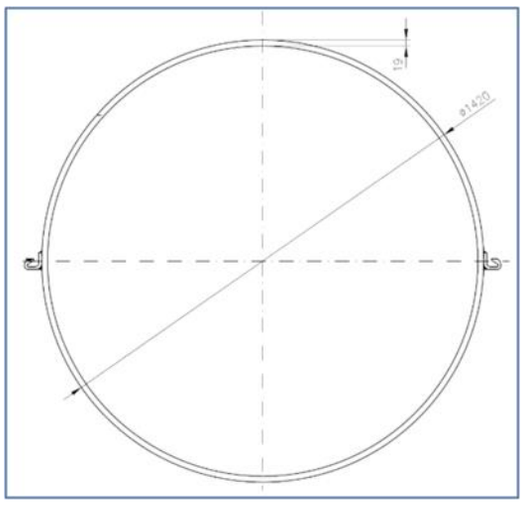
This project includes the construction of new quay wall for the extension of Port of Fujairah Oil Terminal 2, Phase 2, Berths 8 and 9. The total length of the quay wall is 890m and has a retaining height of 23.6m. The structure is a combi wall with driven OD1420mm tubular piles and sheet pile infills with raking H piles used to provide the support for the deep berth.



# ESC SCOPE OF SUPPLY

## SSAW PIPES, H BEAMS & CLUTCHES

ESC was awarded with the supply of SSAW pipe piles (OD1420mm x thk19mm x Length 30.5m) with material API Spec. 5L Grade X65 welded with ESC-C9 clutches and hot rolled H-beam (800mm x 300mm x 14mm in length 26m) with material BS EN 10025 Grade S450J0. Sheet piles were also supplied in singles from Nippon Steel and were type IIIW. The sheet piles were then joined into triples and painted and driven as one 1.8m wide section.



# SSAW PIPE FORMING

Pipe piles were manufactured in accordance with ASTM A252 standard. Welding is carried out in accordance with AWS D1.1/D1.1M, 100% VT and 100% UT performed on all full penetration weld seams.

# CLIENT AUDIT

Client representatives performed product audits during the manufacturing process. The scope of audit include SSAW pipe production process, clutch welding process, witness clutch pull-out test, and sample selection, cutting, and testing from steel pipe.

# ESC C9 CLUTCH

Various pull-out tests are carried out to ensure the reliability of ESC designed hot-rolled C9 clutch.

GRINDING OF THE WELD AREA WHERE THE CLUTCH IS REQUIRED TO BE WELDED ON

ASSEMBLY AND TACK WELD CLUTCHES TO PIPE PILE

AUTOMATIC CLUTCH WELDING PROCESS

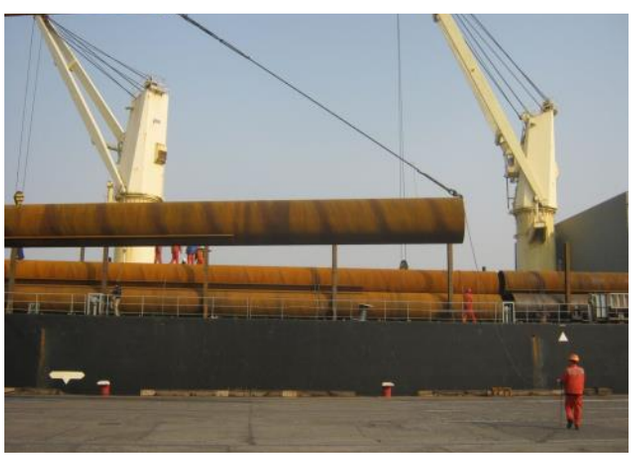
AUTOMATIC CLUTCH WELDING PROCESS

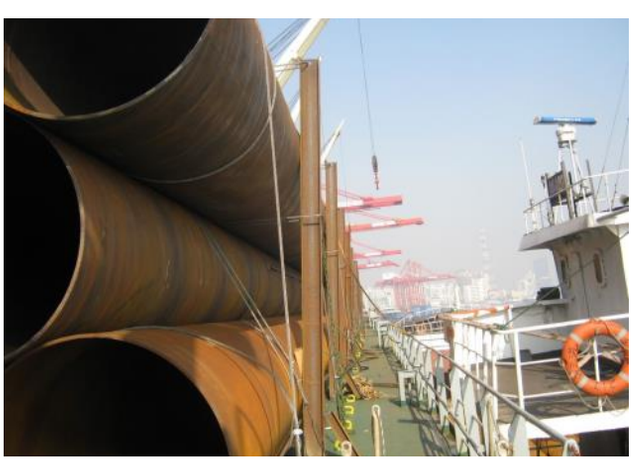
CLUTCH WELDED ON PIPE PILE

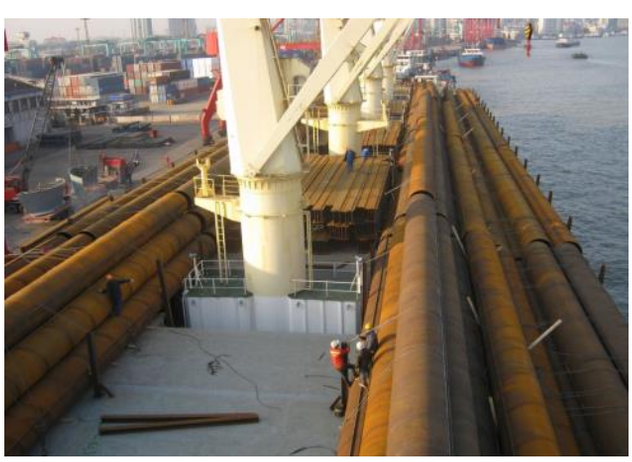
PASS THROUGH TEST USING JIG CLUTCH AFTER CLUTCH WELDED ON PIPE PILE

# FINISHED PRODUCT

# CARGO SHIPPING







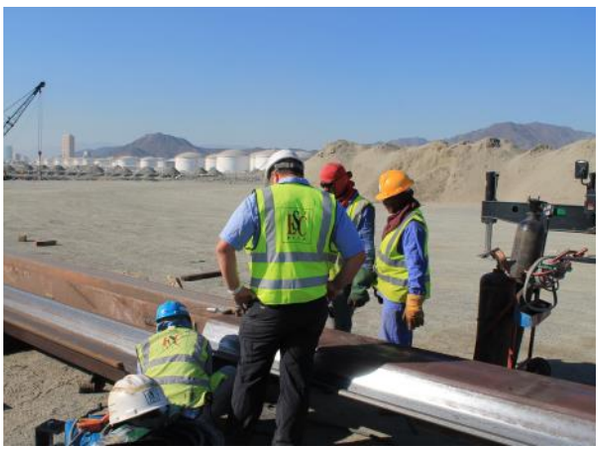
# ON-SITE BLASTING & PAINTING

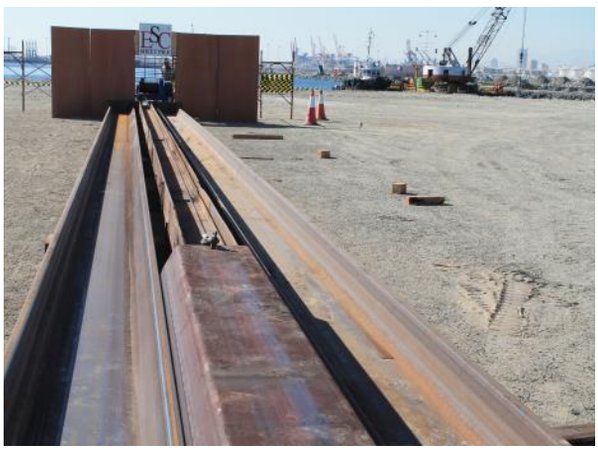
ESC UAE team was responsible to perform on-site blasting & painting for the entire products supplied under this project (Sheet pile, H-beam and pipe pile). Type of paint: Jotamastic 87 (Jotun)  Surface cleanliness: Sa2.5  Total DFT: 480 micron.

ON-SITE SHOT BLASTING

PAINTED SHEET PILES

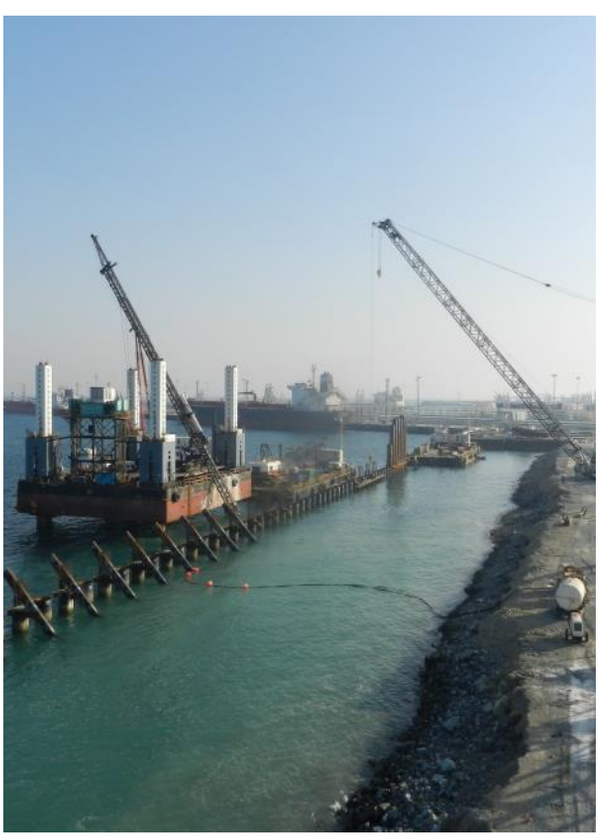
# SHEET PILE THREADING

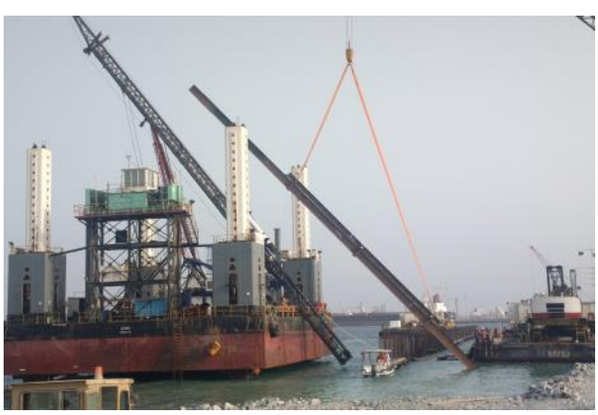


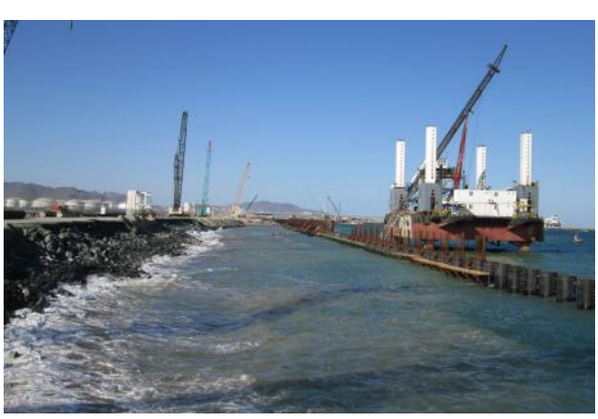


THREADING COMPLETE

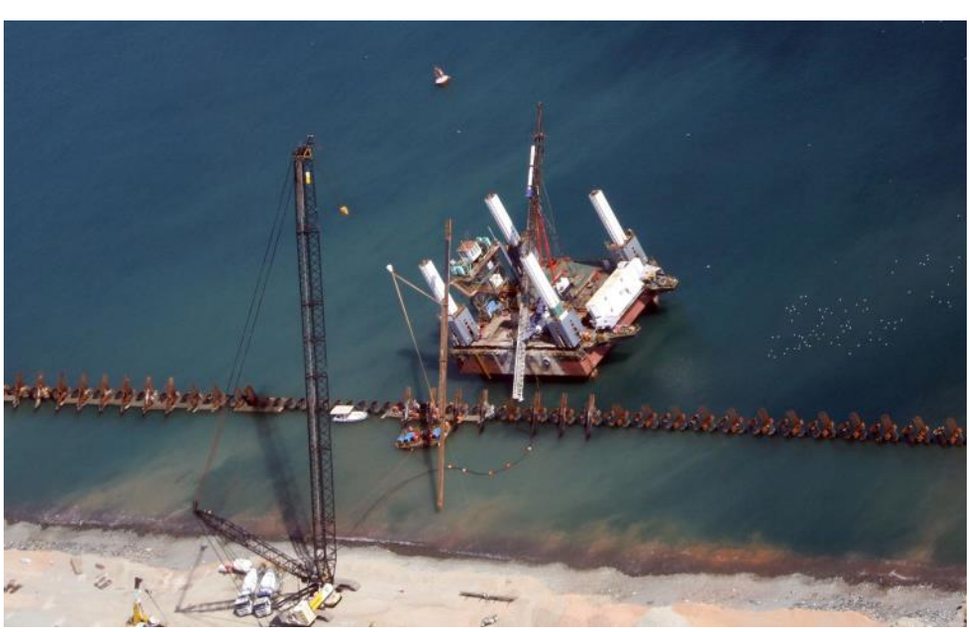
# ON-SITE INSTALLATION







# ON-SITE INSTALLATION



# RAS AL KHAIMAH PORT EXTENSION

## PORT EXTENSION PROJECT

| | |
|---|---|
| **Project Name** | Ras Al Khaimah Port, Phase IA, II, IA-Extension |
| **Main Contractor** | Athena SA |
| **Location** | Ras Al Khaimah,United Arab Emirates |
| **Product** | Sheet Piles, H Piles with connector, Tie Rods |
| **Total Tonnage** | 3,000 MT |
| **Delivery Date** | 2005—2008 |

### INTRODUCTION

ESC has been one of the integral suppliers of the development of Ras Al Khaimah port, one of the main industrial gateways to the UAE. ESC has supplied over 3,000 tons of sheet piles, H piles with connectors, tie rods over the duration of the development. ESC's success can be attributed to its unique sheet pile design, local and international production capabilities, competitive pricing and great customer service. ESC's engineers completed full design verification calculations to British Standards which was fully accepted by the owner's consultant.

The Ras Al Khaimah Port development is located in Ras Al Khaimah, UAE. An existing port is to be extended by reclaiming land behind a permanent sheet pile wall. ESC proposed to use ESC cold formed sheet piles for the Main Wall and the Anchor Wall. All parameters were supplied by the client in terms of required capacity.

CONCEPT 3D DRAWINGS OF PORT

# ESC SCOPE OF SUPPLY

## SHEET PILES, H PILES, TIE RODS

ESC scopes included  Sheet pile design and supply, Corrosion design and connection details of the sheet pile and tieback system. Designs undertaken in all of these projects were in conformance with the relevant British Standards.

ESC's scope of products

ESC carried out the alternative design calculations on behalf of the Contractor (Athena SA) and submitted them for approval to the Client (RAK Government) and their Consultant (Gibb Ltd). All relevant drawings and engineering detailing were provided by ESC for all projects. Once approval was received the manufacturing was carried out in the ESC factory for delivery to the site.

# PROJECT DETAILS

## STRUCTURAL REQUIREMENTS (EXAMPLE FOR PHASE IA)

| WALL TYPE | PILE LENGTH (m) | MAX. DESIGN BENDING MOMENT (kNm/m) | DESIGN LIFE |
|---|---|---|---|
| Main Wall | 16.5 | 616.0 | 30 years |
| Anchor Wall | 3.0 | N/A | 30 years |

## SUPPLIED PILES BY ESC

| WALL TYPE | PILE TYPE | MAX. DESIGN BENDING MOMENT ($N/mm^2$) | MAX SECTION MODULUS ($cm^3/m$) |
|---|---|---|---|
| Main Wall | ESC46A (6059) | 355 | 4040 |
| Anchor Wall | ESC18A | 275 | 1800 |

The sheet pile proposed for the Main Wall was a custom designed pile specifically suited to this project. The sheet pile was built in a modular style which allows the thickness of the plate to be varied to accommodate different stress levels and corrosion zones.

## SHEET PILE DATA TABLE (UNCORRODED PARAMETERS)

Table shows the section modulus and moment capacity of each segment of the ESC46A (6059) sheet pile prior to corrosion loss.

| PILE SEGMENT | LENGTH (m) | THICKNESS T1 (mm) | THICKNESS T2 (mm) | SECTION MODULUS ($cm^3/m$) | STEEL GRADE |
|---|---|---|---|---|---|
| A | 4.5 | 16.0 | 10.0 | 4040.0 | S355JOC |
| B | 6.0 | 15.0 | 9.0 | 3660.0 | S355JOC |
| C | 6.0 | 9.0 | 9.0 | 2500.0 | S355JOC |

Full calculations of the derivation of section modulus for the ESC46A (6059) custom pile, and the ESC18A standard pile were supplied to the Client and their Engineers. All calculations were performed in accordance with the guidelines set out in BS 5950 Part 5.

Steel piles were manufactured and delivered in accordance with the requirements stated in the BS EN 10249 Parts 1 and 2. Steel specifications follow those stated in BS EN 10025:1993.

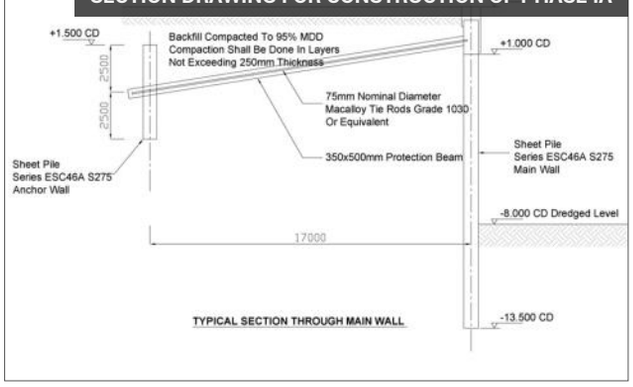
All piles contained welded elements. The welding procedure was designed and approved by accredited certification bodies (Lloyds) to ensure complete strength transfer across the welded joint.

## COATING REQUIREMENTS (PHASE 1A & OTHERS)

The specified coating for the sheet piles was for sand blasting followed by 50 µm of primer and then 400 µm of coal tar epoxy paint. The coating was applied to the entire front surface and two metres of the back surface of the Main Wall piles only.

ESC will be used a product called JotaCoat 550 for all painting works. ESC work closely with the paint manufacturer Jotun and have developed a painting specification that is designed to suit high corrosion environments.

SECTION DRAWING FOR CONSTRUCTION OF PHASE IA




## CORROSION DESIGN (PHASE 1A & OTHERS)

The specification for the corrosion design is that the sheet pile must have a design moment capacity of 616 kNm/m after a thirty year period. Coating was not to be considered in this calculation.

Corrosion rates varied along the length of the pile depending on the corrosion zones. Likewise, moments along the length of the pile will vary with the maximum required moment occurring approximately halfway between the anchor point and the dredged level. The objective of the corrosion design was therefore to ensure that the moment capacity in this zone is at least 616kNm/m after thirty years.

| PILE SEGMENT | CORROSION ZONE | CORROSION RATE (mm/yr) | PERIOD (yrs) | TOTAL Loss (mm) | REDUCED THICKNESS T1 (mm) | REDUCED THICKNESS T2 (mm) |
|---|---|---|---|---|---|---|
| A | Splash | 0.15 | 30.0 | 4.5 | 11.5 | 5.5 |
| B | Immersion | 0.05 | 30.0 | 1.5 | 13.5 | 7.5 |
| C | Embedded | 0.03 | 30.0 | 0.09 | 8.1 | 8.1 |

The loss of thickness in each segment will affect the section modulus of the pile and hence the bending moment capacity.

## SEGMENT PROPERTIES POST CORROSION LOSS

SHEET PILE DATA TABLE (Corroded Parameters)

| PILE SEGMENT | LENGTH (m) | THICKNESS T1 (mm) | THICKNESS T2 (mm) | REDUCED MODULUS ($cm^3/m$) | DESIGN STRESS ($N/mm^2$) | BENDING CAPACITY (kNm/m) |
|---|---|---|---|---|---|---|
| A | 4.5 | 11.5 | 5.5 | 2570.0 | 230 | 591 |
| B | 6.0 | 13.5 | 7.5 | 3090.0 | 230 | 711 |
| C | 6.0 | 8.1 | 8.1 | 2170.0 | 230 | 499 |

The stress of 230 N/mm2 is adopted from BS449 as the design stress for sheet pile walls using high tensile steel. It should also be noted that all the calculations made full allowance for panel buckling considerations in the thin plate sections.

# PROJECT DETAILS

As always, ESC personnel were on site to assist Athena SA during the beginning of the installation process. Several recommendations were made regarding piling guides and handling processes. ESC provided efficient Dawson Lifting Shackles that helped increase the productivity of the installation, while ensuring maximum safety during the process.

## SOIL PROFILE

The existing seabed was between approximately -2.0 EL to +1.0 EL in the vicinity of the proposed wall. Subsequent filling activity has reclaimed the area to approximately +3.0 EL. Fill material is dense to very dense sandy gravel with cobbles and boulders.

The original seabed is a layer of medium dense to very dense silty sand, overlying a medium dense to very dense silty gravel layer with sandstone bands up to 8.0m thick.

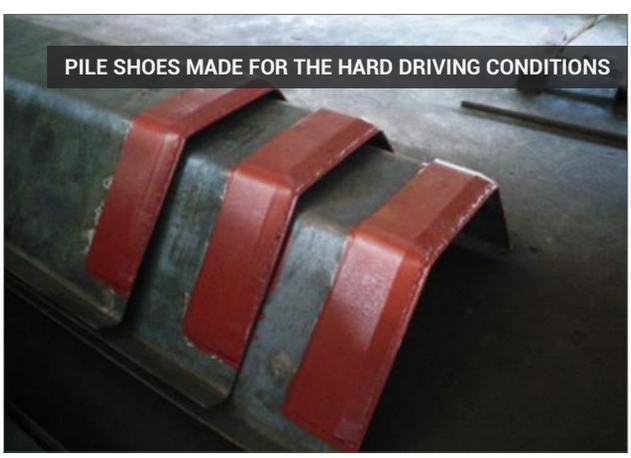
Below the gravel layer are pockets of medium dense to dense sands, overlying a very dense sand layer with sandstone bands at approximately -13.0EL.

INITIAL PLATFORM WORKS BEGINS ON SITE

CATHODIC PROTECTION ANODES

MAIN WALL SHEET PILES

ESC18B ANCHOR WALL PILES


PILE SHOES MADE FOR THE HARD DRIVING CONDITIONS

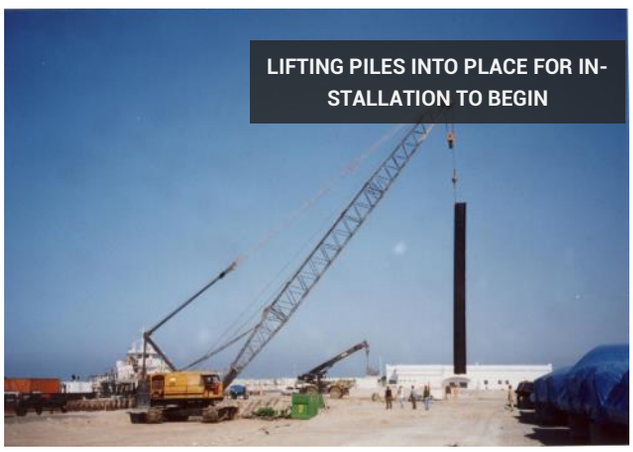
# ON-SITE INSTALLATION

EXCAVATION UNDERWAY FOR THE TIE ROD INSTALLATION

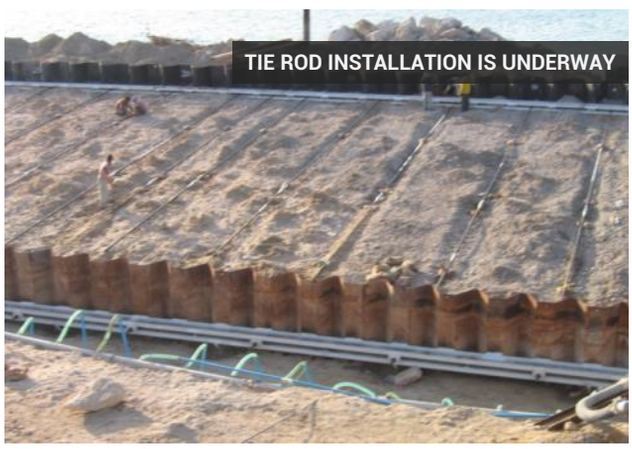
ANCHOR WALL SHEET PILES INSTALLED

INSTALLATION OF THE H PILE CANTILEVER WALL SECTION

FINAL INSTALLATION OF THE SHEET PILES TO DEPTH IS CARRIED OUT BY THE IHC S90 HYDRAULIC DROP HAMMER



LIFTING PILES INTO PLACE FOR INSTALLATION TO BEGIN

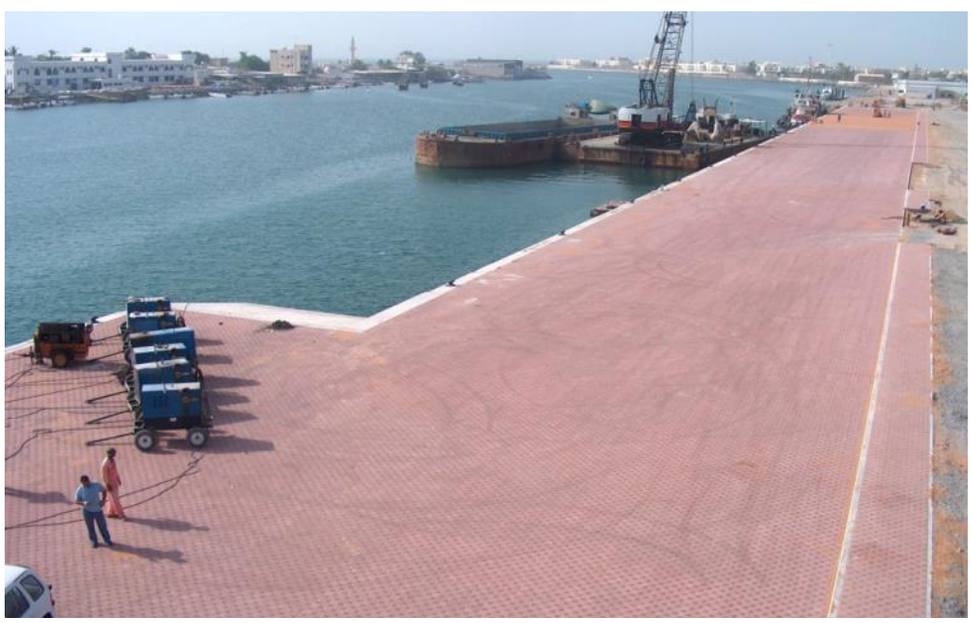


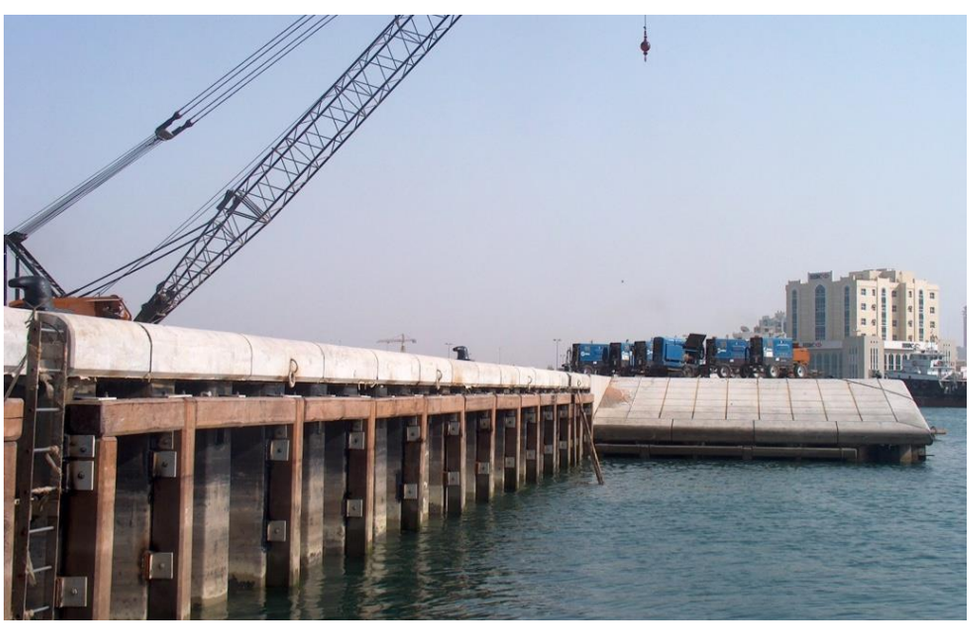
TIE ROD INSTALLATION IS UNDERWAY

FINISHING TOUCHES BEFORE THE COMMISSIONING OF THE PORT

# NEARING COMPLETION

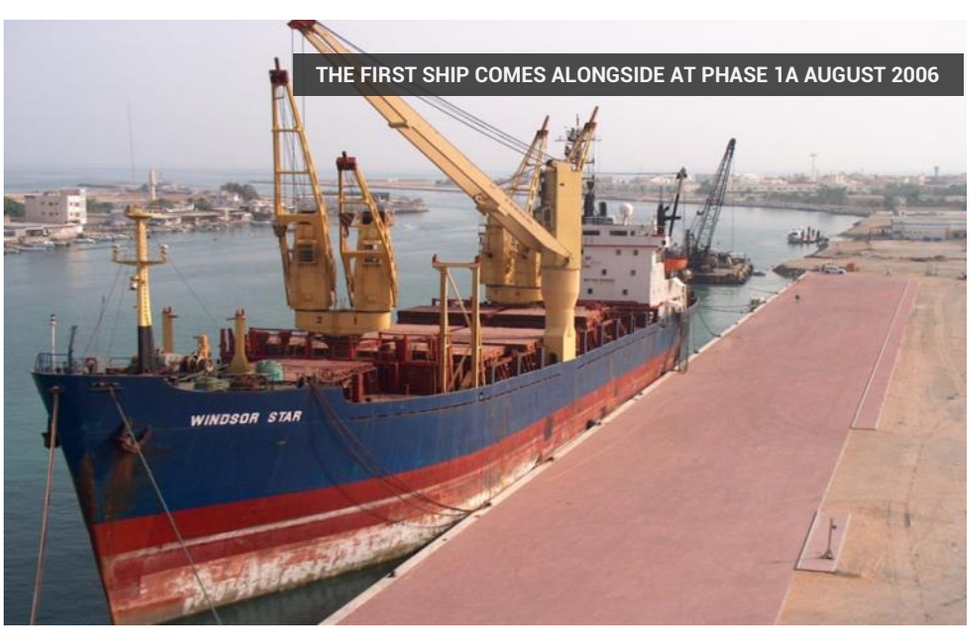
DREDGING TO DEPTH TO ALLOW THE VESSELS TO BERTH AND ITS READY FOR COMMERCIAL WORK





# PROJECT COMPLETED

FINISHED AND READY TO ACCEPT SHIPS




THE FIRST SHIP COMES ALONGSIDE AT PHASE 1A AUGUST 2006

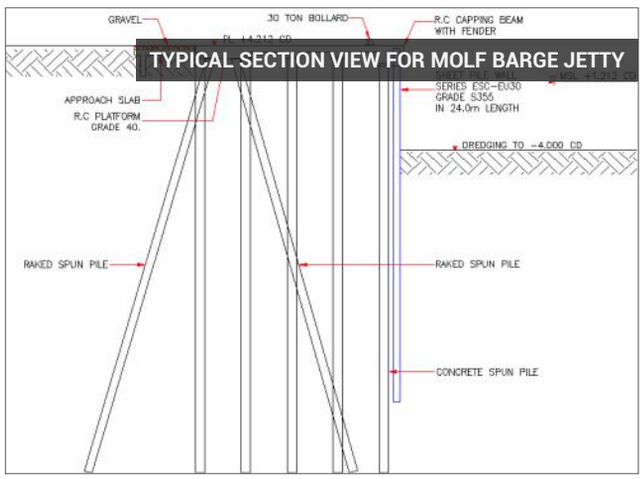
# SABAH OIL & GAS TERMINAL

## OIL & GAS TERMINAL PROJECT

| | |
|---|---|
| **Project Name** | Sabah Oil & Gas Terminal |
| **Client** | PETRONAS (Petroliam Nasional Berhad) |
| **Location** | Kimanis, Sabah, Malaysia |
| **Product** | Sheet Piles |
| **Total Tonnage** | 1,735 MT |
| **Delivery Date** | 2010 |

### INTRODUCTION

The SOGT in Kimanis is one of the mega petroleum development programmes in East Malaysia under PETRONAS, (short for Petroliam Nasional Berhad), lined up as an onshore oil and gas receiving, storage, processing and export terminal.



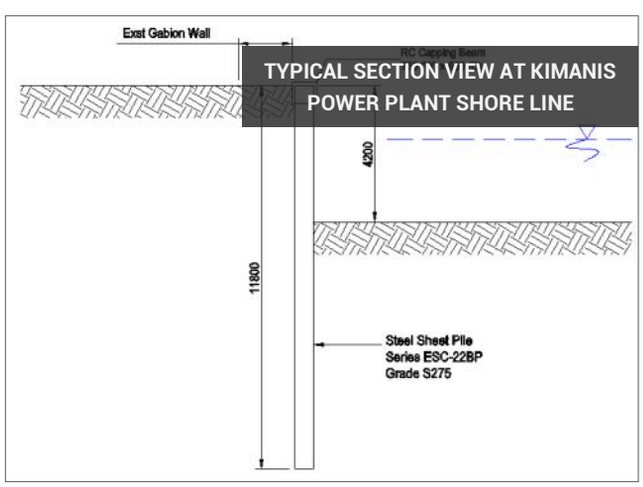

TYPICAL SECTION VIEW FOR MOLF BARGE JETTY

# ESC SCOPE OF SUPPLY

## SHEET PILES, H PILES, TIE RODS

ESC was engaged to provide sheet piling solutions to a few key facilities including engineering design, manufacturing and site assistance for:-

- A proper berthing structure named Materials Off-Loading Facility (MOLF) for loading / unloading of construction materials, equipments and machineries mainly from a barge during the Terminal construction.
- Shore line protection to Kimanis Power Plant at the river mouth.
- Shore line protection to a flare stack structure beside a reserved drain leading to the sea.




TYPICAL SECTION VIEW AT KIMANIS POWER PLANT SHORE LINE

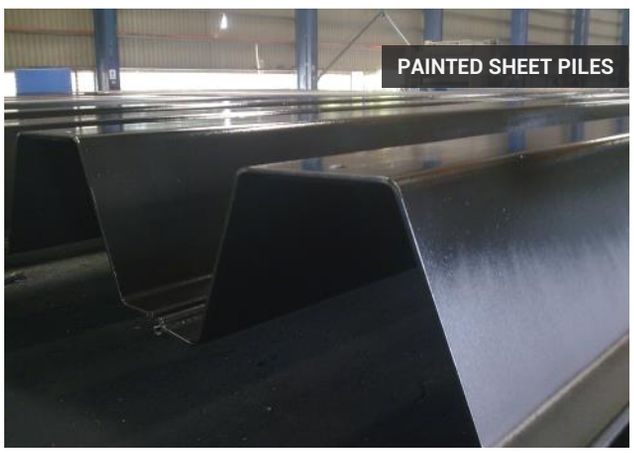
# PROJECT DETAILS

## SHEET PILE SPECIFICATIONS

| MATERIAL OFF LOADING FACILITY | | | | | |
|---|---|---|---|---|---|
| WALL TYPE | PILE TYPE | PILE LENGTH (m) | STEEL GRADE | SECTION MODULUS ($cm^3/m$) | COATING |
| Main Wall (Barge Jetty) | ESC-EU30 | 24.0 | S355 | 3,000 | SA2.5 + 500 micron coal tar epoxy (black) |
| Main Wall (Boat Jetty) | ESC-EU28 | 18.0 | S275 | 2,820 | SA2.5 + 500 micron coal tar epoxy (black) |
| Anchor Wall (Boat Jetty) | ESC-CFW14 | 6.0 | S275 | 1,460 | SA2.5 + 100 micron coal tar epoxy (black) |

| KIMANIS POWER PLANT SHORE LINE PROTECTION | | | | | |
|---|---|---|---|---|---|
| WALL TYPE | PILE TYPE | PILE LENGTH (m) | STEEL GRADE | SECTION MODULUS ($cm^3/m$) | COATING |
| Cantilever Wall | ESC-22BP | 8.0-11.8 | S275 | 2,200 | SA2.5 + 200 micron epoxy paint (grey) |

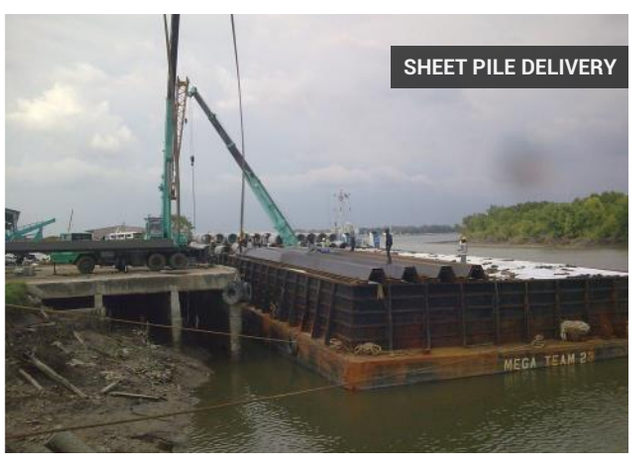
| FLARE STACK SHORE LINE PROTECTION | | | | | |
|---|---|---|---|---|---|
| WALL TYPE | PILE TYPE | PILE LENGTH (m) | STEEL GRADE | SECTION MODULUS ($cm^3/m$) | COATING |
| Cantilever Wall | ESC-EU28 | 16.0 | S275 | 2,800 | SA2.5 + 500 micron coal tar epoxy (black) |


PAINTED SHEET PILES

LOADING OF SHEET PILES

PAINTED SHEET PILES READY FOR DELIVERY

LOADING OF SHEET PILES


SHEET PILE DELIVERY

# ON SITE INSTALLATION

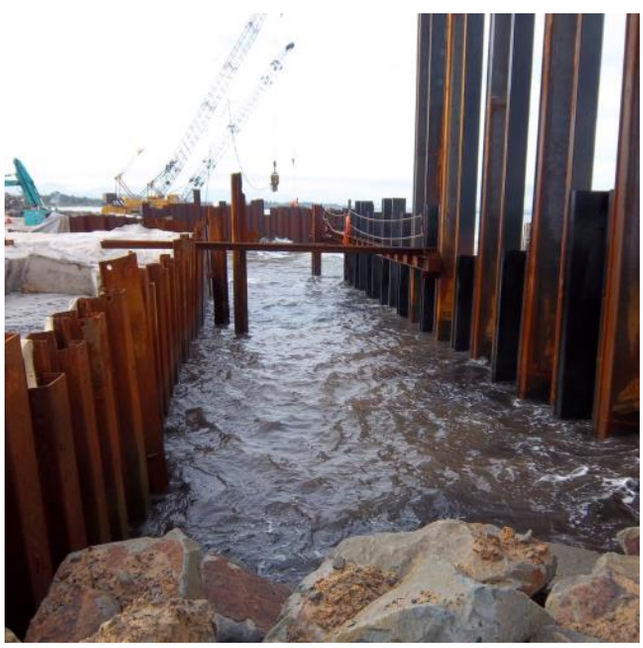
INITIAL MOLF SITE CONDITION

MOLF STAGGERED SHEET PILE INSTALLATION

CONSTRUCTION OF MOLF RC DECK

ESC SHEET PILE PANEL DRIVING METHOD

# ON SITE INSTALLATION



# BARGE JETTY COMPLETED

# SOUTH BREAKWATER BERTHS

## BERTH QUAY WALL PROJECT

| | |
|---|---|
| **Project Name** | South Breakwater Berths |
| **Client** | Athena SA |
| **Engineer** | Moth MacDonald |
| **Location** | Port of Fujairah, UAE |
| **Product** | Sheet Piles, H Pile & Tie Rods |
| **Total Tonnage** | 8,903 MT |

### INTRODUCTION

ESC was asked to look into the alternative for a design that proposed using an H Pile and sheet pile system from Europe for the construction of this vital part of the Port of Fujairah.

Working closely with Athena SA, ESC proposed the ESC H Pile system which eventually won the award from the Port of Fujairah and their Engineer's Mott MacDonald of the United Kingdom. During the course of the design stage of the project ESC held site meetings in the UAE and video conferencing calls with Mott MacDonald's geotechnical and structural team in London, England. ESC ensured that all facets required by the Client and their Engineers were able to be met.

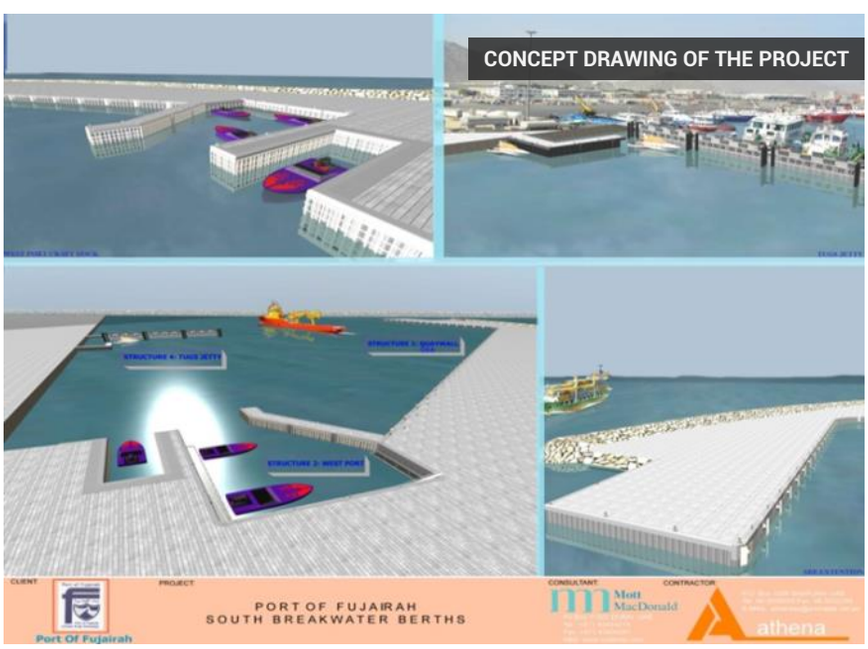
ESC not only worked with the owners but the contractor Athena SA had constant site visits and communication from ESC both during the design stage and the implementation stage of the project. Designs of the wall system took into account the preferred method of construction detailed by Athena SA and were adapted accordingly whilst at the same time ensuring the stringent safety factors of the Clients Engineers were followed in terms of the seismic and structural conditions.

The Port of Fujairah proposed to construct a new quay wall and associated works at the existing facility. The type of wall to be used will be an embedded sheet pile wall, restrained by tie rods to a buried sheet pile anchor wall. The scope of works covered the following structures;

STRUCTURE 1: South Breakwater Berth Quay Wall

STRUCTURE 2: West Port Craft Dock

STRUCTURE 3: Tugs Jetty

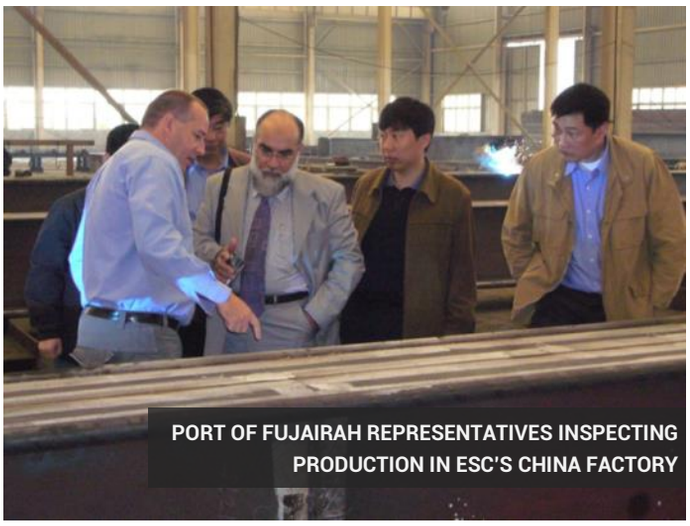


# ESC SCOPE OF SUPPLY

## SHEET PILES, H PILES, TIE RODS

The scope of the design covered;

- Evaluation of geological data and existing site conditions to determine a range of geotechnical parameters for use in the designs.
- Analysis of the retaining wall and restraint system given the geotechnical parameters, site requirements and loading considerations, including seismic design.
- Specification and design of necessary sheet pile and tie rod components to withstand the calculated geotechnical and imposed loads
- Evaluation of the corrosion conditions, and design of the sheet pile system components to accommodate these conditions, including specification of protective coatings



PORT OF FUJAIRAH REPRESENTATIVES INSPECTING PRODUCTION IN ESC'S CHINA FACTORY

### STRUCTURAL SPECIFICATIONS FOR SHEET PILES

| WALL TYPE | PILE TYPE | PILE LENGTH (m) | MAX. SECTION MODULUS $cm^3/m$ | DESIGN STRESS $N/mm^2$ |
|---|---|---|---|---|
| Main Wall | ESC H70/30A-2/10a-F | 25.0m | 6,795 | 345 |
| Anchor Wall | ESC14BP-6157 | 6.0m | 1,815 | 345 |

# PROJECT DETAILS

The British Standards were used as the basis for the design, unless specifically stated otherwise by the Engineer. These standards will include, but not be limited to the following:

| Code | Title |
|---|---|
| BS5950 | Structural Use of Steelwork in Building |
| BS6349 | Marine Structures |
| BS8002 | Earth Retaining Structures |
| BS8081 | Ground Anchorages |
| BS EN 10249 | Cold Formed Sheet Piling of Non Alloy Steels |
| BS EN 12063 | Execution of Special Geotechnical Worl—Sheet Pile Walls |

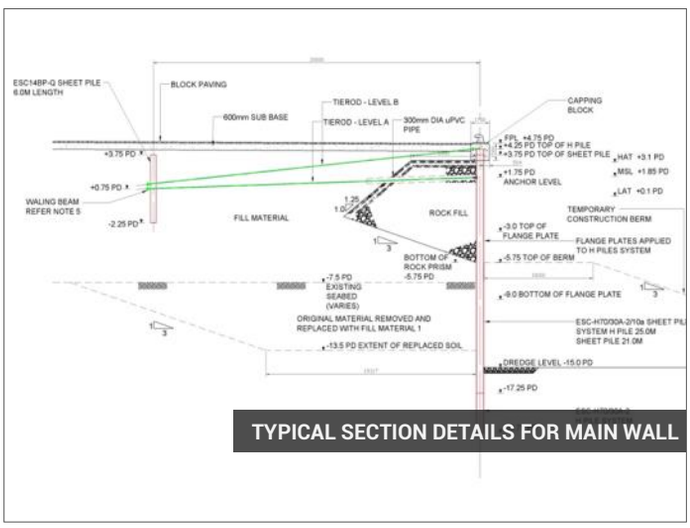
Other publications that were referred to were;

PIANC – "Seismic Design Guidelines for Port Structures"

Global Seismic Hazard Assessment Program – Global Seismic Hazard Map 1999

**COATING REQUIREMENTS**

The specified coating for the sheet piles is for shot blasting followed by 2 layers of 250 micron Jotamastic 87. The coating is to be applied to the top 5.5m front and back surface for main wall; while for anchor wall , the coating is applied to whole length both sides of piles.




TYPICAL SECTION DETAILS FOR MAIN WALL

All calculations for structural capacity of the sheet pile systems were performed post corrosion loss.

The tierod system was designed based on the loads calculated in R 05. Design loads for the tie rod calculations were taken as the working loads with a factor of 2.0, or the seismic loads with a factor of 1.0, whichever is greater. All components of the tie rod system including connections and waling were designed to have to have at least the same capacity of the tierod itself. All calculations were performed post corrosion loss to the tie rod system and its components.

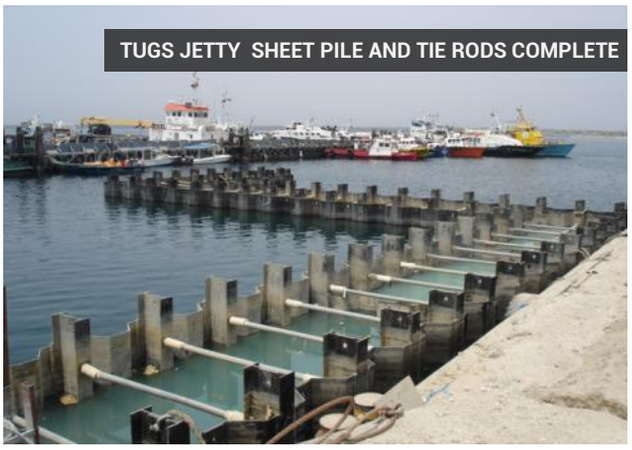
# PROJECT MATERIALS

H PILE PRODUCTS READY TO BE SHIPPED AFTER COMPLETED PAINTING WORKS AND PROTECTIVE WRAPPING PUT IN PLACE

SACRIFICIAL ANODE FOR ADDED CORROSION PROTECTION

# ON-SITE INSTALLATION

TUGS JETTY BARGE INSTALLATION BEGINS USING THE ESC DESIGNED DRIVING GUIDE



TUGS JETTY SHEET PILE AND TIE RODS COMPLETE

CAPPING BEAM INSTALLATION BEGINS AT WEST PORT CRAFT DOCK

WEST PORT CRAFT DOCK IN PROGRESS

# ON-SITE INSTALLATION

WEST PORT CRAFT SHEET PILE INSTALLATION

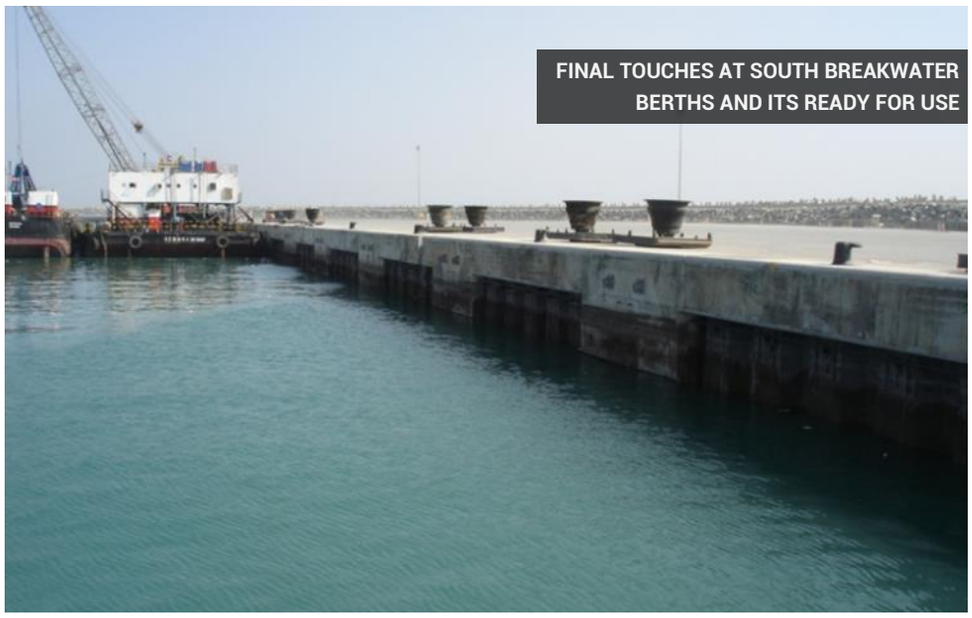
MAIN WALL INSTALLATION USING A HYDRAULIC DROP HAMMER FOR THE FINAL INSTALLATION TO REFUSAL

MAIN WALL AND DEADMAN WALL INSTALLATION COMPLETE. AWAITING THE TIERODS INSTALLATION

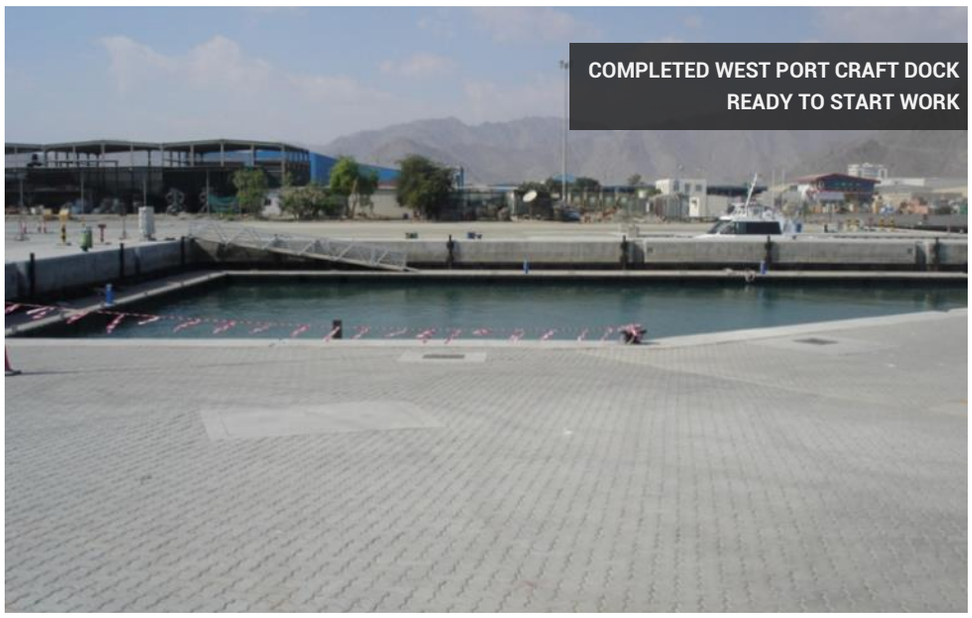
TIE ROD INSTALLATION BEGINS

FILLING BETWEEN THE RODS AND THE BACK FILL COMPACTION

# PROJECT COMPLETED



FINAL TOUCHES AT SOUTH BREAKWATER BERTHS AND ITS READY FOR USE



COMPLETED WEST PORT CRAFT DOCK READY TO START WORK

FULL LENGTH OF THE 1.3KM MAIN QUAY WALL

# TANKPUT 19 VOPAK TERMINAL

## TANK PROTECTION PROJECT

| | |
|---|---|
| **Project Name** | Tankput 19 VOPAK Terminal |
| **Main Contractor** | Geka Bouw B.V. |
| **Location** | Rotterdam, Netherlands |
| **Product** | Sheet Piles & Capping Beams |
| **Total Tonnage** | 425 MT |
| **Delivery Date** | 2009 |

### INTRODUCTION

ESC after working very closely with Europile BV in the Netherlands for several years experienced a major breakthrough into Europe with this order.

VOPAK Terminal in Rotterdam, Netherlands needed to have an impervious fire proof barrier put in place under the Netherlands Government legislation. The oil tanks had to have a perimeter that would withstand the possible scenario of a massive failure of the tanks and all the contents flowing out into the surrounding area. In addition, this liquid could well be on fire at the time so the perimeter had to cater for this potential issue as well. Several alternatives were lobbied by various contractors.

Geka Bouw B.V. won the project with a sheet pile option supplied by ESC. ESC worked closely with Geka Bouw B.V. through its agent in Europe, Europile B.V..

**ESC EU COMBINED PILE PROPERTIES**

ESC-EU12-6665 COMBINED SECTION

COMBINED PILE PROPERTIES

| SERIES | PLATE THICKNESS (mm) | MASS (kg/m²) | CROSS SECTION CLASS | ELASTIC MODULUS (cm³/m) | PLASTIC MODULUS (cm³/m) | MOMENT OF INERTIA (cm⁴/m) |
|---|---|---|---|---|---|---|
| ESC-EU12-6665 | 8 | 82.4 | CLASS 3 | 1180 | N/A | 23,240 |

NOTE:
CROSS SECTION CLASSIFICATION AND MODULUS CALCULATION AS PER EN 1993: PART 5 PILING

# ESC SCOPE OF SUPPLY

## SHEET PILES & CAPPING BEAMS

Calculations were carried out by ESC in order to ensure that the stringent requirements of the Client (Royal Vopak N.V.) and the Contractor were met whilst at the same time the budget constraints needed to be adhered to.

All sheet piles were painted on the top 4 metres (both sides) with 375 microns of Jotamastic 87 black paint. The capping beams were completely coated using the same paint and thickness. All painting works were carried out in the ESC factory in China.

Extra clutches were sent along with the shipment to ensure that if any special corners were needed to be turned or obstacles caused a variation in the driving line then Geka Bouw BV was able to perform the onsite fabrication without any delays to the project timetable.

The Bill of Quantities were as follows:

- ESC-EU12 Steel Sheet Piles in lengths 8-9m (404 tons)
- Capping Beam in 11.8m length (21 tons)

# SHIP LOADING

# ON-SITE INSTALLATION

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