DEVELOPMENT OF VIZHINJAM PORT

Basic Engineering Report - Draft Final

Prepared for

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

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1 General

1.1 Introduction

The document describes the basic engineering carried out for the various components of the port facility.

The EPC executing agency shall carry out all necessary investigations and advanced detailed studies and shall take full responsibility for his design.

1.2 Design Life

1.2.1 General

The design working life is defined as the period for which civil and structural elements are to be used with acceptable maintenance, but without major repair and/ or replacement being necessary.

Acceptable maintenance for the civil and Building elements of the Works is described in the following section. The tables also indicate what would be considered to be unacceptable maintenance, i.e. unacceptable repair or replacement.

The design life for various components has been described in the respective sections of this document.

1.3 Codes and Standards

The codes, standards and Technical specifications applicable for design and Construction Works are listed below:

(i) Indian Standards

(ii) British Standards

(iii) European Standard with UK National Appendices

(iv) American Standards

(v) Indian Road Congress (IRC) Codes and Standards

(vi) Specifications for Roads and Bridges Works issued by the Ministry of Road Transport & Highways (MORTH) hereinafter referred to as MORTH Specifications

(vii) International Standards and Guidelines

(viii) Published Guidance, including but not limited to,

- Permanent International Association for Navigation and Congress (PIANC) Bulletin No. 45 (1984) : Annex 4.1
- PIANC Guidelines for the Design of Fender System, 2002
- PIANC Working Group No 34, Seismic Design Guideline for Port Structure
- PIANC : Criteria for Moored Ship in Harbours, Report of Working Group No. 24, Supplement to Bulletin No. 88
- (Oil Companies International Marine Forum) OCIMF : Mooring Equipment Guidelines
- OCIMF : Guidelines and Recommendations for the Safe Mooring of Large Ships at Piers and Sea Islands
- Construction Industry Research and Information Association (CIRIA) Report 103: 'Design of Laterally Loaded Piles', 1994;
- CIRIA Report C580: Embedded Retaining Walls – Guidance for Economic Design 2003
- International Building Code
- CIRIA C683: The Rock Manual – The Use of Rock in Hydraulic Engineering (2nd Edition), 2007.
- CIRIA, C660 – Control of Contraction Induced Cracking in Concrete
- US Army Corps of Engineers, EM 1110-2-1100 Coastal Engineering Manual,

- Recommendations of the Committee for Waterfront Structures, Harbours and Waterways EAU 2004.
- EurOtop – Wave Overtopping of Sea Defences and Related Structures: Assessment Manual, 2007.
- National Fire Protection Association codes.
- Water Supply (Water Fittings) Regulations SI 1999 1148.
- Water Supply (Water Fittings) Regulations Amendment, SI 1999 1506 (Backflow).
- Water Regulations Advisory Scheme (WRAS), Water Regulations Guide.
- Sewers for Adoption, 7th Edition by the Water Research Council (UK)

In case of any conflict or inconsistency in the provisions of the applicable IS Codes, BS Codes, IRC Codes, Standards or MORTH or any other Specifications, the provisions contained in this document shall apply.

In the absence of any specific provision on any particular issue in the aforesaid Codes or Specifications read in conjunction with the Specifications and Standards contained in this document, the following standards shall apply in order of priority.

(i) Bureau of Indian Standards (BIS)
(ii) British Standard or European Standard with UK National Appendices or American Standards or PIANC Guidelines
(iii) Any other specifications/standards proposed by the Concessionaire and reviewed by the Independent Engineer.

2 Introduction

2.1 Project Brief

The Government of Kerala (GoK) through its special purpose government company (SPV)-Vizhinjam International Seaport Ltd (VISL), is developing Deepwater Multipurpose Greenfield Port at Vizhinjam in Thiruvananthapuram, capital city of Kerala. The SPV is fully owned by the Government of Kerala.

VISL commissioned AECOM for preparation of EPC Tender Document & Contractor Selection and Preparation of Integrated Master Plan for Vizhinjam Port, Kerala, India.

The port will be developed in phases. The Phase 1 development of the port is envisioned to have:

- Breakwater of total length 3,100 (main breakwater 2,960m with 140m extension for fish landing harbour).
- Container berth length of 800m capable of handling up to current largest 18,000 TEU container vessels.
- Container yard behind the quay.
- Facilities for Port craft.
- Fish landing centre with a total berth length of 500m and associated infrastructure facilities.

AECOM prepared the port layout to accommodate the requirements of Indian Navy and Coastguard along with container. The port proposed to cater the requirements of Indian Navy and Coastguard have been deferred in the current Phase 1 development.

The Phase 1 development would cover the facilities for containers handling for the selected Concessionaire.

This decision was taken up by VISL and accordingly directed AECOM to develop the port layout with these requirements. This resulted in optimization of reclamation quantity for onshore operations for these facilities which was proposed to be sourced by over dredging the channel and harbour basin.

The port is designed primarily to cater to the container transhipment business. Fish Landing berths being developed as part of CSR activities as an outcome of the ESIA study to improve the fisheries sector in the project vicinity.

2.2 Rationale for Funded and PPP Works

The proposed project is based on a Landlord Port Model, wherein VISL will provide for the costs associated with the project including breakwaters, associated dredging & reclamation for fishery harbour and facilities for Fishery harbour as part of funded Works in the PPP Concession Agreement. Concessionaire will provide facilities such as capital dredging, reclamation, container terminal & yard development, gate complex development and installation of equipment. VISL will also provide utilities to an agreed upon “hand-shake” point and the concessionaire will be providing the utilities for the rest of the container terminal and the Fisheries Harbour.

Based on various rounds of deliberations with VISL authority, it was decided that the work would be split up into Funded works by VISL and Public Private Partnership (PPP) by selected Concessionaire. The funded works shall be executed by the selected Concessionaire for which the cost shall be borne by VISL authority. This was decided by VISL to negate the involvement of any third party from the Concessionaire’s operational point of view to meet the harbour functional requirements over the allotted Concession period.

The work components covered under the funded works shall include the following:

- Breakwater of 3100m length;
- Fishery harbour and associated on-shore facilities

The project components to be covered under PPP, the cost of which shall be borne and executed by the selected Concessionaire are as listed below:

- Container Berths of 800m;

- Dredging & Reclamation;
- Container Yard
- Equipment
- Buildings
- Utilities and Services
- Port crafts and Aids to Navigation
- Road facilities to the port;

The rail facility and rail yard would be taken up by Rail Vikas Nigam Limited (RVNL) separately for this project.

Since basic engineering for all the major components of port has already been carried out for both the funded and PPP works including the IN and Coastguard, therefore the same has also been incorporated in this report.

2.3 Site Location

The proposed port at Vizhinjam (Lat 8° 22' N, Long 76° 57' E) is located in India in the state of Kerala, at 16 km south of the State Capital, Thiruvananthapuram which falls in close proximity to the international East-West shipping route. The location of the port is as shown in Figure 2.1.

Vizhinjam port would be competing with Cochin and Tuticorin for its gateway containerized cargo; however, the port would primarily be competing with international ports like Colombo in Sri Lanka, Salalah in Oman and Singapore for container transshipment traffic. The natural water depth available at proposed Vizhinjam port is more than any competing Indian port and more or equal than competing international ports. It will be able to capture the increasing trend of larger container vessels which none of the existing Indian ports can service, due to which majority of containers destined or generated from India are being transshipped or double-handled from competing international ports, resulting in higher import/export cost for Indian citizens. Vizhinjam port will further enhance India's ability to handle gateway and trans-shipment cargo while establishing a strong supply chain network in Kerala.

Figure 2.1 Port Location Map

Apart from catering to the needs of hinterland cargo, Vizhinjam Port will facilitate entire country's maritime trade and boost the development of a Special Economic Zones (SEZ) in the region due to opening up of new supply-chain networks.

Vizhinjam benefits from its geographic location – it is almost located at the tip of the southern peninsula on the West Coast of India. It is strategically located approximately 10 nautical miles from the international shipping route which could attract large share of the container transshipment traffic destined or originated to/from India. Vizhinjam Port is located at the proximity of Southern Railway which connects to Mumbai through Konkan railway in the north and southern part of Tamil Nadu through Nagercoil and Tiruchirappalli. Vizhinjam Port is located approximately 8km from NH 47 which connects Kanyakumari in the South to Mumbai in the North.

Kovalam beach is an important tourist centre located about 2km towards the North of Vizhinjam village. Near the Vizhinjam village is the Vizhinjam harbour which is developed in a natural bay protected by breakwaters and is one of the busiest fishing harbour in Thiruvananthapuram (Trivandrum) area.

Vizhinjam fishery harbour is located to the north and communities related to fishing and resort resides to the south of the proposed port. A 2.5km long waterfront has been identified at Vizhinjam for the proposed port development. The coastline is mainly oriented towards Northwest-Southeast direction (bearing of the shoreline is about 155° - 304°N). The terrain along the coastline in the area of interest is hilly and steep.

The port location is selected to tap the potential of development of a deep water international container transshipment port that can handle the largest container vessels serving the East-West shipping route as shown in Figure 2.2. The proposed port location is adjacent to the existing fishery harbour of Vizhinjam. The main competition of the port is with Colombo Port, Sri Lanka.

Analysis was carried out on the number of container vessels travelling East-West or West-East that are stopping at Colombo vs. not stopping at Colombo. It was observed that more than 70% of container vessels that are larger than 10,000 TEU in size do not stop at Colombo. On average only 50% of vessels of size 6,000 to 10,000 TEU make a stop at Colombo in their East-West or West-East voyage. This shows that there is an opportunity to service these bigger vessels at Vizhinjam.

Figure 2.2 Vizhinjam Port Location with respect to International East-West Shipping Route

2.4 This Document

AECOM submitted the Detailed Project Report to VISL in May 2013, based on which Environmental Clearance for the proposed development was accorded by MoEF. The present submission is the 'Basic Engineering Report' for Development of Vizhinjam Port as part of the Contract for the assignment.

This document defines the basis of design, details of basic engineering, standards and specifications for the Vizhinjam Port Project.

2.5 Organization of Basic Engineering Report

The Basic Engineering Report presented is organized in the following sections:

Section 2 : Introduction

Section 3 : Facility Planning and Port Layout

Section 4 : Design Data

Section 5 : Basic Engineering of Structures

Section 7 : Breakwater

Section 8 : Berthing Structures

Section 9 : Dredging and Reclamation Works

Section 10 : Buildings

Section 11 : Internal Roads and Rail Facility

Section 12 : Utilities

Section 13 : Port Craft and Navigational Aids

Section 14 : Fishery Harbour

Section 15 : Capital Cost

Section 16 : Construction Schedule

Annexure 1 : Basic Engineering of Indian Navy, Coast Guard and Cruise cum Multipurpose Berths

Annexure 2 : Figures

Annexure 3 : Drawings

Annexure 4 : Detailed Cost Estimates

3 Facility Planning and Port Layout

3.1 General

The Vizhinjam port Phase 1 development plan has been prepared to guide the development of the first phase of development of the port and identifies the facility requirements in terms of number and length of berths, navigational requirements, terminal equipment, terminal storage area, road and rail access for the receipt and evacuation of cargo and other utilities and service facilities. The focus of the Phase 1 development is primarily on container cargo and other port requirement along with the expansion of the existing fishing harbour. This section summarises the provided port facilities for the projected traffic at the Vizhinjam Port over the first phase of development.

3.2 Design Vessel Sizes

The traffic study has projected the following main cargo commodities for Vizhinjam Port:

- Containers
- General Cargo
  - Fertilizer
  - Raw Cashew
  - Timber

3.2.1 Governing Parameters of Design Ships

Parameters of design ship considered for estimating the navigational requirements (dredged depths, channel widths, safe stopping distance etc.) of the channel and harbour basin for Phase 1 and Master Plan layout development of Vizhinjam port, are presented in Table 3.1.

Table 3.1 Governing Parameters of Design Ship

Development Stage	Vessel Size	Overall Length	Beam	Loaded Draft
	TEU/ DWT	(m)	(m)	(m)
Phase 1	18,000 (165,000)	400	59.0	16.0

3.3 Container Terminal Capacity Analysis Summary

The container terminal has been sized to meet the market demand predicted by IFC/ Drewry in 2010. The following Table 3.2 summarizes the development needs of berths, gate, yard and rail elements for the Port of Vizhinjam. The Phase 1 plan has been prepared to meet this development needs.

Table 3.2 Terminal Development Summary for Vizhinjam Port

S. No	Port Components	Phase 1
1.	Berths (400m each)	2
2.	Container yard storage (TGS)	5,710
3.	Rail sidings (800m each)	3
4.	Entry/Exit Gate (lanes each)	5

Based on the port components planned for Phase 1 development, Table 3.3 shows a summary of the estimated traffic and the planned capacity for the Vizhinjam Port. As evident from the table, the Phase 1 development will provide optimum capacity for handling the projected traffic for Phase 1.

Table 3.3 Terminal Development Capacity Summary for Phase 1 Development

Description	Total	Transshipment Traffic	Gateway Traffic	
			Truck	Rail
	TEU	TEU	TEU	TEU
Phase 1 Container Traffic Forecast	8,22,256	6,83,798	96,921	41,538
Phase 1 Minimum Container Capacity Planned	9,00,000	7,61,541	1,16,305	90,000

3.4 Other Requirements

3.4.1 Port Crafts Area

The port require four tugs i.e. 3 Tugs with 70T bollard pull capacity and 1 Tug with 40T bollard pull capacity to assist the navigation of ships visiting the port, 3 Mooring launches and 1 Pilot launch.

The characteristics of these support crafts are given in Table 3.4.

Table 3.4 Characteristics of Port Crafts

S. No.	Type of Craft	LOA	Beam	Draft	Freeboard
		(m)	(m)	(m)	(m)
1.	Tugs	30.0	9.0	2.5	1.5
2.	Pilot Launch	19.5	4.8	1.8	1.1
3.	Mooring Launch	10.3	3.2	1.2	0.8

3.5 Fishery Landing Centre

The existing Vizhinjam fishing harbour has the berthing facility of 500m and is being utilized to its peak causing congestion in the utilization of the harbour. Apart from this, the harbour requires up gradation in terms of ancillary facilities.

In order to ease the congestion in the existing fishing harbour and provide additional facilities for the local population, VISL has proposed to provide fishery berths along the sea side of north breakwater of the proposed Vizhinjam port as part of Corporate Social Responsibility.

The facilities to be provided are broadly divided into two categories viz.

a) Waterside facilities
- Tranquil condition for harbour operations
- Proper access to the landing area from the sea
- Landing, Outfitting Quay and berthing quay/ jetty
- Navigational Aids etc.

b) Landside facilities
- Auction hall and loading area facility
- Administrative building
- Canteen
- Net mending shed
- Gear Shed
- Cold Storage
- Toilet Block
- Facilities for Effluent treatment

- Vehicle parking area
- Access roads
- Security
- Electric & Water Supply etc.

It is proposed to provide 500m fishing jetty with differential landing facility for the fishing trawlers and country boats fitted with outboard engines.

3.6 Port Layout

3.6.1 Planned Layout

3.6.1.1 Background

As per the Work Contract, the Vizhinjam port planning was carried out to accommodate the containers. However, as the port development study progressed, VISL focussed on not only developing this port as a transhipment port but also to provide the hub for the Indian Navy and Coastguard operations considering its strategic location. The Phase 1 development primarily focussed to cater to Container Cargo, Cruise Terminal, Coastguard, Indian navy and other associated port requirements along with the expansion of the existing fishing harbour.

3.6.1.2 Summary of the Port Facilities

The layout developed for Phase 1 development of Vizhinjam Port consists of the facilities as presented in Table 3.5.

Table 3.5 Summary of Planned Facilities for Phase 1 Development

S. No.	Description	Dimension
		No. (m)
1.	Breakwater*	(3100)
2.	Container Berths	2 (800)
3.	Cruise cum Multipurpose Terminal	1 (300)
4.	Coastguard	1 (120)
5.	Indian Navy	2 (500)
6.	Port Craft	1 (100)
7.	Fishery Berth	(500)

* the length include the fishery harbour breakwater of 140m

The planned layout for Vizhinjam port is as presented in Drawing **DELD11137-DRG-25-0000-CP-1001**.

3.6.2 Modification in the Planned Facilities

VISL in principle decided to go ahead only with the Container berths and Terminal development as envisaged originally in the work contract. Accordingly, the layout developed with the facilities for Indian Navy, Coastguard with discarded and the layout was modified to cater the container traffic only in Phase 1. In doing so, the harbour layout was optimised by reducing the breakwater length as well as the reclamation quantity.

The recommended layout for Vizhinjam port is as presented in Drawing **DELD11137-DRG-25-0000-CP-1002**.

3.6.3 Work Split

The work split for the various port components between the Funded and the PPP works is as shown in Drawing **DELD11137-DRG-25-0000-CP-1003**.

4 Design Data

4.1 Introduction

All data included in this section is provided for information only. However, Concessionaire should verify all site data and shall take full responsibility of the design and data used. The Concessionaire may opt to conduct additional and/or more detailed investigations suited to his design.

4.2 Units and Language

SI units shall be used throughout. All submittals and reference documents shall be in the English language.

4.3 Level Data and Setting Out

Setting out of the Work shall be to Chart Datum (CD). Control points and benchmarks exist in the port development area and these will be made known to the appointed Concessionaire.

Temporary setting out stations and bench marks shall be checked and agreed with the Engineer prior to any construction commencing. These shall be kept intact and undisturbed. Concessionaire shall from time to time verify their relationship to the permanent stations. The temporary bench marks and stations shall be located on stoutly constructed concrete bases.

Details of methods and equipment to be used in setting out the Work shall be submitted to the Engineer.

All dimensions and levels both on the drawings and the Site shall be checked, particularly the co-relation between components and the work in place. Materials and components shall not be ordered, or work carried out, until any discrepancies have been resolved with the Independent Engineer.

4.4 Environmental Data

VISL have carried out the all the required technical studies, which have become the base of this report.

Table 4.1 mention reports related to Vizhinjam port project and work carried out by previous consultants.

Table 4.1 Past Studies carried out for Vizhinjam Port

S. No.	Description of the Study/Investigations	Agency	Time (Month – Year)
I	**OCEANOGRAPHIC/GEOTECHNICAL INVESTIGATIONS**		
1.	Field Surveys and Investigation Report, May 2004	L&T-RAMBØLL Consulting Engineers Limited, Chennai, Rogge Marine Consulting GMBH, Germany (RMC), RAMBØLL, Hannenmann & Højlund A/S, Denmark (RAMBØLL) and L&T Capital Company Limited, India (LTC).	May 2004
2.	Geotechnical and Geophysical Survey Works	Fugro Geotech Pvt. Limited	May 2011
3.	Oceanographic Investigations for Tides Currents and Wave observations	EGS Survey Pvt. Ltd.	March 2013
II	**MODEL STUDIES**		
1.	Mathematical model studies by Royal Haskoning	Royal Haskoning	October 2010

S. No.	Description of the Study/Investigations	Agency	Time (Month – Year)
2.	Updated Mathematical Model Study	L&T-RAMBØLL Consulting Engineers Limited, Chennai	May 2013
3.	Ship Simulation Study for Vizhinjam Port	BMT Consultants India	May 2013
III	**TECHNICAL STUDIES**		
1.	Rapid Environmental Impact Assessment Report	L&T-RAMBØLL Consulting Engineers Limited, Chennai	February 2004
2.	Detailed Techno-Economic Feasibility Study	L&T-RAMBØLL Consulting Engineers Limited, Chennai in association with Rogge Marine Consulting GMBH, Germany (RMC), RAMBØLL, Hannenmann & Højlund A/S, Denmark (RAMBØLL) and L&T Capital Company Limited, India (LTC).	May 2004, Revision June 2007
3.	Preliminary Project Plan Report	Royal Haskoning	October 2010
4.	DPR for Rail Connectivity from Neyyattinkara to Vizhinjam International Seaport	Rail Vikas Nigam Limited, Chennai	July 2011 May 2012
5.	Integrated Master Plan Report	AECOM India Private Limited	November 2012
6.	CRZ Status Report	Centre for Earth Science Studies Thiruvananthapuram	April 2013
7.	DPR for Development of Vizhinjam Port	AECOM India Private Limited	May 2013
IV	**TRAFFIC STUDIES**		
1.	Kerala Port PPP – Market Study	Drewry Shipping Consultants Ltd.	November 2010
V	**ECONOMIC AND SOCIAL IMPACT ASSESSMENT STUDIES**		
1.	Integrated ESIA Report	L&T-RAMBØLL Consulting Engineers Limited	May 2013
2.	Estimation of Economic Internal Rate of Return of the Vizhinjam Port project-Draft Report	Deloitte Touche Tohmatsu India Private Limited	May 2013

4.5 Meteorological and Oceanographic Data

4.5.1 Meteorological Data

4.5.1.1 General

This information has been extracted from previous studies for the project as well as from the West Coast of India Pilot (WCIP) climatological table applicable for the Trivandrum area and the project site.

4.5.1.2 Climate

Vizhinjam has a tropical humid climate with hot summers and the region is characterised by two seasonal monsoons:

- The North-East monsoon occurs between October to December and is characterised by predominant north-easterly winds.
- The South-West monsoon extends from June to September and is characterised by occurrence of rain, with predominantly south westerly winds.

4.5.1.3 Temperature

The mean maximum daily temperature varies from 29°C and 32°C. March, April and May are considered to be the hottest months of the year with temperature rising up to 33° Celsius. Mean minimum daily temperature varies between 24°C to 30°C, with the lowest occurring in December.

4.5.1.4 Relative Humidity

Humidity is high and rises to about 89% during the southwest monsoon in the month of June. The mean monthly average relative humidity varies between 73% and 84%.

4.5.1.5 Precipitation

The average rainfall is around 1835mm per annum. The region gets most of the rainfall from the south west monsoon which lasts till September, while the northeast monsoon commences in October. May to November is the wettest months of the year with an average rainfall in excess of 220mm per month, with a maximum of 356mm in June. Rainfall is at its peak in the month of June and July.

Dry weather sets in by the end of December lasting up to May with average rainfall of approximately 27mm per month.

4.5.1.6 Cyclone

Cyclones occasionally make landfall in the west coast compared to the east coast of India. It is observed from the tracks of the cyclones in the Arabian Sea that in the last 100 years only 4 storms have passed nearby the project location of which only 2 had impact on the study region in the above said period i.e. the frequency of the cyclone occurrence is approximately once in 25 years.

4.5.1.7 Visibility

Throughout the year visibility is good as the region has zero fog days and therefore there are no constraints to the navigation in this regard.

4.5.2 Oceanographic Data

4.5.2.1 Tides

The tides in the region are of the semi-diurnal type i.e. characterized by occurrence of two High and two Low Waters every day. Tidal levels for Vizhinjam are extracted from National Hydrographic Chart 2012 as presented below, the levels are with respect to Chart Datum:

Mean Highest High Water (MHHW)	+ 0.8 m
Mean Lowest High Water (MLHW)	+ 0.7 m
Mean Highest Low Water (MHLW)	+ 0.4 m
Mean Lowest Low Water (MLLW)	+ 0.3 m
Mean Sea Level (MSL)	+ 0.6 m

The storm surge heights calculated for various cyclones in the past were subjected to extreme wind conditions. Based on this, the storm surge height of 0.3m was calculated for the return period of 200 years.

The recorded tides show that the spring tidal range is about 0.5m to 0.7m during the measurement period.

4.5.2.2 Currents

The current flow was parallel to the coast and the surface currents are mostly wind driven. The maximum current of 0.89 knots was measured at the water surface and during the period of observation the current speed was mainly in the range of 0 to 0.5 knots.

4.5.2.3 Waves

The deep water wave climate is dominated by north easterly and south-westerly conditions associated with the (south-westerly) monsoon and the post-monsoon respectively. As the waves travel into progressively shallower water, they are modified by depth-refraction and their crests become progressively more aligned with the bed contours. This causes a reduction in the spread of wave directions in the wave climate with reduction in water depth. Moving into depths of 20m and below, the height of the largest waves is reduced due to the combined effects of refraction and wave breaking.

4.5.3 Hydrographic Survey

VISL carried out the hydrographic survey of the project area. Figure 4.1 shows the bathymetric survey map for the project site. Contours/ Isobaths at 1m interval are depicted in survey map. Generally, Isobaths within the survey area are oriented parallel to the coast line, except the unevenness observed at the rock outcropping areas.

In general, the seabed within the survey area was gently sloping down towards south west. The seabed between the shoreline and 10 m depth contour in the project site has a slope of 1: 36 (1.59°) is comparatively steeper than the seabed between 10 m and 15 m depth contours and these contours run parallel to the shoreline. Consequently the reverse trend is conspicuous in the deeper water i.e., along the seabed between 10 m and 15 m depth contours which has slope of 1: 110 (0.5°) which continues with the similar trend in the region beyond 15m depth in the study region.

4.5.4 Side Scan Sonar Survey

Seabed sediments within the survey area was classified into following types based on the acoustic reflectivity observed on the side scan sonar records.

- Type 1: Low to medium reflective seabed interpreted as Clayey / Silty Fine SAND
- Type 2: Medium reflective seabed interpreted as fine to medium SAND
- Type 3: High reflective seabed interpreted as Rock Outcrops

In general, Type 1 and Type 2 sediments were predominant within the survey area and were randomly distributed over the survey area. Rock out crops (Type 3) was predominant in areas close to the shore line. Distribution of various seabed types within the survey area is depicted.

No significant seabed features were identified within the survey area. No existing pipelines / cables were identified on the survey records within the survey area. The output of side scan surveys is presented in Figure 4.2.

4.5.5 Shallow Seismic Survey

The compactness of the sediment derived from the seismic records, is presented in the form of Isopach map. Isopachs at 1m interval, showing the thickness of this unit, is as shown in Figure 4.3.

Loose to medium dense Silty SAND unit was the topmost geological unit throughout the survey area except in areas wherever rock out crops was recorded. The thickness of this unit was varying between < 1m and 9 m within the survey area. Sedimentary unit underlying the topmost unit was interpreted as medium dense SAND. The intermittent parallel / sub-parallel internal reflectors within this unit can be attributed to presence of thin layers

of Silt / Clay within this unit. This unit was present throughout the survey area except at the rock outcropping areas.

4.5.6 Topographic Survey

Topography along the shore is very steep with weathered rock patches and high land areas. General topography of the port back-up land right behind the shoreline varies from +5m CD to up to +35m CD. Mulloor Naga Temple shown in the figure is located at approximately +12m elevation on a high land area. Figure 4.4 shows the topographic survey map for the project site.

4.5.7 Geotechnical Data

VISL carried out the geotechnical investigations of the area. The location of boreholes is as shown in Figure 4.5.

The various soil profiles developed are shown in Figure 4.6 to Figure 4.10 respectively.

4.5.8 Model Studies

Report of mathematical model studies was carried out by M/s L&T-Ramboll. The outcome of the model studies is summarised in the following sub sections.

4.5.8.1 Wave Tranquillity

The predominant waves in the region are of monsoonal origin, the breakwater alignment effectively provides full protection from such waves. Also it was observed that the north breakwater provides complete protection from offshore waves; hence the South breakwater provided would not be necessary. The breakwater alignment may be further optimized during physical modelling studies.

The proposed port layout is expected to improve tranquillity for the existing fishing harbour as the proposed breakwater shall also provide protection to the existing fishing harbour with the additional spur to the north breakwater.

4.5.8.2 Sediment Transport and Shoreline Change

The proposed port breakwater alignment is not expected to alter the sedimentation pattern around the shoreline significantly. The existing pockets beaches around Kovalam are not expected to be affected while the beaches at Adimalathura, south of proposed port are expected undergo accretion. This accretion is estimated to equilibrate at around 20m at the end of ten years of simulation. The maintenance dredging activities at the port are expected to be minimal. The proposed port is also expected to reduce sedimentation inside the existing fishing harbour.

The proposed bund structure is also expected to obstruct any sediment from entering into the proposed harbour. Hence, maintenance dredging activities at the port are expected to be minimal. The proposed port is also expected to reduce sedimentation inside the existing fishing harbour.

4.5.8.3 Dredged Disposal Site

Offshore dredge material dumping locations have also been identified and modelled. The sediment dispersion studies indicate that the most of the sediments dumped do not travel far from the proposed dumping ground and the concentration of sediments are very minimal away from the dumping grounds.

The sediment plume was confined to the deep water based on the outcome of the study. From the simulated results, it was observed that there is no impact to the fishing harbour due to dumping operation. The location of the dumping ground is in deep waters proximity to the port channel. The designated disposal site is confined to location as indicated below:

Points	Location	
	Latitude	Longitude
A	76°59’39.07”E	8°20’25.48”N
B	77°00’25.04”E	8°19’39.23”N
C	77°00’01.82”E	8°19’16.33”N
D	76°59’15.85”E	8°20’02.59”N

It is recommended to schedule the maintenance dredging activity if any during the NE and non-monsoon periods, considering stronger current prevailing during the SW monsoon.

4.5.8.4 Tranquillity in the proposed Fishing Harbour

As per the modelling studies, the proposed fishery harbour accounts for a 140m breakwater extension will provide adequate tranquillity at the proposed fish landing berths with the operational downtime varying from around 14 days to 49 days at various location of the berth.

4.5.8.5 Water Levels

4.5.8.5.1 Still Water Level

The tide near the project area is found to be mixed, predominantly semi-diurnal in nature. Based on the harmonic analysis and from the predicted data the highest astronomical tide was estimated as 1.20m with respect to CD.

4.5.8.5.2 Storm Surge

The storm surge heights calculated for various cyclones in the past were subjected to extreme wind conditions. Based on this, the storm surge height of 0.3m was calculated for the return period of 200 years.

4.5.8.5.3 Sea Level Rise

The projected sea level rise for the project location after 50,100 and 200 years will be 0.2, 0.4 and 0.8m.

4.5.8.5.4 Extreme Waves

The effect of cyclone is expected to be insignificant at the project site of Vizhinjam port and hence extreme analysis presented in Table 4.2 is applicable for the project site.

Table 4.2 Design Wave Height for various Return Periods

S. No	Return Period (Yrs)	Wave Heights (m)
1.	1	2.60
2.	5	3.40
3.	10	3.60
4.	25	4.10
5.	50	4.20
6.	100	4.50
7.	200	4.70

4.5.8.6 Ship Navigation Study

The fast-time ship navigation study has validated various navigational arrangements at the port in respect of dredge depths, channel widths, turning adequacy, berth arrangements etc. it was recommended from the study that the outer channel width of 400m be provided for safe navigation of vessels at Vizhinjam port.

5 Basic Engineering of Structures

5.1 General

The Vizhinjam Funded Works will involve the construction of:

- approximate 3,100 m of breakwater to protect the harbour basin from waves and swells,
- Fishery harbour and associated onshore facilities

The PPP Works comprise of:

- approximate 800 m of quay for container loading/unloading operation, basin area for port crafts, and 500m fish landing berth;
- revetments to protect the shore and reclaimed land,
- dredging to create harbour basin and approach channel,
- reclamation with the dredged material to create onshore facilities and other associated civil works.

The layout of the proposed facility is shown in the layout **Drawing DELD11137-DRG-25-0000-CP-1002**.

The proposed facility is Phase 1 development and the Authority has intention to expand the facility in future. All design and construction works related to Phase 1 development shall take account of future development planned by VISL.

Basic engineering for various civil infrastructures for Phase 1 development have been carried out. This analysis is based on the various studies carried out by the Authority. AECOM are making recommendations based upon information that has been made available to them from these studies; such recommendations are subject to many factors that are beyond the control of AECOM; and AECOM thus make no representations or warranties with respect to such recommendations and disclaim any responsibility for the accuracy of estimates and recommendations.

It should be noted that during the design stage by VISL and the Concessionaire may modify or optimize this engineering analysis along with associated layouts to suit the requirements.

The basic engineering makes certain assumptions as to the structure types for various port components whereas the Concessionaire may make modifications based on adopted final design, construction methodology and equipment availability.

The basic engineering for the civil works of major work components of the port have been covered in the subsequent section covering the following.

- Breakwater
- Container Berths
- Dredging and Reclamation Works
- Buildings
- Navigational Aids
- Fishery Harbour and associated onshore facilities

The basis of the design is set out in as much detail as possible in the design criteria in this section. The adopted design criteria provided in this report are based on the detailed site studies, outcome of mathematical model studies and the physical details of the port site.

6 Breakwater

6.1 Functional Requirements

The Concessionaire shall design and construct the Breakwater Works to provide protection from the waves so as to ensure a safe and calm harbour basin for the port facility and to ensure 24 hours a day 7 days a week 365 days a year operations in all but the most inclement weather conditions.

The breakwater shall facilitate safe navigation conditions into and around the port providing a haven for port vessels during extreme ocean conditions thereby creating an acceptable wave climate for the design of port infrastructure.

The shore connected breakwater shall be constructed up to the -20m CD seabed contour, and shall comply with the specifications and requirements as shown in the Drawings and herein.

6.2 Breakwater Options

Considering the aspect of breakwater requirements to be provided into deep waters, following alternatives were considered as shown in **Drawing DELD11137-DRG-25-0000-CP-2001**.

6.2.1 Rubble Mound Breakwater

Rubble Mound Breakwaters use structural voids to dissipate the wave energy. Rock or concrete armour units on the outside of the structure absorb most of the energy, while core material prevents the wave energy's continuing through the breakwater core. The slopes of the breakwater are typically between 1.33 and 1:1.5, depending upon the materials used. In shallow water, breakwaters are usually relatively inexpensive. As water depth increases, the material requirements, and hence costs, increase significantly.

6.2.2 Vertical Face/ Caisson Breakwater

Vertical face/ Caisson breakwaters typically have vertical sides and are usually erected where it is desirable to berth one or more vessels on the inner face of the breakwater. They use the mass of the caisson and the fill within it to resist the overturning and sliding forces applied by waves hitting them. They are relatively expensive to construct in shallow water, but in deeper sites they can offer a significant saving over rubble breakwaters.

6.2.3 Composite Breakwater

A typical composite breakwater is composed of upright caisson structure and rubble mound which again consists of core and revetments. For the purpose of efficient disaster prevention or harbour tranquillity, a proper distribution of sections for each part is an essential factor in design and economic construction of composite breakwater. These are generally used in regions where availability of natural stones is sparse and deep water contours are reached at very close intervals.

6.2.4 Preferred Alternative

All the options mentioned above are technically feasible to be considered as the preferred option. The micro scale analysis of the options suggests that the Rubble Mound Breakwaters be opted for proposed port.

The micro scale analysis involves the assessment of required rock sizes, skilled and unskilled labour, and considerably experienced contractor available in the region to carry out the construction works, equipment availability and economics.

The advantages of rubble mound breakwater are:

- The sufficient quantity of natural rocks are available in the vicinity of the proposed site, the quarries identified are capable providing the required tonnage of rock.

- The review of Geotechnical Investigations data suggests that the top layer has an average N value of 15, which is not suitable for founding a caisson or a composite breakwater while the rubble mound breakwater will offer flexibility in terms of maintenance at later stages of its service life.
- In India, most of the breakwaters are constructed as Rubble Mound Breakwater primarily because of the easy availability of natural stone and availability of local contractors in the region to carry-out this type of construction works.

6.3 Design Life and First Maintenance

The design working life is defined as the period for which civil and structural elements are to be used with acceptable maintenance, but without major repair and/ or replacement being necessary.

Acceptable maintenance for the Works is described Table 6.1 below. The table also indicates what would be considered to be unacceptable maintenance, i.e. unacceptable repair or replacement.

Table 6.1 Design Life

Element	Design Life (Years)	Maintenance Interval (Years)	Routine Maintenance by Employer	Unacceptable Repair and Maintenance
Breakwater and Revetments	100	10	Routine inspection and replacement of minor rock/concrete armour damage.	Replacement or regarding of rock/concrete armour, involving damage exceeds 5% of the area. Repair of slumping.

6.4 Codes and Standards

All materials, testing, design and execution shall be in conformity with these codes and standards unless otherwise stated in these specifications. Indian Standards shall generally be followed and wherever the details for parts of the Works are not defined adequately in Indian Standards, relevant acceptable International Standards shall be adopted in the order of preference as given below:

- BS: 6349 Part 7 – Guide to Design and Construction of Breakwaters
- CIRIA, “The Rock Manual” and US Army Corps of Engineers, EM 1110-2-1100 Coastal Engineering Manual.
- EurOtop Manual – ‘Wave overtopping of Sea Defences and Related Structures’
- CIRIA, C660 – Control of Contraction Induced Cracking in Concrete

The following PIANC guidelines shall be used for design of relevant components and shall govern the basis of design for them respectively.

- PIANC Approach Channels – A guide to design, Supplement to Bulletin No. 95
- PIANC Guidelines for design of armoured slopes under open piled Quay walls, 1997

6.5 Design Considerations

6.5.1 Basic Data for Breakwaters Design

6.5.1.1 Tidal levels

Highest Astronomical Tide (HAT)	+1.20m
Mean Highest High Water (MHHW)	+ 0.8m
Mean Lowest High Water (MLHW)	+ 0.7m
Mean Highest Low Water (MHLW)	+ 0.4m
Mean Lowest Low Water (MLLW)	+ 0.3m
Mean Sea Level (MSL)	+ 0.6m

All levels are with respect to the Chart Datum

Source: NHO 2012

6.5.1.2 Design Water Level

With storm surges, the meteorological conditions causing the rise in water levels are sometimes but not always the same as those causing maximum wave attacks. In some cases the two conditions will be independent variables; in others they can be positively or negatively related. The combined probability of the storm causing design wave height at structure along with maximum storm surge (both arrived at after carrying out extreme value analysis) is considered to be relatively small. However, the combined probability estimates are hard to predict.

Based on the storm surge studies carried out by L&T Ramboll, a 200 year storm surge/wave setup value is found to be 0.3m. The wave run-up predicted is negligible at the breakwater locations and hence has not been included. For the basic engineering design included in this section, the storm surge is used at the highest astronomical tide to arrive at the design water level for the breakwater design, as given below:

Design Water Level = Highest Astronomical Tide + Storm Surge + Expected Sea Level Rise

= +1.2 m CD + 0.3m + 0.8m = +2.3 m CD.

6.5.1.3 Design Wave Conditions

Studies were carried out for the design wave heights that can used for various project elements such as breakwater, berths and revetments. For the breakwater design, the design conditions of 1 in 200 years have been considered.

A summary of the predicted wave conditions at various contour levels along the breakwater is provided in the following Table 6.2.

Table 6.2 Extreme Wave Condition at Project Site

Structure	**1 in 200 year Return Period**	
	H_s (m)	**T_p (s)**
Breakwater – Head and trunk (-20m)	4.7	9.9
Breakwater – Trunk(-18m)	4.6	9.9
Breakwater – Trunk (-14m)	4.2	9.9
Breakwater – Trunk (-12m)	3.9	9.9
Breakwater – Trunk (-12m to shore)	2.7	9.9
Revetments	2.5	9.9

Source: Report on Design Wave Heights and Water Levels, April 2013, LTR

6.5.1.4 Other Design Assumptions

- Stones up to 6.0T are economically available with density of 2.65 T/m^3;
- The minimum density of concrete armour units will be 2.39 T/m^3;
- Concrete slab with a vertical wave wall will be provided at the crest of the breakwater;
- The normal design life of the breakwater is 100 years;
- The breakwater design is for the environmental event return period of 200 years;
- The breakwater construction will be by end-on dumping method as well as barge dumping. However, there will be no restriction/ limitations of crane for laying armour units.

6.5.1.5 Crest Elevations and Widths

The primary purpose of the breakwaters at the port is to provide the required tranquillity conditions in the manoeuvring areas and berths. The port is not considered to act as a survival port to allow shelter for ships during cyclone. The required minimum crest height of the breakwater is determined by the allowable wave penetration by overtopping during extreme conditions and stability of the rear face of the breakwater.

The crest level has been decided based on limiting the overtopping discharge to 1 lt/m for the 200 year return period event and checked for 0.4 lts/m for the 50 year return period event. This criterion has been adopted as per EurOtop Manual to provide no damage to equipment for the 50 year event and no damage to building structure

elements during the 200 year design event. A wave wall of clear height varying from 1.5m to 2.0m has also been provided. The calculations have been performed using HR Wallingford tools for overtopping discharge.

Table 6.3 Overtopping Discharge at various Sections of Breakwater

S. No	Bed Level	Design Water Depth	Min. Crest Level	Min. Crest Width	50 Year Discharge	200 Year Discharge
	(m)	(m)	(m)	(m)	(lt/s/m)	(lt/s/m)
1.	-12m to shore	14.3	6.0	3.6	0.06	0.3
2.	-12m roundhead	14.3	7.0	4.5	0.07	0.8
3.	-14.0	16.3	6.0	4.5	0.07	0.8
4.	-18.0	20.3	7.5	5.0	0.12	0.8
5.	-20.0	22.3	7.5	5.6	0.12	1.0
6.	-20m roundhead	22.3	7.5	5.6	0.12	1.0

6.5.2 Armour Units

For the armour units following options have been considered:

- Rock as armour layer
- Concrete Armour Units considered
  - TETRAPOD
  - ACCROPODE I/ ACCROPODE II
  - CORE-LOC
  - XBLOC

Due to greater depths at the proposed breakwaters, concrete armour are primarily used for armour and rock up to 5T is used as secondary armour and smaller filter layers.

The tetrapod have been successfully used as concrete armour layers over the years. These are placed in double layers. The size of the structure and the exposed location lend the breakwater design to the use of single layer concrete armour units on the seaward face. Accropode, Xbloc and Core-loc are the latest concrete armour units, which are placed in single layer at much steeper slopes as compared to the tetrapod. These units allow the use of a revetment slope at 1 vertical to 1.33 horizontal. All three armour units offer similar performance and have similar construction requirements. As a result, breakwaters with these armour units require lower quantity of rock. Further these units have higher stability due to better inter-locking capability as compared to tetrapod resulting in reduced weight of the armour unit. However these units require assessment of very precise design wave conditions at site and have stringent placement requirements.

Accropode have been successfully used in India in Ennore, Gangavaram and Kattupalli projects and these have the advantage of ease in placement at greater depths, where heavy armour units are required.

For the proposed port, Accropode armour units have been chosen for the breakwater design. The Concessionaire may substitute these with a suitable alternative that provides similar or better performance. Based on the design wave heights adopted, the size of Accropode armour units were evaluated as described below.

6.5.3 Breakwater Cross Sections

Hudson formula is used for calculating the weight of armour unit.

$$W = \frac{e_s H^3}{K_D \left(\frac{e_s}{e_w} - 1 \right)^3 \times \cot \alpha}$$

where W = weight of armour unit

e_s = Mass density of armour unit

H = Design Wave height

K_D = Stability Coefficient

e_w = Mass density of water

cot α = Armour slope (H/V)

The design wave height is taken as follows:

- 1 in 200 years return period significant wave height at the corresponding location or the breaking wave height at that location, whichever is severe, when using the concrete armour units.
- $H_{1/10}$ (i.e. 1.27 times H_s) for 200 year return period at the corresponding location or the breaking wave height at that location, whichever is severe, when using rock as armour unit.

The values for K_D considered (under non-breaking conditions) are as follows:

Breakwater Portion	**K_D values**
	ACCROPODE
Trunk	15
Head	11.5

The under layers and toe size have been chosen and sized to correspond to CLI recommendations. The criteria for maximum of 20 Accropode I units along the front face has been utilized to establish the required Toe levels for the breakwater sections.

The rear side armour of the breakwater was determined for the wave heights inside the harbour or by using van Gent formula for waves by overtopping taking whichever is critical.

The breakwater dimensions are based on the calculations above. Various calculations related to sizing of the cross-section are taken from Design Guidance Document for Accropode (2012).

Breakwater

S. No	Bed Level	Design Water Depth	Calculated ACCROPODE Size
	(m)	(m)	(m^3)
1.	-12m roundhead	14.3	4
2.	-14.0	16.3	4
3.	-18.0	20.3	5
4.	-20.0	22.3	6
5.	-20m roundhead	22.3	8

6.5.4 Geotechnical Assessment of Breakwater

The seabed level at the breakwaters increases from +1.0m CD near the shore to a maximum of –20.0m CD. The crest level at the maximum depth is about +7.5m CD.

Based on the geotechnical results from geotechnical investigation report by Fugro, the subsoil at the breakwater locations is loose to medium dense silty sand with shell fragments. The depth of this layer varies from 5m at the north to 21 m along the breakwater. This layer is underlain immediately by a layer of very dense clayey sand followed by the layer of very dense sand with gravels. The subsoil is considered to be suitable for providing the breakwater foundations. An allowance has been used to account for some consolidation of original sea bed material when the initial core is placed.

6.6 EPC Executing Agency's Responsibility

The EPC executing agency shall be responsible for everything necessary and required for the engineering, design, execution, completion and proper functioning and use of the breakwater works, which shall include the proposed future development for marine facilities for which the breakwater will be used for operations roadway access.

The EPC executing agency shall carry out additional surveys, data collection, investigations, and hydraulic and physical model studies for the design of the breakwater works in respect of both the layout, and the cross-section and structure.

Notwithstanding the Authority's exhibited design, and the preliminary nature of the information and data available, the EPC executing agency shall be responsible for the overall design of the breakwater as a part of his design obligations. The EPC executing agency shall submit the detailed design of the Breakwater for review and approval prior to construction.

The type of Breakwater proposed, shall be in operation successfully on two comparable Ports for at least two years in the immediately preceding ten *years.*

6.6.1 Acceptance of Site

In accordance with these Specifications, the Contractor shall be deemed to have examined the Site and familiarize himself with all existing conditions. He shall accept the Site in the existing condition at the time of Award of Contract.

6.6.2 Quarry for Sourcing of Rock and Associated Investigations

The EPC executing agency shall identify and establish suitable quarry/quarries with an adequate supply of rock satisfying the requirements of the related sections of this document. The EPC executing agency shall be responsible for sourcing of quarry to complete the Works as per the contract agreement. The EPC executing agency shall submit preliminary details of the proposed quarry locations for rock and shall submit his final proposals within 60 days of Award of the Contract. The proposal shall contain details of the sources of supply, material test certificates, production capacity, testing facilities and means of transportation to the Site. The EPC executing agency shall also submit for the approval of the Authority a Quarry Analysis Report which meets the grading requirements specified in the Contract Agreement for all grades of rock prior to commencement of regular quarrying operations.

6.6.3 Transport of Rock from Quarries to Project Site

The EPC executing agency shall be responsible for construction of any temporary works, jetty, roads/improvement of roads, culverts, bridges etc. required for transport of rock from quarries to Project Site.

6.6.4 Permits

Except as expressly stated otherwise elsewhere, the EPC executing agency at its own cost shall obtain all permits and licenses required for execution and completion of the Works. The EPC executing agency shall bear cost of all associated fees including royalty/cess. He shall also give the Authority a copy of all relevant correspondence and

other documents relating to the EPC executing agency permits and licenses and proof of payment of all required statutory fees/cess/royalties etc.

6.6.5 Hydrographic Surveys

The EPC executing agency may carry out a pre-construction survey of the areas where the works will be carried out involving the bathymetric survey of the seabed to verify the details provided by Authority. Refer Section 6.10 of this document.

6.6.6 Geotechnical Investigations

The EPC executing agency shall carry out geo-technical investigations in the area for a thorough knowledge of the sub-soils. EPC executing agency shall carry out detailed geo-technical investigations along the Breakwater alignment. Boreholes - in general, at every 100 m intervals or as directed by the Independent Engineer shall be carried out by the EPC executing agency within 60 days of Award of the Contract. The EPC executing agency shall verify the geo-technical and structural stability of the Breakwater as per the results of this investigation and based on detailed stability analysis computations taking into account all loading, meteorological, oceanographic, seismological and environmental conditions as applicable. EPC executing agency shall submit along with their Tenders a Detailed Note on their Proposed- Approach & Methodology of Design of Breakwaters" in this regard.

6.6.7 Design and Drawings

The EPC executing agency shall carryout the engineering design and prepare the drawings for various sections of the breakwater. The design shall be carried out for the section intervals mentioned as per Section 6.7.5. Design of the roundheads is to be taken up separately. The bed level for these design sections will be decided by the Authority on the basis of the bathymetric survey.

6.6.8 Physical Model Studies

The specified designed sections shall be tested through 2-D and 3-D model testing as outlined in the Section 6.7.9. These tests shall be carried out by an internationally recognized laboratory specialized in the field of hydraulic model testing. The laboratory is to be accredited by the owner of any armour unit patents or licenses that may be applicable to the project and approved by the Authority.

6.6.9 Setting Out

The EPC executing agency shall establish working bench marks related to the Reference Bench Mark in the area soon after taking possession of the site. The Authority shall provide the EPC executing agency with one Permanent Bench Mark and its datum. In order to facilitate the setting out of the works, the centre line of the breakwater must be accurately established by the EPC executing agency and approved by the Authority. It must then be accurately referenced in a manner satisfactory to the Authority. A schedule of reference dimensions shall be prepared and supplied by the EPC executing agency to the Authority. These marks shall be maintained until the works reach the finished formation level and are accepted by the Authority.

On construction reaching the formation level stage, the centre line shall again be set out by the EPC executing agency and when approved by the Authority, shall be accurately referenced in a manner satisfactory to the Authority.

No reference mark shall be moved or withdrawn without the approval of the Authority and no work shall be commenced until the centre line has been referenced.

6.6.10 Construction of the Breakwater

The EPC executing agency shall submit to the Authority, for his approval, full details of his proposed method for quarrying of rock and formation of the breakwaters to the profiles indicated on the EPC executing agency's construction drawings. The EPC executing agency shall not commence the construction until the Authority has approved in writing the detailed methods for quarrying, transport of quarry material to site and forming of the breakwaters.

The EPC executing agency shall form the breakwaters to the lines and levels shown in the construction drawings and within the tolerances specified.

The EPC executing agency has to take all the necessary precautions and measures to protect his equipment and the completed sections / structures before the onset of monsoon.

6.6.11 Post Construction Survey

The completion of the works will be examined by the EPC executing agency in the presence of the Authority. During these examinations, the EPC executing agency shall perform an alignment survey, which shall be used to prepare a final drawing showing all dimensions, elevations and cross sections of the "As Built" conditions of the breakwater. The EPC executing agency shall be required to remove excess materials or place additional materials, as directed by The Authority, in order to comply with the Contract Documents. Breakwater sections shall be examined thoroughly by soundings / hydrographical surveys. EPC executing agency shall submit the final position grid which shall show the actual position of each armour unit, deviation from the theoretical position of armour units / rock and actual packing density. Aerial photographs after placement of armour units / rocks shall be made available by the EPC executing agency to the Authority.

6.6.12 Construction during Monsoon

The EPC executing agency shall keep allowance in program of works for any stoppages during monsoon period or any period of bad weather or sea conditions, and he has to take all necessary measures to protect his equipment and the partly completed structures. The EPC executing agency is expected to and shall provide for such stoppages of work during monsoon in his overall schedule for completion. The Independent Engineer will not entertain any claims whether for time or costs from the EPC executing agency on this account.

6.6.13 Diving Support

The EPC executing agency shall provide fully qualified and experienced divers, together with all support equipment, to ensure that all submerged works are constructed in accordance with the Contract. The EPC executing agency shall submit diving inspection reports to the Independent Engineer.

6.6.14 Maintenance Plan

Before submitting a request for Taking over Certificate, the EPC executing agency shall ensure that he has furnished to the Independent Engineer all required documents including but not limited to five copies of maintenance document, manuals etc., covering all aspects of the works for the review of the Independent Engineer. This plan shall be prepared to ensure that the design life periods stated are met in full and where no design life periods are stated, the maintenance plan shall be prepared to maximize the serviceable life.

In the event the EPC executing agency makes any changes effecting such submission he shall submit afresh such document duly revised to that extent.

6.7 Breakwater Requirements

The EPC executing agency shall note that the Authority requires that the breakwater location as shown in the design layout to remain unchanged and that the breakwater be constructed up to -20m CD contour as these provide the Authority the required size and dredged seabed depths of the protected harbour for the harbour operation.

These aspects of the breakwater works are the Authority's Requirements and shall not be subjected to change in the EPC executing agency's proposed design.

The EPC executing agency's design responsibility and scope of the breakwater works shall however include for the proper layout and alignment of the breakwater heads and for the best arrangement and location of the entrance channel (which shall be 300m wide) to ensure the proper design of the protected harbour at the vicinity of the entrance channel.

6.7.1 Breakwater Layout

The Breakwater layout has been developed based on available design data, which is not intended to be the final design and the breakwater layout design shall need to be confirmed by the EPC executing agency especially for the breakwater head arrangement and the location of the entrance channel. The requirements and layout design of the proposed breakwater is as shown in the **Drawing DELD11137-DRG-25-0000-CP-2002**. The EPC executing agency shall comply fully with the definition dimensions and setting out criteria.

The proposed layout of breakwater is as shown in the Drawing and the following are the approximate proposed lengths of breakwaters.

- Breakwater – 2,960m
- Fishery Harbour Breakwater – 140m

6.7.2 Limiting Wave Height

The breakwater configuration and the overall port layout should ensure adequate tranquillity at the berths so that cargo handling may continue even when the offshore wave climate exceeds the limit for ships' movement in and out of the harbour.

The limiting wave heights (Hs) for different wave directions for cargo handling operations are summarized in Table 6.4 below. These numbers are based on IAPH guidelines and apply to the worst wave periods for each direction.

Table 6.4 Limiting Wave Heights for Cargo Handling

S. No	Type of ship	Limiting Wave Height (Hs)	
		Head or stern (0°) (m)	Quadrant (45°- 90°) (m)
1.	Container Vessels	0.5	0.3

6.7.3 Armour Protection

Concrete armour units have been adopted as shown in the exhibited designs for the Breakwater in the **Drawing DELD11137-DRG-25-0000-CP-2003**.

The armour protection (Accropodes) have been widely used internationally given in drawings is indicative. Depending on the breakwater design, its design criteria and requirements, and the environmental and subsoil conditions; different types of concrete armour units are available for use in the design, for example, Cubes, Tetrapods, Accropode I & II and Core-loc etc. The EPC executing agency is free to select his own type of armour units and the EPC executing agency has to give the design and specifications of the same to the Authority for approval.

The EPC executing agency shall undertake hydraulic model laboratory test and site-specific information prior to using these units in the construction of the breakwater. The EPC executing agency is solely responsible for ascertaining the patent status of the armour unit proposed by him and for paying any royalty in this regard.

6.7.4 Crest Height and Width

The requirements for the crest width and height shall be governed by the overtopping criteria mentioned in the subsequent section. The breakwater shall be provided with a maintenance access/ roadway on top of the breakwater to allow for future developments at this area.

An 8m wide road is to be provided on top of the breakwater for access. A 2m corridor is to be provided on top for routing of pipes/other utilities along the breakwater length.

6.7.5 Design Criteria

6.7.5.1 General

The EPC executing agency shall design the sections of breakwater for every 2m variation in the level of seabed from the root to the Roundhead. These sections shall be tested in physical hydraulic model for the cases stipulated in the design criteria.

The EPC executing agency may submit alternative designs for all or parts of the breakwaters, subject to the following conditions. The alternative designs shall be based on the design criteria specified below and must be verified by 2-D and 3-D physical hydraulic model testing in accordance with this Specification. The cost of model studies shall be borne by the Concessionaire.

Modifications to the layout of the Port and Fishery Harbour, including that of the breakwaters, will not be permitted.

6.7.5.2 Extreme Wave Conditions Inside Harbour

The Table 6.5 shows the significant wave heights expected from penetration of the extreme waves inside the harbour. The study only calculates the 50 and 200 return period events; 100 year return period events have been interpolated using these. For all other revetments inside the harbour, a 1.5m wave height to be used for design.

Table 6.5 Extreme Wave Penetration Inside harbour

S. No	Location	Significant Wave Height		
		50 Year	100 Year	200 Year
		Hs (m)	Hs (m)	Hs (m)
1.	Container Berth 1 (North)	0.5	0.7	0.7
2.	Container Berth 2 (South)	1.6	1.7	2.1
3.	Revetments along south of the port	2.3	2.4	2.5

Source: Updated Mathematical Model Study, LTR, May 2013.

The assessment of internal waves will also need to consider:

- Ship / Vessel wakes
- Overtopping waves (if any)

6.7.5.3 Extreme Water Level

Table 6.6 shows the design extreme water levels.

Table 6.6 Extreme Water Levels

S. No	Return Period	HAT	Storm Surge	Sea Level Rise	Total
	(years)	(m)	(m)	(m)	(m)
1.	50	1.2	0.3	0.2	1.7
2.	100	1.2	0.3	0.4	1.9
3.	200	1.2	0.3	0.8	2.3

Source: Updated Mathematical Model Study, LTR, May 2013.

6.7.5.4 Wave Conditions Impacting harbour Breakwater

Table 6.7 shows the design wave heights for breakwater with the associated design spectral peak wave periods presented in Table 6.8.

Table 6.7 Breakwater Design Wave Heights

S. No.	Water Depth	Significant Wave Height, Hs (m) for various Return Period				
	(m CD)	10 Year	25 Year	50 Year	100 Year	200 Year

S. No.	Water Depth	Significant Wave Height, Hs (m) for various Return Period				
	(m CD)	10 Year	25 Year	50 Year	100 Year	200 Year
1.	6	2.1	2.2	2.4	2.5	2.7
2.	8	2.0	2.1	2.3	2.4	2.6
3.	10	1.2	1.3	1.4	1.5	1.7
4.	12	3.1	3.2	3.4	3.6	3.9
5.	14	3.5	3.6	3.7	4.0	4.2
6.	16	3.7	3.8	3.9	4.2	4.4
7.	18	3.9	4.0	4.1	4.4	4.6
8.	20	4.0	4.1	4.2	4.5	4.7

Source: Updated Mathematical Model Study, LTR, May 2013.

Table 6.8 Design Wave Periods

S. No	Return Period	Wave period, T
	(years)	(s)
1.	10	9.4
2.	25	9.5
3.	50	9.7
4.	100	9.8
5.	200	9.9

Source: Updated Mathematical Model Study, LTR, May 2013.

6.7.5.5 Operating and Survival Criteria

The breakwater and revetments will be designed to meet standard operational conditions of the port, structural no damage conditions and structural survival conditions.

6.7.5.6 Extreme Design Criteria

For individual elements it may be possible to vary the adopted design criteria based on the use of the structure. As a guide the recommended design event exceedance for varying structure importance and design lives is presented in Table 6.9.

Table 6.9 Annual Probability of Exceedance of Design Events

Project Element	Design Working Life	Annual Return Interval for Design
	(Years)	(Years)
Breakwaters	100	200
Revetments	50	100 for armour design 200 for overtopping

For structures functional only during the construction phase the assumed design life is 5 years. For these structures the ultimate design event will typically be a 50 year return period event. These structures might include partially completed breakwater sections or temporary docking facilities.

At the design event damage is permissible but the structure shall not fail. This is equivalent to a van der Meer armour damage level (Sd) ≤ 6.

It is noted that this criteria will not apply to the single layer concrete armour design. The nature of the failure mechanism for single layer concrete armour requires that the face sustains no damage up to the ultimate design criteria.

6.7.5.7 No Damage Criteria

Separate to the ultimate design event it is expected that the structure should not require maintenance after minor or common events. This shall be achieved by designing the structure to have a no damage criteria. A no damage condition for the breakwater will be based on the wind, waves, currents and water levels associated with a 50 year return period event. This is equivalent to a van der Meer armour damage level (Sd) ≤ 2.

6.7.5.8 Overtopping Criteria

Overtopping of a breakwater and revetment crest present a hazard to vehicles, and can result in significant damage to the breakwater rear slope and leeward structures. Table 6.10 presents the relevant limiting overtopping rates from the EurOtop Manual (2007).

Table 6.10 Limiting Overtopping Criteria

S. No	Hazard Type and Reason	Limiting Mean Discharge (lt/s/m)
1.	Damage to equipment set back 5-10m from crest	0.4
2.	Damage to building structure elements	1
3.	Driving at low speed	10-50
4.	Start of damage to breakwater if crest and rear slope are well protected	50-200

6.7.5.9 No Damage Overtopping

The general overtopping principal to be applied during a no damage criteria event (50 year return period) is that the overtopping rate for the breakwater and revetments shall be restricted to 0.4l/m/s. It is assumed that any equipment located on the crest should not be damaged.

6.7.5.10 Extreme Event Overtopping

During extreme events the design shall ensure that the breakwater and revetments are not destroyed, that overtopping does not pose a risk to life resulting from vehicular traffic on the breakwater and the reclaimed land, and that overtopping does not pose a risk to any buildings or structures located on the lee of the breakwater and reclaimed land.

For revetments around the reclaimed land, overtopping must be limited to no more than 1 l/s/m for the 200 year return period event.

Phase 1 of the port development includes, berths on the lee side of the breakwater. Overtopping rates during extreme events must be limited to an amount which will not cause damage to the structures associated with the leeward berths. Therefore sections of breakwater with structures on the lee ward side, and extending for 100m beyond the structure, overtopping must be limited to no more than 1 l/s/m for the 200 year return period event.

For rest of the breakwater, the design shall account for vehicular traffic and consider the risk of the overtopping causing damage only. For this to be achieved the general overtopping limit shall be 10 l/s/m for the 200 year return period event.

6.7.5.11 Operating Criteria and Construction Loads

Operating conditions when the port would be functioning normally are deemed to be ambient or non-cyclonic conditions up to a 10 year return period. The breakwater and revetment structures are to ensure that port operations are not impacted during operating conditions.

6.7.5.12 Overload Conditions

The breakwaters are to be tested for both the design and overload conditions.

The acceptance criteria of damage levels of the primary armour layer on both the seaward and leeward faces of the breakwaters under these conditions are as follows:

Design Conditions

- Displacement - less than 1% of units
- Movement (rocking) - less than 5% of units

Overload conditions

- Displacement - less than 5% of units
- Movement (rocking) - less than 20% of units

The acceptance criteria for the construction case testing are that the breakwater section should survive the test conditions without excessive loss of material or irreparable damage to the various component layers.

6.7.5.13 Design Events

Although storm surge and severe wave conditions are both driven by large storm systems, the chance that the wave climate with an annual 2% chance of exceedance (50 year return period) would occur at the same time a water level with an annual 2% chance of exceedance is significantly less likely than the individual events. However, the project site is governed by monsoonal waves with minimal storm surge effects. A conservative method of concurrent occurrence higher water levels with the wave climate is thus suggested to be used.

The nominated design events along the northern breakwater face at -20m are presented in Table 6.11 to Table 6.14. The nominated design events along the revetments along the southern part of the port are presented in Table 6.15 and Table 6.16. All other revetments are to be designed as per Table 6.5.

Table 6.11 10 yr Return Period Events for Breakwater

Description	H_s	T_p	DWL
	(m)	(s)	(m CD)
10 yr H_s & 10 yr DWL	3.9	9.4	1.54

Table 6.12 50 yr Return Period Events for Breakwater

Description	H_s	T_p	DWL
	(m)	(s)	(m CD)
50 yr H_s & 50 yr DWL	4.2	9.6	1.70

Table 6.13 100 yr Return Period Events for Breakwater

Description	H_s	T_p	DWL
	(m)	(s)	(m CD)
100 yr H_s & 100 yr DWL	4.5	9.7	1.90

Table 6.14 200 yr Return Period Events for Breakwater

Description	H_s	T_p	DWL
	(m)	(s)	(m CD)
200 yr H_s & 200 yr DWL	4.7	9.9	2.3

Table 6.15 100 yr Return Period Events for Revetment along south of the port

Description	H_s	T_p	DWL
	(m)	(s)	(m CD)

Description	H_s	T_p	DWL
100 yr H_s & 100 yr DWL	2.4	9.7	1.90

Table 6.16 200 yr Return Period Events for Revetment along south of the port

Description	H_s	T_p	DWL
	(m)	(s)	(m CD)
200 yr H_s & 200 yr DWL	2.5	9.9	2.3

6.7.5.14 Design Wind

Design wind speeds shall be selected in accordance with IS 875.

6.7.5.15 Design Currents

Current speeds close to the breakwater structure during design extreme events shall be assumed to be 1.5m/s. Although waves are typically not breaking in front of the structure it is assumed that some of the wave energy will be dissipated into a current that will occur concurrently with design waves.

For all revetments inside the harbour, a propeller wash of 4 m/s shall be considered, (PIANC, 1997).

6.7.5.16 Crest/Wave Wall

Crest wall shall be designed as per BS 6349 Part 7 and the mentioned stability factors be adopted.

6.7.6 Settlement to Breakwater

The breakwater core material shall be placed to achieve the desired properties. Breakwater core material shall be free of fine particles to avoid erosion which would result in uneven settlement of the breakwater. The breakwater shall be designed such that the maximum post-construction differential settlements along the crown wall shall be less than 50mm.

6.7.6.1 Geotechnical Stability

The EPC executing agency shall verify the geotechnical stability of the breakwater both for:

- Un-drained (short-term) soil conditions, and
- Drained (long-term) soil conditions.

Initial and long-term settlements should be determined and, if necessary, implemented in the design.

To verify the geotechnical stability, the EPC executing agency shall include in his calculations the most up-to-date geotechnical investigation results available.

Stability analysis shall be carried out for the proposed breakwater sections at every 1m contour interval, to ensure safety against slip circle failure.

Analysis shall be carried out using one of the following internationally used software such as SLOPE/W (GeoStudio), SLIDE, GGU etc. Use of the proposed software and its version (latest version available at the time of tender submission date shall be used) to be employed shall be got approved by the Authority/ Authority's Representative, prior to use for the Project.

Bishops method of analysis shall be adopted for computation of Factor of Safety (FOS). The minimum value of FOS shall be:

- Normal Case: 1.3
- Seismic Case: 1.1

The geotechnical stability, as well as any design modifications, resulting from geotechnical stability requirements shall be submitted to the approval of the Authority's Representative before start of construction.

6.7.7 Crown Wall

The wave wall has to be designed for the wave forces that occur for design waves and water levels indicated in subsequent sections. The EPC executing agency has to consider the following conditions but not limited to, while designing the Crown wall:

- Wave forces due to breaking and non-breaking waves;
- Instantaneous uplift pressure acting under the base of the pavement;
- Dynamic and quasi static nature of wave force;
- Slamming forces that can occur while breaking takes place directly on the wall face;
- Overturning with a factor of safety of 2.0;
- Sliding with a factor of safety of 1.5;
- Friction coefficient of 0.6 shall be used between the concrete and stone.

The EPC executing agency has to satisfy himself with wave loads, load combinations and coefficients that have to be adopted for designing the crown wall and have to submit the details to the Independent Engineer for approval.

6.7.8 Roadway

The roadway on top of breakwaters shall be reinforced concrete road designed for a loading of IRC 70R. The clear width of the roadway shall be minimum 8m. The roadway shall be of a durable construction under the marine and sea environments encountered, and its surface finish and riding surface shall allow trucks and vehicles to travel safely at operating travelling speeds of up to 25km/hour.

6.7.9 Physical Hydraulic Model Testing

The following return periods shall be used for the design and overload wave and water level conditions:

Component	Design Return Period	Overload Return Period
	(Years)	(Years)
Breakwater	1:100	1:200

The proposed design shall be verified by 2-D and 3-D model testing as defined in the following clauses. All costs and expenses involved in the model testing, including the costs of observation and supervision by the Independent Engineer and the repetition of tests to reach a satisfactory result shall be borne by the EPC executing agency.

The testing shall be carried out by an internationally recognized laboratory specialized in the field of hydraulic model testing. The laboratory is to be approved by the Independent Engineer.

The physical hydraulic model testing shall verify and optimize the design, based on the stability of the armouring, under-layers and other details, and the degree of overtopping and wave transmission.

6.7.10 Breakwater Armour Units

6.7.10.1 Single Layer Concrete

The size of the structure and the exposed location lend the breakwater design to the use of single layer concrete armour units on the seaward face. Commercially available examples include Core-loc, X bloc and Accropode. These units allow the use of a revetment slope at 1 vertical to 1.33 horizontal. All three armour units offer similar performance and have similar construction requirements so the choice of unit has been left open to encourage a competitive tendering process. Basic Engineering design assumes Accropode armour units will be used.

Being single layer units that rely on interlocking for stability, the design philosophy has to be more stringent than required for conventional rubble mound structures. Design implications include:

- The armour face cannot be allowed to suffer damage for design events up to and including the ultimate design event.

- Consolidation of the armour face during design events can occur. To avoid excessive armour movements the number of rows of armour units up the face cannot exceed 19.
- Due to interlocking nature of armour, integrity of the extremities is vital. As such, care is required to ensure that the armour transitions, crest and toe design are stable.

Note that due to the strong swell at the site, divers may be required to aid in the placement of armour units below the water.

Concrete armour units require graded rock armour for use in the filter layer (secondary armour).

6.7.10.2 Conventional Double Layer Rock

Typically the use of rock armour is more economical than concrete armour where suitable sized rock can be readily sourced. The internal face of the breakwater will be constructed using double layer rock armour on a revetment slope of 1 vertical to 1.5 horizontal. This conventional rubble mound structure design offers a robust solution that is permitted to sustain damage but not be destroyed for design events up to the ultimate event.

6.8 Shore Protection Works

Shore protection works along the port waterfront are essential in the form of revetments, rip-raps and headlands to protect the reclaimed land from waves and currents. For revetments, rock armour is typically used and suitable sized rock would be used in the construction of these shore protection works. It is assumed that reclamation revetments will be constructed using double-layer rock armour on a slope of 1 vertical to 1.5 horizontal. This conventional rubble mound structure design offers a robust solution that is permitted to sustain damage but not be destroyed for design events up to the ultimate event.

The revetment crest should tie-in with levels as indicated on the **Drawing DELD11137-DRG-25-0000-CP-2004**. The drawing indicates the shore protection bund section to the north and south of the container terminal.

A suitable rock armour solution has been used for protection underneath berths from scour due to ship propeller or currents.

To prevent the escaping of the onshore fill material through the voids of the rock, geotextile is provided on the inside slope. The geotextile shall be placed on the inner side of the retention bund. The geotextile shall be a polypropylene, non-woven, continuous filament, needle punched; chemically U.V stabilized geotextile and shall comply with the following physical and hydraulic properties:

Property	Test Method (ASTM)	Units	Value
Physical Properties			
– Mass	D3776	g/m^2	100
– Thickness	D1777	mm	1
Mechanical Properties			
– Wide-Strip Tensile Strength	D4595	kN/m	6.5
– Trapezoidal Tear Strength	D4533	N	150
– CBR Burst Strength		N	1390
– G Rating		N	>1050
– Grab Tensile Strength	D4632	G	380
Hydraulic Properties			
– Pore Size – Dry Sieving	D4632	O_{95} – um	200
– Permittivity	D4491	S^{-1}	3.5
– Coefficient of Permeability	D4491	$x10^{-4}$ m/s	
– Flow Rate Under 100mm Head	D4491	$1/m^2/s$	250

– Planar Flow Rate – i = 1.0 (under 100kPa normal compressive stress)	D4716	1/hr/m width

6.9 Design Methodology

6.9.1 Calculation

The breakwater sections shall be designed using the Hudson and Van Der Meer formulae for sizing of armour units in accordance with the more onerous of the requirements of BS 6349 'Maritime Structures' : Part 7 and CIRIA 683. The more onerous rock size will be used in the design.

The design of the crest elevation shall indicate compliance with EurOtop (www.overtoppingmanual.com).

The criteria mentioned in Section 6.7.5 are to be followed for the design.

The EPC executing agency will provide calculations to demonstrate that thresholds are not exceeded.

6.9.2 Physical Hydraulic Model Testing

The proposed design shall be verified by 2-D and 3-D model testing as defined below. All costs and expenses involved in the model testing, including the costs of observation and supervision by the Engineer and the repetition of tests to reach a satisfactory result shall be borne by the EPC executing agency.

The testing shall be carried out by an internationally recognized laboratory specialized in the field of hydraulic model testing. The laboratory is to be approved by the Independent Engineer.

The physical hydraulic model testing shall verify and optimize the design, based on the stability of the armouring, under-layers, crest structure and other details, and the degree of overtopping and wave transmission.

6.9.3 Scale

Models should be constructed to as large an undistorted geometric scale as is practicable and modelled according to the Froude scaling law.

For rubble mound breakwaters the behaviour depends partly on the flow of water through, into or out of the structure. Flow through the voids depends on Reynolds number which, as water is used in the model, is not correctly scaled and therefore flow and permeability cannot be correctly reproduced at all locations in the model.

It has been found in practice that scale effects are insignificant if the armour unit Reynolds number Re is greater than about 3×10^4, although some recent studies suggest that it can be as low as 8×10^3. Reynold's number is defined as:

$$R_e = \frac{\rho V L}{\mu}$$

where

Re Reynold's number
ρ is the density of the fluid (in t/m^3);
V is the Velocity of the flowing fluid (in m^2/s);
μ is the Viscosity of the fluid (9.81 m/s^2).
L is the Length or the Diameter of the fluid

EPC executing agency shall determine the suitable scale on the above mentioned criteria. Scales are usually in the range 1:30 to 1:80.

6.9.4 2-D Hydraulic Model Testing

The 2-D hydraulic model testing shall be carried out at a scale of 1:50 or better.

The testing shall be carried out in a suitable wave flume with a minimum width of 1 metre. The flume shall be equipped with a wave paddle capable of reproducing a random uni-directional wave spectrum based on the JONSWAP standard spectrum, or similar. The flume shall also be equipped to deal with the reflection of unwanted wave energy from the test section. The natural bathymetry in the area of the breakwater test section shall be moulded in the base of the flume in sand cement mortar or similar.

Wave measurements shall be made to a resolution of better than 0.1mm using wire probes or other means. Measurements shall be made in front of the test section of the incident wave climate and behind to determine the transmitted waves. Means must be included in the testing for the measurement of overtopping quantities. If this cannot be done without interfering with wave action on the lee slope and transmitted waves the test runs must be repeated with and without overtopping measurement.

The flume shall be calibrated before construction of the test section for each combination of wave conditions and water level to be used and checked for agreement with the theoretical JONSWAP spectra.

The model section shall be built up by hand placing on the prepared bed in layers in accordance with the prototype design. As far as possible each of the different materials used in the breakwater shall be modelled correctly to scale.

The sections to be tested in the 2-D hydraulic modelling shall be the main breakwater trunk sections adjacent to the roundheads.

The construction case testing shall be performed on the main section with the outer primary armour layer removed. The breakwater superstructure shall also be removed down to the top level of the breakwater core or such other levels may be agreed with the Independent Engineer to represent the temporary condition of the breakwater during construction.

The 2-D model shall be tested in a random wave spectrum based on the return period wave heights and periods given in Section 6.7.5. The choice of standard wave spectrum to be used in the testing (JONSWAP, etc.). Each test run shall represent duration of at least three hours in the prototype. The acceptance criteria for displaced or moving units specified in section 6.7.5.12 shall apply to the full duration of each test. Armour movements are to be quantified using an overlay photographic technique.

The following test runs shall be performed for each model section:

a) 1:10; 1:50; 1:100; 1:200 year waves, HWL (+2.3m);
b) 1:100; 1:200 year waves, LWL (0.0 m);
c) Repeat (a) with measurement of overtopping;
d) 1:1; 1:5 year construction case, HWL (+1.52m).

If the tests show the design to be inadequate in any respect, the cross-section shall be adjusted or rebuilt until satisfactory results are obtained.

6.9.5 3-D Hydraulic Model Testing

The 3-D hydraulic model testing shall be carried out at a scale of 1:80 or better. The testing is to be carried in a suitable wave basin equipped with a wave paddle capable of generating a random wave spectrum.

In general, the same requirements as specified for the 2-D hydraulic modelling in Section 6.9.4 above are to apply equally to the 3-D model testing. Quantitative measurement of overtopping quantities is not required in the 3-D model testing. Sufficient wave probes are to be provided in positions to provide an adequate record of the wave conditions in front of and around the test section.

The 3-D model testing shall be carried out on the roundhead of the Breakwater with an adjacent length of the breakwater trunk representing at least 200m in the prototype.

The 3-D test series is to be as follows:

a) 1:10; 1:50; 1:100; 1:200 year waves, HWL (+2.3 m);
b) 1:100; 1:200 year waves, LWL (0.0 m)

If the tests show the design to be inadequate in any respect, the model shall be adjusted or rebuilt and re-tested until satisfactory results are obtained.

6.10 Field Investigation Surveys

6.10.1 Hydrographic Surveys

The EPC executing agency may undertake hydrographic survey along the proposed alignment of breakwaters to verify the data provided by the Authority. Such survey should cover an area of 100m on either side of the breakwater axis.

The datum to which all levels shall be the reference Bench Mark as indicated up by the Authority, which has to be subsequently reduced to Chart Datum (CD) by the EPC executing agency. Necessary tidal corrections have to be made by installing a tide gauge at the site.

The EPC executing agency shall notify the Authority 24 hours in advance of his intention to set up control points or to establish levels for any part of the works so as to allow proper arrangements to be made for their checking during normal working hours.

The EPC executing agency shall construct such temporary benchmarks and setting out points as the Authority may prescribe and approve. The EPC executing agency may maintain these until the completion of the works to the satisfaction of the Authority.

The survey shall be carried out using a launch fitted with an approved type of echo-sounder (minimum accuracy 0.10 m) and positioning shall be done by a DGPS. All positioning equipment requiring calibration shall be calibrated immediately prior to the execution of the field work and at intervals during the field work as recommended by the manufacturer of the equipment.

6.10.2 Geotechnical Investigations

The EPC executing agency may undertake additional soil investigations on land and underwater in the works area for the purpose of getting additional details sub soils and to verify the data provided by the Authority.

The investigation shall generally include but not limited to soil borings in sufficient number and to a sufficient depth;

- Taking undisturbed soil samples and conducting SPT alternatively at interval of 1.50m and at change of strata;
- Carrying out vane shear tests in the clay layer (if any).
- Carrying out field and laboratory testing of samples for determining the index and structural properties of the different sub soils;
- Finally computing bearing capacities of the different soils.

7 Berthing Structures

7.1 Functional Requirements

7.1.1 Container Berths

The requirements for the container berths are as indicated below:

- Provide 800 m quay wall with a alongside berth dredged depth -18.4m CD. The quay construction shall provide an operational continuous quay for berthing and mooring of container vessels and feeder vessels in the range of 20,000 dwt to 165,000 dwt.
- Support high capacity track mounted electrically operated ship to shore gantry cranes and container handling equipment.
- Provide access and suitable jacking points for delivery, erection, commissioning, operation and maintenance of quay side gantry crane.
- Provide stowage pin slots for securing the quay side gantry cranes against movement parallel to the quay.
- Provide storm tie down points for securing quay side gantry crane during storm condition.
- Provide cable turn over pits for the connection of the crane power supply.
- Provide access for vessel berthing and mooring operation.
- Provide for handling/ storage of container and vessel hatch covers over/ on the quay deck/ back reach and for tractor- trailer operation.
- Provide access for fuel browsers for the vessel
- Limit scour arising from ship wash, propeller action, current etc. to the extent required to comply with the Authority's requirements and with the detailed design by the EPC executing agency.
- Provide lighting arrangements for operation

7.1.2 Quay Services

The quay services shall incorporate pits and ducts to facilitate the requirements for the following:

- Provide adequate drainage to the quays.
- Provide adequate drainage of cable slots, crane track slots and pits.
- Provide adequate marking/signage for safe operation over the quay deck.
- Easily accommodate future expansion in length.

7.1.3 Crane Offload Area

The EPC executing agency shall design and construct a strengthened area of container quay for gantry crane offloading operations.

7.1.4 Quay Termination Zone

Construction of the future quay extension and apron will require modification to the proposed quay. Local breaking out of the structures and foundations in future may be carried out to provide structural continuity required by the EPC executing agency's design subject to confirmation that such works shall not adversely affect the performance, stability, durability and continuous operation of the proposed structures and foundations.

7.1.5 Safety Barriers

A sufficient number of the vehicle/ pedestrian barriers shall be positioned along the 'open' edges of the quay areas to form a vehicle restraint barrier. The spacing of the barriers required to form an adequate barrier shall be determined by the EPC executing agency.

7.1.6 Crane Cable Pits and Slots

7.1.6.1 Cable Pit

The pits shall be sized to accommodate equipment for up to four cranes for each container berth. Access ladders shall be provided into each chamber of the cable pit. Equipment and parts to be cast into the pits shall be to the approval of the Independent Engineer.

7.1.6.2 Crane Cable Slot

An open cable trench shall be provided to accommodate up to eight crane cables simultaneously.

7.1.6.3 Superimposed Load

The crane track supporting structures shall be designed to carry the loads set out in Section 7.8.9.3. The pavement structures shall be designed to carry the loads set out in Section 7.8.7.

7.2 Geometric Requirements

7.2.1 General

The requirements for the quay structure shall be as shown in the Layout as shown in **Drawing DELD11137-DRG-25-0000-CP-3001**. The EPC executing agency shall comply fully with the definition dimensions and setting out criteria.

7.2.2 Depth Alongside

The required depth alongside at the quay is as follows:

Table 7.1 Design Depth

Parameter	Value
Design dredged depth – berth pocket (any scour protection to be below this level.	-18.4 m CD
Operation requirement bed level	-18.4 m CD
Allowance in design for over dredging /bed scour	0.3 m below within 70 m of new or existing structure

7.2.3 Crane Tracks and Crane Beams

The requirements for the crane track and crane beam shall be as per this document and specifications.

7.2.4 Location and Orientation of Berths

Container berths have been planned in North-West to South-East direction parallel to shore line. Berthing line is oriented at an angle of 140° N approximately.

7.2.5 Deck Levels

The deck level has been arrived at taking into the following factors:

- The maximum wave height expected at the berths under design conditions;
- The deck of the berths should be high enough to prevent the wave slamming underneath during extreme weather conditions;
- This deck level will also ensure adequate clearance to the deck during operational wave conditions;
- Sea level is currently rising and is expected to continue rising during 21st century. This would mean about 0.2m increase in sea levels over life of the structures (50 years).

Highest High Water Springs (HHWS)	1.01	m CD
Add for Wave Crest Height (0.6 *Design wave=0.6*1.6)	0.95	m
Add for Storm Surge/Wind Setup	0.3	m
Clearance for Sea level rise (50 Yr)	0.2	m
Clear freeboard allowance	0.25	m
Add for Deck Thickness	1.5	m
Total	**4.21**	**m CD**

It is therefore proposed to keep the deck elevation at +4.20 m CD. However, this may change as a result of studies during the detailed design stage.

7.3 Design Criteria

7.3.1 Design Ships and Dredged Levels

The structural design of the berths shall be carried out for the design dredged level based on the design vessel sizes to be handled at these berths:

Table 7.2 Design Ships and Dredged Levels at Various Berths

S. No.	Vessel Type	Design Vessel Size	Design Vessel Dimensions (m)			Dredged Level at Berth
		(DWT)	LOA	Beam	Loaded Draft	(m w.r.t. CD)
1.	Container Vessel	165,000 (18,000 TEU)	400	59	16.0	-18.4

7.3.2 Vessel Data

The facilities shall be designed to accommodate the container vessels within the ranges listed below.

Table 7.3 Design Vessel for Container Berth

Parameter	Maximum Design Vessel	Minimum Design Vessel
Vessel type	Post Panamax Container ship	Container Ship
TEU Capacity (TEU)	18,000	1,000
Deadweight tonnage – DWT (T)	1,65,000	20,000
Length overall – LoA (m)	400	175
Length between perpendiculars – LPP (m)	380	160
Beam (m)	59	27
Loaded Draft (m)	16	10
Displacement tonnage – DT (T)	2,50,000	29,200

7.3.3 Geotechnical Criteria

Design and basic engineering of berths have been carried out considering relevant subsoil profiles at the location of berths.

The following safety factors are used to establish the safe geotechnical working load capacities of the piles.

Table 7.4 Values for Factor of Safety for Piles

S. No	Type of Pile	Factor of Safety
1.	End Bearing	3.0
2.	Skin Friction on compression piles	3.0
3.	Skin Friction on tension piles	4.0
4.	Lateral Load	3.0

The design pile penetration depths would be estimated based on the generalised soil profile in order to develop adequate capacity to resist the maximum computed axial bearing and pull out loads, if any. In the present case the piles will mainly be end bearing onto rock.

7.3.4 Design Loads

7.3.4.1 Dead Loads

It comprises the self-weight of the structure plus superimposed loads of permanent nature are considered as per IS: 875 (Part-I) 1987.

7.3.4.2 Live Loads

Uniformly distributed load of 5 T/m^2 have been considered for container berths on the deck and also on the fill behind.

7.3.4.3 Vehicle and Crane Loads

The following loads are considered on various berths:

Load Type	Container Berth
Vehicle and Crane Loads	2.50 T/m^2 UDL OR Multiple lanes of IRC class AA Vehicle (number of lanes being the same as the number of cranes operating on the berth) AND Loads due to quay cranes, whichever is critical

7.3.4.4 Seismic Loads

The seismic loads on the structures are computed in accordance with the seismic code of India IS: 1893-2002. Vizhinjam falls under Zone III as per seismic map of India with the following factors:

Zone factor	0.16
Important factor (I)	1.5
Response reduction factor (R)	3

The seismic horizontal coefficient shall be determined in accordance with IS:1893.

7.3.4.5 Wind Loads

As per IS Code 875 – Part III: Code of Practice for Design Load (Other Than Earthquake) for Buildings and Structures for calculating the wind loads on the structures a basic wind speed of design wind speed of 43.5m/s has been used as per the Indian standards.

However, during design studies the wind pressure shall be determined from the design wind speed in accordance with BS 6399 Part 2:1997.

7.3.4.6 Current Loads

The current loads on the structure have been applied on the submerged parts of the structure with the current velocity as 0.3m/s. The current load shall be determined in accordance with BS 6349 Part 1, Section 5.

7.3.4.7 Wave Loads

A design wave height of 1.6 m will be considered for the container berths. These are the maximum wave heights that could be expected at these berth locations under the extreme conditions.

7.3.4.8 Mooring Loads

As per IS 4651: Part III, the bollard pull of 200 T at each bollard location will be considered for the design of the container berths.

In the detailed design stage, the capacity of bollards shall be determined in accordance with BS 6349 from the mooring loads generated by the design maximum vessel when in ballast and at full displacement under the combined action of the maximum current flow, the operational wave conditions at the berth and the design wind conditions. The same need to be confirmed through mooring study.

7.3.4.9 Berthing Loads

Berthing Energy

Based on the design ships to be handled at various berths, the approach velocity perpendicular to the berths has been assessed based on the design vessel size under favourable conditions at an angular approach of 6°. Based on this the design berthing energy for various design ships has been worked out.

Fender System

Considering the tidal range at the site and also the variation in the sizes of vessels to be handled at the jetty, the fendering system is designed such that sufficient contact area between the hull of the ship and the fender face is ensured at all tidal levels.

It is required to provide a suitable fender system, not only to absorb the design berthing energy of the vessel but also to keep the vessel's hull pressure below the limit of 200 kN/m^2. PIANC suggests abnormal impact safety factors be applied to the design (normal) energy. Accordingly, it is recommended to design for 150% of normal berthing energy so as to prevent the damage to the fenders and the ship's hull. Based on these criteria the suitable fendering system has been proposed at the different berths.

7.3.4.10 Fender Reaction (Berthing Force)

Corresponding to the energy to be absorbed and the fender selected, the design reaction force has been worked out based on the standard fender design catalogues.

The berthing energy, fender selection and the berthing force applied at the container berths is given in the following table:

Components	Container Berths
Berthing Energy	288 Tm
Fender	Trelleborg SCK Cell Fenders 2500H E1.0 or Equivalent
Berthing Reaction	295T

In addition a longitudinal force equal to the 20% of above transverse berthing force is also applied simultaneously on the fender point to account for the friction between the ship's hull and the fender. The parameters of the fender need to be confirmed after getting the exact details from the supplier during the detailed engineering stage.

7.3.4.11 Load Combinations

The above loads with appropriate load combinations, as per IS 4651 (Part IV): 1989 have been applied on the different components of the berths.

7.3.4.12 Materials and Material Grades

Concrete of grade M 40/50 and high corrosion resistant thermo-mechanically treated bars of Fe 500 grade shall be used for berth construction.

7.4 Options of Berth Structure

Considering the requirements of keeping the berth structure contiguous to the reclaimed land area, following alternative berthing structures were considered as shown in as shown in **Drawing DELD11137-DRG-25-0000-CP-3002**.

7.4.1 Alternative I: Berth Supported on Piles with a Protected Slope Underneath and a Retaining Wall at the Rear

In this alternative it is considered to provide the deck structure on the piled foundation. A stable slope of 1.5 H: 1 V from the design dredged level at the berth face to the rear end is provided. The width of the apron in this case is considered as 42 m. A retaining wall of suitable height would be provided in the rear end to make the structure contiguous. It is proposed to provide bored cast-in-situ piles for reasons of economy.

The berth face is dredged only after the piles are tied by grid beams but before the construction of the deck, the opening for which is utilized for trimming of the slope underneath. Once the design slope and slope protection is formed, the deck is cast.

7.4.2 Alternative II: Berth Supported on Piles with Diaphragm Wall at the Rear

Considering the difficulties likely to be encountered in creating a stable slope through the stiff clay in the layers above the design dredged level another alternative has been proposed where a diaphragm wall is provided in the rear of the berth and the slope underneath the deck is left as a natural slope. The diaphragm wall is integrated with the piled structure, which would be designed to carry the lateral loads on the diaphragm wall. A natural bed slope of 1 V: 4 H from the berth face has been assumed on a conservative side for design of the diaphragm wall

7.4.3 Alternative III: Berth Supported on Diaphragm Wall

In this type of structure, the face of the berth will be a continuous diaphragm wall. The quay apron comprises a hard stand pavement. The diaphragm wall is tied back to a concrete dead man. The dredging is carried out once the diaphragm wall is built and anchored to the dead man.

7.4.4 Preferred Alternative

All of the alternatives mentioned above are technically feasible for the construction of the berths. The choice depends primarily upon the construction time and costs. Considering the site conditions and design parameters of the berth Alternative I with retaining wall at rear seems to be most appropriate.

Sheet pile Wall has the following drawbacks:

- In Indian conditions, sheet pile wall will be susceptible to large corrosion and will have to be over-designed. They would also result in high maintenance costs.

Block wall berthing structures have the following technical drawbacks:

- The review of geotechnical data shows that the top layer (including founding level of -18mCD) of existing sea bed only has an average N value of 15, which is not suitable for founding a 22m high block work wall. The hard stratum is only available at -22m CD. To found the block work at -22m CD we will need to dredge additional 5m depth at foundation trench and fill that volume by rubbles/stones.
- Avoidance of construction work that must be carried out underwater is an important goal in modern berth design. Emphasis is placed on the application of construction method that allow as much work as possible to be carried out from a position above water, thus keeping the amount of diving at a minimum. Pile structures are ideal in this respect.
- In India all container berths are built as an open pile (bored cast in situ) structure and the local agencies are highly experienced in this type of construction. The equipment required for block work berth construction will need to be transported from outside the country and hence require high transportation and installation cost.
- The current berth line will need to be expanded going into the Master Plan development. With block work wall, It is difficult and will involve high construction risk with need to dredge foundation trench close to existing block work berth. It is not impossible but the operations will need to be suspended for the duration.

In view of all of the above, pile supported deck structures have been recommended. The EPC executing agency may explore some of these or other alternatives to arrive at a technically and economically superior option during detail design.

7.5 Construction Methodology

The ground level at the proposed location of the container berths is about -11m CD. The soil profiles at the container berths reveal the presence of loose to medium dense silty sand with shell fragments from level of approximately -8.0 m CD to -24 m CD. This layer has got high shear strength and any dredging carried out at front of the deck, after construction, might not impact on the stability of the structure. The construction sequence duly takes this factor into account. The rock level varies from -21 m on the northern end to -24m near the southern end of container berth.

It is proposed to first reclaim the site using the suitable dredged spoil up to a level of +4.2 m CD.

The bored cast in-situ piles supporting the quay deck are then constructed using the land based equipment. The erection of pile muff longitudinal and transverse beams connecting the berth piles are also constructed using land based construction. After the integration of beam with pile is established, the dredging operation in the berth area can presume, until the design dredged level of -18.4m CD. The soil behind the berth is strengthened using vibro compaction along with the hydraulic fill.

It is expected that the soil mass within the piles would form a natural slope through hydraulic filling after the dredging in front of berths is carried out. A stone pitching is then placed below the deck from the ultimate dredged level to the quay wall at a slope of 1 in 2. The retaining wall is constructed behind the berth to retain the reclaimed fill. Once the retaining wall is placed reclamation material is filled and thoroughly compacted with e help of vibro compaction.

The concrete deck for the berth and the fixtures are placed thereafter. **Drawing DELD11137-DRG-25-0000-CP-3003** presents the sequence of construction for the container berths.

7.6 Structural Arrangement of Container Berth

Basic engineering of the proposed scheme was carried out based on the design criteria established above. The proposed scheme consists of five rows of bored cast-in-situ piles of 1.4m, spaced at 6.5m c/c in the longitudinal direction. The piles will be founded at an average level of -30 m CD or 4.2m below rock level, whichever is lower.

In the transverse direction, main beams are provided supported over the piles, which in turn support beams in the longitudinal direction. The longitudinal beams, at the front and last rows of piles, are designed for the quay crane loads. A 400mm thick deck slab will be provided supported over the intermittent longitudinal beams. A 75mm thick wearing coat will be provided over the RCC deck slab.

Bollards and rubber fenders will be provided @ 19.5m c/c along the berthing face. A service trench will be provided on the berthing side to accommodate cables/utilities. The total length of the quay provided is 800 m.

Drawing DELD11137-DRG-25-0000-CP-3004 presents the structural arrangement and cross-section of the container berths.

7.7 Design Life

The permanent works shall be designed and constructed to give the following design lives:

Table 7.5 Design Life

Element	Design Life (Years)	Maintenance Interval (Years)	Routine Maintenance by Employer	Unacceptable Repair and Maintenance
Marine Structure – Reinforced Concrete	50	25	Making good any protective coating to the concrete. Cutting out and replacement of spalled concrete in small areas.	Cutting out/replacement of defective/spalled concrete and corroded reinforced concrete.
Marine Structure – Steel Piles	50	25	Routine inspection	Recoating of protective treatment systems.
Side slope to dredged area	50	50	None	Removal of materials from the main dredged areas that has collapsed/slipped and fallen in from the adjacent side slope.
Steel Works	25	15	Recoating of protective treatment systems.	Cutting out/ replacement of defective/corroded steel. Welding of steel plate on to existing steel structure/ elements.
Crane Track System	20	1	Yearly tightening of fixing clips and repositioning of neoprene mat.	Repair/replacement of any component part.
		5	Sundry replacement of fixing clips but not exceeding 1% over 5 year period.	
Bollards	50	15	Re-coating of protective treatment system every 15 years.	Cutting out/ replacement defective corroded steel or its fixing.
Fender:				
– Steel Works	50	15	Re-coating of protective treatment system every 15 years.	Cutting out/ replacement defective corroded steel or its fixing.
– Rubber	20	To suit routine maintenance programme in accordance with manufacturer's requirement.	Annual visual inspection.	Any fender replacement which is not due to damage from an accident while berthing or excessively abnormal load.

Above design lives are defined as a period within which the asset will continue to be serviceable for design loads without collapse.

7.8 Basis of Design

7.8.1 Quay Structure Settlement/Deflection

The quay wall design shall consider the maximum permissible tolerances for horizontal and vertical alignment under the design loading conditions.

7.8.2 Environmental Condition

The full length of the quay structure shall be designed to withstand all environmental loads arising from the environmental conditions for a minimum return period of 100 years if not mentioned separately here.

7.8.3 Quay Structure Differential Movement

The EPC executing agency shall design and construct the quay so that the differential movement of one bay of the quay relative to the other bays (if expansion joints provided) does not exceed that which can be rectified by adjustment to the crane tracks, to maintain the requirements of Track tolerances for quayside gantry cranes and to ensure safe and efficient operation of the cranes. Such adjustments will be the responsibility of the EPC executing agency up to the end of the Defects Notification Period.

In the event that the relative movement exceeds that which can be accommodated by adjustment of the crane tracks the EPC executing agency shall be responsible for making adjustments to the structure to allow the tracks to be adjusted to permit the safe and efficient crane operation.

7.8.4 Crane Tracks & Crane Beams

The container berth quay structure shall incorporate a quayside gantry crane track, supported on rigid foundations or supported on an adjustable crane track system such that the crane track tolerance criteria given in Section 7.8.9.3 can be achieved and maintained over the design life.

The track and the cranes that shall operate on will have the characteristics and loadings defined in Section 7.8.9. The crane track fixing system shall be designed for normal operating conditions. The design of the crane track and fixing system shall take account of the requirement for crane tracks to be continuous across the ‘open’ track beam expansion joints if provided. Joints in parallel crane tracks shall be staggered by a minimum of 5m.

Crane tracks shall be installed in pre-formed slots, within which provision shall be made for drainage from both sides of the track at a maximum of 7.5m centers. The slots shall be constructed taking into account the movements during construction.

The upper external corners of the rear crane track slot shall be protected by cast-in 100mm × 100mm × 12mm galvanized steel angles.

Soleplates shall be designed to permit fine adjustments for levelling to within the requisite tolerances.

Steel-reinforced resilient bearing pads shall be by the same manufacturer of the track clips and shall:

- distribute the crane wheel load
- reduce load concentrations and eliminate resulting fatigue stresses
- provide an even contact between the track and its sole-plate
- reduce noise and vibration transmission

Track clips, to restrain tracks, shall be galvanized rubber faced clips, and the EPC executing agency shall determine the required clip spacing by own calculation.

The track clips shall secure the track against surge along its length, and against transverse and overturning forces. The fixings shall be designed to satisfactorily absorb the stresses resulting from the interaction between the track beam and the track, including the ‘bow-wave’ effect created by the crane while travelling.

The EPC executing agency shall demonstrate that the designed fixing system prevents in-service loosening of the bolts.

The track clips shall:

- allow for free longitudinal expansion and contraction of the track due to temperature variation
- allow damaged track to be removed and replaced with ease
- beself-locking and self-tightening when the track clip fixing bolt is torqued to the manufacturer's recommendation.

7.8.5 Berthing

7.8.5.1 Berthing Parameters

Table 7.6 Berthing Parameters*

Parameter	Value	Source
Berthing mode	Side berthing	BS 6349 "Maritime Structure – Part 4, Code of Practice for design of fendering and mooring system and PIANC Guideline for The Design of Fender System – 2002.
Maximum eccentricity	Quarter point vessel impact	
Berthing mode	Difficult berthing condition, sheltered	
Maximum vessel berthing angle	10° for vessels up to 50,000 T loaded displacement 6° for vessels over 50,000 T loaded displacement	
Bow flare angle	15°	
Bow radii	Fender performance to take account of bow radii	
Bulbous bow	Fender design to take account of bulbous bows	

* Values to be finalized after Terminal Operator selection

7.8.5.2 Quay Equipment and Layout

Table 7.7 Quay Equipment and Layout

Item	Comment
Crane Tracks	Allowance shall be made for movement during construction and for static deflection of the structure under permanent loads and the correct alignment shall be achieved after completion of all filling and excavation including dredging.
Berthing face	To align the berthing face approximately 6.5m* from the centre line of the seaward crane rail head for container berth.
Cope line	The distance between the cope line and the berthing face shall be the minimum compatible with the size and spacing of the fenders (see Fender Design)
Cope level	+4.2 m CD approx., with falls on the deck surface to ensure rainfall run-off.
Overall quay structure	Operational quay length not less than 800 m for container berth
Fenders	At spacing to accommodate all vessel ranges
Bollards	At spacing to accommodate all vessel ranges 1m clear access way required between bollard and any part of the gantry crane bogey
Safety ladders and hand grips	At not more than 30m centres • Galvanized and painted steel ladders; • Ladders to extend 1.0m below LAT level; • Recessed handgrips shall be provided at deck level; • Ladders to be accommodated in recesses and shall not protrude beyond the cope face;
Crane power connection pit	Single pit with 4 connection points located at the centre of each berth.
Gantry crane unloading points	Provision to be made within the design of the structure for the unloading by

Item	Comment
	others of gantry cranes to be delivered in a fully erected form. • EPC executing agency to agree with the Authority the location(s) of such unloading point(s) and whether or not any other special provisions are required.
Gantry crane storm pin slot	To resist a horizontal force of 1170kN* (approx. 117t) per pin slot.
Gantry crane tie down points	Pull out force of 1000kN* (approx. 100t) per tie-down.
Crane buffer	Two permanent set to be provided at both North and South ends of the quay; Design of buffer and their fixing on the wharf shall be such that they can be removed/replaced if so required.
Cope edging	To be finalized
Navigation Aids	None at berth

* Values to be finalized after Terminal Operator selection

7.8.5.3 Fender Design

Fenders shall be designed for a range of container ships between the minimum and maximum design vessels.

Table 7.8 Fender Parameters*

Parameter	Value	Source
Energy absorption (multiple fender impacts can be considered)	Berthing energy from normal impacts, within rated deflection for container berth (whichever is critical) – 150% for design vessel – 200% for smaller vessel	PIANC Guideline for The Design of Fender System – 2002.
Distance between cope edge and berthing line	To be the minimum dimension which will allow 300mm clear between the vessel hull and the cope with the fender compressed. The fender size and spacing selected to satisfy this criterion. And also the fender spacing shall not be more than 0.15 times of LoA as per BS: 6349 Part 4.	
Fender panel facing	UHMW – PE low friction, minimum 40mm thick, black.	
Coefficient of friction UHMW-PE to steel (dry)	Not less than 0.2	
Chains between quay and fender (to prevent rope snagging)	Required	
Restrain chain	Required	
Factor of safety on restraint chains and fixings	3	
Fender spacing (between centre lines of fender units)	To accommodate all range of vessels to be berthed	
Allowable hull pressures	20 T/m^2 maximum,	
Fender panel	The steel fender panel shall be designed to accommodate a horizontal line load equal to the abnormal fender reaction at any point.	

* Value to be finalized after Terminal Operator selection

7.8.5.4 Fender Types

Fenders shall be of the following approved types for Container Berth:

- Conical cell fenders with a rated deflection of not more than 72% of the height of the fender
- Cylindrical cell fenders with a rated deflection of not more than 52.5% of the height of the fender
- Element type fenders with a rated deflection of not more than 57.5% of the height of the fender

7.8.6 Mooring

7.8.6.1 Bollards

Bollards shall be as described in table below.

Table 7.9 Bollard Details*

Parameter	Value	Source
Maximum Bollard spacing	Container berth: 19.5 m	IS: 4651 Part 3.
Bollard capacity	Container berth: 200 T	
Bollard type	Container berth: Proprietary manufactured twin horn type bollards capable of accommodating two adjacent ships	

* Values to be finalized after Terminal Operator selection

Bollard size and spacing shall be confirmed by the Contactor after completion of Mooring Study during detailed design.

7.8.6.2 Mooring Study

A mooring study shall be carried out to ensure that the final bollard arrangement is adequate for container berth.

The mooring study shall consider the following load cases and notes:

7.8.6.2.1 Mooring Line Loads

Actual mooring line loads will be determined for the berths for the following conditions:

- A maximum operating environment;
- A maximum survival condition for the ships on the Berth;

A check on the structure shall also be carried out for:

- An extreme environment;

The above load cases shall take full account the multiple directions and strengths/sizes of:

- Wind;
- Waves;
- Current;
- Effect of passing ships etc.;

These forces are to be determined by the EPC executing agency.

7.8.6.2.2 Mooring Point Loads

The mooring points shall be designed to satisfy each of the following requirements:

a. A working load equal to the breaking strength of the strongest single mooring line to be connected to the mooring point.
b. A working load equal to the maximum combined load developed in all mooring lines run to the mooring point due to the worst case of Survival condition of wind, waves, and current acting on the moored vessel, considering the vessel's draft condition and mooring equipment.
c. An ultimate load (yield stress) equal to the breaking strength of one line plus 50 percent of the breaking strength of all other lines to be run to the mooring point.

The mooring line load shall be assumed to act over the following range of directions:

7.8.6.2.3 Spring Lines

- Horizontal plane: parallel to axis of ship zero to ±10°
- Vertical plane: horizontal load to +25°.

7.8.6.2.4 Breasting Lines

- Horizontal plane: perpendicular to axis to ship zero to ±45°.
- Vertical plane: horizontal load to +25°.

All spring line mooring points shall be designed for two lines. All breasting line mooring points shall be designed for three lines.

7.8.6.2.5 Mooring Fitting Loads

The horizontal and vertical load components from the mooring lines for the specified vessels expected shall be used in the design of mooring fittings.

All bollards and individual mooring fittings shall have working loads equal to the minimum breaking load of the largest size line.

The design layout shall have one mooring line per bollard, hook, or individual mooring fitting.

7.8.6.2.6 Environmental Loads

Environmental loads, where appropriate, shall be used for three specified situations, a maximum operating environment, maximum survival condition and an extreme environment.

7.8.6.2.7 Maximum Operating Environment

The operating environment shall be the worst combination of wind, waves, current and passing ships that will occur with the ship moored at the berth. Operating wind load and wave conditions on vessels shall correspond to a 30 second gust at 10m elevation for a 1 year return period.

7.8.6.2.8 Maximum Survival Condition

The EPC executing agency shall determine the maximum conditions, and combination of condition of wind, waves and passing ships that can occur with a ship safely moored at the berth. The maximum survival condition shall be not less than that given in the 60 knot, one-minute gust wind with current.

7.8.6.2.9 Extreme Environment

The extreme environment shall be the worst combination of wind, waves and current, that will act at the berth with no ship alongside. Extreme wind and wave conditions shall, as a minimum, be based on a hundred-year recurrence interval storm, with no vessel at the berth.

Loads shall be determined using the load factors taken from BS: 6349.

7.8.7 Dead Weight of Structure

Dead weight of structure will include the weight of all structural components, using the following specific weights as minimum.

Table 7.10 Dead Weight for Structures

S. No	Structural Components	Dead Weight
		(T/m^3)
1.	Structural Steel	7.85
2.	In situ reinforced concrete	2.40
3.	Pre cast reinforced concrete	2.50
4.	Sea water	1.03
5.	Compacted Earth Fill	1.80
6.	Plain Concrete	2.35

7.8.8 Buoyancy Loads

Buoyancy loads will include the uplift due to submergence in sea water using a specific gravity of 1.03.

Buoyancy loads may be disregarded where it is demonstrated that the buoyancy of submerged structural component do not contribute to higher stress levels in the structures or piles.

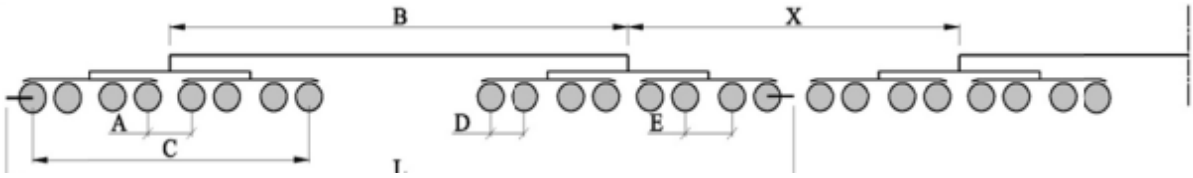
7.8.9 Quayside Gantry Crane

The data provided in this section is preliminary and represents configuration of a representative Kalmar Quay Crane.

7.8.9.1 General Parameters and Wheel Configuration

Table 7.11 Gantry Crane Parameters and Wheel Configuration*

Design Parameter	Unit	Design Value
Total Dead Load	(T)	1420
Overall length buffer to buffer width	(m)	27
Wheels per corner – water side	No.	8
Wheels per corner – land side	No.	8
Wheel spacing (per bogie)	(mm)	1450
Bogie spacing	(mm)	2900
Wheel diameter	(mm)	630
Buffer height	(mm)	1100
Buffer load	(kN)	2010 (Including buffer factor)
Wheel Spacing between equalizer (A)	(m)	1.45
Leg center line (B)	(m)	14.5
Corner wheel CL to CL distance (C)	(m)	10.15
Wheel spacing with in bogie (D)	(m)	1.45
Wheel spacing between bogie (E)	(m)	1.45
Distance between two cranes (X)	(m)	13



* Values to be finalized after terminal operator selection

7.8.9.2 Wheel Load Data – Analysis

Table 7.12 Gantry Crane Wheel Configuration*

Description	Details	Value	Units
Crane type	Super Post Panamax		
Numbers of wheel per bogie		8	No.
Gantry rail gauge		35	m
Out reach	from centreline of WS rail	63	m
Back reach	from centreline of LS rail	14	m

Description	Details	Value	Units
Crane mass with spreader	Empty spreader	1439	T
Spreader mass		13	T
Head block mass		6	T
Trolley mass	Without spreader	36	T
Total crane mass	At maximum load	1504	T
Heavy lifting beam mass		9	T
Capacity under wire rope		84	T
SWL under spreader		65	T
SWL under heavy lift beam		75	T
Structure surface area	Perpendicular to quay (Boom Down)	1570	m^2
	Perpendicular to quay (Boom Stowed)	2080	m^2
	Parallel to quay	1790	m^2

*Values to be finalized after Terminal Operator selection

The following wheel loading based on 8 wheels per corner arrangement, and a wheel spacing of 1450 mm.

Table 7.13 Gantry Crane Wheel Loads*

S. No.	Criteria	Maximum Wheel Load (kN)
1.	Crane in service, boom down – operational wind speed of 20 m/s	825
2.	Crane out of service, boom stowed – operational wind speed of 20 m/s	650
3.	Crane storm pinned, boom stowed – extreme wind speed of 40 m/s	800
4.	Storm pin horizontal load	1170

* Values to be finalized after Terminal Operator selection

7.8.9.3 Quayside Gantry Crane Track

The requirements for the waterside and landside tracks are shown below.

Table 7.14 Rail Track Requirements*

Design Parameter	Design Value
Track span -centre line/centre line	35m
Track section	ISCR 150; Steel grade to be determined by the EPC executing agency
Top of track	To be flush with berth surface
Track slot width	Construction to allow for potential quay movement during construction
Track slot depth	To suit track system
Track slot edge detail	Rear slot edge: 100×100×12 steel angle Front slot edge: 25mm arises
Track slot drainage	Required at 30 m intervals
Track slot fill material	Not required

* Values to be finalized after Terminal Operator selection

7.8.9.4 Track Tolerance

The track tolerance for installation of crane rail is as per the specification of rail fixing.

7.8.9.5 Cable Slots

Quay side gantry crane cable slots shall be as follows:

Table 7.15 Quay Side Gantry Crane Cable Slot Details*

Design Parameter	Design Value
Position of cable slot	Seaward of seaside track
Distance of cable slot from waterside track (centre line of track to centre line of cable slot)	Between 1100mm to 1600mm
Cable slot type	Open cable trench
Cable slot depth	To hold 8 cables at a time
Cable slot drainage	At not more than 7.5m centre

*Values to be finalized after Terminal Operator selection

7.8.9.6 Cable Turnover Pits

Table 7.16 Cable Turnover Pit Details*

Design Parameter	Design Value
Position of cable turnover pit	Seaward of seaside track – centre of each berth
Number of crane connections per pit	Four crane connections per pit required
Equipment	– Cable tulip to be provided and installed by the EPC executing agency – Cable anchor drum to be provided and installed by EPC executing agency.

* Values to be finalized after Terminal Operator selection

7.8.9.7 Crane Jack Up Points

Table 7.17 Crane Jack-up Point Details

Design Parameter	Design Value
Position	To be finalized after terminal operator selection
Dimension	To be finalized after terminal operator selection
Design	Suitable for jacking up a fully erect quay crane

All gantry crane data presented in this section is preliminary and subject to change based on the type of crane to be considered by the selected Terminal Operator.

7.8.10 Area Loading

7.8.10.1 General

Structural design shall take account of dynamic factors resulting from vehicle braking, cornering, and accelerations.

7.8.10.2 Areas for Designated Loading

Areas for different types of loading as per standard industry practice are indicated in the table below.

Table 7.18 Area Loadings

Area	Description	Loading/Comments
Container Quay and Apron*	Quay area seaward of the seaward crane track	50 kN/m^2 UDL and capable of delivery of fully-erected gantry cranes by sea
	Quay area between seaward and landward crane tracks	Standard Class AA - wheeled vehicle on the deck as per IRC Code of Practice for Road Bridges (Article II – Loads and Stresses) 45 T, 4 high reach stacker with 100 T front axle load

Area	Description	Loading/Comments
		Fully loaded fork lift of 94 T Axle Load on Berth Vessel hatch covers stacked 4 high Containers stacked 4 high, but not within 1m of the crane tracks. The equivalent UDL shall not be less than 50kN/m^2

* Values to be finalized after Terminal Operator selection

7.8.11 Wind Loads

Wind forces on the structure and projecting superstructure of the berth are calculated with the methods given in recent version of IS 875 (Part III).

7.8.12 Wave and Current Loads

Following waves and currents data shall be used to design the berth structures.

Table 7.19 Wave and Current Loads for Extreme Condition

Extreme Condition (100 Year Return Period)		
Significant Wave Height	Hs (m)	1.7
Design Wave Height	Hmax	
Time Period	T (s)	9
Current (all direction)	V (m/s)	0.3
Tide level	MHWS (m)	0.8
Surge level	Wind Setup (m)	0.3
Sea Level Rise	(m)	0.2

Table 7.20 Wave and Current Loads for Operating Condition

Operating condition (5 Year Return Period)		
Significant Wave Height	Hs (m)	1.0m
Design Wave Height	Hmax	1.86 times Hs
Time Period	T (s)	9s
Current (all direction)	V (m/s)	0.3m/s
Tide level	MHWS (m)	0.8m
Surge level	Wind Setup (m)	0.3m

Wave and current force calculation shall be in accordance with BS 6349. Wave and current shall be considered in the same direction and relevant velocities added vectorially.

Assumed Morrison's coefficients are:

- Tubes : C_d = 0.7 and C_m = 2.0
- Profiles: C_d = 2 and C_m = 2

Marine growth of 50 mm on radius shall be considered on all submerged elements.

7.8.13 Temperature Loads

Temperature load shall be considered and combined with the other loadings as per the relevant standards, the difference in temperature gradient between top and underside of the deck shall be considered in the analysis and design.

7.8.14 Settlement to Quay Wall and Apron

Maximum differential settlement to the quay and apron is to be defined in accordance with the requirements of Indian or International Design Standards, whichever is the most onerous. Additional requirements are defined below:

- Differential settlement shall not exceed 15mm over 5m;
- Settlement of the vertical piles under all load cases shall not exceed 25mm.

7.8.15 Shrinkage and Creep Stresses

Unless otherwise specified, the magnitude of shrinkage and creep effects shall be assessed with the relevant methods as per code of practices.

- Mean Annual highest Temperature : 34°C
- Mean Annual Relative Humidity : 84%

7.8.16 Safety Factor

The partial safety factor shall be considered as below in the design of berthing structures.

Load	Limit State	Normal	Storm
Dead Load	ULS	1.15	1.15
	SLS	1.0	1.0
Dead Load: superimposed	ULS	1.2	1.2
	SLS	1.0	1.0
Live Loads	ULS	1.4	1.2
	SLS	1.1	1.0
Berthing or mooring	ULS	1.4	1.2
	SLS	1.1	1.0
Environmental (Wave, Wind, Seismic etc.)	ULS	1.4	1.2
	SLS	1.0	1.0
Soil/earth pressure	ULS	1.3	1.15
	SLS	1.0	1.0
Hydrostatic uplift	ULS	1.2	1.0
	SLS	1.0	1.0

ULS- Ultimate Limit State;
SLS- Serviceability Limit State

The load combinations shall be in accordance with IS 4651 (Part IV) and any other combinations as instructed by the Authority during detail engineering.

7.8.17 Serviceability Checks

Crack width of all the structural elements shall be calculated wherever necessary as per IS:456.

Deflection of piles shall be limited to L/350.

7.9 Design Methodology

7.9.1 Quay Structure

7.9.1.1 Calculation

Seismic design shall be carried out in accordance with Section 7.9.2. The quay structure shall be designed in accordance with IS 4651 'Code of Practice for Planning and Design of Ports and Harbours.

Crack widths shall be checked as follows:

- under Dead Load + 50% of UDL Live Load + Operational Wave and Current: 0.1mm.
- for serviceability combinations of IS 4651 part 4: crack width anywhere in the structure shall be limited to 0.004 times the cover to any reinforcement, main or secondary, subject to maximum of 0.2mm.

Hydrodynamic effects in retained ground and on submerged faces shall be accounted for in the design in an appropriate manner. Detailing of reinforcement and connections shall be carried out to codes which explicitly include placing of reinforcement fully consistent with the design approach, taking into account the seismic design requirements.

Foundations shall be designed according to best modern practice in accordance with the recommendations of the relevant Indian Standard. Piles and bearing elements shall be to a level or set which shall be predetermined by load tests sufficient to validate the design assumptions and construction method. On retaining structures required to support axial loads the design method shall show how the structure resists the combined effect from lateral and vertical loads.

Bored cast-in-place piles and diaphragm wall elements shall be tested for soundness by sonic logging tests.

Based on the results of static load tests the piles and bearing elements shall be designed with the following minimum factors of safety applied at working loads:

The lesser of:

$$Q_a = Q_{su}/1.5 + Q_{bu}/3.5$$

or

$$Q_a = (Q_{su} + Q_{bu})/2.5$$

Where

Q_a = Allowable pile capacity

Q_{su} = Ultimate shaft capacity

Q_{bu} = Ultimate base capacity

Laterally loaded piles or elements shall be designed in accordance with CIRIA Report 103: 'Design of Laterally Loaded Piles'.

The fendering system shall be designed in accordance with BS 6349-4:1994 and PIANC/INA ‘Guidelines for the Design of Fender Systems: 2002’.

Mooring forces shall be determined from a mooring analysis following the guidance BS 6349 'Maritime Structures': Part 1 'General Criteria and Part 4 Code of Practice for Design of Fendering and Mooring Systems'. The EPC executing agency shall submit the proposed mooring layout to the Engineer’s Representative for agreement before commencing his design.

The quay design calculations to be submitted shall include, but not limited to, the following:

- A contents sheet
- Detailed written methodology setting out the design philosophy, construction sequence and design assumptions
- A summary of the geotechnical parameters adopted for the design together with supporting interpreted factual data and geological sections.
- Any assumptions made in developing the geotechnical design parameters shall be reported and justified. Copies of references used to justify the design parameters and assumptions shall be supplied with the calculations.
- Time-histories or response spectra used in the analysis
- The design calculations shall be logically structured and appropriately annotated. They shall incorporate all checks required by the adopted code of practice
- The design calculations shall include a clear statement of the loads and load combinations used in the analysis and the application of material factors. The calculations shall clearly define ‘normal’, ‘abnormal’ and ‘extreme’ load cases and combinations.

- The properties of the fill material including any ground improvement required by the design, and how the attainment of these properties will be assessed in the field for material both above and below the water level.
- Original copies of the relevant Standards and Codes of Practice used in the design shall be included with the calculations.
- Copies of computer model data files on CD-ROM sufficient to regenerate the model and re-run the analysis.

7.9.2 Seismic Design

7.9.2.1 General Requirement

The seismic design of the quay structure and its components shall be carried out using performance-based design methods as described in either the Indian Design Standards or the 'Seismic design guidelines for port structures', PIANC Working Group 34, 2001 (WG34) and 'Performance-Based Seismic Engineering of Buildings', Version 2000 Committee, SEAOC, whichever is the most onerous.

In accordance with the definitions of the Level 1 and Level 2 seismic events given in WG34, the over-riding requirements for the seismic design shall be:

- Level 1 – Serviceable
- Level 2 - Repairable

This is equivalent to performance Grade 'A'.

For the quay structure, these terms can be further defined as follows:

- Serviceable – container handling operations can recommence immediately after the seismic event while minor repairs are carried out
- Repairable - the structure can be reasonably repaired and restored to operation in a reasonable period of time, not exceeding 3 months.

Derailment of cranes or disruption to power supplies is not permitted under the Level 1 event.

After a Level 2 event, reasonable repairs could include:

- Reinstatement of the berthing line by modification to the fenders to accommodate forward movement of the structure
- Modifications to the cope edge to restore the minimum hull clearance to vessels during berthing and mooring
- Repairs to expansion joints between sections of the quay and between the quay and adjacent pavement
- Realignment of crane tracks
- Remounting of de-railed cranes
- Repairs to buried services
- Repair of localized damage to structural elements to restore durability

Damage resulting in excessive forward movement of the structure, reduction in overall stability and reduction in strength of primary load bearing elements shall not be permitted. Guidance on damage criteria can be obtained from WG34.

The EPC executing agency shall prepare and submit a fully comprehensive design submission demonstrating that the specified performance requirements are satisfied by his design.

7.9.2.2 Code and Standards

The EPC executing agency shall demonstrate that his design meets the performance requirements by using a single recognized code of practice that specifically addresses the performance based approach set out in PIANC WG34. All parameters, material factors, strength reduction factors, partial factors of safety, factors of safety, load cases, load combinations and the like used in the design shall be derived and applied in accordance with the chosen standard.

The design and detailing of structural elements and connections to achieve the required strength and ductility shall comply with recognized international standards and shall be checked for compliance with Indian national standards. The more onerous requirements shall apply.

7.9.2.3 Design Earthquake Event

The peak horizontal and vertical ground acceleration shall be modified as required by the adopted design standard. The design earthquakes shall consider the site amplification effect.

The design shall assume that horizontal and vertical components of motion are statistically independent. Responses from the three earthquake components shall be calculated separately and the earthquake-induced response shall be obtained using a statistical approach, such as the SRSS rule.

7.9.2.4 Analysis Method

The choice of analysis shall reflect the form of construction and design earthquake event and shall follow the recommendations of Tables 5.3 and 5.4 of WG34. It is considered that quasi-static analysis is not sufficient for demonstration of performance under the seismic event because movements are not adequately addressed by this method. However, quasi-static analysis may be used to determine strength requirements and overall stability. Analysis shall take account of the STS gantry cranes.

The analysis shall cover the following as a minimum:

- Modelling of the quay structure and miscellaneous facilities
- Crane-quay interaction
- Site amplification effects
- Cracking of reinforced concrete (sensitivity analysis)
- Sensitivity analysis to determine the effect of uncertainties in input motions, geotechnical parameters, etc.
- Liquefaction assessment
- Verification of software to demonstrate that the software can correctly carry out the required analysis

For quasi-static analysis, the peak horizontal ground acceleration shall be increased by a subsoil condition or soil foundation factor to account for the soil properties at the site. This factor is code-dependent but shall in all cases exceed 1.0.

Where the adopted code requires the use of an importance factor, this shall be taken as not less than 1.0.

In his design submission, the EPC executing agency shall identify the possible modes of failure of the quay structure. The EPC executing agency shall carry out and submit separate analyses to define the critical mode of failure. The EPC executing agency hall analyse the critical mode of failure using an appropriate level of analysis as defined by WG34 to demonstrate that the performance requirements are met.

7.9.3 Corrosion Rate

The following corrosion rate will be considered for all structural steel members:

Exposure Zone	Corrosion Rate (mm/side/year)	
	Mean [a]	Upper limit [b]
Atmospheric Zone	0.04	0.10
Splash Zone	0.08	0.17
Tidal Zone	0.04	0.10
Intertidal Low Water Zone	0.08	0.17
Continuous Seawater Immersion Zone	0.04	0.13
Below Seabed Level or in contact with Soil		0.015 Max

[a] the rate for each free exposed to the environment of the zone
[b] the upper limit figures are with the 95% of probability values

[Source: BS 6349: Part II:2000 Table 25]

8 Dredging and Reclamation Works

8.1 Dredging Works

8.1.1 General Requirements

Dredging is required to be carried out to meet the following

- Dredging shall be carried out in any type of material which may be encountered, which may include natural bed materials, rock in varying states of weathering including fresh rock, and materials or items of a manufactured nature, such as, inter alia., chains, wires, cables, ropes, anchors, pipes, castings, steelwork, concrete, timber, tyres or similar.
- The suspended solid content anywhere in the water column measured from the dredging site shall be in compliance with the requirements of the Environmental Impact Assessment.
- The EPC executing agency shall maintain the required dredged depths in the entire navigation area by adopting a suitable periodic maintenance dredging program.

Prior to commencement of works, the EPC executing agency shall submit to the Independent Engineer a comprehensive method statement for environmental mitigation measures and monitoring in compliance with the requirements of Environmental Clearance.

8.1.2 Dredging

Dredging shall be carried out to achieve the lines and levels shown on the Layout Drawing **DELD11137-DRG-25-0000-CT-4001**. The dredged level is defined as the level above which no part of the base of the dredged area protrudes at the time of the post dredging survey.

The proposed dredged level behind the quay line shall be such as to provide stable foundation to the quay structure that fulfils the Authority's Requirements.

The dredging works includes but is not limited to the design, construction and maintenance up to the date of the issue of the relevant Taking-Over Certificate of the following:

- A berth pocket with a minimum level of –18.4m CD, extending 70m seaward of the berthing line is required. These depths shall be the minimum level after the placing of any bed scour protection. No additional dredging shall be carried out at this location.
- The turning circle, internal dredged basin and inner approach channel shall be dredged to a minimum level of -18.4m CD and the outer approach channel shall be dredged to a minimum level of -20.8m CD.

8.1.3 Capital Dredging

Table 8.1 provides the various dredge depths and the calculated dredging volumes.

Table 8.1 Capital Dredging from different areas for the Vizhinjam Port

S. No.	Dredge Area	Dredge Depth (wrt CD)	Dredge Volume (m^3)
1.	Approach Channel	20.8	2,882,788
2.	Inner channel and Harbour Basin area	18.4	2,159,785
	Total		**5,042,573**

8.1.4 Characteristics of Dredged Material

The geotechnical investigation borehole data at the site reveals that the subsurface generally consists of marine deposited silty sand for the full depth of exploration in the approach channel area while layers of sand and rock

were encountered in the terminal area. Rock was not encountered during borehole investigations in the proposed dredged area with exception of rock found at a depth of around -25m CD in front of proposed container berths.

The borehole profiles show that the dredge spoils (except the initial surface material up to the depth of approximately 0.5-1m below the existing seabed) comprise of good quality sand and is suitable for reclamation for the development of the onshore facilities.

However, geophysical survey shows that we may encounter a very dense sand layer beyond depth of -22m CD in the outer approach channel. It is also observed that rock can be expected along the container berth face at around -20m CD to -22m CD. In other areas, very dense sands or weathered rocks are expected to be found at depths at or below -24m CD. The dredge depths proposed for the port are shallower than rock levels and very dense sand layer levels and hence it is not expected to encounter any hard material.

8.1.5 Maintenance Dredging

Based on the mathematical model studies on siltation, the siltation that would be expected in the channel entrance and the harbour basin is negligible.

8.1.6 Disposal of Dredged Material

The disposal of the dredged material which is unsuitable for onshore development shall be as specified in BS: 6349 Part 5. The disposal of dredged materials (method, level, etc.) shall be in compliance with the requirements of the Environmental Impact Assessment. Disposal of material shall be done in such a fashion that the disposed material shall not create any hindrance to any operation at present or future.

The designated disposal site shall be confined to location as indicated below:

Points	Location	
	Latitude	Longitude
A	76°59’39.07”E	8°20’25.48”N
B	77°00’25.04”E	8°19’39.23”N
C	77°00’01.82”E	8°19’16.33”N
D	76°59’15.85”E	8°20’02.59”N

The designated location is as shown in **Drawing DELD11137-DRG-25-0000-CT-4002**.

8.1.7 Tolerance Limits

Tolerance limits to be followed for the dredging works are given below:

Table 8.2 Tolerance Limits

Type of Soil	Tolerance Limits		
	Horizontal	Vertical	Side Slope
Soft clay, silt, fine dense and with silt, sand, gravels etc.	– +100 cm total for the width of the channel – 0.50 m on either side	– Nothing above – Not more than 30cm below	1: 6 in Sand and 1: 8 in Clay As per PIANC Guidelines
Rock without Blasting	– +100 cm total for the width of the channel – 0.50 m on either side	– Nothing above – Not more than 50cm below	1: 1 Rock

8.1.8 Boundary Conditions

- Part construction of breakwater of the port prior to commencement of dredging & reclamation works;
- The entire Dredging and Reclamation work is planned to be completed in 21 months including mobilization period of 2 months;
- Reclamation for Port Terminals has to be done on priority;
- Long Leads to Reclamation areas other than Port (Limitations/ Constraints related to Sinker / Floating and shore lines, requirement of boosters and re-handling etc.);
- Sections of Stage 1, 2, 3 & 4 of dredging areas are in deep waters varying from 11m to 20m.

8.2 Reclamation Works

Reclamation works are required at the back side of the berth to create land for building container storage yard and spaces for other utilities required for the port.

The reclamation works include filling of suitable dredged material inside reclamation bund up to a level mentioned in the **Drawing DELD11137-DRG-25-0000-CT-4001**. The formation level of the backup operational area behind the berth is +4.2m CD. This level is considered adequate to avoid any flooding of site under the storm conditions and also enable better planning of drainage system at site.

The quantum of material required for the backfill to raise the ground level in the port operational areas to +4.2 m is of the order of **5.9 million m^3**.

The land level is raised to the level from the existing ground to +4.2 m CD by placing excavated/dredged material without any compaction other than achieved by Hydraulic action and/or movement of Earthmoving Equipment in fill areas.

The dredged material pumping areas shall be divided into bays of suitable size by formation of bunds with weirs for allowing the excess water to overflow. The dredged material shall be pumped to the designated site in the port area. This would facilitate settled water to flow into the empty bays and finally to the drain which leads into the sea.

8.2.1 Material for Site Grading

The estimated quantity of soil filling for stage 1 port development works out **to 5.9 million cum**, which would be made available from the dredged material obtained from the approach channel and the harbour basin area. To meet this requirement, it would require total dredging to be of the order of around **6.6 million m^3**. This additional dredging of around 1.6 million m^3 over the required dredging reported in Table 8.1 may be obtained by over-dredging the navigational channel.

The reclamation works method shall be planned such a way that environment of the nearby area shall be preserved. The EPC executing agency may over dredge to get more suitable dredge material at turning circle, inner and outer approach channel area. Dredged material unsuitable for reclamation purposes shall be dumped at location shown in the Drawing **DELD11137-DRG-25-0000-CT-4002**.

It is usual to use only granular materials for land reclamation. Occasionally, long-term land reclamation may be carried out using cohesive materials. Fill material shall be well-graded granular material obtained by specified dredging, selected from stockpiles or imported from borrow pits. The grading and compaction of the fill shall be such that it will achieve the requirement used in the design. Material used in reclamation shall meet the following requirements:

- The material shall be free from organic matter, and shall have the following properties (when tested in accordance with BS 1377: Part 2: 1990, unless stated otherwise):
- Maximum particle size : 100mm
- Maximum silt content dispersed in the granular material (material passing a 63 micron sieve): 10%
- Plasticity Index: <6%
- Clay ball content shall not exceed 5% of the reclamation volume unless otherwise permitted by the Engineer. The material shall be dispersed uniformly throughout the area and not aggregated as large lumps or zone of clay balls.

- Particle Density (BS 812) (for gravel or larger in size): >2.3Mg/m3
- Aggregate Impact Value (for gravel or larger in size)
  - Aggregate Impact Value (BS 812) (dry): <30%
  - Aggregate Impact Value (BS 812) (saturated): <40%
- Water Absorption Test (BS 812): <6% (for gravel or larger in size)

In the event that the volume of material contained within these stockpiles is insufficient for the completion of the works, suitable arrangement to supply and stockpile Imported Suitable Material shall be made. The imported material shall also meet the requirements listed above for Suitable Material.

All Imported Suitable Material shall, in addition, be tested by means of shear tests (AASHTO T234 or T235, or BS 1377: Part 7 or Part 8, as appropriate) to prove that it will achieve, in its final state of compaction, a minimum internal angle of friction greater than 30°. All Imported Suitable Material shall also be tested to determine the compaction characteristic in accordance with BS 1377: Part 4: 1990.

The reclaimed land shall require ground improvement for developing the storage and yard operational area. Proper spreading of the material in layers using dozers and compaction to 95% maximum dry density will be necessary. The ground improvement works includes but is not limited to design, construction and maintenance up to the date of the issue of the relevant Taking-Over Certificate.

The ground improvement for the yard development has to be carried out by the selected terminal operator at his own cost. Hence, the same has not been incorporated in detail in this document.

Borrow materials would be required as sub-base for ground preparation for the development of yard. The specifications for the borrow materials is as described in the section below.

8.2.2 Specification for Borrow Material

8.2.2.1 General Requirements

The materials shall be obtained from approved sources with preference given to materials becoming available from nearby roadway excavation or any other excavation identified for the project.

The work shall be so planned and executed that the best available materials are saved for the subgrade and embankment portion just below the subgrade.

8.2.2.2 Borrow Materials

Where the materials are to be obtained from designated borrow areas, the location, size and shape of these areas shall be as indicated by the Independent Engineer and the same shall not be opened without his written permission. Where specific borrow areas are not designated by the employer/the Independent Engineer, arrangement for locating the source of supply of material for embankment and subgrade as well as compliance to environmental requirements in respect of excavation and borrow areas as stipulated, from time to time by the Ministry of Environment and Forests, Government of India and the local bodies, as applicable, shall be the sole responsibility of the EPC executing agency.

Borrow pits, along the road shall be discouraged. If permitted by the Independent Engineer, these shall not be dug continuously. Ridges of not less than 8m width should be left at intervals not exceeding 300m. Small drains shall be cut through the ridges to facilitate drainage. The depth of the pits shall be so regulated that their bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the edge of the final section of the bank, the maximum depth in any case being limited to 1.5m. Also, no pit shall be dug within the offset width from the toe to the embankment required as per the consideration of stability with a minimum width of 10m.

Haulage of material to areas of fill shall proceed only when sufficient spreading and compaction plant is operating at the place of deposition.

No excavated acceptable material other than surplus to requirements of the contract shall be removed from the site. Should the EPC executing agency be permitted to remove acceptable material from the site to suit his operational procedure, then he shall make good any consequent deficit of material arising therefrom.

Where the excavation reveals a combination of acceptable and unacceptable materials, the EPC executing agency shall, unless otherwise agreed by the Independent Engineer, carry out the excavation in such a manner that the

acceptable materials are excavated separately for use in the permanent works without contamination by the unacceptable materials. The acceptable materials shall be stockpiled separately.

The EPC executing agency shall ensure that he does not adversely affect the stability of excavation or fills by the methods of stockpiling materials, use of plants or siting of temporary buildings or structures.

The EPC executing agency shall obtain representative samples from each of the identified borrow areas and have these tested at the site laboratory following a testing programme approved by the Independent Engineer. It shall be ensured that the subgrade material shall not be less than 90% when compacted to the density requirements and shall yield the design CBR value of the subgrade.

8.2.2.3 Physical Requirements

The materials to be used in subgrades shall be soil, murrum, gravel, mixtures of these or any other material approved by the Independent Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment or the subgrade. The following type of material listed below shall be considered unsuitable:

- Materials from swamps, marshes and bogs
- Peat, log, stump and perishable, material: any soil that classifies as OL, OI, OH or Pt in accordance with IS :1498,
- Materials susceptible to spontaneous combustion;
- Materials in frozen condition;
- Clay having liquid limit exceeding 70 and plasticity index exceeding 45; and
- Materials with salts resulting in leaching in the embankment.

Expansive clay exhibiting marked swell and shrinkage properties (“free swelling index” exceeding 50% when tested as per IS: 2720 – Part 40) shall not be used as a fill material. Where expensive clay with acceptable “free swelling index” value is used just as a fill material, subgrade and top 500mm portion of the embankment just below subgrade shall be non-expansive in nature.

Any fill material with a soluble sulphate content exceeding 1.9 grams of sulphate (expressed as SO_2) per litre when used in accordance with BS: 1377 test 10, but using a 2:1 water- soil ratio shall not be deposited within 500mm or other distance described in the contract, of concrete, cement bound, materials or other cementations materials forming part of the permanent works.

Materials with a total suitable content (expressed as SO_2), exceeding 0.5 percent by mass when tested in accordance with BS: 1377 test shall not be deposited within 500mm, or other distress described in the contract, of metallic items forming part of the permanent works.

The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm when being placed in the embankment and 50mm when placed in the subgrade. However, the Independent Engineer may at his discretion permit the use of material coarser than this also if he is satisfied that the same will not cause any difficulty as regards to the placement of fill material and its compaction to the requirements of these specifications. The maximum particle size shall not be more than two-thirds of the compacted layer thickness.

Generally the density requirements of the subgrade shall not be less than 17.5 kN/m^3. The Independent Engineer may relax these requirements at this decision taking into account the availability of materials for construction and other relevant factors. The material should also satisfy the design CBR at the dry unit weight as applicable.

8.2.3 Ground Improvement

The properties of the soils across the site are such that ground improvement measures may be required to meet the performance requirements of the reclamation area. The reclaimed and filled areas shall be treated as necessary to provide adequate stability and bearing capacity to withstand the applied loadings, including seismic loads, and to provide a firm foundation for construction of terminal paving.

In addition to the operational requirements, a primary function of the ground improvement works is the modification to the liquefaction potential of soils and fills such that the requirements of the Specification are met. Modification shall take the form as set out within the Specification.

The scope of the ground improvement will be subject to the EPC executing agency detailed design. The precise extent of the works shall be dependent on the findings of ground investigations and settlement analyses to be undertaken by the EPC executing agency. The ground improvement work elements shall be planned and undertaken at such times and in such a sequence across the Site as to suit the design of the Works, including as necessary the design of ground improvement works, the overall Sectional Completion requirements and the EPC executing agency programme.

The EPC executing agency shall be fully responsible for selecting, designing, constructing and proving the capability of the ground improvement works to comply with the requirements. The EPC executing agency design shall take account of but shall not be limited to the following:

- the supplied factual ground investigation information;
- the EPC executing agency own research of ground improvement measures with a proven track record in similar ground conditions.

8.2.3.1 Geotechnical Conditions

The subsoil in the reclamation area is silty sand with shell and rock fragments varying from the seabed to a depth of approximately 22m and hence all settlements will be rapid and over within a short duration. The following describes options for stabilization.

8.2.3.2 Overview of the Considered Options

8.2.3.2.1 Soil Improvement by Band Drains & Preloading

Improvement of the subsoil properties by installation of band drains, also known as Prefabricated Vertical Drains; which are in essence, vertical drainage channels serving to expedite release of pore pressures developed in the subsoil on account of loading. They are normally installed in a square or triangular grid at a spacing of 1 to 2 m, depending upon the permeability of the subsoil and the time period that can be allowed for strength gain in the subsoil.

Building up a preload can cause consolidation of the subsoil, hence causing gain in strength of the subsoil. The strength gain is a function of the intensity of preload intensity. Usually, this process is employed where the primary requirement is to eliminate potential settlements. The cost of building and removal of preloading is an added cost.

Generally, preloading requires to be done in stages so that the subsoil strength is built up gradually and failure due to rapid loading is avoided. This time needs to be factored into the schedule.

8.2.3.2.2 Soil Improvement by Stone Columns

Stone Columns are columns formed in the ground using stone aggregates, 75mm & down. Special equipment are required to ensure proper construction. The process is also known as “Vibro Replacement”. While in sandy strata stone columns serve to increase the φ value, in clays, they impart “φ” values to the strata on an overall basis, owing to their granular composition.

The ratio of the area of one stone column to its command area is known as “replacement ratio”. The closer the spacing, the higher the replacement ratio and consequently higher improved soil parameters are achieved. Based on the replacement ratio, the improved parameters “C” and “φ” are computed.

Stone columns are installed in a square or a triangular grid. For the same grid spacing, the triangular grid gives a higher replacement ratio.

8.2.3.2.3 Soil Improvement by Vibro-Compaction

In this method the soil particles are rearranged in to a denser configuration by the use of powerful depth vibrators. By vibro compaction there will be reduction in settlement. This method is more applicable in the strata comprising of silty sand. The reclamation at the port is estimated to be dredge spoils and will consist of silty sand. Thus, Vibro-Compaction will be the preferred method for soil improvement.

8.2.3.3 Shallow Foundations and Piled Foundations

In the event of concentrated loads being applied it is preferable to use the shallow foundations to evenly distribute these loads to the soil strata underneath. However, if the bearing capacity of the strata below is inadequate piled foundations would need to be provided.

8.2.3.4 Container Yard

Since the yard would be developed, by reclaiming the suitable dredged material comprising of, dense sand with shell fragments as well as gravels. In order to consolidate the area surcharge fill would be required. The surcharge is placed in various section of the reclaimed area for consolidation to avoid any liquefaction in conjunction with vibro-compaction. Apart from this no ground improvement would be required for the yard development.

8.2.4 Ground Settlement

8.2.4.1 Overall Settlement to Reclaimed Area

The allowable levels of overall ground settlement across the site, to be recorded from the date of handover of the sectional completion areas shall be as below and in no case exceeding:

Maximum overall ground settlement shall not exceed 250mm over design life.

8.2.5 Differential Settlement to Reclaimed Area

The maximum allowable differential ground settlements which are required for operational reasons are:

Condition	Value
Longitudinal or transverse slope of box	1 in 60
Out of plane @ corners of 20' long container	± 20 mm
Differential settlement adjacent to structures	15 mm
Vertical steps, including rutting, cracking & potholes	15 mm

Special measures shall be employed by the EPC executing agency to eliminate the adverse effects of excessive differential settlement of the surfacing at the rear of the quay, and adjacent to the rear crane beam.

8.3 Dredging and Reclamation Methodology

8.3.1 General

This method statement is prepared based on the information available at this stage the aim of not to freeze the methodology but to consider possible alternatives and feasibility of the dredging and shall be modified /revised by the specialised dredging contractor to be appointed through EPC executing agency. The final approach has to be developed by the contractors who are experienced and innovative in the field of marine dredging operations.

8.3.2 Work Method

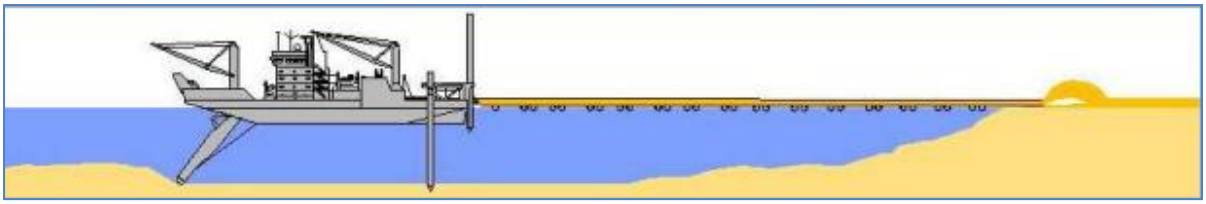
The prevailing site conditions and equipment properties dominate the selection of the equipment and work method. The materials to be dredged consist of layers varying from coarse sand to silty clay at the top. Separate dredging of suitable and unsuitable materials will be carried out. The suitable sandy and gravel material will be placed in the reclamation area for container yard construction. The unsuitable material, such as slity clay, will be dredged and discharged to the designated offshore disposal area. Considering the variety of soils (soft and hard) in combination with a limited pumping distance between the dredging- and reclamation areas, the work method utilizes a large Cutter Suction Dredger (CSD).

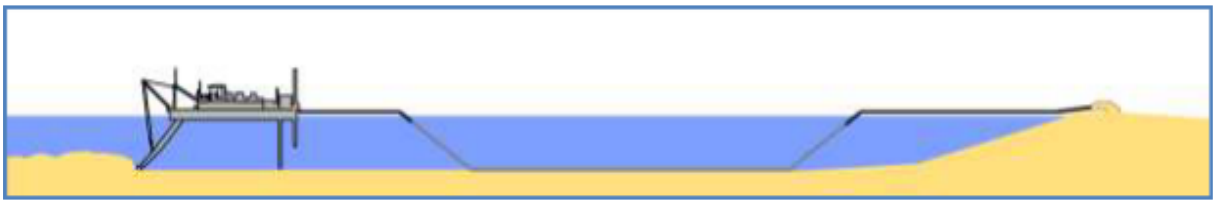
A large Cutter Suction Dredger will be deployed to dredge the materials and hydraulically transport these to the required reclamation areas. The dredged suitable materials will be pumped ashore by means of a system of onboard dredging pumps in combination with floating, submerged and land lines. The suitable materials will be pumped ashore into the reclamation areas A, B, C & D. All the dredged unsuitable materials will be discharged into a split bottom barge and transported and dumped to the designated offshore disposal area.

The suitable and unsuitable soil layers will be placed in a soil model which will be loaded into the onboard dredge computer. The dredging will take place in several cuts. Based on this plan the dredge master can determine his dredging strategy and synchronize this with the reclamation crew.

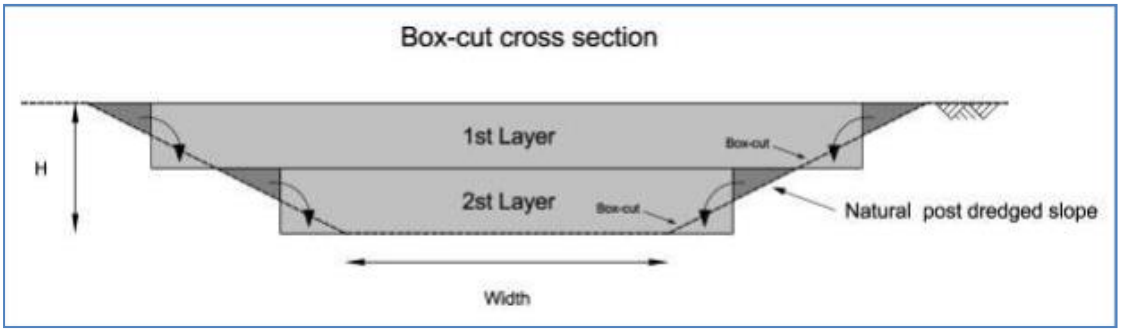
8.3.3 Dredging by Cutter Suction Dredger (CSD)

The CSD is deployed for dredging and pumping materials directly into the reclamation area. The pipeline may consist of a combination of floating, submerged and shore lines. In this particular situation, the CSD is connected directly to a shore connection point by means of a floating pipelines where required in combination with a submerged line and there off to the reclamation area, by means of a shore pipeline. As the reclamation progresses, the shoreline will be extended. Two different pipeline configurations i.e. discharging onshore through floating pipe and through submerged pipe are schematized in the figure below.





Depending on the layer thickness to be dredged and the characteristic of the materials, the CSD will cut and dredge the material in one and more layers. On an average 0.5m vertical over depth will be dredged by the CSD. The dredging will be carried out by using the box-cut method and slopes will be allowed to fall to natural angle of repose. The example of box-cut cross section is as shown below.



8.3.4 Reclamation Works

The suitable dredged materials will be discharged by the CSD into one of the reclamation areas.

Prior to commencement of the dredging and reclamation works, land based equipment will be used to install water boxes in between the sea and reclamation bunds (where deemed necessary). Bunds will be constructed around each of the reclamation areas prior to start filling.

Permanent bund will constructed partly by dredged materials and armour stones. The borders/edges (temporary bunds) of the various reclamation areas between A to D are pumped in by using hydraulic filling methods. As a result the reclamation slopes will become natural angle of repose and will be in the order of approximately 1:7 in steepness.

After preparation of the reclamation area, the CSD will be connected to the shore connection point by means of a floating pipeline where required in combination with a submerged line. The shore connection point is installed as close as possible to the reclamation area. From this point, shore pipelines will transport the soil/water mixture to the

reclamation area. The layout of the total pipeline trajectory will depend on the location of the shore connection, the local circumstances, the number of earth moving equipment available.

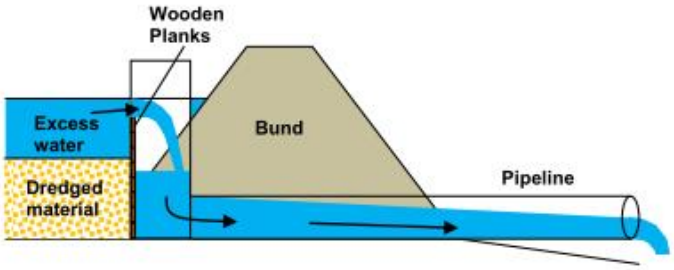
The reclamation areas to be filled in maximum two layers to final fill level (+3.50mCD near the berth increasing to +5.3m CD to the shore). Suitable sub-grade and pavement will be used on top of the fill level for a depth of around 0.70m. Land-based equipment will be used to spread and level the delivered materials. During the progress of the reclamation works the shore pipeline will be extended as the reclamation area is being filled with material and bunds will be raised. A cross-section for the raising of bunds is given below.

On reaching the design fill level of +3.50m CD, vibrating roller compaction is applied before placing of the surcharge loads (if required). This is in order to reach the required 95 % MDD (Maximum Dry Density) for the top 1.5m of the fill. After a fill area is completed, parts of the shore pipeline can be disconnected and used at the next fill area.

In order to ensure continuity of dredging and reclamation process, the reclamation area is generally laid out in such a way that there are always different discharge points available. The pipeline trajectory is arranged in such a way that switching from the suitable to unsuitable reclamation area can be made quickly by the use of valves system. This will create certain flexibility and provide the ability to respond to external factors.

The transport water will be guided through the reclamation area and in order to control the outflow of transport water from the reclamation area, Weir Box (or water boxes) is installed. With Weir boxes, the water level inside the reclamation areas can be controlled by means of changing the elevation of the weir box boards. By adjusting the

weir level, the outflow of fines into the sea can be controlled. As a result, significantly more fines can be retained. A cross section of a weir box is shown below. This will also control the turbidity level of the sea water.



8.3.5 Work Sequence

The following figures reflect the sequence for execution of the works. It is remarked that the figures are indicative and can be modified based on the contractor's equipment and execution method. The pipeline trajectory or sequence can deviate from the presented figures. Important aspects that can influence the sequence of works are shipping traffic (if any), currents, stratification of suitable and unsuitable materials. (Refer **Drawing DELD11137-DRG-25-0000-CP-4003** for each stage of work sequence).

8.3.5.1 Work Sequence Stage 1

- One of the first activities at the site is to start building the breakwater which will help the dredger to work in adverse weather condition.
- Breakwater will start from the landside and will provide permanent bund for the reclamation area A at the north end.
- Permanent reclamation bunds to be constructed parallel to the berth alignment (north to south).
- Temporary bund will be created by hydraulic fill in between area A & B by land based equipment.
- Dredging will be carried out at the basin and turning circle area as shown in the figure above.
- Dredged material will be pumped to area A through the combination of floating and land based pipeline.

8.3.5.2 Work Sequence Stage 2

- Extension of permanent bund towards south to cover Area B as shown in the figure above.
- Temporary bund will be created by hydraulic fill in between area B & C by land based equipment.
- Dredging will be carried out at the basin and turning circle area as shown in the figure above.
- Dredged material will be pumped to area B through the combination of floating and land based pipeline.
- Ground improvement works will start at Area A

8.3.5.3 Work Sequence Stage 3

- Extension of permanent bund towards south to cover Area C as shown in the figure above.
- Temporary bund will be created by hydraulic fill in between area C & D by land based equipment.
- Dredging will be carried out at the inner approach channel as shown in the figure above.
- Dredged material will be pumped to area C through the combination of floating and land based pipeline.
- Ground improvement works will start at Area B

8.3.5.4 Work Sequence Stage 4

- Extension of permanent bund towards south to cover Area D as shown in the figure above.
- Further extension of permanent bund towards east to connect the land.
- Dredging will be carried out at the outer approach channel as shown in the figure above.
- Dredged material will be pumped to area D through the combination of floating and land based pipeline.
- Booster pumps may be required to pump the dredged material to Area D
- Ground improvement works will start at Area B

8.3.6 Other Aspects

Field measurements and processing of data shall be executed to a degree of accuracy in both the horizontal and vertical plane and drawn to scales to the full satisfaction as per International Hydrographic Organization (IHO) specifications.

Tide gauges are to be established at suitable places to measure the tide during the entire course of dredging. All survey charts to be prepared after reducing the observed depths to Chart Datum (CD), and the depths and / or heights shall be plotted in meters.

Data generated by the surveys shall be elaborated in accordance with sound topographic and hydrographical practices and be presented on survey charts. If necessary, the chart shall incorporate all reference points, buoys, beacons, markers, gauges and benchmarks, together with the location and nature of obstructions, structures and facilities.

In case of bad spells during SW monsoons there shall be some down time in stage 3 and 4. Hence some margin has to be catered for CSD. However, the monsoon issues would have to be addressed appropriately in the method statement of the EPC executing agency. It is better to leave it to the EPC executing agency to work out the best methodology.

8.3.7 Measurement of Works

The total amount of material dredged will be quantified based on the in-situ measurements. The volume will be computed based on the differences pre-dredged bathymetry survey and the post dredging bathymetry survey as agreed with the EPC executing agency and includes tolerance limits for payment.

8.3.8 Ground Improvement

Ground improvement may be required for the expansion of the container yard in the areas A to D. Several techniques are available for ground improvement, such as:

- Placement of surcharge loads;
- Installation of vertical wick drains,
- Installation of vertical vacuum wick drains;
- Execution of vibro compaction;
- Execution of dynamic compaction;
- Execution of surface compaction, such as Roller compaction.

Based on the reclamation material and time available the EPC executing agency will decide the actual method to be used for ground improvement.

9 Buildings

9.1 General Requirements

For enclosed buildings, wall and roof cladding and building service systems shall satisfy the following criteria throughout the design life of the supply base facility:

- Provide a completely watertight envelope around all storage materials, plant, equipment and personnel within;
- Create an acceptable, controllable working environment for all building users;
- Be sufficiently flexible to allow necessary change and expansion with minimal disruption to plant operation;
- Have a clear minimum maintenance programme based on design life cost appraisal;
- Be readily replaceable if damaged during the design life;
- Be sufficiently robust to resist all anticipated movements caused by wind, thermal, seismic and other loadings during the design life;
- Be of a high quality and consistent appearance;
- Satisfy all appropriate standards, regulations and quality requirements;
- Be capable of resisting any environmental or chemical effects produced by the plant or external environment;
- Allow penetrations in the building enclosure to be formed and sealed easily.
- Allow means of escape in the event of an emergency.

9.2 Land Lord Facility Building

The Land Lord facility Building is located so as to allow visual access to the Port. It will be 3-storeyed building with a total floor area of 800m^2.

The typical plan for the land lord facility building is as shown in **Drawing DELD11137-DRG-25-0000-CP-5001**.

The building is a ground + two storey building to accommodate the facility for overlooking the harbour operations by VISL personnel. This building shall be supported on shallow foundation comprising of a combination of strip and isolated footing owing to better soil condition at the proposed location.

9.3 Design Life

Table 9.1 Design Life for Structural Elements of Buildings

Element	Design life (years)	Maintaienence interval (years)	Routine Maintenance by Authority	Unacceptable repair or maintaienence
Structures				
– Concrete	25	None	None	Cutting out/replacement of defective/spalled concrete and corroded reinforcement
– Steel works	25	10	Recording of protective systems every 10 years	Cutting out/replacement of defective/ corroded steel or its fittings
Roof canopy and wall cladings (metallic)	25	10	Sundry caulking to joints and fixing holes every 10 years	Removal replacement of dry corroded or distorted/ defective sheeting and its fixings and repair of leakages

Element	Design life (years)	Maintaienence interval (years)	Routine Maintenance by Authority	Unacceptable repair or maintaienence
Roofing systems (excluding metallic)	25	10	As above	Removal/Replacement of Screeds, etc
		15	Replacement of waterproof membrane layers every 15 years	
External doors, louvres and windows and hardware	25	10	Replacement of seals and caulking every 10 years	Removal/replacement of any part and repair of leakages
		5	Recoating every 5 years (where previously painted) Routine maintenance to hardware	
Sundry metal work items external and internal	25	5	Repainting every 5 years (where previously painted)	Removal/replacement of any corroded or defective part
Internal walls	25	None	None	Breaking/replacement of any part/area of walls
Internal doors, screens and hardware	25	5	Re-coating to doors and screens every 5 years (where previously painted) Routine maintenance to hardware	Removal/replacement of any part
Internal plaster/paint finishes	25	5	Repainting every 5 years	Removal of existing plaster back to sub-strata
Internal floor screed finishes	25	None	None	Any removal/replacement
Internal ceramic/PVC tile finishes	25	None	None	Any removal/replacement
Suspended ceilings	25	5	Replacement of warped tiles every 5 years	Any removal/replacement of suspension grid
Fitting/fixtures – painted	25	5	Repainting every 5 years	Any removal/replacement
– metal/ laminate		None	None	Any removal/replacement
E&M Installations	25	As per manufacturer's requirements	Periodic normal and routine maintenance of all items of equipment/controls in accordance with manufacturer's manuals	Any removal/replacement of any items or parts of equipment and controls, pipes, cables, ducts, components, accessiories, fittings, fixings, etc. but excluding consumables, e.g. filters, lamps, fuses, etc.

9.4 Functional Requirements

- Buildings shall be primarily functional, but aesthetics are also important, and architectural appearance and detailing shall be in accordance with the Authority's Requirements and be to the satisfaction of the Independent Engineer.
- Buildings constructed under this Contract shall be water-tight, weatherproof, vermin-proof and durable to ensure minimal maintenance requirements.
- Floor areas below ground level shall be of waterproofed construction.

- Buildings shall be provided with fire alarms connected to flashing lights mounted in prominent positions, and fire extinguishers.
- Windows shall be proprietary units of high quality polyester powder coated aluminium, with toughened glass, complete with all necessary glazing gaskets, beads, drips, flashings, catches and the like.
- Buildings shall be provided with adequate power outlets and power supplies generally to serve the Authority's systems and building services.
- Buildings shall be provided with adequate telephone and telecommunication outlets and cableways to serve the Authority's systems and services.
- Buildings shall be provided with adequate internal and external lighting installations to meet the required functional performance night and day. Emergency lighting shall be provided where required by the Indian standards.
- Buildings shall be provided with heating, ventilation and air conditioning systems to maintain comfort conditions for the occupants and for specific requirements related to the needs of the type of use for unoccupied spaces. Air Conditioning systems shall be provided with Duty / Standby plant.

9.5 Architectural Aspects

- Architectural treatment for the buildings and facades shall be designed to enhance the look of the land lord facility building as much as possible whilst being sympathetic as possible to the surrounding environments. Colour, texture and shapes shall combine in order to produce an attractive and impressive complex.
- In order to achieve the above, the EPC executing agency shall indicate which reputable architect is to be employed on the project, providing references for past work. Architects impressions for the completed project shall be submitted for the Independent Engineer's approval.
- Buildings shall be designed to be sympathetic with the site surroundings and environment.
- All buildings and structures on the site shall relate to one another visually through use of consistent cladding materials and a coordinated approach to layout and material detailing.
- Individual visual elements shall be such that their massing and relationship to one another results in an overall uncluttered appearance and clear building facades wherever possible.
- Visual intrusion of elements above the building parapets shall be minimised, as far as possible, consistent with the Port layout requirements. Layout planning studies shall be used to establish the constraints on relationships between elements including coordinating routing for cabling, pipe work and trenches, establishing links between buildings and plant items, identifying site, structural and foundation layout constraints, and considering pedestrian and vehicular traffic access routes.

9.6 Design Criteria

- The work shall be carried out as per General Technical Specifications for Building Works of the State of Kerala or C.P.W.D.
- The minimum grade of reinforced concrete shall be M 30 conforming to IS: 456-2000 for columns, foundations and superstructure unless otherwise specified.
- The reinforcement shall be high strength deformed bars of grade Fe500 conforming to IS: 1786 - 1985.
- All structural steel shall conform to IS: 226/IS: 2062 - Grade A.
- Proper Anti Corrosive Treatment (ACT) shall be done for the reinforcement before placing.
- Construction joints shall be provided for buildings exceeding the length of 40m.
- Loose Pockets in foundations shall be removed and filled up with PCC mix (1:4:8).
- Back filling shall be done with granular soil in layers not exceeding 200mm and each layer shall be well compacted as per specification requirements.
- All reinforcement shall be sheared only. Flame cutting is not permitted. All bars shall be bent at normal temperature.
- The flooring shall be 40mm thick Kota stone polished, with under layer of 30mm thickness in cement concrete mortar 1:2:4, as per specifications.
- All outdoor paved areas shall be cement concrete 1:2:4 - 40mm thick laid in one layer, finished with floating coat of neat cement as per Technical Specifications.
- All woodwork shall be of teak wood.
- All doors and windows shall be of steel, duly painted with anticorrosive paint.

- Electrical fittings and wiring shall be provided as per specifications.
- All sanitary and water supply fittings shall be provided conforming to specifications.
- All RCC slabs for roofing shall be provided with water proofing treatment.

9.7 Design Loading

9.7.1 Dead Loads

All dead loads used in the analysis of structural elements will be based on the actual unit weights of the materials used. The dead load of the structure is typically comprised of its self-weight and includes finishes, services and fixed partitions.

Material	kN/m^3
Reinforced concrete	25
Structural steelwork	78.50
Masonry (dense block partitions)	22
Tarmac	24
Sand / cement screed	23
Plaster	17
Glass	27
Natural Stone (Granite)	27.50
AAC Thermalite Aerated block	5.50 (Excluding plaster)

9.7.2 Live loads

Live Loads used in the analysis and design of the structural elements shall conform to the loads prescribed in IS 875 Part 2, with due consideration for particular local authority requirements.

Table 9.2 Dead & Live Load Summary

Location	Dead Load (kN/m^2)			Live Load
	Partitions	Finishes, Ceiling & Services	Other	
Stairs & Lobbies	-	1.8	-	4.0
Offices	1.0	1.8	-	4.0
Inclined Roofs without Access	-	0.25	-	0.75
Flat Roofs with Access	-	2.5	-	1.5
Water Features & Tanks	-	1.0	Water, 10kN/m^3	-

9.7.3 Horizontal Loads

The horizontal design loads at any level of the structures shall consist of the following lateral loading conditions:

- Wind loads shall be based on the requirements of IS 875: Part 3 for a basic wind speed of 39m/s
- Seismic loads based on the IS1893 recommendations and all structures are to be designed for Seismic Zone 3.

9.7.3.1 Design Load Combinations

For the purpose of computing stresses and deformations, the following minimum load types and consequential effects shall be taken into account as applicable.

- Self-Weight SW
- Superimposed Dead loads SDL
- Live loads LL
- Seismic Loads EQ
- Wind Loads WL

DL includes SW and SDL

Serviceability Limit State Load Combinations

S. No	Load Combination	Dead Load (DL)	Live Load (LL)	Seismic Load (EQ)	Wind Load (WL)
1.	DL + LL	1.0	1.0	-	-
2.	DL + EQ	1.0	-	1.0	-
3.	DL + WL	1.0	-	-	1.0
4.	DL + LL + EQ	1.0	0.8	0.8	-
5.	DL + LL + WL	1.0	0.8	-	0.8

Ultimate Limit State Load Combinations

S. No	Load Combination	Dead Load (DL)	Live Load (LL)	Seismic Load (EQ)	Wind Load (WL)
1.	DL + LL	1.5	1.5	-	-
2.	DL + EQ	1.5 or 0.9	-	1.5	-
3.	DL + WL	1.5 or 0.9	-	-	1.5
4.	DL + LL + EQ	1.2	1.2	1.2	-
5.	DL + LL + WL	1.2	1.2	-	1.2

Notes:

1. Earthquake and wind loads are reversible.

2. DL plus appropriate percentage of LL is to be used for calculating Seismic Weight for seismic loads in the load combinations 2&4.

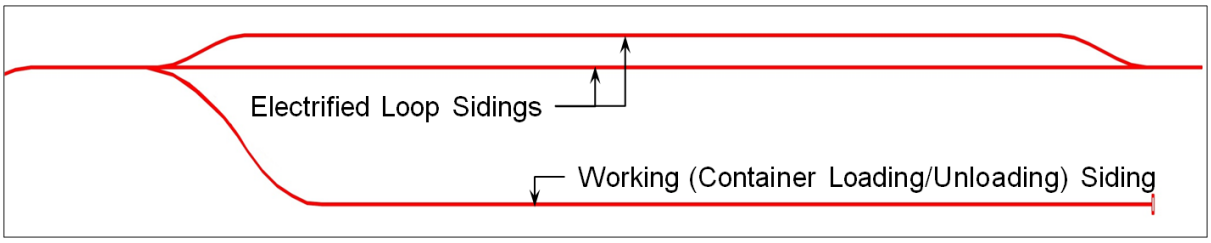
10 Internal Rail and Road Facility

10.1 Internal Rail Facility

10.1.1 Functional Requirement

The port is proposed with 3 full length rail lines with two electrified loop siding for pull and push operation of rake on a working siding and single working siding for loading/unloading of containers.

The schematic layout of the rail yard is as shown below:



The total length of the internal rail link to the Container Terminal is estimated at 2870m. The rail terminal is planned with 3 sidings (a working siding and two loop sidings) with clear length of 700 m. The track spacing for the Rail Terminal is 6m between two adjacent rail sidings to allow for maintenance access and inspection of containers and wagons. Spacing between working siding and loop siding is planned considering the future deployment of extra rail sidings to cater to the future hinterland traffic. A secondary storage area for containers is provided adjacent to working sidings.

The proposed rail lines and the associated rail facilities within the port is shown in **Drawing DELD11137-DRG-25-0000-CP-6001**.

10.1.1.1 Design Criteria

The rail yard area is planned with a total outer dimension of 1,110m length and 62m width. This area will also be on reclaimed land. After consolidation of dredged material reclaimed, the yard area will be levelled and fill material (CBR 20) will be spread and compacted for base layer. For the track portion the sub-base will be CBM and infill concrete will be provided in between sleepers and rails.

Since the rail yard would be developed, by reclaiming the suitable dredged material comprising of, dense sand with shell fragments as well as gravels. In order to consolidate the area surcharge fill would be required. The surcharge is placed in various section of the reclaimed area for consolidation to avoid any liquefaction in conjunction with vibro-compaction. Apart from this no ground improvement would be required for the rail yard development.

10.2 Internal Road

10.2.1 General Requirement

The Internal Terminal Access Road includes, ground preparation, formation of subgrade and construction of new heavy duty pavement roadway of approximately 2900m length on the reclaimed land.

The Internal Terminal Access Road works include the provision of concrete kerbing, line marking, signage, road lighting, surface and subsurface storm water drainage and all other services/utilities and miscellaneous road furniture.

10.2.2 Functional Requirement

Internal connectivity of the terminal will be developed by the terminal operator selected by VISL authority. The proposed internal road for traffic flow within the port is shown in **Drawing DELD11137-DRG-25-0000-CP-6002**.

Most of the terminal roads will have two-way traffic. The truck lanes under the RTG as well as under the quay crane will have one-way traffic. The quay apron - yard movement will be anti-clockwise whereas the yard – gate/ rail yard movement will be clockwise.

10.2.3 Type of Pavement

Hard surfacing will be required for the terminal roads. Hard surfacing options include the following.

10.2.3.1 Concrete Block Paving

Block paving has a highly durable hard surface, possessing at the same time, flexibility to accommodate limited amounts of differential settlement.

High quality concrete blocks are laid on a layer of screeded but un-compacted sand on top of lean concrete or cement bound granular material. The surface is vibrated to give the final profile and forcing the sand into the inter-block joints, so connecting the individual units into a homogeneous surfacing and at the same time giving the surface its strength and continuity. Performance of block paving is very sensitive to the skill of the EPC executing agency, but there are numerous examples of successful installation world-wide.

Concrete block paving can be maintained without sophisticated construction plant. Necessary plant such as jackhammer, power source, hand tools, plate compactor and hand held diamond bladed demolition saw can be owned and operated by the terminal operators without the need for external Agencies. Another advantage is that as the paving can be lifted and re-laid for installation of services with minimal disruption and without heavy breaking equipment, noise and dust.

Some localized cracking can occur at high point loads (corner castings, dolly wheels) but these are unlikely to have a significant impact on operations if the cracking is within small areas.

10.2.3.2 Asphaltic Paving

Asphaltic paving is relatively quick and easy to construct and maintain. It has been successfully used in roads and in container terminals. However, high performance asphalt requires specialized binders (eg. very stiff bitumen) and asphalt mix design and is not always reliably available. Control of quality can be more difficult than for concrete block construction.

Asphaltic/ bituminous materials can deteriorate more quickly than concrete paving and this can lead to poor performance in a ports environment. In particular the surfacing is susceptible to deterioration and rutting under high point loads and narrowly channeled vehicle movements with heavy vehicles moving at relatively low speeds. Local indentations can readily occur under high point loads.

10.2.3.3 Concrete Slab

Concrete slab construction can be either cast in-situ or precast panels.

Cast in-situ concrete provides a hard and durable surface for port paving. It is more expensive to construct than concrete block or asphaltic paving. Differential settlement may cause cracking in the slab which, in turn would be expensive to repair.

Pre-cast concrete paving consists of reinforced concrete panels (approximately 2m × 2m) laid on a base similar to block paving. Use of in-situ panels can result in problems where differential settlement occurs, including uneven surfaces and discontinuities or ‘steps’ between panels.

10.2.3.4 Preferred Pavement for Internal Roads

Based on the above it is proposed to adopt the asphalt paving for the internal road.

10.2.4 Design Life

The road shall be designed and constructed to give the following design lives:

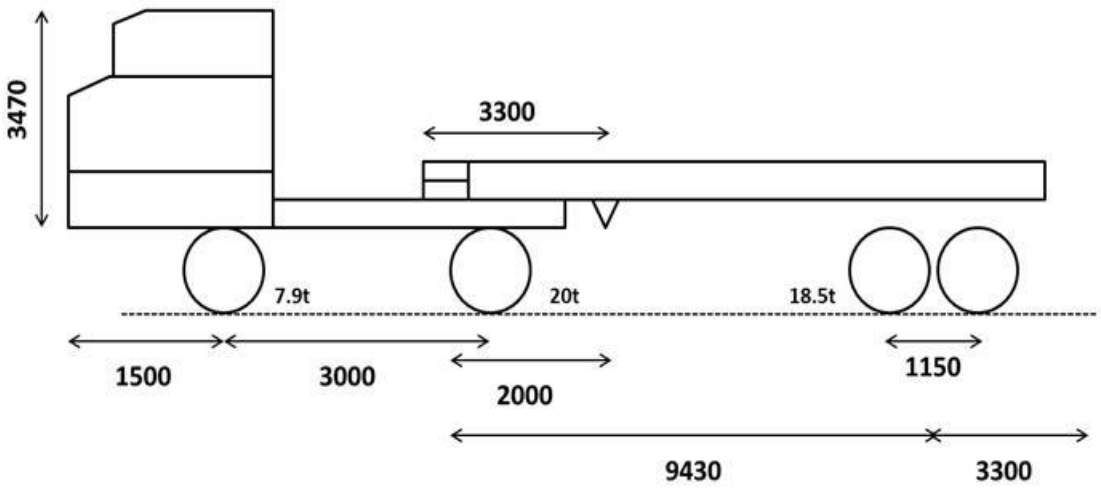
Table 10.1 Design Life for Roads

Component	Design Life (Years)	Maintenance Interval (Years)	Routine Maintenance by Employer	Unacceptable Repair and Maintenance
Road	20	5	Repair of localised damage	Any removal/ replacement to correct out of tolerance settlement.

10.2.5 Design Criteria

The road pavement shall be designed for the following vehicles/plant:

- Tractor / trailer trucks (assume throughput 1.0M TEU per annum)
- Geometric Design of internal roads shall be done as per IRC and MORTH specifications
- The design traffic of 150 MSD (Million Standard Axle) is to be considered for the sub-base.
- Typical configuration of trucks to be confirmed with the selected terminal operator.



- Axle load
  - Front axle - 7.9T
  - Second axle - 20T
  - Third axle - 18.5T
  - Rear axle - 18.5T

Access Road pavement design is to be carried out as per the provision of IRC: 37 - 2001 and IRC: 58 – 2002 which is used for heavy duty pavement design for National Highways in Indian climatic condition.

10.3 Logistics Area

10.3.1 Introduction

The logistic area includes the proposed container yard area, yard pavement, circulation within the yard and the other utilities. The requirements of various components have been briefed in this section.

10.3.2 General Requirement

The design and construction of pavement for Container yard shall be carried out in accordance with the criteria, standards and specifications given in this section. Where alternative specifications or materials are proposed to bring in innovation in design etc., those shall be approved by the Independent Engineer with specific relevance to the standards.

The Concessionaire shall undertake the necessary soil, material and pavement investigations and traffic volume and axle load studies in accordance with the Good Industry Practice for preparing detailed designs.

The materials, mixes and construction practice shall meet the requirements prescribed in the IRC, IS, MORTH and British Pavement Association (BPA) Specifications and Guidelines.

10.3.3 Type of Pavement

The type of pavement within the yard shall be classified as:

- Roadways : Vehicle movement areas
- RTG runways : Specific strip of land required as RTG crane wheels path and may be separately strengthened depending on the RTG Crane wheel load specifications
- Stack area : Space for stacking of containers/cargo

10.3.4 Design Requirement

Flexible and rigid pavements shall be designed and constructed as per the specifications of relevant IRC Standards and MORTH Specifications.

For Pavements in container stack area, effects due to sustained loading due to container stacking shall be evaluated following the recommendations of BPA Guidelines.

Runways for cranes shall be reinforced concrete beams supported on compacted ground or on piles. Concrete Beams shall be designed and constructed as per the specifications of IS: 456. The method of design of Precast Concrete Slab shall be done as per the specifications in IS: 15916 and IS: 15917.

10.3.5 Design Life

Design life of the yard pavements shall be as mentioned in section 10.2.4.

10.3.6 Performance Requirements

- The longitudinal gradient of yard and the slope of RTG runway shall not exceed 0.5% (point five per cent).
- The pavement structure shall be capable of giving the specified performance over, the entire operation period.
- During the operation and maintenance period, the pavement strength shall be evaluated periodically through the standard testing methodologies in accordance with the procedure given in IRC: 81. Any stretches exhibiting any structural deficiency shall be rectified.

10.3.7 Materials

The pavement construction materials for sub-base, base course shall conform to the requirements prescribed in MORTH Specifications and IRC Standards.

All materials, construction operations, workmanship, surface finish and quality of completed construction for all pavement works including sub-grade, sub-base, base course, bituminous surface course for the pavement shall conform to the specified requirements and comply, with the provisions of Section 900 of the MORTH Specifications.

10.3.8 Road Structure

The approach roads to the Container terminal area are designed taking into consideration the density of traffic and the wheel pressure of the tractor trailers, tankers, trucks etc. All roads are designed to IRC Class AA standards.

10.3.8.1 Ground Improvement

As discussed in section 8.2.3, no ground improvement is envisaged for the internal roads within the yard area

As no ground improvement needs to be carried out throughout the container terminal area based on the soil strata it is expected that compacted reclamation fill would be adequate bearing stratum for the internal roads, no specific improvement measures are proposed for the internal roads.

10.3.8.2 Maintenance of Road

Road maintenance work is to be carried out as per IRC Code 82-1982. The Maintenance work will involve following

- Restoration of rain cuts;
- Maintenance of earthen shoulders;
- Maintenance and Repairs work in connection with Bituminous work viz. Filling potholes and patch repairs, Fog seal, Crack fill, resurfacing of carriageway, etc.

Major maintenance by resurfacing the carriageway will be required in every 5 years.

10.3.9 Road Furniture

The road furniture required will include standard lane marking strips of thermo plastic compound of 10cm width (white) as lane dividers and 15cm width (yellow) edge strips on either sides. Road signage like stop signs, give way, merging or diverging traffic signs will also be required in accordance with IRC: 67 and IRC: 35.

10.3.10 Drainage

10.3.10.1 System Requirements

Storm Water Drainage will be through a system of underground covered drains provided to discharge the collected runoff into the natural waterways already existing so that storm water gets drained from all areas of port operations quickly.

The Container Yard will have heavy duty grated channel on both ends, draining half of the container yard on either both sides of the yard road for the full stretch.

10.3.10.2 Design Requirements

Grading and drainage schemes need to be fully integrated with terminal operating plans so as not to create impediments to efficient operations.

The desired grades in roadways and paved container stacking areas shall not be more than 1.0%.

Surface catch basins shall be avoided in wheeled driving areas and the empty container storage areas as they require warped surfaces that reduce equipment efficiency and service life.

The use of 1% sloped continuous planes with slot drains within these areas should be maximized.

Site drainage is developed through a series of graded planes, creating a series of peaks and valleys. Level slot or trench drains are located in the valleys to collect runoff within the paved container stacking areas, gate area, and roadways. Peaks and valleys shall run east-west in the traffic aisles wherever possible.

RMG runways shall be designed to be level.

Run-off collected from yard shall not be drained off directly to sea, but shall be sent to effluent treatment plant first.

All drain components must be structurally capable of carrying all the incidental loads including that of travelling crane wheel load, if there comes a possibility of crossing/running of the crane wheel at any point of time over the said drain component or any part of it.

Drains must not be located close to an electrical trench/facility unless it becomes imperative.

Design of drainage network and parts of it shall follow Good Industry Practices.

Separate storm water and sewerage systems shall be provided with the Port which shall be designed to comply with the following requirements:

- CPHEEO: Manual on Sewerage and Sewage Treatment
- BS EN 752: Drains and sewer systems outside buildings; and
- BS:8301: Code of practice for building drainage.

Storm / rain water drainage system from the roof terrace and various levels of the building and drains shall be by means of draining and surface run-off water to rain water recharge pits for ground water recharging.

Effluent treatment plant shall comprise of preliminary, secondary (chemical & biological) and tertiary treatment units. The treated effluent shall be recycled and reused for desired areas make up, flushing and for vehicle washing requirement. As per guidelines by MoEF, it shall be ensured to provide high flow UV System in tertiary effluent treatment plant.

10.3.11 Sewerage Pipe Work

All ductile iron pipes and fittings shall be lined internally with a lining of high alumina cement mortar in accordance with BS EN 598. Where Zinc coating is proposed for the external finish, it shall be in accordance with BS EN 598 and be followed by an epoxy finish. This shall cover the internal surface of the socket.

Flanged pipes shall comply with BS EN 545. Ductile iron flanges shall have the dimensions given in the relevant tables in BS EN 1092-2. All bolts and nuts for flange joints shall be of grade 4.6 of BS: 4190 and shall be hot-dipped galvanized in accordance with the requirements of BS EN 1461.

10.3.12 Street & Yard Lighting

The lighting system shall consist of the following major components.

- High Mast Lighting
- Lighting on both side approaches to the gate complex
- Canopy lighting of gate complex

The lighting shall comply with the standards, requirements and specifications given in Indian Standard ‘Code of Practice for Lighting of Public Throughfare’ IS: 1944.

Power supply shall be from the Port substation along with standby generating set of the capacity to supply the required power.

30 m high masts with numerous luminaries of suitable type and power shall be used in yard. These are fitted with mechanisms to bring down the luminary assembly along with the frame to accessible height for installation/maintenance.

Lighting on internal traffic circulation roads, if not covered by high mast lighting, can be covered by standard street lights at suitable spacing to achieve the illumination level. These lighting shall be installed on street light poles of 9m height at spacing of 30m fitted with high pressure sodium lanterns with 15 Lux average level of illumination.

10.3.13 Cable Installation System

The system comprises of cable trays and concrete encased underground trenches. The tray and conduit system provides support and mechanical protection for cables. The cable trays will be of steel pre-fabricated type, connected together as an integrated unit. The vertical spacing between any two-cable trays will be 300-mm minimum. Separate cable trays shall be used for HT power, LT power, and control and instrumentation cables.

All outdoor runs of cables shall be routed on overhead trays or buried directly in ground depending upon the layout considerations to be worked out during detailed engineering.

11 Utilities for Land Lord Facility

11.1 Requirements

The utilities related to the land lord facility shall cover the following:

- Land lord facility building
- Fishery Harbour
- Breakwater

11.2 Services

The services systems for the land lord facility building have been conceptualized based on past experience and acceptable International design standards. Effort shall be made to conceal all services and still provide access to these for accommodating changes in requirement in future. Conservation of energy, optimization of resources, eco-friendliness and State-of-the-art technology shall be the key factors in the design to ensure and reduce maintenance hassles.

Every effort shall be made to design, layout and install equipment in locations which will tend to encourage routine preventive maintenance by providing easy access for operation personnel. Manual isolation will be provided to enable servicing, expansion or renovation of any part of the system without interrupting the services in adjacent areas.

11.2.1 HVAC System

11.2.1.1 Reference Standards

Following standard & guidelines shall be adopted while designing the HVAC system.

- National Building Code of India (NBC) 2005
- Energy Conservation Building Code 2007 (Revised on May 2008)
- ASHRAE Hand Books.
  - Refrigeration 2010
  - Fundamentals 2009
  - HVAC System & Equipment 2008
  - HVAC Applications 2007
- Duct construction standards as per relevant BIS Codes & SMACNA standards
- Air filters as per ASHRAE 52.1-1992 and 52.2-2007
- Indoor Air Quality as per ASHRAE 62.1-2010
- Motors, cabling, wiring and accessories as per BIS Codes
- National Fire Codes 2000
- National Electric Codes (NEC)
- ASHRAE Standard 90.1 2010

11.2.1.2 Basis of Design

11.2.1.2.1 Outdoor Design Conditions

Outdoor design conditions that correspond to 0.4% annual cumulative frequency of occurrence for HVAC system design have been considered as follows:

Summer	:	33 °C (91.4 °F) DB 29 °C (84.2 °F) WB
Monsoon	:	32°C (89.6 °F) DB 26 °C (78.8 °F) WB

Winter	:	30°C (86 °F) DB 24 °C (75.2 °F) WB

11.2.1.2.2 Indoor Design Conditions

Based on our past experience, indoor design condition for Office area is proposed as follows:

Dry Bulb Temperature	:	DB : 24 + 1 °C (75 + 2 °F)
Relative Humidity	:	Less than 60%

11.2.1.2.3 Air Conditioned areas

Office area including conference room shall be provided with air conditioning using Variable refrigerant volume (VRV) units.

11.2.1.3 Mechanical Ventilation

Toilet : 10 ACPH with equivalent amount of conditioned air from adjacent space. Door under cut out of 40mm or double louvered air transfer grilles shall be provided in main entrance door to the Toilet for achieving the desired result.

Stores : 6 ACPH

Pantry : 5 ACPH with equivalent amount of conditioned air from adjacent space. Door under cut out of 25 mm or double louvered air transfer grilles shall be provided in main entrance door to the Pantry for achieving the desired result.

Canteen: Air circulation by ceiling fans

11.2.1.4 Design Parameters

VRV Units - Performance rating of the Units shall be based on following design parameters:

Maximum input power for VRV units

- At full Load : 1.3 IKW/TR

Ventilation Fan:

Maximum fan outlet velocity for fan upto 450 mm dia	:	9.14 m/s (1800 fpm)
Maximum fan outlet velocity for fan above 450 mm dia	:	12 m/s (2400 fpm)
Maximum fan speed for fans upto 450 mm dia	:	1440 RPM
Maximum fan speed for fans above 450 mm dia	:	1000 RPM

Filtration:

Air Washer units	:	Washable synthetic type air filters having 90% efficiency down to 10 microns (MERV 8)

11.2.1.5 System Description

11.2.1.5.1 Central Variable Refrigerant Volume Control System

Major air conditioning space (workstation area) shall be provided with Variable Refrigerant Volume (VRV) air conditioning system having centralized outdoor condensing unit (with multiple scroll compressors) mounted on terrace. This outdoor unit shall be connected to multiple indoor units like duct-able, cassette or hi-wall. The indoor units shall be connected to outdoor unit through a single copper refrigerant pipe system. At-least one compressor in each outdoor unit shall be provided with variable frequency drive whereby refrigerant flow through copper pipe shall be varied based on the AC load being encountered. The outdoor unit shall have built-in energy efficiency features like capacity control, oil return operation controls, intelligent defrost control and compressor control etc.

The indoor units shall be similar in operation and appearance as conventional split units and shall provide independent on-off control, temperature setting etc. However, in terms of energy efficiency, the system shall be capable of operation down to 5% of total installed capacity with proportionate power consumption. The system shall provide approximately 30% energy saving over traditional air-conditioning system (consisting of split units) in view of following features:-

- Individual accurate space control
- Multiple compressors in outdoor unit in conjunction with inverter drive compressor to modulate refrigerant flow based on requirement.
- Minimizing heat transfer losses due to superior refrigerant piping system.

The variable refrigerant volume (VRV) system shall provide additional benefits in terms of low sound level due to remote compressor location. Temperature setting of each indoor unit shall be controllable through individual corded micro-processor based controller. This remote controller shall have self-diagnostic facility to automatically identify fault for more reliable operation.

11.2.1.5.2 Duct Construction and Fire Safety

All ducts shall be fabricated out of galvanized sheet steel (GSS) as per SMACNA standard for long life and as per fire norms.

11.2.1.5.3 Toilet/Pantry Exhaust

Pantries and toilets shall be provided with mechanical ventilation system. The system shall consist of in-line / propeller fan with ducting and grills.

11.2.2 Electrical Services

11.2.2.1 Reference Standards

The following standards and codes shall be followed during detailed design of the services:

- Local By - Laws
- National Building Code of India – 2005
- Energy Conservation Building Codes 2007 (Revised Version May 2008)
- Relevant codes of National fire Codes 2008
- Relevant codes of Bureau of Indian Standards
- Institute of Electrical & Electronic Engineers (Design Hand Book)
- Illuminating Engineering Society of North America (Design Hand Book)
- IEC 60726/ IS: 2026 (Part 1, II and IV)/ IS 11171(Part III): Transformers (Cast Resin)
- IEC 60831/ IS 13340 & IS 13341: Capacitors
- IEC 60947 / IS 13947: Specification for low voltage switch gear & control gear
- IEC 62305 / IS 2309: Lightning protection system
- BS 7430, IS 3043: Earthing & bonding
- BS 7671 requirements for electrical installation
- NEC – NFPA 70, National Electric Code
- NFPA 101, Life safety code
- NEC, National Electric Code of India

11.2.2.2 Source of Power Supply

Kerala State Electricity Board shall provide the power supply to the port facilities by upgrading the 66 KV line to the existing Vizhinjam substation to 110/220KV, along with a dedicated GIS substation planned to VISL at the land adjoining the truck terminal at Kdrarakkuzhy. It is required to run a new receiving line to the Port Main Receiving Substation to draw the power load requirement for the port development activities. Some critical loads such as emergency lighting, headed equipment of ELV systems etc. shall be additionally backed up using UPS system.

11.2.2.3 Emergency Power Supply

Entire land lord facility building is provisioned for 100% emergency power backup. All lighting, convenience power, HVAC, PHE and Fire Fighting System shall be backed up by the DG sets generating power at 415 Volts, 50 Hz. All DG sets shall be radiator cooled type. The DG sets are proposed to be located on ground floor. The proposed configuration of DG sets shall be 1 No. 315 kVA and 1 No.100 kVA.

All DG sets shall be operated with Auto Mains Failure panel. AMF panel will switch the above loads onto DG supply within 15 seconds. In case of repair/ maintenance or operational difficulty with any DG set, DG sets shall be manually interchangeable to cater only to the critical loads

Residential silencer shall be provided for each DG set. Independent flue pipe from each DG set shall be taken out up to the terrace level. Stack height for the flue pipe from the DG sets shall be as per CPCB norms and DG flue gas shall be discharged outdoors minimum 30 m in standalone chimney. The noise level from DG sets will not exceed 75 dB(A) at 1 m distance, during day time and 70 dB(A) during night time. Entire installation and distribution shall be in accordance with guidelines laid down by the CPCB.

11.2.2.4 UPS Power

Centralized UPS power shall be planned to support critical services such as Security systems, Data networks, emergency lighting.

11.2.2.5 System Arrangement

The power will be made available by KSEB to VISL (by constructing a new 220/66 KV substation near proposed truck terminal at Kdarakkuzhy from their 220 kV overhead transmission lines from the main receiving substation and shall be stepped down to 66 kV in the outdoor switch yard and with necessary metering arrangement to the indoor switch yard through 3×1 run of singles core underground cables.

The power from the 220/66 kV switch yard is drawn through twin 66 kV feeders each of 3 core XLPE cables to the Gas insulated substation SS-1 through the 2 Km dedicated approach road to the Port.

The power is distributed from this substation SS-1 to respective loads. All the low tension loads meant for illumination, office buildings etc. are drawn from SS-1 through a 66 /11 kV transformers. The substation shall be equipped with capacitor banks for automatic power factor correction and for maintaining a PF of not less than 0.9.

The system design is in accordance with rules and regulations of central electricity authority (CEA) / the chief electrical inspectorate of the state government, and as per standards prescribed by BIS / IEC.

All the LT loads will be drawn from SS-1 through adequately sized UG cables and to feeder pillars of the respective buildings.

The voltage of the different systems is as under.

Main incoming from KSEB	220 kV
Outdoor switch yard	220 kV / 66 kV
One No of GIS switch yard to SS-1	66 kV
Transformers at SS-1 for loads of yard and Quay Equipments	66 kV / 11 kV
Transformer for LT loads at SS-1	11 kV / 415 V
Feeder cables from SS-1 to the Electrical houses of equipment	11 kV or 415 V as per requirement
LT feeders for illumination and of roads, yards, Buildings, etc.,	415 V / 230 V, 3 Ph / 1 Ph

The schematic diagram and the conceptual layout of electrical requirement is as shown in Drawing **DELD11137-DRG-0000-CP-7001**.

11.2.2.6 System Earthing

Earthing system shall be designed in accordance with IS: 3043/ BS 7430. Dedicated Cooper earthing pits shall be provided for neutral earthing of major substation equipment like Transformers & DG sets. Interconnected GI Earthing pits shall be provided for body earthing of major substation equipment like HT Panel, transformers, DG sets, MV panel etc. Distribution earthing shall be carried all along the MV distribution system, and effectively bonding the equipment.

Earthing for light and power points shall be carried out with insulated copper earth wire running throughout the length of the circuit and shall be terminated at equipment, fixtures, etc. with effective bonding to main earthing grid.

Separate and distinct earth stations with insulated electrode shall be provided for the following system:

- Main LV panels
- MV Panels
- UPS
- Server
- EPABX
- Neutral of transformers
- Neutral of DG Sets

All the pits and main earthing bars are to be connected to each other to make a common earthing electrode grid. However, equipment earthing pits shall not be connected to common grid and separate insulated copper cable shall be laid from earth pit to equipment. If the resistivity of the soil is very high then, earthing calculations shall be done to ensure that the conductivity is maintained at less than 1 Ω.

11.2.2.7 Recommended Illumination Levels

The general lighting of various spaces shall be planned to provide the following illumination levels:

S. No.	Space	Recommended Type of Lamps	Illumination Level Lux
1.	Corridors & General Circulation area	LEDs	100 - 150
2.	Toilets	LEDs	100 - 150
3.	Offices	T5 Lamps/LED	350
4.	Service Areas	LEDs	150-200
5.	Outdoor parking	High mast	30

Utility areas shall be provided with energy efficient LEDs lamps. In general fluorescent tubes shall be T5 lamps designed for high lumen output and system miniaturization, specially designed for operation with electronic gear and best suited for dimming. Lamps shall have highest energy efficiency for T5 lighting and lowest CO_2 emission compared to any other comparable light source. High mast light shall be provided with sodium lamp mounted at 30m high for average 30 lux. Lamps shall be specified for the lowest mercury content and 100% lead free.

11.2.2.8 Lighting Control System

It is recommended that lighting fixtures in common areas may be provided with centralized control from distribution boards as per BIS 3646 Part II.

11.2.2.9 Street and Security Lighting

Street/security lighting must be provided as per minimum physical security and fire safety requirements employing vandal resistant light fittings.

Lighting for secluded areas shall be low maintenance, vandal resistant, high intensity and energy efficient type. Lighting for grade car park areas, walkways (both covered and uncovered) and external areas shall be automatically controlled by timer for energy saving.

11.2.2.10 Emergency Lighting Installation

Emergency lights through centralized UPS system shall be provided for 50% of the Stairways and 10% of circulation space, corridor, lift lobby; indoor car parking and all the aviation lamps shall be provided through UPS.

Self-illuminated Exit Signs shall be provided on all entry and exit locations.

11.2.2.11 System of Wiring

The system of wiring shall consist of PVC insulated HFFR copper conductor stranded flexible wires of 1100 volts grade of insulation, in metallic conduits for all exposed wiring. Minimum size of copper conductor shall be 2.5 sq. mm for lighting and 4 sq mm for power. Colour code shall be maintained for the entire wiring installation that is Red, Yellow and Blue for the three phases, Black for neutral and Green with Yellow band for earthing.

11.2.2.12 Switching Arrangement

Switching arrangement at various locations shall be planned keeping in view the ease with which isolation can be achieved and also the level of fault protection desired at the particular current rating.

In the panel, switching on incoming circuits shall consist of air circuit breaker (ACB) whereas switching on outgoing circuits up to 1000 amps shall be moulded case circuit breaker (MCCB) and above 1000 amps shall be ACB's. Main distribution panels and sub-distribution panels shall incorporate moulded case circuit breakers. Final distribution panels shall incorporate miniature circuit breakers and earth leakage circuit breakers.

Air circuit breakers (ACB) moulded case circuit breakers (MCCB) and miniature circuit breakers (MCB) shall be of 4 pole for 3 phase power distribution with advance neutral feature for safety, which shall ensure connecting first and breaking last of the neutral contact and avoiding high voltage in the single phase circuits. However, in case of synchronization of DG sets, 3 pole breakers with NIC (neutral isolation contactor) shall be provided for incomer of all DG sets. Four pole breakers shall provide further safety against the unbalance floating current in the neutral, which could be dangerous, especially to the maintenance staff in case the floating voltage is more than 50 volts.

Main Distribution Boards and Sub-distribution Boards shall incorporate moulded case circuit breakers. Final distribution boards shall incorporate miniature circuit breakers & residual current devices (also known as "earth leakage circuit breakers") and shall have a minimum interrupting capacity of 10 kA. ELCB shall be of 30mA.

11.2.2.13 Lightning Protection System

The entire building shall be protected from lightning by providing Advanced Lightning Protection System – based on NFC 17-102.

This system contains Air terminal mounted on top of the building, screened insulated cable as down conductor, lightning event counter and low impedance ground. From Air terminal to the low impedance grounding grid only one conductor will be used or connected using copper cable installed from each arrestor to earthing stations. This system eliminates requirement of multiple horizontal and vertical down conductors used with conventional system. The installation shall conform to French standard NFC 17-102 and Australian Standard as 1768-1991.

11.2.2.14 Cable Supports

The following shall be used for carrying wires / cables from the electrical distribution boards to loads:

- PVC conduit wherever the conduit is buried in slab at the time of casting.
- PVC FRLS conduits wherever the conduit runs exposed in ceiling space or chased in wall.
- GI cable trays or cable ladders and MS powder coated raceways for carrying multi-conductor cables to workstations.
- The fire partitions penetrations by raceways/cable trays shall be protected by approved sealing methods, maintaining the same fire resistance rating as the partition.

11.2.2.15 Location of Substation

The location of the substation is proposed in the utility area, west of the main container gate.

11.2.2.16 Sub Station – 1

The twin feeders of 3 core 66 KV XLPE cables coming from the 220/66 KV switchyard feeds to this substation through necessary circuit breakers. In this substation two 66 kV / 11 kV of 17.5 MVA capacity transformers are installed to step down the voltage to 11 kV meant for feeding the HT loads of the quay & gantry cranes. The capacity of transformer allows for additions in future.

In this substation separate 11 kV / 415 V transformers are also planned for taking care of all LT loads & other equipment operating at LT voltage. The substation is also planned with necessary circuit breakers and isolators. The substation is designed with independent feeders to the respective loads and adequate number of spare feeders.

11.2.3 Telecommunication

11.2.3.1 Reference Standards

The following standards shall be followed:

- ANSI/ TIA/ EIA 568-B Commercial Building Telecommunications Cabling Standard – March 2001
- ANSI/ EIA/ TIA-569-A Commercial Building Standard for Telecommunications Pathways and Spaces – February, 1998
- ANSI/ EIA/ TIA-606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings – February 1993
- ANSI/ TIA/ EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications – August, 1994

Following infrastructure shall be planned for voice/ data systems of the various areas in the Complex:

- All voice points as identified by VISL for Public areas, Service areas, and Common areas shall be connected through 10 pair telephone cable from the tag block located on each wing and each floor.

Provision shall be made for receiving 9 no. 10 pair incoming lines for the Complex. The location of the panel shall be decided by the client. The tag block to every point shall be supplied with 2 pair 0.81mm cables from the tag block to the point. The main telecom cable provided by the utility company shall be terminated in the building adjacent to outgoing tag blocks. The following shall be used for carrying wires/ cable:

- PVC conduits wherever the conduit is buried in slab.
- GI cable trays or cable ladders for carrying multi-conductor cables.
- RCC Hume pipes in external areas.

11.2.4 CCTV System

The requirements of security system vary as per VISL's requirement along with its geographical location. CCTV system is needed for security purposes and to monitor entry/exist gates and the boundaries.

The security system proposed shall comprise of Closed Circuit TV System (CCTV)

11.2.4.1 Closed Circuit TV System (CCTV)

Following spaces shall be provided with cameras:

- Main Entry/Exit to Complex
- Peripheral of parking
- Administration Building

The security console shall be located in the security room. Ample space shall be provided to view monitors. CCTV camera will help in internal surveillance such that images can be stored in any number of servers and can be viewed from any number of computers for which license has to be purchased. This will gives monitoring team flexibility in viewing the images from multiple locations.

The images can also be exported through secret network to the nearest police station in case of any emergencies.

Care shall be taken to ensure that the number of displays per screen is limited so that "individuals" can be recognized when viewing the display in all areas.

For image recording following procedure shall be adopted:

- CCTV recording method shall be DVR based;
- Utilizing "Watermarking" software to insure integrity of all image recording;
- Storage Memory - to maintain a record of two weeks minimum, unless local laws require a longer storage time;
- Administration functions for user access and system auto recovery as required;
- Real time monitoring of all images as required;
- Triplex function as required;

- On screen display function as a standard requirement;
- Use of pan tilt & zoom cameras shall be reduced to a minimum.

11.2.4.2 Installation Requirements

Colour TV cameras and monitors shall be used in locations where this is perceived as having a particular advantage based on “local” conditions or requirements. However, vehicle monitoring shall utilize colour cameras at all times.

Picture quality of all cameras shall have a horizontal resolution of 480 lines minimum.

Camera locations shall insure that picture “glare” is not present at the CCTV monitors in the control room.

Cameras located shall be capable of recording an identifiable image of all persons entering the area. Where cameras in corridors are installed it shall be possible to identify any person entering any room.

For public areas, CCTV cameras shall normally be concealed in a dome shape enclosure. Some cameras shall have special protection (Cameras exposed to weatherproof shall be for exterior areas, vandal proof, etc.) depending on their locations.

11.2.5 Water Supply

The mechanical service details for the various developments are indicated as below.

- Firefighting – pumping station requirement to be confirmed by the terminal operator
- Water supply to land lord facility building and other port functional buildings

The treated water from Kerala Water Authority connection will be brought into the underground storage tank of 1200 cum capacity. The treated water from the potable water sump near the proposed resort complex shall be pumped through pumps and pipeline of 200mm diameter supply to the overhead tank of 200 cum capacity located near the storage sump tank. The overhead tank is provided with the pipeline of two separate pipelines of 100mm diameter through which water is supplied to all port usage points and the land lord facility building by gravity.

11.2.5.1 Plumbing System

11.2.5.1.1 Reference Standards

National Building Code of India		Part IX September 2005
Codes & Design Guidelines:		
i.	American Society of Plumbing Engineers(ASPE)	Design Data Book Volume I to IV
ii.	Institute of Plumbing Engineers UK	Design Data Book – 2002
iii.	International Plumbing Code	2003 Edition
iv.	Uniform Plumbing Code of India	2008 Edition
v.	Energy Conservation Building Code	2007 Edition (Revised 2008)

11.2.5.1.2 Approach to Planning

The Plumbing services for the project shall be designed keeping in view the following:

- Requirement of adequate and equal pressure of cold water in public toilets, and other designated areas.
- The water storage tank capacity shall be adequate to ensure availability of water for 1.5 days required.
- Levels of roads / pavements and other services in the area.
- Water conservation using low flow fixtures.

11.2.5.2 Water Storage Sizing

It has been proposed to provide 1.5 days water storage capacity based on ultimate requirement at a central storage. The incoming mains shall be from underground storage sump proposed for the port activities. Water

supply line shall be led into fire reserve tanks, from where it shall be allowed to overflow in domestic water storage tanks. The water storage capacities of the tanks are as follows:

S. No.	Description	
1.	Underground Treated Water Storage	1 No. 15000
2.	Overhead Fire Reserve	1 No. 10,000
3.	Overhead Domestic Water Storage	1 No. 5,000

11.2.5.3 Water Distribution

Water distribution for domestic water supply shall be designed to ensure availability of minimal residual pressure and flow at all user outlets. The water distribution system for domestic water supply and flushing to all floors shall be through gravity feed. Domestic and flushing water tanks at the terrace level of building shall receive water through transfer pumps installed at plumbing plant room to transfer the water. However, flushing water shall have the provision to receive water from domestic tank.

Underground water storage tank and pump room housing fire pumps, transfer pumps shall be proposed in underground. All inlets, outlets, washouts, vents, ball cocks, overflows control valves and all such other piping connections including level indicator shall be provided for underground water storage tanks.

Full way gate valves of approved make shall be provided as close to the underground tank as practicable on every outlet pipe from the storage tank, except the overflow pipe. Overflow and vent pipes shall terminate with mosquito proof grating.

The overflow pipe shall be placed so as to allow the discharge of water can be readily seen. The overflow pipe shall be of size as indicated. A stop valve shall also be provided in the inlet water connection to the tank. The outlet pipes shall be fixed approximately 75mm above the bottom of the tank towards which the floor of the tank is sloping to enable the tank to be nearly emptied for cleaning.

The pipe sizing shall be based on fixture unit calculation as per ASPE standard. The pipe size of riser shall be restricted to nearest 4" size to optimize on capital cost, and for ease of installation and maintenance. However, the maximum velocity in the water supply piping shall not exceed 2.4 m/s.

Electronic water meters shall be provided in identified areas for water consumption recording for efficient monitoring and assessment. Head losses through water meter shall be accounted for in water distributions calculations.

Colour coding for flushing, domestic water supply piping shall be ensured for clear identification of the piping.

11.2.5.4 Appurtenant

Following appurtenant shall be included in the design of water supply system for efficient functioning:

Domestic Air Vents: Automatic air vent shall be provided on water risers to eliminate possibility of air locking and to ensure efficient water flow / pressure availability at the user outlets.

Flow Restrictors: Appropriate flow restrictors shall be provided for economizing on water consumption. The flow resistors shall be typically sized for following flow / discharge.

- Wash Basin : 6.3 LPM
- Kitchen Sink : 6.3 LPM
- WC Flushing : 3/6 LPF
- Urinal Flushing : 2.0 LPF

Ball Valve: Full bore gun-metal ball valve shall be provided for isolation of water supply for the designated area. Further chrome-plated angle valve shall be provided for water isolation to wash basin faucets and for WC cistern water supply.

Pressure Gauge: Pressure Gauge shall be provided on cold water supply piping for efficient balancing and monitoring of the system.

11.2.5.5 Sewage, Sullage and Storm Water Drainage

The following parameters/ site conditions shall be considered when designing the sewage, sullage and storm water drainage system:

- Natural slope of the area;
- Layout of different facility in the complex;
- Sub-soil water table;
- Soil condition;
- Provision of Sewage lifting station;
- Provision of venting arrangement for manholes;
- Construction of manholes & laying of pipes considering ground condition;
- Termination of vent cowl at terrace level;
- Provision of adequate slope for horizontal header in the under slung pipes especially for toilets

11.2.5.6 Sewage & Sullage Waste Drainage

The soil and waste shall be carried down in separate independently vented pipes. Two pipe drainage systems shall be adopted as per ASPE standard. The sanitary, waste & vent system shall be water tight and gas tight designed to prevent escape of foul gas and odour from various fixtures. Provision of ASP vertical vent shall be made for hygiene, safety considerations, and to avoid entry of foul smell into occupied areas.

Vent system shall be designed to facilitate escape of gases and odour from all parts of sanitary and waste system to the atmosphere at a point above the building and to allow admittance of air to all part of the system, so that siphon-age, aspiration or back pressure conditions do not cause loss of seal at traps.

It is proposed to use cast iron pipe for soil / waste drainage. The soil & waste piping shall be under-slung (in the ceiling slab of floor below) and the horizontal header shall be subsequently connected to the vertical stack located inside the associated pipe shaft which shall be coordinated carefully with other services and in consultation with Architect. Care shall be taken to avoid pipe runs in electrical switch rooms and other critical areas.

Provision for cleaning and rodding eyes shall be made at strategic locations to allow the system maintenance.

Grease interceptors are proposed for kitchen/pantry waste, located close to the source of grease. The design of grease inceptors shall be in accordance with ASPE standard and shall include cleanout at entry and exit. The cover shall be non-slip. Provision of independent vent shall be made to avoid odour / smell nuisance in the surrounding areas.

Drain channels shall be provided with adequate slope to affect self-cleaning velocity and shall terminate in sumps.

11.2.5.7 Design Criteria

The system shall be designed as per following design criteria stipulated in the “Manual for Sewerage & Treatment” published by the Central Public Health and Environment Engineering Organization, Ministry of Urban Development, Govt. of India, IS-SP/35(S&T)-1987 and National and International practices on the subject.

a.	Flow of sewage	:	90% of water supply (peak flow)
b.	Peak flow	:	3 times average flow
c.	Min. diameter of pipe	:	150/200 mm dia
d.	Min. velocity in pipe	:	0.6 mps
e.	Max. velocity in pipe	:	3 m / second
f.	Flow conditions in pipes:		
	– Pipes upto 400 mm dia	:	0.50 full running
	– Pipes above 400 mm dia	:	0.67 full running
g.	Min. depth of pipe below ground level:		
	– For branches	:	0.6 m

–	For other	:	1.0 m
h.	Formula for calculation and design of sewer lines	:	Manning's Formula

11.2.5.8 Sanitary fixtures and fittings

The selection of sanitary fixtures and fittings shall be carried out in consultation with the client. However, based on past experience, the following selection is proposed:

- All sanitary wares shall be white vitreous china. Water closets (European pattern) shall be wall hung. Water closet shall be provided with concealed dual flush type cistern.
- All wash basins throughout the complex shall be of white vitreous china under counter, oval wash basin / flat back wash basins with pedestal, single lever mixer fitting, waste coupling with CP bottle trap fixed to the outlet. Inlet connections shall be connected by CP angle stop cocks below the counter.
- Suitable accessories such as toilet paper holder, towel rings, soap dispenser. Soap dish shall be provided at suitable locations.
- Drinking water coolers with individual UV system shall be installed at suitable locations at each floor.

11.2.5.9 Sewage System

The sewage generated shall be disposed at the soak pit proposed near the land lord facility building.

11.2.5.10 Material of Piping

Following material for piping are proposed to be used on the project:

- CPVC pipes in chases, in shafts, GI pipes & on terrace for domestic and flushing water supply.
- CI & CILA material for sewage & drainage pipes within the core of the building.
- UPVC pipes (heavy density) for rainwater down-takes on the external fascia of the building.
- RCC pipes for external sewage disposal (manhole to manhole connection).
- RCC pipes for external storm water drainage (manhole to manhole connection).

11.2.6 Fire Protection Installation

11.2.6.1 Reference Standards

The design and planning of Fire Protection System shall be done keeping in view the following criteria:

- National Building Code Sept 2005: Part IV for Fire Protection
- Local Bye-Laws
- Relevant BIS codes: Specifically IS: 3044, IS: 5290 and IS: 5312, IS: 908 and IS: 2190, IS: 3844, IS: 15105
- TAC Manual (for reference and guideline)
- Consultation with local Chief Fire Officer

11.2.6.2 Basis of Design

The firefighting arrangement shall be designed as per the requirement of local guidelines, TAC & engineering design standard.

The entire fire safety installation shall be compliant with the most stringent codes / standard for the entire project area to ensure the highest safety standard and uniformity of system. Further, before property is opened to public, the fire protection shall be fully operated and tested under simulated conditions to demonstrate compliance with the most stringent standards, codes and guidelines.

Following functional system shall be provided; strictly in compliance with the listed reference standards:

a.	Piping System	:	Piping system confirming to IS: 1239 – MS Heavy Class
b.	Fire water static Storage	:	Fire water static storage has been provided in accordance to NBC requirement.
c.	Fire Pumping system	:	Pumping system comprising of independent pumps for hydrant, sprinkler & jockey application has been provided.

d.	Hydrant system	:	External & internal hydrant complete with hose reel.
f.	Trolley mounted CO_2 system	:	For Transformer Room / LT Panel Room / DG Room, all as per local bye-laws.
g.	Hand held fire Extinguishers	:	Strategically placed at designated areas.

11.2.7 Drainage

The port land is about 500m wide and about 800m in length along the coastline and a hilly area in the rear of the proposed port. The drainage system needs to be designed to minimize the potential pollution in the port basin. The rainy season persists during the Southwest and the northeast monsoon. May to November is the wettest months of the year with an average rainfall in excess of 220mm per month, with a maximum of 356mm in June. The average annual rainfall is around 1800mm. The average number of rainy days per year is 132 days. The maximum rainfall intensity has been taken as 30mm / hr.

It is proposed to lay the trench drain parallel to the proposed internal road. These drains are connected through various cross drains bringing the water from the different areas of the terminals covering the port operational buildings. All the drains will be of Random Rubble (RR) stone pitched and grouted with cement mortar of 1:4.

A drainage system will be provided below the stacking area, with buried perforated drain lines. An impervious layer will be placed in the ground below these transverse drain lines. The storm water runoff from the yard area and adjacent roads will be collected, via trenches and buried pipelines.

The storm water from the administrative offices, transit sheds and all other buildings will also be connected to the storm water drain. The waste water collected from the workshop will be treated in an oil skimmer before disposing off to the storm water drain.

11.2.8 Sewerage System

The sewerage system is limited to the areas wherever office buildings, canteens, and other operational buildings are constructed. For the isolated buildings where the quantity is negligible, it is proposed to construct septic tanks and connect the septic tank outlets to soak pits for disposal. The treated sewage shall be discharged to the main drainage network. During monsoon months, the sludge will be stored separately in a storage structure with adequate capacity. The treated water will be discharged into the main drainage system of the port. The sludge from the treatment plant will be processed and converted into Biomass used as manure.

There will be very little sewage water generated at the berths and hence separate treatment proposals are not contemplated.

The ships will not be allowed to discharge their sewage in the port complex. As per MARPOL convention, the ships are now required to have STP on board. In the initial phase of development, no STP has been planned in the port complex.

11.3 Fire Fighting System

The firefighting system is to be designed to be capable of both controlling and extinguishing fires. There will be two types of system i.e. Sea Water and Fresh Water. The sea water system would broadly consist of a fire water intake to draw water from the sea, pump house with pumps, nozzles for water curtains along the front side of operating platform, hydrants and distribution networks. The container berths will also be covered under the sea water system.

A centralized fire station will be provided for attending to all calls which will house 2 mobile fire tenders. One fire tender will be provided with snorkel attachment.

Fire Alarm Bells will be located on permanent structures at strategic locations that can be heard by the terminal operators. Buildings where the hazard of fire and the occupancy are high will be provided with alarm bells (e.g. the workshop, administration building etc.). The fire alarm system will be activated by push buttons located at strategic places within the terminal areas and around the port's perimeter.

The conceptual layout depicting the utility requirements is as shown in Drawing **DELD11137-DRG-0000-CP-7002** to **DELD11137-DRG-0000-CP-7005**.

11.3.1 Fencing

The EPC executing agency shall provide permanent fencing around the site boundary. This comprises the relocation and, where necessary, replacement of the existing fencing located at the existing facility if any. Temporary fencing shall be provided to surround the Sectional Completion Areas and the EPC executing agency working areas.

Fencing shall comply with BS 1722-10 or equivalent relevant code of the Indian Design Standards.

12 Port Craft and Navigational Aids

12.1 Harbour Crafts

The summary of the requirements of Harbour Crafts envisaged for the Vizhinjam Port development are given in Table 12.1 below based on the Ship Navigation Studies.

Table 12.1 Harbour Craft Requirements

S. No.	Harbour Craft	Number of Crafts
1.	Tugs	
	– 70 T bollard pull	3
	– 40 T bollard pull	1
2.	Mooring Launch	2
3.	Pilot cum Survey Vessels	1

12.1.1 Tugs

Vizhinjam Port envisages a creation of a 1.2 km long inner channel dredged to 18.4m depth with 2 berths for handling large size container vessels. The maximum size of the ships to call at this port during initial development is fully loaded 18,000 TEU container vessels. As per the results of the ship navigation simulation studies carried out, for berthing / de-berthing of the design container vessels a minimum of three tugs of 70T and one tug of 40T bollard pull capacity are required.

These tugs are required to undergo statutory survey and dry dock at prescribed intervals. ASD tugs have better manoeuvrability and suitable for towing on line as well as for push pull method. The exact choice has to be based during detailed engineering stage, if these are to be purchased. If the marine operations are to be outsourced the EPC executing agency would decide on the type and number to be provided.

The broad design parameter for Tugs is as below:

Bollard Pull	70 T ASD
LOA	30m
Beam	9m
Draft	2.5 m
Speed	10 Knots-12 Knots
Fuel Capacity	86 m^3
Fresh water capacity	33 m^3
Main Engines/propulsion	Two diesel engines (Caterpillar)
Type of fuel	HSD/HFHSD
Genset	Prime mover- Caterpillar/Cummins Alternator – Same as prime mover Indian /Japanese /European Make
Auxiliary Equipment	Reputed Indian/ Japanese/ European Make
A/C	Centrally Air Conditioned
LSA	As per SOLAS
Fire Fighting	FFS or equal
Navigation and Electronic	Radar, GPS, DGPS, Echo-Sounder, AIS, Chart Plotter, Magnetic Compass,

Equipment	Autopilot, Bridge Watch Alarm, General Emergency Alarm, Intercom, Engine Telegraph, GMDSS A2
Pollution Requirements	As per MARPOL.

12.1.2 Mooring Launches

The main activities with these small boats are the transfer of mooring ropes between vessel and quay and transfer of mooring crew.

The mooring launches with good manoeuvrability will be about 10m long with open deck and single screw. The propulsion power shall be delivered by an electrically starting diesel engine of approximate 75-100 kW, driving the propeller shaft via a reverse reduction gearbox. Two mooring launches will be provided at the port.

12.1.3 Pilot cum Survey Vessels

Pilot boats transfer pilots to and from the incoming / outgoing vessels.

It is proposed to provide one all-weather type pilot launch. The pilot launch should be a twin screw with 15 to 20m overall length and of steel construction. The speed range shall be 15-20 knots. The pilot launches will be provided with survey equipment and it can be used for hydrographic surveys and for buoy lights maintenance.

12.2 Navigational Aids

12.2.1 Functional Requirement

Navigation aids for the port are required to ensure safe and efficient navigation of ships entering and leaving the port through the approach channel as well as berthing / un-berthing requirements inside the docks. It is required that that navigation will be carried out throughout the year, by day and night, except during cyclonic weather.

This section describes the minimum requirement of navigational buoys and leading lights to be installed in manoeuvring area for new port area.

The EPC executing agency shall develop a detailed Navigation layout and finalize the requirement and location of navigation buoys and layout in consultation and approval by the Independent Engineer.

This defines the minimum requirements, inspection and testing for navigational aids and leading light system to be installed.

All the Navigational aids, shall be supplied with complete inspection and certification of Internationally Recognized certification Authority.

The channel buoys are covered by the World Navigation Aid System rules which divide the buoyage system in two regions: “Region or System A” - “Region or System B”. Our project region or system is under “Region A”.

All the lights system shall be in accordance with IALA recommendations. The rules for System “A”, which include both cardinal and lateral marks, shall be in accordance with:

IALA - International Association of Lighthouse Authorities

IHO - International Hydrographic Organization

IMCO - International Maritime Code Organization

IAPH - International Association of Ports and Harbours

12.2.2 Navigational Buoys

Navigation aids for the port are required to ensure safe and efficient navigation of ships entering and leaving the port through the approach channel as well as berthing / un-berthing requirements inside the docks. It is envisaged

that navigation will be carried out throughout the year, by day and night, except during cyclonic weather. These aids will assist the captains and pilots in determining the position of vessel while transiting the navigational channel and manoeuvring inside the port.

The approach channel stretching from the breakwaters head to 21.0m contour has a width of 400m. The channel has a total length of about 2.8km. From the deep water initially the channel is oriented 343°, it takes a turn at a radius of 1200m before approaching straight into the harbour at an orientation of 317° N.

These aids as listed below are proposed to be installed on land or in water for guidance to all vessels for safe and regulated navigation in channels, basin, berths and docks.

- Fairway buoys, Port and Starboard buoys
- Leading / Transit lights
- BEACONS and
- Vessel Traffic Management Information System (VTMIS)

VTMIS will have the requisite communication, Radar system integrated into it.

Drawing DELD11137-DRG-25-0000-CP-8001 indicates the layout of navigational aids at Vizhinjam Port.

12.2.2.1 Fair Buoys, Port and Starboard Buoys

Fairway buoy (FB) marks the entry to the approach channel and also indicates the location of the pilot boarding area. Hence the vessels calling at port should be able to detect the fairway buoy while approaching the port. As per PIANC guidelines the maximum spacing of paired navigation buoys is 1 nautical mile. However, as per IALA guidelines the ideal spacing of paired buoys should be 3 times the width of the channel in the straight portion and 2.8 times the channel width in the curved portion of the channel. IALA[1] maritime buoyage system as per Region A in which Vizhinjam port falls will be followed. The lateral marks will be red and green colours to denote the port and starboard sides of channel.

A total of 14 buoys, which include 11 outer channel buoys i.e. one fairway buoy (3.5m dia.), 5 port side buoys (3m dia.) & 5 starboard buoys (3m dia.) and 3 buoys (2.5m dia.) in the inner channel and harbour basin marking the periphery of the harbour basin area would be required for the navigational purpose.

12.2.2.2 Leading Lights

It is necessary to mark the centre line of the channel with leading lights to ensure safe day and night navigation of vessels visiting the port.

The leading lines may meet the following criteria:

- Useful range: Navigation channel
- Visibility range: 20 nautical miles

The Leading lines and Leading lights are designed in accordance with IALA Guidelines and recommendations and the details are as follows:

Leading Light Requirements	Characteristics
Lead Light 1	
– Height of Front Leading light (FLL) above MHW	21m
– Height of Rear Leading light (RLL) above MHW	13m
Lead Light 2	
– Height of Front Leading light (FLL) above MHW	18m
– Height of Rear Leading light (RLL) above MHW	12m
Day Mark	As per IALA Guidelines

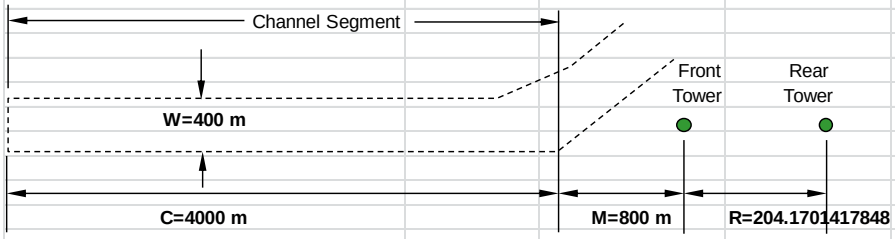
[1] *International Association of Marine Aids to Navigation and Lighthouse Authorities*

Leading Light Requirements	Characteristics
Light Characteristics	
– Front Light	Fl Y 1s
– Rear Light	Occ. Y 3s

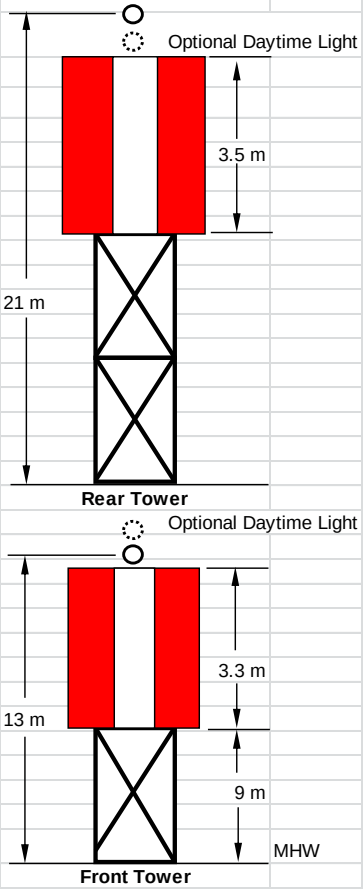
The schematic representation and details of the requirements of Leading Lights i.e. LL1 and LL2 is as indicated below:

Final Leading Line Configuration

Leading Line Name:	**VISL Channel LL1**	
Channel Length (C):	4,000	Meters
Channel Width (W):	400	Meters
Distance Near End/Front Twr (M):	800	Meters
Distance between Towers (R):	204	Meters
Range Front Light Intensity (Day):	70,000	Candela
Range Front Light Intensity (Night):	500	Candela
Front Dayboard Height:	3.3	Meters
Range Front Light Height (Night):	13.0	Meters
Range Front Light Height (Day):	14	Meters
Range Rear Light Intensity (Day):	80,000	Candela
Range Rear Light Intensity (Night):	500	Candela
Rear Dayboard Height:	3.5	Meters
Range Rear Light Height (Night):	21.0	Meters
Range Rear Light Height (Day):	20	Meters

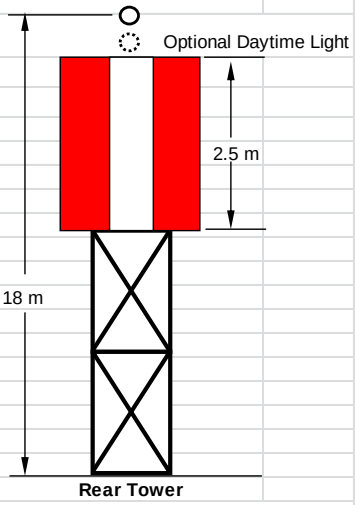


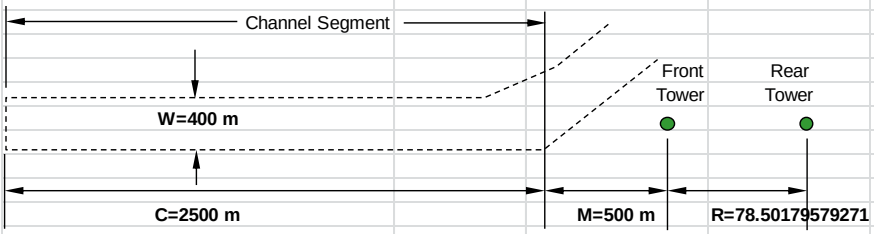
Final Channel Layout

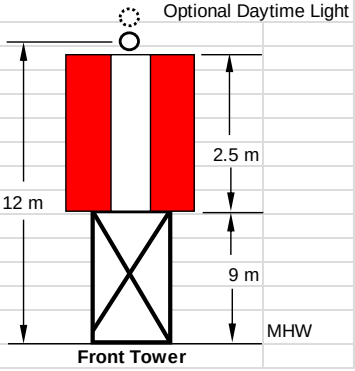


Final Leading Line Configuration

Leading Line Name:	**VISL Channel LL2**	
Channel Length (C):	2,500	Meters
Channel Width (W):	400	Meters
Distance Near End/Front Twr (M):	500	Meters
Distance between Towers (R):	79	Meters
Range Front Light Intensity (Day):	20,000	Candela
Range Front Light Intensity (Night):	500	Candela
Front Dayboard Height:	2.5	Meters
Range Front Light Height (Night):	12.0	Meters
Range Front Light Height (Day):	13	Meters
Range Rear Light Intensity (Day):	30,000	Candela
Range Rear Light Intensity (Night):	500	Candela
Rear Dayboard Height:	2.5	Meters
Range Rear Light Height (Night):	18.0	Meters
Range Rear Light Height (Day):	17	Meters







Final Channel Layout

The leading lights will be controlled by a sun-switch to ensure that the lights operate only during darkness or bad visibility. Power supply will be provided by batteries, to be recharged by solar panel systems mounted on the supporting structure, and/ or by power supply from the port distribution system. The battery banks shall be sized to ensure 24 hours continuous operation of the lighting system.

12.2.2.3 BECONS/ Breakwater Lights

Roundhead of the harbour and fishery breakwater will be provided with Beacon. The harbour breakwater will also be provided with RACON. The structure would consist of 200mm CHS with an access ladder on mass concrete block foundation to reach light position.

12.2.3 Design Life

The Navigational aids shall be provided to suffice the design life as mentioned in the table below:

Table 12.2 Deign Life for Navigational Aids

Component	Design Life	Maintenance Interval	Routine Maintenance by Employer	Unacceptable Repair and Maintenance
	(Years)	(Years)		
Navigation Aids	20	5	In accordance with manufacturer's manual.	Any removal/replacement of defective items or its fixing.

12.2.4 Design Criteria

The buoy is to be installed together with appropriate length of anchoring chain and verified that there is no fouling with the sinker in Lowest Astronomical Tide (LAT) with maximum ebb current. Similarly it should be verified that the length of the chain is sufficient and there is no undue strain on the buoy securing arrangement on Highest Astronomical Tide (HAT) with maximum current and wave condition. The buoy design shall include the follow as minimum.

- The buoy must be very visible and stable to grant good visibility considering a focal plane at over 6 meter height.
- The buoy float section or modules is to be manufactured in polyethylene while the buoy tower, to act as day mark, is manufactured in marine steel grade.
- Fastening is to be manufactured from stainless steel.
- The main float section or modules are filled with expanded closed-cell foam to ensure a water tight assembly.
- The buoy is to be self-coloured and resistant to UV degradation. If any painting is required, the applicable paint specification shall be supplied.
- The buoy float section shall be of 3 m diameter and complete with at least two lifting eyes on top side of buoy body.
- Two mooring eyes are fitted at opposite sides of the ballast skirt to allow the use of a standard bridle assembly.
- The Top marks, required, is comply with IALA recommendations and shall be complete with passive Radar Reflector.
- The buoy light should be solar charged.
- The buoy upper-structure shall grant easy and safe access to the Marine Lantern, Solar Panel(s), Top Mark and Radar Reflector for maintenance purposes.
- The buoy has sufficient static support area for safe transport and storage.
- The Solar Panel(s) is manufactured from silicon photo cells laminated between tempered glass and ethylene vinyl acetate. The frames are of anodized aluminium. The junction box is complete with protective diodes.
- All the lanterns are fitted with a six position lamp-changer, field selectable flasher, external sun-switch and six halogen lamps .
- The lantern lens is manufactured from an acrylic Fresnel moulding and has a minimum of 8° (eight degree) of vertical divergence. Lantern bases, is non-metallic.
- The lantern assembly is water proof and protected from sand and dust. The wiring is continuous.
- Spikes to be provided on top of lantern and solar panel for bird scare.

12.2.4.1 Mooring System for Buoys

The buoy mooring shall be designed in accordance with the site specific environmental data.

All the buoys chains shall be certificates by an International Classification Authority.

12.2.4.2 Leading Lights

These are normally used in pairs to guide vessels along channels. When viewed the light beam of one lantern appears directly above the other. One lantern is installed at a given point and the other is located at a distance behind and at a higher level and in line with the intended channel centre line. The lanterns are synchronized.

Height and position of leading lights to be decided in detail engineering.

Leading lights are to be fixed piled structure together with associated platform, ladder and fixed light structure fitted with required lights and day marks. It should have visibility range of at least five nautical miles.

A visual day-board is to be provided for daytime use in conjunction with a range light for night time use. Typically the day-boards are rectangular or triangular in shape.

Striped colours are to be provided in highlighting the board assisting in lining up the vessel in centre of the channel.

13 Fishery Harbour

13.1 General

The fishery harbour development is an added scope to the original contract as part of the CSR activity by VISL. This section details out the basic engineering of the various components of the fishing harbour and are described in detail in the subsequent sections below.

13.2 Introduction

The facilities at the fishing harbour include the following:

13.2.1 Functional Requirements

The fishery harbour functional requirement is as below:

- Fish landing centre with a total berth length of 500m.
- Provide access for berthing and mooring of the small mechanized vessels and country boats.
- Provide calm conditions for the fishery harbour operations.
- Connect the berth access with current road to the existing fishing harbour.
- Facilities for on-shore operations of fishery activities
- New beach area for the local community

The fishery harbour layout is as shown in Drawing **DELD11137-DRG-25-0000-CP-9001**.

13.3 Breakwater

13.3.1 General

The requirements for the fishery harbour breakwater shall be as shown in the Drawings. The EPC executing agency hall comply fully with the definition dimensions and setting out criteria.

13.3.2 Design Criteria

The design criteria for the breakwater have been discussed in Section 6 of this document and same is adopted to arrive at the requirements and design of fishery harbour breakwater.

The breakwater layout and the cross section of the same arrived at is as shown **Drawing DELD11137-DRG-25-0000-CP-9002**.

13.4 Quay Structure

13.4.1 Geometric Requirements

The berths for fishery harbour shall be constructed for overall dimension of 500m×8m. Initial 200m length of berth from the shoreline shall have deck top level of +1.7m CD while rest 300m berth shall have its deck top level at +1.5m CD.

The quay furniture's viz., Fenders and Bollards required for the fishery berth shall be provided at regular intervals to cater the requirements.

13.4.2 Deck Levels

Deck Level for various berths is as below:

Berth Type	Deck Level (m CD)
Fishery Berth	
– For Mechanized Boats	+1.70
– For Country boats	+1.50

13.4.3 Depth Alongside

The required depth alongside at the quay is as follows:

Parameter	Value
Design dredged depth – berth pocket (any scour protection to be below this level.	
– Fish Landing Berth	-2.0m CD
Allowance in design for over dredging /bed scour	Natural Depth available

13.4.4 Vessel Data

The design vessel sizes range and characteristics to be considered for design of berths is as follows:

Parameter	Design Vessel
Vessel type	Small Mechanised Fishing vessels and country boats
Length overall – LoA (m)	10
Beam (m)	4
Loaded Draft (m)	2

The vessel characteristics shall be confirmed with VISL during the detailed design of the structure.

13.4.5 Quay Structure Settlement/Deflection

The quay wall design shall consider the maximum permissible tolerances for horizontal and vertical alignment under the design loading conditions.

13.4.6 Environmental Condition

The full length of the quay structure shall be designed to withstand all environmental loads arising from the environmental conditions for a minimum return period of 100 years unless otherwise specified.

13.4.7 Design Criteria

13.4.7.1 Geotechnical Criteria

The safety factors to be used to establish the safe geotechnical working load capacities is as discussed in Section 7.3.3.

13.4.7.2 Design Loads

13.4.7.2.1 Dead Loads

It comprises the self-weight of the structure plus superimposed loads of permanent nature are considered as per IS: 875 (Part-I) 1987.

13.4.7.2.2 Live Loads

Uniformly distributed load of 1 T/m^2 have been considered for fishery berths on the deck and also on the fill behind.

13.4.7.2.3 Vehicle and Crane Loads

The following loads are considered on various berths:

Load Type	Fishery Berth
Live Load	1 T/m^2 OR Single lane of IRC class B vehicle, whichever is critical

13.4.7.2.4 Seismic Loads

The seismic loads on the structures are computed as mentioned in Section 7.3.4.4.

13.4.7.2.5 Wind Loads

As per IS Code 875 – Part 3: Code of Practice for Design Load (Other Than Earthquake) for Buildings and Structures for calculating the wind loads on the structures a design wind speed of 43.5m/s has been used as per the Indian standards.

However, during design studies the wind pressure shall be determined from the design wind speed in accordance with BS 6399 Part 2:1997.

13.4.7.2.6 Current Loads

The current loads on the structure have been applied on the submerged parts of the structure assuming the maximum current velocity as 1.5m/s. The current load shall be determined in accordance with BS 6349 Part 1, Section 5.

13.4.7.2.7 Wave Loads

A design wave height of 2.7m will be considered for the fishery berths. These are the maximum wave heights that could be expected at the berth locations under the extreme conditions.

13.4.7.2.8 Mooring Load

As per IS 4651: Part III, the bollard pull of 5 T at each bollard location will be considered for the design of the Fishery berth.

13.4.7.2.9 Fender Reaction (berthing force)

For fishery berths, inclined arch tyre fenders are to be provided at regular interval along the jetty.

13.4.7.2.10 Load Combinations

The above loads with appropriate load combinations, as per IS 4651 (Part 4): 1989 have been applied on the different components of the berths.

13.4.7.2.11 Materials and Material Grades

Concrete of grade M 40/50 and high corrosion resistant thermo-mechanically treated bars of Fe 500 grade shall be used for berth construction.

13.4.8 Design Life

The design life shall be as mentioned in Section 7.7.

13.4.9 Dead Weight of Structure

Dead weight of structure will include the weight of all structural components, using the specific weights mentioned in Section 7.8.7 as minimum.

The unit weight of all other materials shall satisfy the requirements of IS:875.

13.4.10 Buoyancy Loads

Buoyancy loads will include the uplift due to submergence in sea water using a specific gravity of 1.03.

Buoyancy loads may be disregarded where it is demonstrated that the buoyancy of submerged structural component do not contribute to higher stress levels in the structures or piles.

13.4.11 Area Loading

Structural design shall take account of dynamic factors resulting from vehicle braking, cornering, and accelerations.

Areas for different types of loading as per standard industry practice as indicated in Section 13.4.7.2.2.

13.4.12 Wind Loads

Wind forces on the structure and projecting superstructure of the berth are calculated with the methods given in recent version of IS 875 (Part 3).

13.4.13 Seismic Loads

Seismic loads on the structure are calculated with the methods given in recent version of IS 1893 (Part I).

13.4.14 Wave and Current Loads

Following waves and currents data shall be used to design the berth structures.

Extreme condition (100 Year Return Period)		
Significant Wave Height	H_s	2.7m
Design Wave Height	H_{max}	1.86 times Hs
Time Period	T	9.9s
Current (all direction)	V	0.3m/s
Tide level	MHWS	0.8m
Surge level	Wind Setup	0.3m

Wave and current force calculation shall be in accordance with BS 6349. Wave and current shall be considered in the same direction and relevant velocities added vectorially.

Assumed Morrison's coefficients are:

- Tubes : Cd = 0.7 and Cm = 2.0
- Profiles: Cd = 2 and Cm = 2

Marine growth of 50 mm on radius shall be considered on all submerged elements.

13.4.15 Temperature Loads

Temperature load shall be considered and combined with the other loadings as per the relevant standards, the difference in temperature gradient between top and underside of the deck shall be considered in the analysis and design.

Temperature differential shall satisfy the codal provisions mentioned in IRC 6.

13.4.16 Shrinkage and Creep Stresses

Unless otherwise specified, the magnitude of shrinkage and creep effects shall be assessed with the relevant methods as per code of practices.

- Mean Annual highest Temperature : 34°C
- Mean Annual Relative Humidity : 84%

13.4.17 Safety Factor

The partial safety factor shall be considered as discussed in section 7.8.16 in the design of berthing structures.

The load combinations shall be in accordance with IS: 4651 (Part IV) and any other combinations as instructed by the Authority during detail engineering.

13.4.18 Serviceability Checks

Crack width of all the structural elements shall be calculated wherever necessary as per IS:456.

Deflection of piles shall be limited to L/350.

13.4.19 Construction Methodology

The ground level at the proposed location of the fishery berth varies from -4m near the shore to -10m CD into the sea. The soil profiles near the fishery berth reveal the presence of loose to medium/ very dense silty sand with shell fragments from level of approximately -8.75 m CD to -27 m CD with SPT values varying from 10 at the surface to 80 within the layer.

It is proposed to first reclaim the site using the suitable dredged spoil upto a level of +1.0 m CD. The diaphragm wall, anchor wall supporting the quay deck are then constructed using the land based equipment. The soil behind the quay wall is strengthened using vibro compaction along with the hydraulic fill.

The concrete deck for the berth and the fixtures are placed thereafter. **Drawing DELD11137-DRG-25-0000-CP-9003** presents the sequence of construction for the Fishery berth.

13.4.20 Structural Arrangement of Fishery Berth

Basic engineering of the proposed scheme was carried out based on the design criteria established above. The proposed scheme consists of diaphragm wall of 0.50 m thick to provide the front face of the berth. The founding level of diaphragm wall varies based on the seabed level. High strength steel tie rods of 40mm diameter tied to the anchor wall are provided spaced at 4 m c/c.

The quay apron comprises of a hard stand pavement designed for the movement of fishery vehicles and other fishery operations.

Bollards and rubber fenders will be provided at regular intervals along the berthing face. The total length of the quay provided is 500 m.

Drawing DELD11137-DRG-25-0000-CP-9004 presents the structural arrangement and cross-section of the Fishery berth.

13.5 New Beach Area

Reclamation of 3.5 Ha till a level of +1.5m Chart Datum after consolidation, except the area demarcated for fishing harbor building, which shall be reclaimed till +1.70m Chart Datum after consolidation. Reclamation shall be carried out as mentioned in Section 8.2.

The reclaimed sea beach is provided with protection bund as shown in Drawing **DELD11137-DRG-25-0000-CP-9005**. The sea front shall have gentle slope (maximum 5 horizontal to 1 vertical).

13.6 Fishery Harbour Buildings

13.6.1 Geometric Requirements

Following buildings are provided for the fishery harbour. These buildings are required to cater the specific functional requirements.

S. No	Building	No.	Dimension (m×m)	Additional Requirements
1.	Auction Hall	2	100×10	Concrete floor with anti-skid granite flooring with open shed with powder coated aluminium sheeting or equivalent.
2.	Loading area	2	100×20	At the back of the auction halls with concrete flooring.
3.	Administration Building	1	30×10	Single storey building with toilets (2 men's + 2 women's) and steel furniture.
4.	Canteen Building	1	30×10	
5.	Cold Storage	1	25×15	Only space provided. Engineering, Construction & Maintenance Work shall be taken by HED.
6.	Net Mending Shed	1	25×15	Open shed with raised concrete floor.
7.	Gear Shed	1	20 × 8	Single storey building with separate small rooms of similar plan dimensions.
8.	Toilet Block	1	To suit requirements	10 men's + 5 women's toilet
9.	Gate Building	1	5×2	Single floor building

The typical plan of these buildings is as shown in **Drawing DELD11137-DRG-25-0000-CP-9006** to **Drawing DELD11137-DRG-25-0000-CP-9010**.

13.6.2 Functional Requirement

Buildings shall be primarily functional, but aesthetics are also important, and architectural appearance and detailing shall be in accordance with the Authority's Requirements and be to the satisfaction of the Independent Engineer.

13.6.3 Design Criteria

- Buildings constructed shall be water-tight, weatherproof, vermin-proof and durable to ensure minimal maintenance requirements.
- Windows shall be proprietary units of high quality polyester powder coated aluminium, with toughened glass, complete with all necessary glazing gaskets, beads, drips, flashings, catches and the like.
- Buildings shall be provided with adequate power outlets and power supplies generally to serve the building services.
- Buildings shall be provided with adequate telephone and telecommunication outlets and cableways to serve the Authority's systems and services.
- Buildings shall be provided with adequate internal and external lighting installations to meet the required functional performance night and day. Emergency lighting shall be provided where required by the Indian standards.
- Floor areas below ground level shall be of waterproofed construction.
- Buildings and the building services shall be designed and constructed to the National Building Code of India.

13.7 Internal Roads

Roads for fishery harbour shall comprise of 3 lane undivided road from breakwater to the fishing harbour entry gate, a divided road inside the fishing harbour area, and a 3 lane undivided road along the fish landing jetty with provision for turn-around at the western end. The internal road for the fishery harbour is as shown in **Drawing DELD11137-DRG-25-0000-CP-9010**. The design criteria of the same are similar to the one as mentioned in Section 10.2. Associated road furniture and lighting shall be provided as suitable.

Parking space of 25m x 10m shall be provided inside the fishing harbour nearby the administration building as shown in the layout. This shall be constructed with heavy duty paving blocks.

13.8 Utilities

The utilities for the fishery harbour in terms of water and electric supply, drainage and sewerage, illumination, communication etc. shall be provided as mentioned by the Authority. The EPC executing agency shall prepare and provide his basis of design for the same to meet the Utilities requirements.

Space for Effluent Treatment Plant has been marked in the overall plan of the fishing harbour area. The same shall be engineered, constructed and maintained by HED.

13.9 Fencing

The EPC executing agency shall provide permanent fencing at the locations shown in **Drawing DELD11137-DRG-25-0000-CP-9011**. This comprises of boundary wall to be constructed around the periphery of the proposed fishery operational areas.

The security system must comply with the requirements as mentioned below:

a) A security office and check post at the entrance to the fishery harbour.
b) Fishing Harbour boundary comprises of a rubble masonry wall 2m high and fixing Mild Steel (M.S.) posts with 4 rows of barbed wire fencing including necessary stays as shown in the drawing(s).

The M.S. posts shall conform to IS: 226 and shall be of angle iron of size indicated in the drawings. The angle iron shall be embedded in concrete to a sufficient depth below ground as indicated in the drawings. The barbed wire shall be of galvanised iron and shall conform to IS: 278.

14 Capital Cost

14.1 Introduction

The CAPEX (**Cap**ital **Ex**penditure) estimate has been prepared for the Phase 1 development. The development budget estimates are provided for reference only, and represent a professional opinion based on “macro” cost level and available site information. Actual costs may vary significantly from the provided cost estimates, depending on the construction timeline, changed market conditions, availability of materials, change of policy and other unlisted factors. Therefore, these budget cost estimates are not guaranteed figures for financing or carrying out any transactions.

The cost is divided into major components such as Project Preliminaries & Site Development, Dredging & Reclamation, Breakwaters, Berthing Structures, Buildings, Container Yard, Equipment, Utilities, Port Crafts & Aids to Navigation and Gate Complex etc. For each major component, based on its functional requirements, cost has been estimated as per the proposed development. For berthing structures, dredging & reclamation, breakwaters the cost estimation has been done by considering the basic engineering for the Vizhinjam Port site and environmental conditions. The unit rates have been taken based on the past projects carried out by AECOM in India and current market rates obtained from ongoing projects and vendors.

The calculations used to create the estimates reflect current construction costs (2014 base year), as well as estimated allocation of funds for construction contingencies and planning/design costs.

The following assumptions were used during the development of these estimates:

- The capital cost estimates are based on the project descriptions and drawings which were prepared after carrying out basic engineering of various components of the project. These will need to be developed, revised, and refined during the detailed design phase, and, therefore, some quantities shown in the cost estimates may undergo revision.
- A 5% planning, design and construction administration contingency has been included.
- A 15% overall contingency to allow for variation in physical & price contingencies has been included.
- All mobilization costs are included in respective entities.
- A construction methodology has been assumed based on experience of similar structures and utilized for costing provided in this section.
- The costs for components of the port outside the secured boundary that include components that are responsibility of VISL or RVNL (Rail Vikas Nigam Limited) such as VISL Building, Rail Yard and External connectivity, land etc. have been directly provided by VISL.
- Costs for environmental studies and potential mitigation have been estimated by LTR as part of the EIA studies.

The following exclusions were used during the development of these estimates:

- No taxes such as Service Tax, VAT etc. are included.
- The costs to furnish buildings and operate the facility are not included.
- General administrative supplies are not included.
- The estimate does not include the costs towards Interest during construction (IDC) and Financing

14.1.1 Project Preliminaries and Site Development

This includes the cost involved in site preparation & development for construction activities, pre-operative expenses, initial surveys & project studies.

14.1.2 Dredging and Reclamation

Dredging and reclamation is one of the major cost parameter for any port project. Based on the bathymetry contours provided by VISL and as per the proposed phase wise development plan, the dredging and reclamation quantities have been estimated.

It is estimated that reclamation quantity required for Phase 1 development will be met by dredging needs. The initial reclamation bund and shore protection revetment costs have also been included. The ground improvement costs are estimated over the complete gross reclaimed area of the port.

14.1.3 Breakwaters

As per the site specific near shore wave climate studies, basic engineering has been done for the breakwater considering the recommended design wave height. The breakwater is considered to have single layer concrete armour (ACCROPODE) unit. The cost estimation has been done for the breakwater based on estimated Bill of Quantities (BOQ) of armour units, crown wall, rubble requirements for secondary layer, core, bedding and toe protection. The Schedule of rates from Govt. of Kerala Public Works Department has been used to arrive at average cost of quarry material.

14.1.4 Berthing Structures

Cost estimated for the berthing structures includes container terminal berths and Fishery berths (8m apron width). The cost estimates are done considering the basic design of an open pile berthing structure with stone pitching underneath the berth. These include costs for piles, diaphragm wall crane rails where applicable, fenders, bollards, in-situ and pre-cast concrete works for container berths. While, for fishery berths, it is a diaphragm wall with tie rod arrangements and berth fixtures.

14.1.5 Container Yard

Major items included in the cost estimate for container yard development are site grading, pavement and RTG beams.

14.1.6 Equipment

Costs for required equipment's considered for Phase 1 development include Rail Mounted Quay Cranes (RMQC), Rubber Tire Gantry (RTG for container yard), Reach Stackers, Empty Handlers and Internal Transfer Vehicles (ITV), etc. including the spares.

14.1.7 Buildings

Major buildings included in the cost estimate include:

- Administrative Building including Port Users
- Port Marine Operations Building
- Yard Operations Building
- Crane Maintenance Building
- Maintenance & Repair Building
- Trouble Kiosk & Restrooms
- Quay Workers Restrooms
- Railway Master Building
- Reefer Shop & Genset
- Gate Canopy
- Canteen
- Fire Station
- Utilities Building
- Electric Substation
- Guard booth (Entry & Exit Gate)
- Fuel Station
- Fish Landing Centre Buildings
    - Auction Hall
    - Administration Office
    - Canteen
    - Net Mending Shed
    - Gear shed
    - Cold Storage

    - Toilet Block
    - Security Block
- Other Miscellaneous Buildings

14.1.8 Utilities

The following within the terminal utilities have been included in the cost estimate:

- Electric supply & distribution including high mast lighting for container yard and fishery harbour
- Fire fighting
- Lighting & Earthing
- Water supply
- Drainage & Sewerage
- Communication & IT (including Terminal Operating System)
- Compound wall for land side port area
- Workshop equipment
- Security infrastructure.

14.1.9 Port Craft & Aids to Navigation

The terminal will need tug boats for berthing, stopping & turning manoeuvers for the container & other vessels. The other port crafts include mooring launch and pilot cum survey launch. Aids to Navigation requirements have been assessed as per the IALA guidelines.

14.1.10 Gate Complex & Terminal Road

The gate complex, customs processing area and main terminal road (4 lane road along the container yard) costs have been included. The cost also includes the external road connectivity from NH 47 bypass to the port.

14.2 Block Cost Estimation Summary

The cost estimates have been summarized in Table 14.1 . The Phase 1 development is estimated to cost INR 4,280 Crores.

Table 14.1 Phase 1 Port Block Cost Estimate Summary

S. No.	Item	Capital Cost (in Crore INR)
1.	Project Preliminaries and Site Development	13
2.	Dredging and Reclamation	563
3.	Breakwaters	1,040
4.	Berths	354
5.	Buildings	29
6.	Container Yard	161
7.	Equipment	935
8.	Utilities and Others	80
9.	Port Crafts and Aids to Navigation	306
10.	Gates Complex & Road Development	86
	Total	**3,567**
	Allowable for variation in physical & price contingencies @ 15%	535
	Engineering and Project Management @ 5%	178

S. No.	Item	Capital Cost
		(in Crore INR)
	GRAND TOTAL	**4,280**

Table 14.2 below lists out the estimated capital cost split between VISL and Private Terminal Operator/) on the basis of discussions with VISL and AECOM understanding of the market. VISL will provide for the costs associated with the project including breakwaters, associated dredging & reclamation for fishery harbour and facilities for Fisheries harbour as part of Funded Works in the PPP Concession Agreement.

Private operator will provide facilities such as capital dredging, reclamation, container berth, terminal and gate complex development costs as well as equipment costs. It is also assumed that VISL will provide utilities to an agreed upon “hand-shake” point and the private terminal operator will be providing the utilities for the rest of the container terminal and the Fisheries Harbour.

For Phase 1 development, it is estimated that VISL will incur INR 1,317 crores whereas the private operator will incur around INR 2,963 crores. These cost numbers are for the FY14 base year and may vary depending on actual contractual agreements between VISL and the potential terminal operator.

Table 14.2 Phase 1 Port Block Cost Estimates Split between VISL and Private Port Operator

S. No.	Item	Capital Cost	
		VISL	Private Operator
		(in Crore INR)	(in Crore INR)
1.	Project Preliminaries and Site Development	5	8
2.	Dredging and Reclamation	30	533
3.	Breakwaters	1040	0
4.	Berths	16	338
5.	Buildings	5	23
6.	Container Yard	0	161
7.	Equipment	0	935
8.	Utilities and Others	0	80
9.	Port Crafts and Aids to Navigation	0	306
10.	Gates Complex & Road Development	1.4	85
	Total	**1,098**	**2,469**
	Allowable for variation in physical & price contingencies @ 15%	165	370
	Engineering and Project Management @ 5%	55	123
	GRAND TOTAL	**1,317**	**2,963**

14.3 External Infrastructure Cost Summary

The external infrastructure cost including land purchase, external connectivity, utilities and costs for environmental management & corporate social responsibility activities etc. has been provided by VISL and is summarized in this section:

Table 14.3 Total Phase 1 Project Costs (as provided by VISL)

S. No.	Item	Capital Cost (INR Crores)
1.	**External Infrastructure**	**410**
1.1	Rail	350
1.2	Power	50
1.3	Water	10
2.	**Phase 1 Port Costs**	**4,280**
3.	**Total (1+2)**	**4,690**
4.	**CSR & EMP Costs (5% of Item 1 plus 5% of VISL portion of Phase 1 port costs)**	87
5.	**Land Cost (140.42 Ha)**	937
	Grand Total (3+4+5)	**5,714**

15 Construction Schedule

15.1 General

The following sections describe significant construction elements in the development of port at Vizhinjam. Construction timeframes are described further based on BOQs and construction schedule for Phase 1 development is provided in this section.

It should be noted that the timeframes have been estimated based on an assumed construction methodology. The EPC executing agency may choose a different construction methodology depending on their capability and understanding and this may change the calculations presented below.

It should also be noted that delays in project implementation due to environmental or other statutory approvals, financial closure, and construction delays etc. that are beyond AECOM's control and cannot be estimated, have not been factored in the implementation schedule.

15.2 Breakwater

The breakwater construction is proposed to be the foremost activity as it is needed to provide shelter for other activities such as reclamation and berth construction to commence. It is intended to construct the rubble mound breakwaters using plant based on land and at sea. Due to the size of the Breakwater and a tight completion timeframe for Phase 1 development, it is believed it would be economical to incorporate both methods and work on two fronts or more. The typical sequence of construction is as follows:

- Bed preparation
- Core placing
- Toe construction
- Under-layer
- Armour- seaward and leeward sides and
- Crest structure.

It is estimated that about 10.5 million tons of rock is required for the construction of breakwaters and shore protection bund. The stones from the quarry sites would be brought and stacked at site in the plots earmarked for the different size of stones. The rock quarries are located at a distance of 50 km from site. There would need to be some improvements carried out in the approach road to the quarries to enable free movement of dumpers carrying rock to the barge loading site.

It is estimated that majority of the material will be supplied through barges from identified quarry sites. It is proposed that core of the breakwater be formed up to say -5.0m CD by end on dumping method as well as using the marine equipment viz. self-propelled side dumping and/or bottom opening barges.

It is envisaged that using the end on dumping and the floating equipment, about 12,000 T stones can be placed per day. The placement rates would also depend upon the adequate supply of stone to site from the quarry sites. The rest of the breakwater profile can be constructed by dump trucks from land. The building of breakwaters section shall be initially progressed by end on dumping, supplemented by barge dumping. Upon completion of the Accropode armour / stone armour to full length, the mass concrete capping shall be commenced from the root.

Both marine and land plants could be used for placement of under-layer and armour layers. It is expected that breakwater construction through marine plant will be halted for around 4 months/year during the monsoon season whereas construction through land plant will experience considerable downtimes. It is also acknowledged that some rock will be lost in the monsoon.

An allowance has been made in the development of the preliminary schedule covering the construction phase for downtime due to adverse weather. There will be a need to perform a detailed assessment of the potential for downtime during construction planning in order to derive the optimum solution in terms of working fronts, equipment selection and so on for the likely conditions at the site. It is expected that breakwater construction will be very

crucial for completion of the project in time. This will involve careful analysis of the logistics chain. It is estimated that the overall time schedule for breakwater can be completed in a period of 20 fair weather months from the start of construction.

Table 15.1 shows a calculation to assess breakwater construction schedule. The EPC executing agency may optimize this construction schedule based on equipment availability, adopted final design and construction methodology.

Table 15.1 Breakwater Construction Timeframe Calculation

Breakwater Construction		
Characteristics	**Quantity**	**Unit**
– Length	3,100	m
– Core	74,41,596	T
– Stone	30,73,100	T
– ACCROPODE (Total)	19,030	No.
Supply Needed	**Quantity**	**Unit**
– Rock/Core (Total)	1,05,14,696	Tons
– ACCROPODE (Total)	19,030	No.
Construction Time		
Rock/Core	**Quantity**	**Unit**
– Transport by barge	12,000	Tons per day
For 7 day week, expected duration of core/rock placing	**20**	**Months**
ACCROPODE	**Quantity**	**Unit**
– Placing rate	10	Min. each
– No. placed per day	54	Per 9 hour day
For 7 day week, expected duration of armour placing	**13**	**Months**

15.3 Berths

The container berths will be formed from concrete piles socketed into rock beneath the seabed supporting a suspended concrete slab for the quay apron. For the container berths, behind the concrete quay apron will be L section retailing wall on the reclamation bund that will contain the fill material for container yard.

To provide adequate protection from waves during monsoons the piling activity will have to be synchronized with the construction of breakwater. It is proposed to first reclaim the site using the suitable dredged spoil up to a level of +3.5m CD. The bored piles supporting the quay deck are then constructed using the land based equipment. The longitudinal and transverse beams connecting the berth piles are also constructed using land based construction.

Table 15.2 provides a calculation for estimating timeframe of completion for Phase 1 berth construction. It is estimated that container berths will be completed within 20 months and the fishery berths will take around 12 months for construction. It is assumed that construction activity will be impacted during monsoon and 50% of the time will be lost. It is important to note that breakwater will provide significant sheltering for the marine works. The EPC executing agency may optimize this construction schedule based on equipment availability, adopted final design and construction methodology.

Table 15.2 Marine Works Construction Timeframe Calculation

S. No	Description	Unit	Container Berths	Fishery Berths
			Quantity	Quantity
1.	Total Length	m	800	500
2.	Spacing of piles	m	6.5	0
3.	Bends/Piles/ diaphragm wall per Week	no.	1.7	3
4.	Number of Working Weeks Reqd.	no.	72	28
5.	No. of Simultaneous Operation	no.	2	2
6.	Efficiency of Operation	%	80%	85
7.	Effective Schedule with 80% Efficiency	Weeks	45	17
8.	Pre-Cast Works Lag	Weeks	12	8
9.	In-Situ Works Lag	Weeks	12	12
10.	Monsoon Delay	Months	2	2
	Total Work Completion	**Months**	**20**	**12**

15.4 Dredging

The dredging methodology has been explained in Section 8.3.

As discussed, it is recommended to deploy CSD for undertaking capital dredging works for the harbour. If the EPC executing agency wishes to operate in rougher weather conditions than permissible with CSD dredges, TSHD can also be deployed in the outer approach channel. This enables dredging operation to start before the construction of breakwater. It is recommended that CSD be used for dredging within the basin including the turning circle and berth pockets.

Table 15.3 shows calculation for calculating dredging completion time for Phase 1 capital dredging. The dredging work for outer harbour dredging is estimated to take 12 months whereas dredging inside the harbour is estimated to take 9 months accounting for the overall dredging time of 21 months. The EPC executing agency may optimize this construction schedule based on equipment availability, adopted final design and construction methodology.

Table 15.3 Dredging Works Timeframe Calculation

Dredging Calculations	Unit	Quantity
Average Production Rate (per Hr)	Cum	800
Number of Dredgers	no.	2
Hours Per Day	Hr/day	20
Working Days per Month	no.	25
Outer Channel Dredging		
Efficiency	%	85
Production per Day	Cum	27,200
Production per Month	Cum	680,000
Approach Channel Dredging Qty.	Cum	4,845,048
Working Months Needed	Months	9

Dredging Calculations	Unit	Quantity
Monsoon delay	Months	3
Total Time	**Months**	12
Inner Channel & Basin Dredging		
Efficiency	%	85
Production per Day	Cum	13,600
Production per Month	Cum	340,000
Turning Circle Dredging Quantity	Cum	904,300
Harbour Basin+ Berth Pockets Dredging Quantity	Cum	883,320
Working Months Needed	Months	7
Monsoon delay	Months	2
Total Time	**Months**	9

15.5 Reclamation

During Phase 1 the fill is needed from a depth varying between -13m and -5m up to 3.5m to 5.3m CD. It is estimated that all fill material for reclamation for Phase 1 development will come from dredging of the basin and the channel. It is assumed that reclamation can start after one month delay from construction of reclamation bund and continues for the duration of dredging activities.

15.6 Shore Protection Works

The reclaimed ground will be protected by providing rubble mound bund on all sides supported by sand fill from dredge spoils. This reclamation bund will be designed for a design life of 50 years. The methodology provided in the Construction Industry Research and Information Association (CIRIA) manual (manual on use of rock in coastal and shoreline engineering) has been followed.

The reclamation bund will comprise of quarried rock / stones from quarry sites and sand fill from dredge spoils. It will include a geotextile membrane on the rear face to enhance its fill retention properties. The outer face will be protected against wave action with suitable protection. The stones required for the construction of bund will be supplied by local quarry through barges and road trucks similar to breakwater construction.

The rock bund and revetment capital works are proposed to be performed in advance of the reclamation work in order to provide the containment necessary for the reclamation material. Assuming similar supply and placement rates as for the breakwater construction, it is estimated that reclamation bund be in parallel with initial dredging works and precede the reclamation works. It is approximated that reclamation bund and shore protection work will last for approximately 16 months. The EPC executing agency may optimize this construction schedule based on equipment availability, adopted final design and construction methodology.

15.7 Fishery Harbour

The fishery berths will be built along the seaward side of the proposed breakwater after the fish landing centre breakwater extension. It is estimated that around 500m berth length will be provided. The berth structure consists of 0.5m thick diaphragm wall to provide the front face of the berth. The founding level of diaphragm wall arrived at varied from -10m near the shore to -18m CD into the sea. . High strength steel tie rods of 40mm diameter tied to the anchor wall are provided spaced at 4 m c/c.

provides a calculation for estimating timeframe of completion for Phase 1 berth construction. It is estimated that the fishery berths will take around 12 months for construction. It is assumed that construction activity will be impacted during monsoon and 50% of the time will be lost. It is important to note that breakwater will provide significant sheltering for the marine works. The EPC executing agency may optimize this construction schedule based on equipment availability, adopted final design and construction methodology.

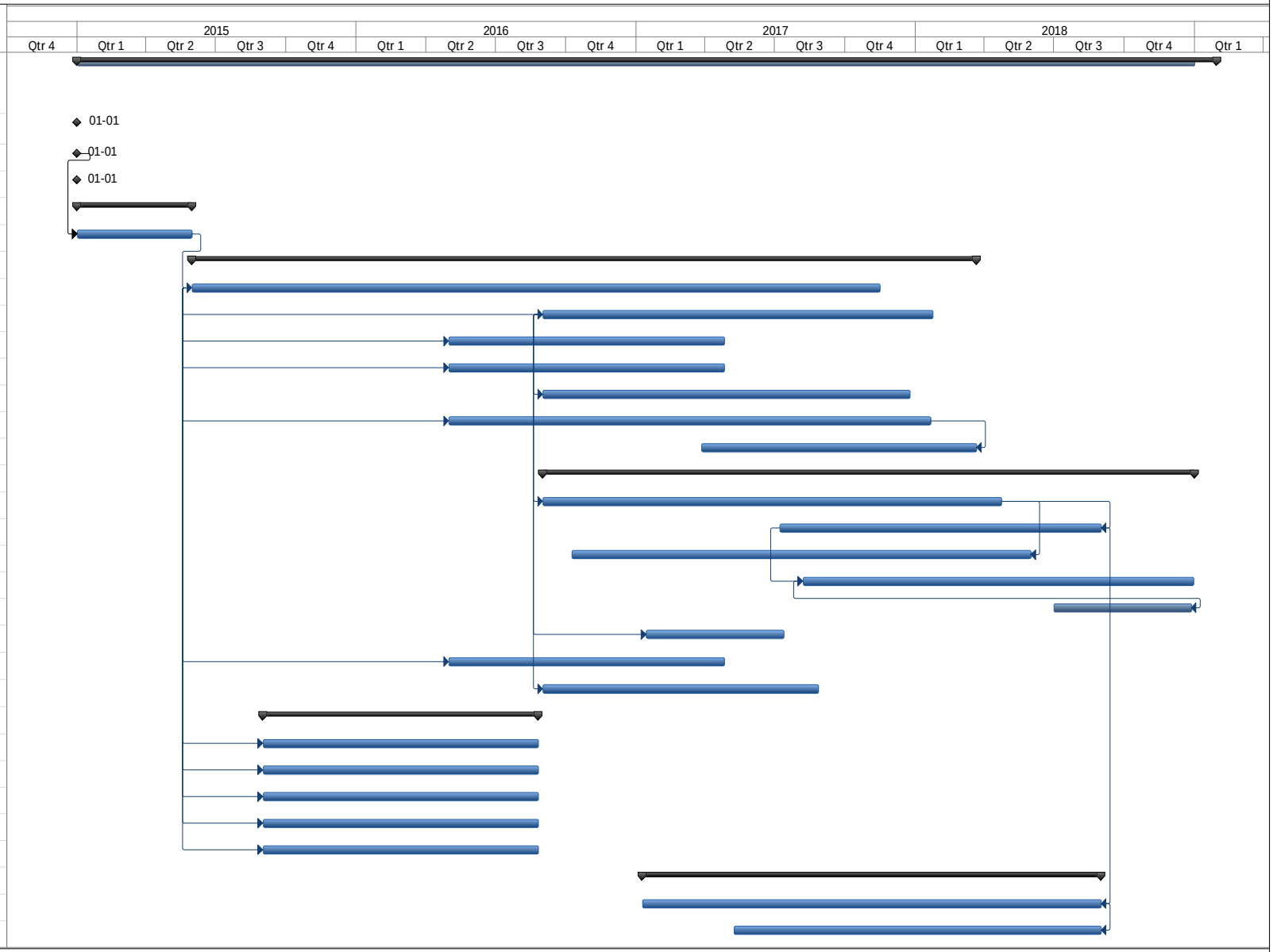
15.8 Utilities

The following within the terminal utilities have been included in the construction schedule:

- Electric supply & distribution including high mast lighting for container yard
- Fire fighting
- Lighting & Earthing
- Water supply
- Drainage & Sewerage
- Communication & IT (including Terminal Operating System)
- Compound wall for land side port area
- Workshop equipment's
- Security infrastructure.

Table 15.4 Vizhinjam Port Implementation Schedule

ID	Task Name
1	**Vizhinjam Port Implementation Schedule**
2	**Millstone**
3	Project Start
4	Project Completion
5	**Mobilization**
6	Mobilization
7	**Harbour Construction**
8	Breakwater Construction
9	Dredging - Approach Channel
10	Dredging - Harbour Basin
11	Reclamation Bund
12	Shore Protection Revetment
13	Reclamation
14	Ground Improvement
15	**Container Terminal**
16	Container Berth
17	Container Yard & Paving
18	Equipment Acquisition
19	Buildings & Other Infrastructure
20	Commissioning
21	**Port Craft Berth**
22	**Fishery Berths**
23	**FLC Buildings & Infrastructure**
24	**Port Estate Development**
25	Container Freight Station (CFS)
26	Warehousing/Distribution Center
27	Truck Terminal
28	Commercial Facilities
29	Residential Facilities
30	**Ancillary Infrastructure Works**
31	Road/Rail Access Within Port
32	Utilities



Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress

Annexure 1

Basic Engineering of Indian Navy, Coast Guard and Cruise cum Multipurpose Berth

Prepared for

Vizhinjam International Seaport Limited (VISL)

Prepared by

AECOM India Private Limited

December 2014

1 Indian Navy, Coast Guard and Cruise cum Multipurpose Berths

1.1 Background

1.1.1 Indian Navy and Coast Guard Facilities

Indian Navy (IN) and Coastguard (CG) showed keen interest in the Greenfield port development of Vizhinjam port to provide a terminal from strategic location point of view to cater the IN and CG ships in the region. Accordingly, VISL asked AECOM to incorporate the facilities for the same within the port as part of the proposed development which was an added scope to the original contract.

1.1.2 Cruise Berth

To boost the tourism sector in the region, a cruise terminal was proposed to be developed by VISL. However, VISL deferred the terminal development in Phase 1 with the primary focus to cater the container vessels. The cruise terminal is proposed to come up in the future phases as and when needed based on the prospective Concessionaire's interest.

1.1.3 Tasks Performed

AECOM prepared and submitted the Master Plan report and the DPR to VISL incorporating the above facilities within the port. AECOM also carried out the basic engineering of the IN and CG facilities to arrive at the CAPEX of the port development. However, as the project progressed, VISL decided to defer the facilities for the IN and CG from Phase I development.. VISL advised AECOM to modify the port layout and optimise the port CAPEX without these facilities. Based on this, AECOM modified the layout and the overall project cost during finalisation of the feasibility report.

The Basic Engineering of the IN, CG and Cruise cum Multipurpose facilities which was carried out by AECOM have been annexed to the Basic Engineering Report.

1.2 General Requirements

- The basic architecture of the Berth shall be determined to meet the operational requirements.
- The Berth design shall be:
  - Capable of handling range of ships at respective berths for safe, efficient and reliable operations
  - Shall be designed and constructed in accordance with Good Industry Practice
  - limit scour arising from ship wash, propeller action, currents etc. to the extent required for compliance with the Authority's Requirements and by the Contractor's design.
  - Provide access to trucks, fuel browsers and other vehicles at respective berths.
- The berthing structures shall have all the required accessories/fixtures including but not limited to rubber fenders including all its ancillaries, kidney type bollards to facilitate mooring of vessels, mooring rings on berth face, safety ladders, galvanised iron rubbing strip for the protection of edges of berths from rubbing of mooring ropes, slope towards landside to drain off water, galvanised iron edge angles at various locations including on the sides of openings/pits viz. rail grooves, tie down pits, storm anchor pockets, trenches etc., cable duct with two centre pits for power and water reeling drums.
- Berths shall be designed capable to handle the loads at the respective berths
- Berth should have adequate access for dealing with the heaviest User demand.

1.3 Introduction

1.3.1 Quay

The quay structures and associated fittings are required for the IN and CG berths are as below:

1.3.1.1 Indian Navy Berths

Construction of 500m long berths comprising of

- Navy berth 1:
  - 200m long berth of 20m wide with a loading ramp arrangement of width 35m to enable loading of vehicles through 20m wide bow ramps for 20,000 DWT Indian Naval Ships of 178m long vessels; Inclination of Ramp 12° (will be confirmed later), Ramp should be capable of taking loads up to 60 T.
- Navy Berth 2:
  - 300m berth with 30m width to the west on the lee of breakwater capable to handle 45,000 DWT Indian Navy vessels of 275m long;
- The berths shall be capable to take loading from 30 T mobile harbour crane with an outreach arm of about 23m and 18m at Navy berth 1 & 2 respectively for loading/ unloading of equipments, machineries, and other equipment etc.
- Provide access to trucks, fuel browsers and other navy vehicles.
- Provide access for berthing and mooring of the vessels.
- limit scour arising from ship wash, propeller action, currents etc. to the extent required for compliance with the Authority's Requirements and by the Contractor's design.
- A services gallery below the wharf deck just behind the berthing surface is provided to carry all the services lines. The said gallery is having a clear height of 2m inside for easy inspection. This gallery shall carry all electrical, communication, water, sewer, firefighting, fuel lines as necessary. For easy entry-exit to this gallery multiple access points are provided along with suitable ventilation system. For access to this gallery for cables and/or pipes, cope points at every 30m are envisaged.
- For security of the entire area earmarked for Navy, chain-link fencing with barbed wire at top, 10m high watch towers, high mast lightings, sentry post with rest rooms are provided at both Navy Berth Areas.
- Toilet blocks with 2 men's & 2 women's toilets with bathroom facility are provided, one block in each Berth.

1.3.1.2 Coast Guard Berth

- Provide 120 m long coast guard berth. The berth shall capable for handling 30m long coast guard vessel with maximum size of 3,000 DWT.
- Loading of vessels through 2T capacity mobile crane. No rail mounted or mobile harbor crane required.
- Provide access to trucks, fuel browsers, forklifts.
- Provide access for vessel berthing and mooring of the vessels.
- A services gallery below the wharf deck just behind the berthing surface is provided to carry all the services lines. The said gallery is having a clear height of 2m inside for easy inspection. This gallery shall carry all electrical, communication, water, sewer, firefighting, fuel lines as necessary. For easy entry-exit to this gallery multiple access points are provided along with suitable ventilation system. For access to this gallery for cables and/or pipes, cope points at every 30m are envisaged.
- Slots in deck provided for installing/fixing portable ladders for access from smaller vessels or emergency purposes.

1.3.1.3 Cruise cum Multipurpose Berth

- Provide 300m long berth capable to handle cruise and multipurpose vessels of 265m long vessels of approximately 70,000DWT.
- Provide access to passengers to embark and disembark.
- Provide access for berthing and mooring of the vessels.
- limit scour arising from ship wash, propeller action, currents etc. to the extent required for compliance with the Employer's Requirements and by the Contractor's design.

1.3.2 Quay Services

Incorporate facilities, pits and ducts for the following:

- Provide adequate drainage to the quays.
- Provide adequate drainage of cable slots, crane track slots and pits.
- Provide adequate marking/signage for safe operation over the quay deck.

1.4 Geometric Requirements

1.4.1 General

Permissible tolerances for surfaces and manufacturing and installation of elements are as per the Technical Specification.

1.4.2 Quay

The requirements for the quay structure shall be as set out in the Layout **Drawing DELD11137-DRG-25-0000-CP-A001**. The Contractor shall comply fully with the definition dimensions and setting out criteria.

1.4.3 Depth Alongside

The required depth alongside at the quay is as follows:

Parameter	Value
Design dredged depth – berth pocket (any scour protection to be below this level. – Indian Navy Berth 1 – Indian Navy Berth 2 – Coast Guard Berth – Cruise cum Multipurpose Berth	 – -12.0m CD – -15.0m CD – -7m CD – -7.8m CD
Operation requirement bed level	Small area dredging required for Indian Navy berth 1
Allowance in design for over dredging /bed scour	Natural Depth available

1.4.4 Crane Tracks and Crane Beams

The requirements for the crane track and crane beam shall be as per this document and specifications.

1.4.5 Location and Orientation of Berths

The IN berth 1, berth 2 and CG berth are located on the leeside of the breakwater. The IN berth 1 and CG berth are contiguous and are perpendicular to the shore, while IN berth 2 is to the west of container terminal on the other side of the channel as shown in layout **Drawing DELD11137-DRG-25-0000-CP-A001**.

1.4.6 Deck Levels

Deck Level for various berths is as below:

S. No	Berth Type	Deck Level (m CD)
1.	Cruise cum Multipurpose Berth	+4.20
2.	Indian Navy Berths – Indian Navy Berth 1	+4.20

S. No	Berth Type	Deck Level
		(m CD)
	– Indian Navy Berth 2	+4.20
3.	Coast Guard Berth	+4.20
4.	Cruise cum Multipurpose Berth	+4.20

1.4.7 Design Criteria

1.4.7.1 Design Ships and Dredged Levels

The structural design of the berths shall be carried out for the design dredged level based on the design vessel sizes to be handled at these berths:

Table 1.1 Design Ships and Dredged Levels at Various Berths

S. No.	Vessel Type	Design Vessel Size	Design Vessel Dimensions (m)			Minimum Designed Dredged Level at Berth
		(DWT)	LOA	Beam	Loaded Draft	(m w.r.t. CD)
1.	Coast Guard	3,000	120	16	4.7	-7
2.	Indian Navy berth 1	20,000	178	35	-	-12
3.	Indian Navy berth 2	45,000	275	32	-	-15
4.	Cruise cum Multipurpose	70,000	265	32.2	7.8	-9

1.4.7.2 Geotechnical Criteria

The brief description of the existing geotechnical information at site has been provided in Section 4.5.7 of this report. Basic engineering design of the berths has been carried out considering relevant subsoil profiles at the location of berths.

The following safety factors are used to establish the safe geotechnical working load capacities of the piles.

Table 1.2 Adopted Values for Factor of Safety for Piles

Type of Pile	Factor of Safety
End Bearing	3.0
Skin Friction on compression piles	3.0
Skin Friction on tension piles	4.0
Lateral Load	3.0

The design pile penetration depths would be estimated based on the generalised soil profile in order to develop adequate capacity to resist the maximum computed axial bearing and pull out loads, if any. In the present case the piles will mainly be end bearing onto rock.

1.4.7.3 Design Loads

1.4.7.3.1 Dead Loads

It comprises the self-weight of the structure plus superimposed loads of permanent nature are considered as per IS: 875 (Part I) 1987.

1.4.7.3.2 Live Loads

Uniformly distributed load of 3 T/m^2 have been considered.

1.4.7.3.3 Vehicle and Crane Loads

The following loads are considered on various berths:

Load Type	Cruise cum Multipurpose Berth
Live Load	2 T/m^2 UDL Standard Class AA - wheeled vehicle on the deck as per IRC Code of Practice for Road Bridges (Article II – Loads and Stresses)
	Indian Navy Berth
	3 T/m^2 UDL or Standard Class AA - wheeled vehicle on the deck as per IRC Code of Practice for Road Bridges (Article II – Loads and Stresses). 30 T capacity mobile harbor crane with maximum out reach of 30 m.
	Coast Guard Berth
	2 T/m^2 UDL Standard Class AA - wheeled vehicle on the deck as per IRC Code of Practice for Road Bridges (Article II – Loads and Stresses). 10 T capacity mobile harbor crane with maximum out reach of 20 m.

1.4.7.3.4 Seismic Loads

The seismic loads on the structures are computed in accordance with the seismic code of India IS: 1893-2002. Vizhinjam falls under Zone III as per seismic map of India with the following factors:

Zone factor	0.16
Important factor (I)	1.5
Response reduction factor (R)	3

The seismic horizontal coefficient shall be determined in accordance with IS1893.

1.4.7.3.5 Wind Loads

As per IS Code 875 – Part III: Code of Practice for Design Load (Other Than Earthquake) for Buildings and Structures for calculating the wind loads on the structures a design wind speed of 43.5m/s has been used as per the Indian standards.

However, during design studies the wind pressure shall be determined from the design wind speed in accordance with BS 6399 Part 2:1997.

1.4.7.3.6 Current Loads

The current loads on the structure have been applied on the submerged parts of the structure assuming the maximum current velocity as 1.5m/s. The current load shall be determined in accordance with BS 6349 Part 1, Section 5.

1.4.7.3.7 Wave Loads

A design wave height of 0.5 m has been considered for the IN and CG berth. These are the maximum wave heights that could be expected at these berth locations under the extreme conditions.

1.4.7.3.8 Mooring Loads

As per the requirements of IN and CG, the requirements of bollard are as below.

S. No.	Berth	Bollard Pull (T)
1.	Indian Navy Berth 1	80
2.	Indian Navy Berth 2	100

S. No.	Berth	Bollard Pull (T)
3.	Coast Guard Berth	50
4.	Cruise cum Multipurpose Berth	150

1.4.7.3.9 Berthing Loads

1.4.7.3.10 Fender Reaction (Berthing Force)

Corresponding to the energy to be absorbed and the fender selected, the design reaction force has been worked out based on the standard fender design catalogues.

The berthing energy, fender selection and the berthing force applied at the navy and coastguard berths is given in the following table:

Components	Coastguard Berth	Indian Navy Berth 1	Indian Navy Berth 2	Cruise cum Multipurpose Berth
Berthing Energy*	42 Tm	42 Tm	66 Tm	60 Tm
Fender	Trelleborg 2000mm × 1200mm inclined cylindrical fender	Trelleborg 2000mm × 1200mm inclined cylindrical fender	Trelleborg 2400mm × 1200mm inclined cylindrical fender	Trelleborg SCK Cell Fenders 1450H E1.4
Berthing Reaction	89T	89T	135T	94 T

* Values are preliminary which is to refined by IN and CG as per their requirements and respective terminal operator

1.4.7.3.11 Load Combinations

The above loads with appropriate load combinations, as per IS 4651 (Part IV): 1989 have been applied on the different components of the berths.

1.4.7.3.12 Materials and Material Grades

Concrete of grade M 40/50 and high corrosion resistant thermo-mechanically treated bars of Fe 500 grade shall be used for berth construction.

1.4.8 Structural Arrangement of Berths

1.4.8.1 Indian Navy Berth 1

Basic engineering of IN berth 1 was carried out based on the above design criteria. The proposed scheme consists of three rows of bored cast-in-situ piles of 1.2m diameter, spaced at 6.5m c/c in the longitudinal direction. The piles will be founded at a level of -25 m CD or 3m below rock level, whichever is lower.

In the transverse direction, main beams are provided supported over the piles, which in turn support beams in the longitudinal direction. The longitudinal beams, at the front and middle rows of piles, are designed for the quay crane loads. A 300mm thick deck slab will be provided supported over the intermittent longitudinal beams. A 75mm thick wearing coat will be provided over the RCC deck slab.

An inspection gallery in the form of tunnel of 2m×2m clear is provided below the berth on the berthing side to accommodate and regular inspection/maintenance of cables/utilities.

Bollards and rubber fenders will be provided @ 13m c/c along the berthing face. The total length of the quay provided is 200 m.

Drawing DELD11137-DWG-25-0000-CP-A002 presents the structural arrangement and cross-section of IN berth 2.

1.4.8.2 Indian Navy Berth 2

Basic engineering of IN berth 2 was carried out based on the above design criteria. The proposed scheme consists of three rows of bored cast-in-situ piles of 1.2m diameter, spaced at 6.6m c/c in the longitudinal direction. The piles will be founded at a level of -40 m CD or 3m below rock level, whichever is lower.

Rest of the other arrangement is similar to that of IN berth 1. The total length of the berth provided is 300 m.

Drawing DELD11137-DWG-25-0000-CP-A003 presents the structural arrangement and cross-section of the IN berth 2.

1.4.8.3 Coast Guard Berth

Basic engineering of Coastguard berth was carried out based on the design criteria established above. The proposed scheme consists of two rows of bored cast-in-situ piles of 1.2m, spaced at 6.45m c/c in the longitudinal direction. The piles will be founded at a level of -25 m CD or 3m below rock level, whichever is lower.

Over the piles, longitudinal & transverse beams are provided as the main structure which will support the 300mm thick deck slab above. A 75mm thick wearing coat will be provided over the RCC deck slab.

An inspection gallery in the form of tunnel of 2m×2m clear is provided below the berth on the berthing side to accommodate and regular inspection/maintenance of cables/utilities.

Bollards and rubber fenders will be provided @ 12.9m c/c along the berthing face. The total length of the berth provided is 120 m.

Drawing DELD11137-DWG-25-0000-CP-A004 presents the structural arrangement and cross-section of Coastguard berth.

1.4.8.4 Cruise cum Multipurpose Berth

Based on the design criteria established above, the structural arrangement of the multipurpose berths is arrived at. The proposed scheme consists of four rows of vertical bored cast-in-situ piles of 1.2 m diameter, spaced at 7.5 m c/c in the longitudinal direction. The piles will be founded at a level of about -30 m CD or 3 m below hard rock level, whichever is lower.

In the transverse direction, main beams are provided supported over the piles, which in turn support beams in the longitudinal direction. A 200 mm thick deck slab will be provided supported over the intermediate longitudinal beams. Stone pitching would be provided over a stable slope at the end of the dock.

Bollards and rubber fenders will be provided @ 21.5 m c/c along the berthing face. A service trench will be provided on the berthing side to accommodate cables/utilities.

Drawing **DELD11137-DWG-25-0000-CP-A005** presents the structural arrangement and cross-section of Cruise cum Multipurpose berth.

1.4.9 Design Life

The permanent works shall be designed and constructed to give the design lives as mentioned in Section 6.3.9 of Basic Engineering Document.

1.4.10 Quay Structure Settlement/Deflection

The quay wall design shall consider the maximum permissible tolerances for horizontal and vertical alignment under the design loading conditions.

1.4.11 Environmental Condition

The full length of the quay structure shall be designed to withstand all environmental loads arising from the environmental conditions defined elsewhere in this document for a minimum return period of 100 years if not mentioned separately here.

1.4.12 Quay Structure Differential Movement

The Contractor shall design and construct the quay so that the differential movement of the one bay of the quay relative to the other bays (if expansion joints provided) does not exceed that which can be rectified by adjustment to the crane tracks, to maintain the requirements of Track tolerances for quayside cranes and to ensure safe and efficient operation of the cranes. Such adjustments will be the responsibility of the Contractor up to the end of the Defects Notification Period.

In the event that the relative movement exceeds that which can be accommodated by adjustment of the crane tracks the Contractor shall be responsible for making adjustments to the structure to allow the tracks to be adjusted to permit the safe and efficient crane operation.

1.5 Berthing Structures

1.5.1 Dead Weight of Structure

Dead weight of structure will include the weight of all structural components, using the following specific weights as minimum.

S. No	Structural Components	Dead Weight
		(T/m^3)
1.	Structural Steel	7.85
2.	Plain Concrete	2.35
3.	Pre stressed concrete	2.50
4.	In situ reinforced concrete	2.40
5.	Pre cast reinforced concrete	2.50
6.	Sea water	1.03
7.	Compacted Earth fill	1.8

The unit weight of all other materials shall satisfy the requirements of IS:875.

1.5.2 Buoyancy Loads

Buoyancy loads will include the uplift due to submergence in sea water using a specific gravity of 1.03.

Buoyancy loads may be disregarded where it is demonstrated that the buoyancy of submerged structural component do not contribute to higher stress levels in the structures or piles.

1.5.3 Area Loading

Structural design shall take account of dynamic factors resulting from vehicle braking, cornering, and accelerations.

Areas for different types of loading as per standard industry practice are indicated in the table below.

Area	Description	Loading/Comments
Indian Navy Berths	Full deck	30 kN/m^2 UDL Standard Class AA - wheeled vehicle on the deck as per IRC Code of Practice for Road Bridges (Article II – Loads and Stresses). 30 T capacity mobile harbor crane with maximum out reach of 30 m.

Area	Description	Loading/Comments
Coast Guard Berth	Full deck	20 kN/m^2 UDL Standard Class AA - wheeled vehicle on the deck as per IRC Code of Practice for Road Bridges (Article II – Loads and Stresses). 10 T capacity mobile harbor crane with maximum out reach of 20 m.
Cruise cum Multipurpose Berth	Full Deck	20 kN/sqm UDL Standard Class AA - wheeled vehicle on the deck as per IRC Code of Practice for Road Bridges (Article II – Loads and Stresses)

* Values to be finalized in consultation with IN, CG and respective terminal operator

1.5.4 Wind Loads

Wind forces on the structure and projecting superstructure of the berth are calculated with the methods given in recent version of IS 875 (Part III).

1.5.5 Seismic Loads

Seismic loads on the structure are calculated with the methods given in recent version of IS 1893 (Part I).

1.5.6 Wave and Current Loads

Following waves and currents data shall be used to design the berth structures.

Extreme condition (100 Year Return Period)		
Significant Wave Height	Hs	0.4m
Design Wave Height	Hmax	=1.86 times Hs
Time Period	T	9s
Current (all direction)	V	0.3m/s
Tide level	MHWS	0.8m
Surge level	Wind Setup	0.3m

Wave and current force calculation shall be in accordance with BS 6349. Wave and current shall be considered in the same direction and relevant velocities added vectorially.

Assumed Morrison's coefficients are:

- Tubes : Cd = 0.7 and Cm = 2.0
- Profiles: Cd = 2 and Cm = 2

Marine growth of 50 mm on radius shall be considered on all submerged elements.

Wave slamming effect shall be considered for structure anticipated of full/partial submergence in any combination of water levels, storm surge and wave height.

1.5.7 Temperature Loads

Temperature load shall be considered and combined with the other loadings as per the relevant standards, the difference in temperature gradient between top and underside of the deck shall be considered in the analysis and design.

Temperature differential shall satisfy the codal provisions mentioned in IRC 6.

1.5.8 Berthing Load

Berthing loads shall be determined in accordance with IS:4651. For the purpose of calculating the berthing energy the following parameters are to be considered.

Parameter	Value
Berthing mode	Side berthing
Maximum eccentricity	Quarter point vessel impact
Berthing mode	Difficult berthing condition, sheltered
Maximum vessel berthing angle*	10° for vessels up to 50,000 t loaded displacement
Bow flare angle	15°
Bow radii	Fender performance to take account of bow radii
Bulbous bow	Fender design to take account of bulbous bows

*defined based on the size of the vessel in IS:4651 (Part III).

1.5.9 Mooring Load

Mooring Load shall be calculated based on the design vessel size with an operating speed corresponding to signal no. 7 on Beaufort scale, i.e. wind speed of 65 km/hr (18 m/s). It shall also take into account the effect of currents.

1.5.10 Equipment Load

1.5.10.1 Indian Navy Berths

The Indian Navy berths shall be designed for rail mounted crane loads which shall be provided by the IN.

In addition, this berth shall be designed for storm pins, tie downs, rear side cable duct with two center pits for power and water reeling drums, end buffers, equipment/ crane unloading loads, crane rail trench etc.

1.6 Quay Equipment and Layout

Item	Comment
Crane Tracks	Allowance shall be made for movement during construction and for static deflection of the structure under permanent loads and the correct alignment shall be achieved after completion of all filling and excavation including dredging.
Berthing face	To align the berthing face approximately 5.5m from the centre line of the seaward crane rail head for Indian Navy berth.
Cope line	The distance between the cope line and the berthing face shall be the minimum compatible with the size and spacing of the fenders (see Fender Design)
Cope level	+4.2m CD with falls on the deck surface to ensure rainfall run-off for Coast Guard and Indian Navy Berths.
Overall quay structure	Operational quay length not less than 500m total for Indian Navy berth, 120m for Coast Guard berth.
Fenders	At spacing to accommodate all vessel ranges
Bollards	At spacing to accommodate all vessel ranges One meter clear access way required between bollard and any part of the gantry crane bogey
Safety ladders and hand grips	At not more than 30m centres • Galvanised and painted steel ladders; • Ladders to extend 1.0m below LAT level;

Item	Comment
	• Recessed handgrips shall be provided at deck level; • Ladders to be accommodated in recesses and shall not protrude beyond the cope face; • Slots shall be provided on the deck edge to install portable ladders anywhere as required.
Crane power connection pit	Single pit with 4 connection points located at the centre of each berth.
Crane unloading points	Provision to be made within the design of the structure for the unloading by others of cranes to be delivered in a fully erected form. • Contractor to agree with the Authority the location(s) of such unloading point(s) and whether or not any other special provisions are required.
Crane storm pin slot	To be provided by IN and CG.
Crane tie down points	To be provided by IN and CG.
Cope edging	To be finalized
Navigation Aids	None at berth

1.6.1 Fender Design

Fenders shall be designed for a range of navy and coastguard ships between the minimum and maximum design vessels.

Table 1.3 Fender Parameters*

Parameter	Value	Source
Energy absorption (multiple fender impacts can be considered)	200% of berthing energy from normal impacts, within rated deflection for Indian Navy, Port Craft, Coast Guard, and Fish Landing berths	PIANC Guideline for The Design of Fender System – 2002.
Distance between cope edge and berthing line	To be the minimum dimension which will allow 300mm clear between the vessel hull and the cope with the fender compressed. The fender size and spacing selected to satisfy this criterion.	
Fender panel facing	No panel	
Coefficient of friction UHMW-PE to steel (dry)	Not less than 0.2	
Restrain chain	Required	
Factor of safety on restraint chains and fixings	3	
Fender spacing (between centre lines of fender units)	To accommodate all range of vessels to be berthed	
Allowable hull pressures	20 T/m^2 maximum	
Fender panel	No Panel	

1.6.2 Fender Types

Fenders shall be of cylindrical fender with a rated deflection not more than 100% of the Internal Diameter of the fender for IN and CG berths while Cell fenders for Cruise cum Multipurpose berth.

1.6.3 Bollards

Bollards shall be as described in Table below.

Parameter	Value
Maximum Bollard spacing	Indian Navy Berths: 12m Coast Guard berth: 5m Cruise cum Multipurpose Berth: 21.5m
Bollard capacity	Indian Navy Berth 1 – 80 T Indian Navy Berth 2 – 100 T Coast Guard berth: 50 T Cruise cum Multipurpose Berth: 150 T
Bollard type	Kidney type bollards for Indian Navy and Coast Guard berth and proprietary manufactured bollard for Cruise cum Multipurpose Berth

Bollard size and spacing shall be confirmed by the terminal operator during detailed design.

1.6.4 Quayside Crane

Navy Berths shall be capable to take loading from 30 T rail mounted crane with an outreach arm of about 30 m for loading/ unloading of equipments, machineries, and other equipment etc.

Design Parameter	Design Value
Total Dead Load	To be provided by IN
Overall length buffer to buffer width	
Wheels per corner – water side	
Wheels per corner – land side	
Wheel spacing (per bogie)	
Bogie spacing	
Wheel diameter	
Buffer height	
Buffer load	
Wheel Spacing between equalizer (A)	
Leg center line (B)	
Corner wheel CL to CL distance (C)	
Wheel spacing with in bogie (D)	
Wheel spacing between bogie (E)	
Distance between two cranes (X)	

1.6.4.1 Wheel Load Data – Analysis

Description	Details	Value	Units
Crane type	30 T Capacity		
Numbers of wheel per bogie	7+7	14	No.
Crane rail gauge		10.5	m
Out reach	from centerline of WS rail	23	m
Crane type	Mobile Harbour Crane of capacity	30	T
Numbers of Pads	2+2	4	No.
C/C distance between Pads		10	m

Description	Details	Value	Units
Out reach	from centerline of WS rail	18	m

The following wheel loading based on 7 wheels per corner arrangement, and the wheel spacing need to be decided with IN.

Criteria	Maximum Wheel Load
Crane in service, boom down – operational wind speed of 20 m/sec	LS – 145 kN/Wheel WS – 215 kN/Wheel
Crane out of service, boom stowed – operational wind speed of 20 m/sec	To be provided by IN & CG
Crane storm pinned, boom stowed – extreme wind speed of 40 m/sec	To be provided by IN & CG
Storm pin horizontal load	117 T per pin slot (pull out force 100T)

* Values to be finalized by IN and CG

Table 1.4 Mobile Harbour Crane Loads*

Criteria	Maximum Wheel Load
Crane in service, boom down – operational wind speed of 20 m/sec	LS – 15T/ Pad WS – 85T/Pad Pad Sizing – 5.5m X 0.8m
Crane out of service, boom stowed – operational wind speed of 20 m/sec	To be provided by IN & CG
Crane storm pinned, boom stowed – extreme wind speed of 40 m/sec	To be provided by IN & CG

* Values to be finalized by IN and CG

1.6.4.2 Quayside Crane Track Tolerance

The track tolerance for installation of crane rail is as per the specification of rail fixing.

Quay side gantry crane cable slots shall be as follows:

Design Parameter	Design Value
Position of cable slot	Seaward of seaside track
Distance of cable slot from waterside track (centre line of track to centre line of cable slot)	800mm*
Cable slot type	Open cable trench
Cable slot depth	To hold 3 cables* at a time
Cable slot drainage	At not more than 7.5m centre

* Values to be finalized by IN

1.6.4.3 Cable Turnover Pits

Design Parameter	Design Value
Position of cable turnover pit	Seaward of seaside track – centre of each berth
Number of crane connections per pit	Three* crane connections per pit required
Equipment	– Cable tulip to be provided and installed by the Contractor – Cable anchor drum to be provided and installed by Contractor.

* Values to be finalized by IN and CG

1.6.4.4 Crane Jack Up Points

Design Parameter	Design Value
Position	To be finalized by IN and CG
Dimension	To be finalized by IN and CG
Design	Suitable for jacking up a fully erect quay crane

All gantry crane data presented in this section is preliminary and subject to change based on the requirements of IN.

1.6.5 Area Loading

1.6.5.1 General

Structural design shall take account of dynamic factors resulting from vehicle braking, cornering, and accelerations.

1.6.5.2 Areas for Designated Loading

Areas for different types of loading as per standard industry practice are indicated in the table below.

Table 1.5 Area Loadings

Area	Description	Loading/Comments
Indian Navy Berth	Quay area seaward of the seaward crane track	30 kN/m^2 UDL and capable of delivery of fully-erected gantry cranes by sea
	Quay area between seaward and landward crane tracks	Standard Class AA - wheeled vehicle on the deck as per IRC Code of Practice for Road Bridges (Article II – Loads and Stresses)
Coast Guard Berth	Quay area seaward of the seaward crane track	20 kN/m^2 UDL and capable of delivery of fully-erected gantry cranes by sea
	Quay area between seaward and landward crane tracks	Standard Class AA - wheeled vehicle on the deck as per IRC Code of Practice for Road Bridges (Article II – Loads and Stresses)
		Wheel mounted mobile crane of capacity 2t at any location and orientation.

1.6.6 Wind Loads

Wind forces on the structure and projecting superstructure of the berth are calculated with the methods given in recent version of IS 875 (Part III).

1.6.7 Wave and Current Loads

Following waves and currents data shall be used to design the berth structures.

Table 1.6 Wave and Current Loads for Extreme Condition

Extreme Condition (100 Year Return Period)		
Significant Wave Height	H_s (m)	0.4
Design Wave Height	H_{max}	1.86 times Hs
Time Period	T (s)	9
Current (all direction)	V (m/s)	0.3
Tide level	MHWS (m)	0.8
Surge level	Wind Setup (m)	0.3

Table 1.7 Wave and Current Loads for Operating Condition

Operating condition (5 Year Return Period)

Operating condition (5 Year Return Period)		
Significant Wave Height	H_s (m)	0.3m
Design Wave Height	H_{max}	1.86 times Hs
Time Period	T (s)	9s
Current (all direction)	V (m/s)	0.3m/s
Tide level	MHWS (m)	0.8m
Surge level	Wind Setup (m)	0.3m

1.6.8 Shrinkage and Creep Stresses

Unless otherwise specified, the magnitude of shrinkage and creep effects shall be assessed with the relevant methods as per code of practices.

- Mean Annual highest Temperature : 34°C
- Mean Annual Relative Humidity : 84%

1.6.9 Safety Factor

The partial safety factor shall be considered as below in the design of berthing structures.

Load	Limit State	Normal	Storm
Dead Load	ULS	1.15	1.15
	SLS	1.0	1.0
Dead Load: superimposed	ULS	1.2	1.2
	SLS	1.0	1.0
Live Loads	ULS	1.4	1.2
	SLS	1.1	1.0
Berthing or mooring	ULS	1.4	1.2
	SLS	1.1	1.0
Environmental (Wave, Wind, Seismic etc.)	ULS	1.4	1.2
	SLS	1.0	1.0
Soil/earth pressure	ULS	1.3	1.15
	SLS	1.0	1.0
Hydrostatic uplift	ULS	1.2	1.0
	SLS	1.0	1.0

ULS- Ultimate Limit State;
SLS- Serviceability Limit State

The load combinations shall be in accordance with IS 4651 (Part IV) and any other combinations as instructed by the Authority during detail engineering.

1.6.10 Serviceability Checks

Crack width of all the structural elements shall be calculated wherever necessary as per IS:456.

Deflection of piles shall be limited to L/350.

Annexure 2

Figures

Prepared for

Vizhinjam International Seaports Limited (VISL)

Prepared by

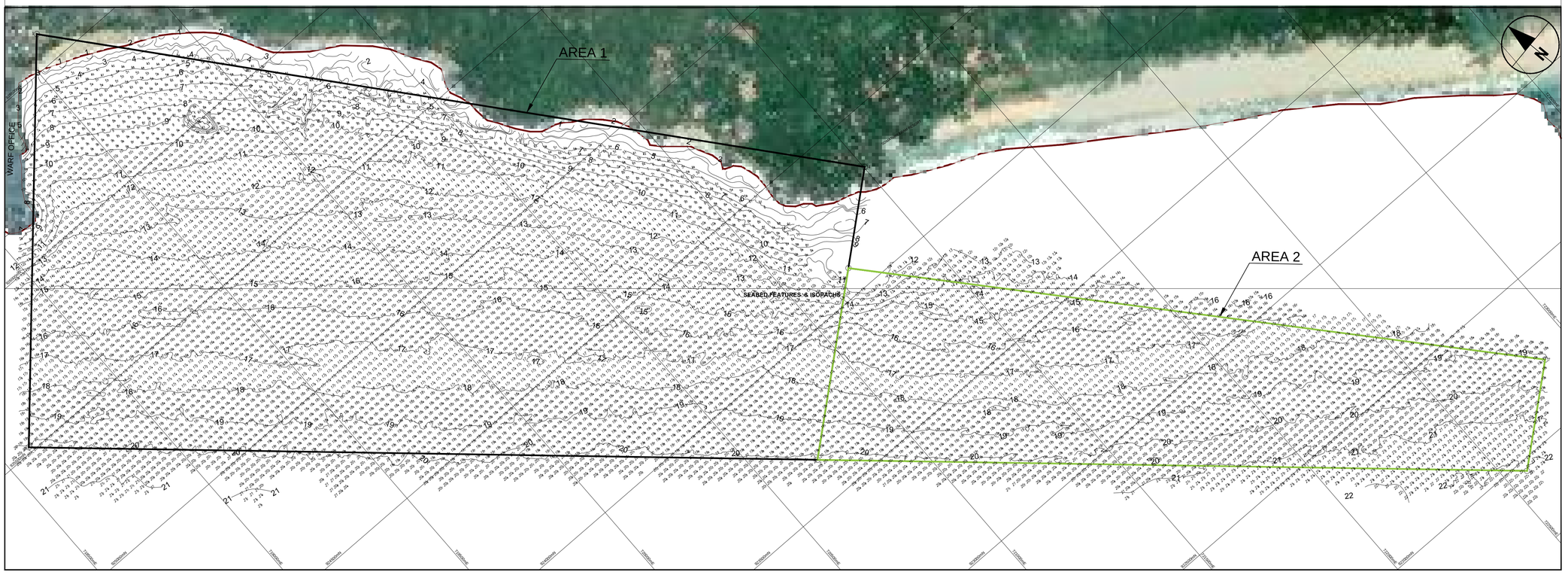
AECOM India Private Limited

December 2014

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

LIMITS OF SURVEY AREA

AREA	ID	WGS84 Datum, UTM Projection (CM 075° E, Zone 43)	
		Easting (m)	Northing (m)
Area 1	1	719 585	926 611
	2	718 601	925 519
	3	720 694	923 647
	4	721 503	924 324
Area 2	5	720 694	923 647
	6	721 224	924 090
	7	722 885	922 220
	8	722 577	921 963



LEGEND:

FEATURES IDENTIFIED FROM CURRENT SURVEY

GENERAL

- GEOGRAPHICAL INTERSECTION
- SIDE SCAN SONAR COVERAGE

BATHYMETRY

- DEPTHS IN METRES BELOW CHART DATUM
- MINOR CONTOUR WITH DEPTH IN METRES
- MAJOR CONTOUR WITH DEPTH IN METRES

FEATURES OBTAINED FROM OTHER SOURCES (AS INDICATED)

- SURVEY AREA BOUNDARY

NOTES:

1) LOCALLY HIRED SURVEY VESSEL MB PEARLS-1 WAS DEPLOYED FOR THIS SURVEY IN FEBRUARY & MARCH 2011.
2) THE COORDINATES OF THE SURVEY CORRIDOR WERE PROVIDED BY THE CLIENT.
3) FUGRO'S STARFIX SYSTEM WAS USED FOR POSITIONING AND CONTROL OF SURVEY.
4) REFER TO FSINPVT SURVEY REPORT NO. J-MAR-11-006/MO 2011-060 FOR DETAILS ON THE RESOURCES MOBILISED AND METHODOLOGY ADOPTED FOR THIS SURVEY.
5) ATG WAS SET UP AT THE NORTH WEST OF JETTY AND LEVELED TO CLIENT SUPPLIED SOI BM ON A ROCK ADJOINING TO BASEMENT ON THE WESTERN SIDE OF VIZHINJAM MOSQUE (NEAR THE GATE OF HARBOUR ENTRANCE) WHICH IS 6.945m ABOVE CHART DATUM.
6) RECORDED DEPTHS WERE REDUCED TO CHART DATUM USING OBSERVED TIDES AT THE JETTY.
7) THE RESULTS OF SURVEY ARE PLOTTED IN WGS84 DATUM, UTM PROJECTION, ZONE 43.
8) THE COASTAL FEATURES SHOWN ARE SOURCED FROM GOOGLE IMAGE.
9) THIS IMAGE HAS BEEN RUBBER-SHEETED AND PLACED FOR RELATIVE APPRECIATION ONLY.
10) COORDINATES OF COASTAL AND LAND FEATURES IN THIS IMAGE ARE NOT RELIABLE AND HENCE NOT TO BE USED FOR ANY OTHER PURPOSE.

Geodetic, Projection and Grid Parameters

Global Positioning System Geodetic Parameters

Datum	World Geodetic System 1984 (WGS84)
Spheroid	World Geodetic System 1984
Semi major axis	a = 6 378 137.000 m
Inverse flattening	1/f = 298.257 223 563

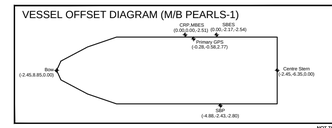
Projection and Grid Parameters

Projection	Universal Transverse Mercator
Grid System	UTM Zone 43 N
Central Meridian	075A00' 00" East
Latitude of Origin	0A00' 00" North
False Easting	500 000 m
False Northing	0 m
Scale factor on Central Meridian	0.9996
Units	metre

REFERENCE DRAWINGS

Rev. No.	Date:	Drawing No.	Source	Description
-	16/07/2010	0150.011	CLIENT	BOREHOLE INFORMATION

VESSEL OFFSET DIAGRAM (M/B PEARLS-1)



NOT TO SCALE

OVERVIEW PLAN

LAYOUT PLAN — VIZHINJAM — INDIA - WEST COAST

NOT TO SCALE

CLIENT

FUGRO GEOTECH PVT. LTD
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SURVEY CONTRACTOR

FUGRO SURVEY (INDIA) PVT. LTD.
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(AN ISO 9001:2008 COMPANY)

PROJECT TITLE

GEOPHYSICAL SURVEY FOR VIZHINJAM DEEPWATER INTERNATIONAL TRANSHIPMENT TERMINAL
KERALA OFFSHORE, WEST COAST OF INDIA
FEBRUARY - MARCH 2011

CHART SHOWING

BATHYMETRY, SEABED FEATURES & ISOPACH

SHEET 01 OF 01

HORIZONTAL SCALE 1 : 5000

100m 0m 100m 200m 300m 400m 500m

Vessel:- M/B PEARLS-1 — Project Ref: J-MAR-11-006

Rev. No:	Date:	Description:	Surveyed :	Interpr:	Drawn:	Chkd:	Appr:
1	12/07/2011	FINAL ISSUE	AS	LPL	OD/DJ	AVD	SKR
0	30/03/2011	ISSUED FOR APPROVAL	AS	LPL	SD/MG	AVD	SKR

Drawing File No: S320-01R1 — Drawing No: J-MAR-11-006/MO 2011-060/FGEOTECH/VIZHINJAM/BS/BS/01/S320 — Encl. 01 of 09

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BATHMETRIC SURVEY MAP

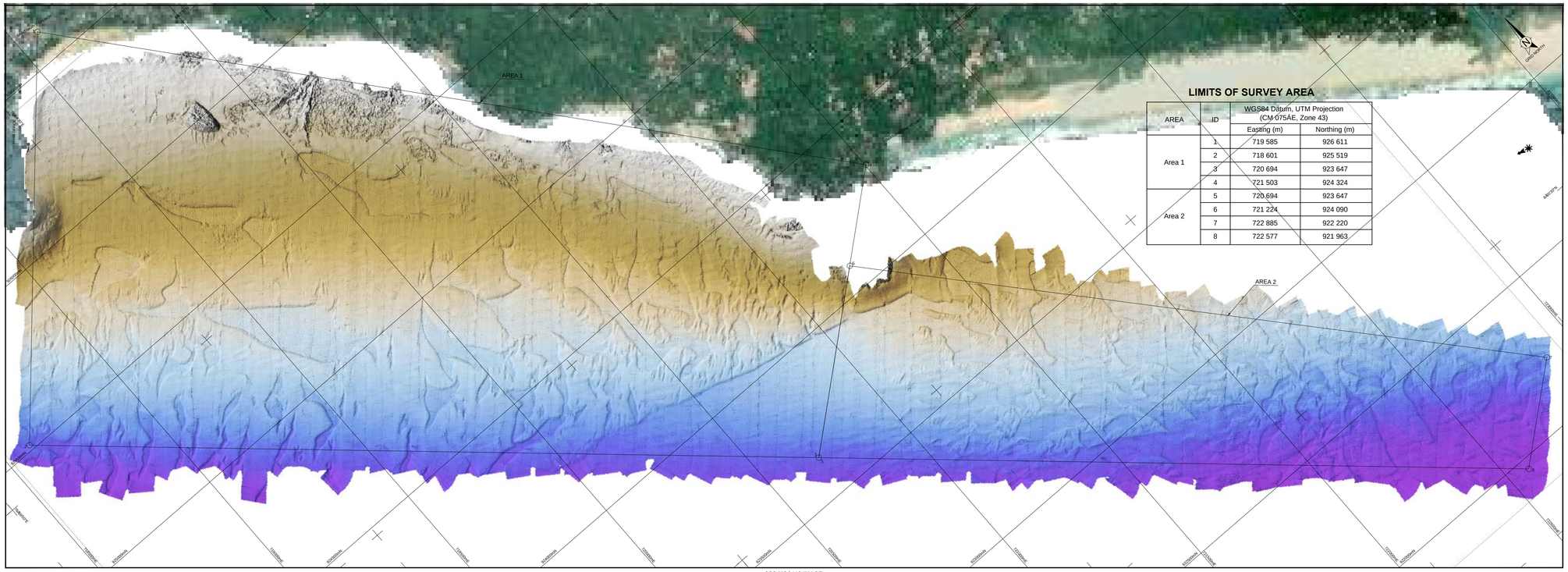
AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 07.02.2014

FIGURE No. : 4.1

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

MULTIBEAM IMAGE



LIMITS OF SURVEY AREA

AREA	ID	WGS84 Datum, UTM Projection (CM 075AE, Zone 43)	
		Easting (m)	Northing (m)
Area 1	1	719 585	926 611
	2	718 601	925 519
	3	720 694	923 647
	4	721 503	924 324
Area 2	5	720 694	923 647
	6	721 224	924 090
	7	722 885	922 220
	8	722 577	921 963

SSS MOSAIC IMAGE

LEGEND:

FEATURES IDENTIFIED FROM CURRENT SURVEY

GENERAL

- GEOGRAPHICAL INTERSECTION
- SSS MOSAIC
- DIRECTION OF ILLUMINATION AZIMUTH=265A ELEVATION=85A
- DEPTH IN METERS (REDUCED TO CHART DATUM)

FEATURES OBTAINED FROM OTHER SOURCES (AS INDICATED)

- SURVEY AREA BOUNDARY

NOTES:

1) LOCALLY HIRED SURVEY VESSEL M/B PEARLS-1 WAS DEPLOYED FOR THIS SURVEY IN FEBRUARY & MARCH 2011.
2) THE COORDINATES OF THE SURVEY CORRIDOR WERE PROVIDED BY THE CLIENT.
3) FUGRO'S SYMPAX SYSTEM WAS USED FOR POSITIONING AND CONTROL OF SURVEY.
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Geodetic, Projection and Grid Parameters

Global Positioning System Geodetic Parameters

Datum	:	World Geodetic System 1984 (WGS84)
Spheroid	:	World Geodetic System 1984
Semi major axis	:	a = 6 378 137.000 m
Inverse flattening	:	1/f = 298.257 223 563

Projection and Grid Parameters

Map Projection	:	Universal Transverse Mercator
Grid System	:	UTM Zone 43 N
Central Meridian	:	075A00' 00" East
Latitude of Origin	:	0A00' 00" North
False Easting	:	500 000 m
False Northing	:	0 m
Scale factor on Central Meridian	:	0.9996
Units	:	metre

REFERENCE DRAWINGS

Rev. No.	Date:	Drawing No.	Source	Description
-	16/07/2011	0100.011	CLIENT	BOREHOLE INFORMATION

VESSEL OFFSET DIAGRAM (M/B PEARLS-1)

NOT TO SCALE

OVERVIEW PLAN

LAYOUT PLAN

NOT TO SCALE

CLIENT

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PROJECT TITLE

GEOPHYSICAL SURVEY FOR VIZHINJAM DEEPWATER INTERNATIONAL TRANSHIPMENT TERMINAL
KERALA OFFSHORE, WEST COAST OF INDIA
FEBRUARY - MARCH 2011

CHART SHOWING

MULTIBEAM AND SSS MOSAIC IMAGE

SHEET 01 OF 01

HORIZONTAL SCALE 1 : 5000

100m 0m 100m 200m 300m 400m 500m

Vessel:- M/B PEARLS-1 | Project Ref: J-MAR-11-006

Rev. No:	Date:	Description:	Surveyed:	Interpr:	Drawn:	Chkd:	Appr:
0	15/07/2011	ISSUED FOR APPROVAL	AS	LPL	SAC	GNH	SKR

Drawing File No: 5434-01R0 | Drawing No: J-MAR-11-006/MO 2011-060/FOEOTECH/VIZHINJAM/BS/MG01/5434 | Encl. 08 OF 09

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

OUTPUT OF SIDE SCAN SURVEYS

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 07.02.2014

FIGURE No. : 4.2

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

LIST OF SONAR CONTACTS

WGS84 Datum, UTM Projection (CM 075° E, Zone 43)				
ID	Easting (m)	Northing (m)	Dimensions (m) Length x Width x Height	Remark
SC01	719 487,50	924 797,76	1,7 x 0,7 x nmh	Hard contact
SC02	719 680,29	924 779,45	2,5 x 1,0 x nmh	Hard contact
SC03	720 066,23	924 430,04	1,6 x 0,7 x nmh	Hard contact
SC04	721 869,66	923 099,44	3,0 x 0,6 x nmh	Hard contact
SC05	722 234,78	922 465,61	1,3 x 0,7 x nmh	Hard contact

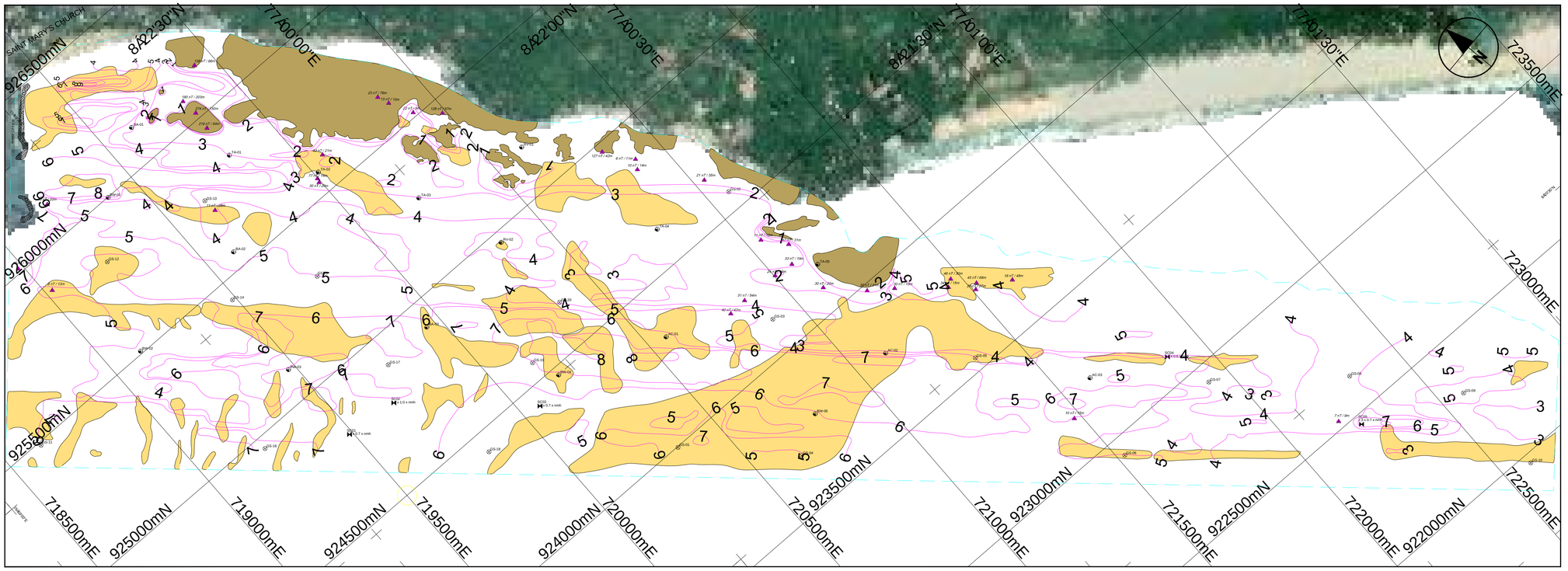
nmh - no measurable height

BORE HOLE LOCATION COORDINATES

ID	WGS84 Datum, UTM Projection (CM 075° E, Zone 43)	
	Easting (m)	Northing (m)
AC-01	720 568	924 322
AC-02	721 121	923 767
AC-03	721 613	923 223
BA-01	719 617	926 132
BA-02	719 602	925 560
BA-03	719 946	924 906
BW-01	719 391	925 998
BW-02	719 120	925 509
BW-03	719 475	925 115
BW-04	720 190	924 470
BW-05	720 789	923 767
RV-01	720 621	925 170
RV-02	720 344	924 961
TA-01	719 816	925 830
TA-02	720 016	925 577
TA-03	720 226	925 273
TA-04	720 794	924 633
TA-05	721 145	924 164

GRAB SAMPLES COORDINATES

ID	WGS84 Datum, UTM Projection (CM 075° E, Zone 43)	
	Easting (m)	Northing (m)
GS-01	720 341	923 997
GS-02	721 074	924 567
GS-03	720 895	924 121
GS-04	720 654	923 687
GS-05	721 350	923 545
GS-06	721 525	922 934
GS-07	721 922	922 935
GS-08	722 315	922 623
GS-09	722 582	922 312
GS-10	722 600	921 967
GS-11	718 632	925 488
GS-12	719 238	925 827
GS-13	719 643	925 764
GS-14	719 486	925 433
GS-15	719 769	925 299
GS-16	719 227	924 957
GS-17	719 754	924 895
GS-18	719 822	924 426
GS-19	720 147	924 564
GS-20	720 361	924 664



LEGEND:

SEABED FEATURES

- SC02 Datum, 2.5 x 1.0 x nmh — SONAR CONTACT WITH DIMENSIONS IN METRES (length x width x height) (nmh = no measurable height)
- GS-11 — GRAB SAMPLE LOCATION
- BW-04 — BOREHOLE LOCATION
- 73 nT/42 m — MAGNETIC ANOMALY IN NANO TESLAS / WIDTH OF ANOMALY IN METRES
- TYPE 1:- LOW TO MEDIUM REFLECTIVITY (CLAY / SILTY FINE SAND)
- TYPE 2:- MEDIUM REFLECTIVE SEABED (FINE TO MEDIUM SAND)
- TYPE 3:- HIGH REFLECTIVE SEABED (ROCK OUTCROPS)
- BREAK WATERS

ISOPACH

- ISOPACH OF TOP MOST SEDIMENTARY UNIT AT 1M INTERVAL

FEATURES OBTAINED FROM OTHER SOURCES (AS INDICATED)

- SURVEY AREA BOUNDARY

NOTES:

1) LOCALLY HIRED SURVEY VESSEL M/B PEARLS-1 WAS DEPLOYED FOR THIS SURVEY IN FEBRUARY & MARCH 2011.
2) THE COORDINATES OF THE SURVEY CORRIDOR WERE PROVIDED BY THE CLIENT.
3) FUGRO'S STARFIX SYSTEM WAS USED FOR POSITIONING AND CONTROL OF SURVEY.
4) REFER TO FSINPVT SURVEY REPORT NO. J-MAR-11-006MO 2011-060 FOR DETAILS ON THE RESOURCES MOBILISED AND METHODOLOGY ADOPTED FOR THIS SURVEY.
5) ATG WAS SET UP AT THE NORTH WEST OF JETTY AND LEVELED TO CLIENT SUPPLIED SOI BM ON A ROCK ADJOINING TO BASEMENT ON THE WESTERN SIDE OF VIZHINJAM MOSQUE (NEAR THE GATE OF HARBOUR ENTRANCE) WHICH IS 6.945m ABOVE CHART DATUM.
6) RECORDED DEPTHS WERE REDUCED TO CHART DATUM USING OBSERVED TIDES AT THE JETTY.
7) THE RESULTS OF SURVEY ARE PLOTTED IN WGS84 DATUM, UTM PROJECTION, ZONE 43.
8) THE COASTAL FEATURES SHOWN ARE SOURCED FROM GOOGLE IMAGE.
9) THIS IMAGE HAS BEEN RUBBER-SHEETED AND PLACED FOR RELATIVE APPRECIATION ONLY.
10) COORDINATES OF COASTAL AND LAND FEATURES IN THIS IMAGE ARE NOT RELIABLE AND HENCE NOT TO BE USED FOR ANY OTHER PURPOSE.

Geodetic, Projection and Grid Parameters

Global Positioning System Geodetic Parameters :

Spheroid	:	World Geodetic System 1984 (WGS84)
	:	World Geodetic System 1984
Semi major axis	:	a = 6 378 137.000 m
Inverse flattening	:	1/f = 298.257 223 563

Projection and Grid Parameters :

Map Projection	:	Universal Transverse Mercator
Grid System	:	UTM Zone 43 N
Central Meridian	:	075A00' 00" East
Latitude of Origin	:	5A00' 00" North
False Easting	:	500 000 m
False Northing	:	0 m
Scale factor on Central Meridian	:	0.9996
Units	:	metre

15A

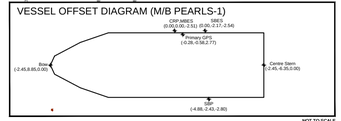
REFERENCE DRAWINGS

Rev. No.	Date:	Drawing No.	Source	Description
10A	16/07/2010	0100.011	AECOM SRI LANKA	BOREHOLE INFORMATION

This Chart

15A

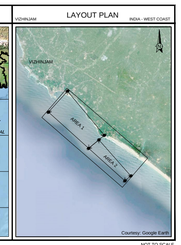
VESSEL OFFSET DIAGRAM (M/B PEARLS-1)



NOT TO SCALE

OVERVIEW PLAN

LAYOUT PLAN — VIZHINJAM — INDIA - WEST COAST



NOT TO SCALE

CLIENT

FUGRO GEOTECH PVT. LTD
PLOT NO. 51, SECTOR 6,
KAMOTHE
NAVI MUMBAI - 400 705, INDIA.
TEL: (91) (22) 6516 8662 FAX: (91) (22) 2762 0768

SURVEY CONTRACTOR

FUGRO SURVEY (INDIA) PVT. LTD.
FUGRO HOUSE
D-222/30, TTC INDUSTRIAL AREA, MIDC,
NERUL, NAVI MUMBAI - 400 706, INDIA.
TEL : +91 22 2762 9900 FAX : +91 22 2762 9140
(AN ISO 9001:2008 COMPANY)

PROJECT TITLE

GEOPHYSICAL SURVEY FOR VIZHINJAM DEEPWATER INTERNATIONAL TRANSHIPMENT TERMINAL
KERALA OFFSHORE, WEST COAST OF INDIA
FEBRUARY - MARCH 2011

BATHYMETRY, SEABED FEATURES & ISOPACH

SHEET 01 OF 01

HORIZONTAL SCALE 1 : 5000

100m 0m 100m 200m 300m 400m 500m

Vessel:- M/B PEARLS-1 — Project Ref: J-MAR-11-006

Rev. No:	Date:	Description:	Surveyed	Interpr.	Drawn:	Chkd:	Appr:
1	12/07/2011	FINAL ISSUE	AS	UPL	DD/DJ	AVD	SKR
0	30/03/2011	ISSUED FOR APPROVAL	AS	UPL	SD/MG	AVD	SKR

Drawing File No: 5320-01R1 — Drawing No: J-MAR-11-006/MO 2011-060/FGEOTECH/VIZHINJAM/BS/BS/01/5320 — Encl. 01 of 09

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

ISOPACH MAP

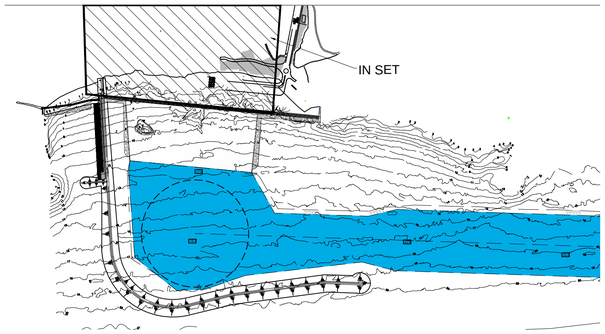
AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 07.02.2014

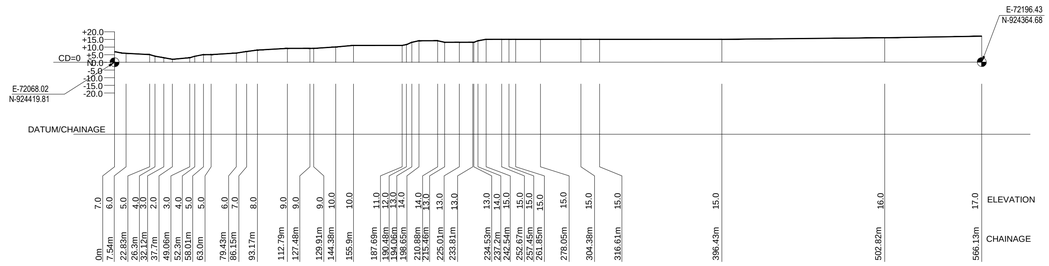
FIGURE No. : 4.3

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

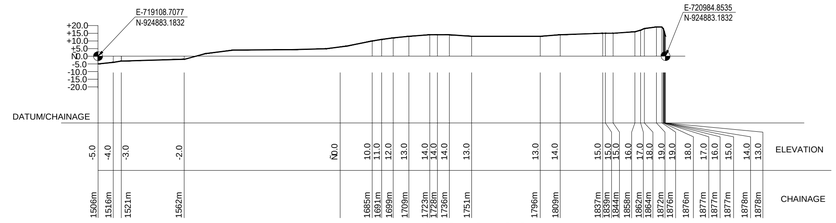
PLAN
SCALE 1:2000



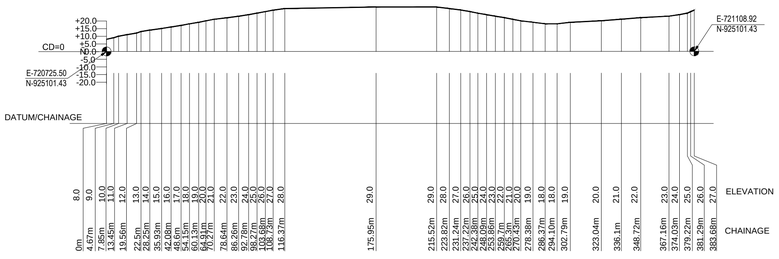
KEY PLAN



SECTION 1-1
SCALE 1:2000



SECTION 2-2
SCALE 1:2000



SECTION 3-3
SCALE 1:2000

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

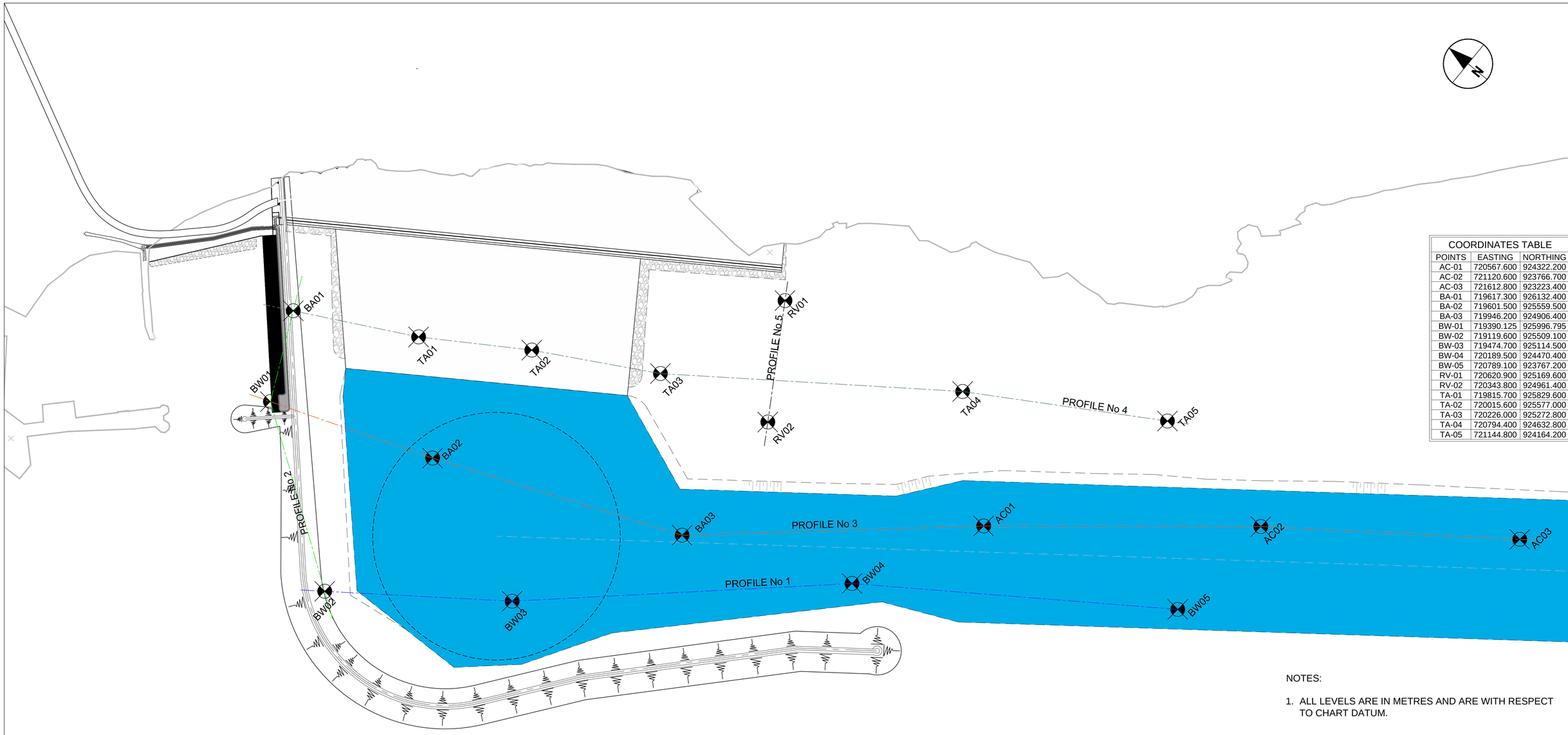
TOPOGRAPHIC SURVEY MAP

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 07.02.2014

FIGURE No. : 4.4

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm



COORDINATES TABLE		
POINTS	EASTING	NORTHING
AC-01	720567.600	924322.200
AC-02	721120.600	923766.700
AC-03	721612.800	923223.400
BA-01	719617.300	926132.400
BA-02	719601.500	925559.500
BA-03	719946.200	924906.400
BW-01	719390.125	925996.795
BW-02	719119.600	925509.100
BW-03	719474.700	925114.500
BW-04	720189.500	924470.400
BW-05	720789.100	923767.200
RV-01	720620.900	925169.600
RV-02	720343.800	924961.400
TA-01	719815.700	925829.600
TA-02	720015.600	925577.000
TA-03	720226.000	925272.800
TA-04	720794.400	924632.800
TA-05	721144.800	924164.200

NOTES:

1. ALL LEVELS ARE IN METRES AND ARE WITH RESPECT TO CHART DATUM.

LEGEND:

MARINE BOREHOLE

BOREHOLE PROFILE

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

0m 100 200 300 400

SCALE 1:5000 FULL SIZE (A1)

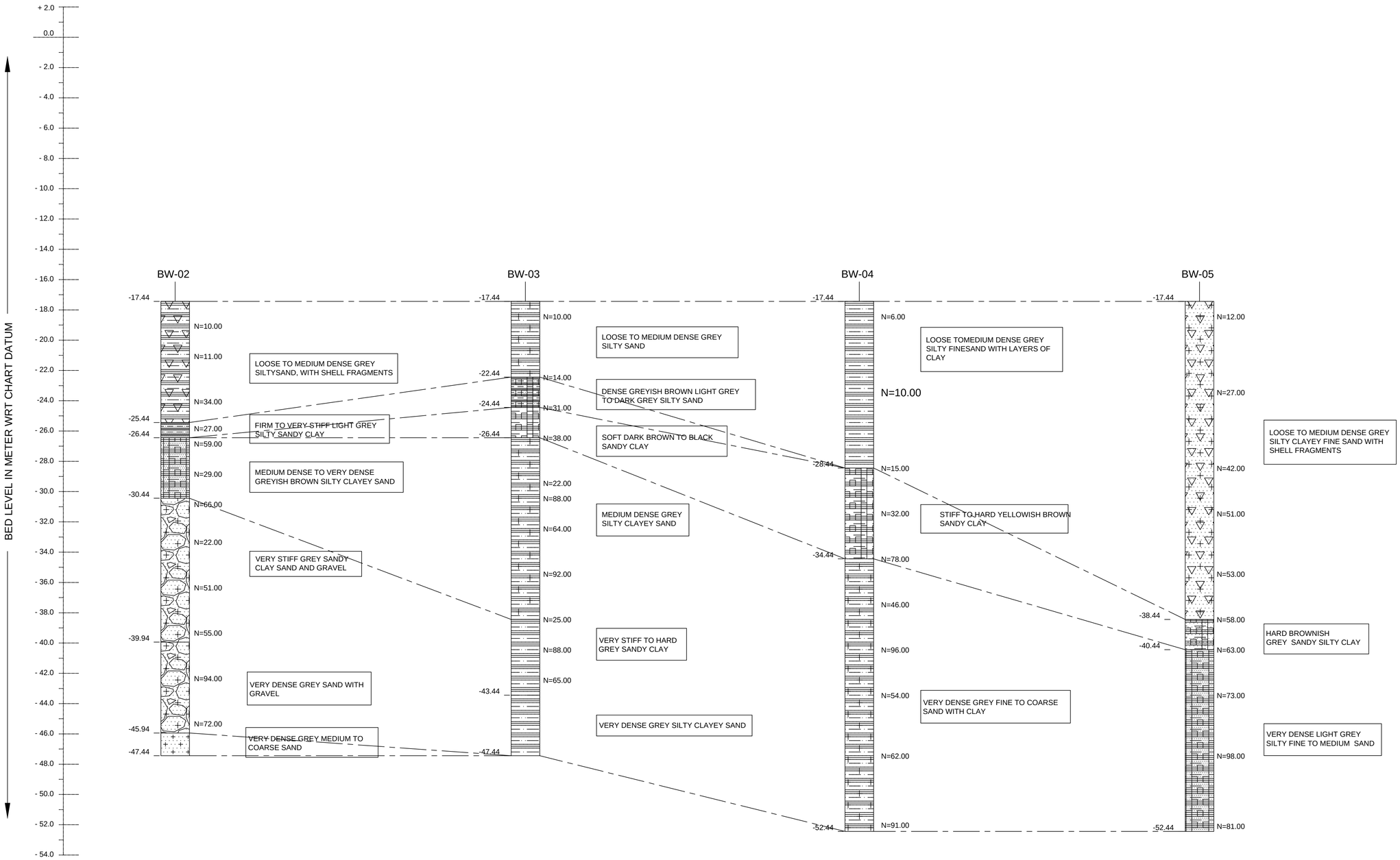
LOCATION OF BOREHOLES

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 07-02-2014

FIGURE No. : 4.5

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm



NOTES:

1. ALL LEVELS ARE IN METRES AND ARE WITH RESPECT TO CHART DATUM.

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

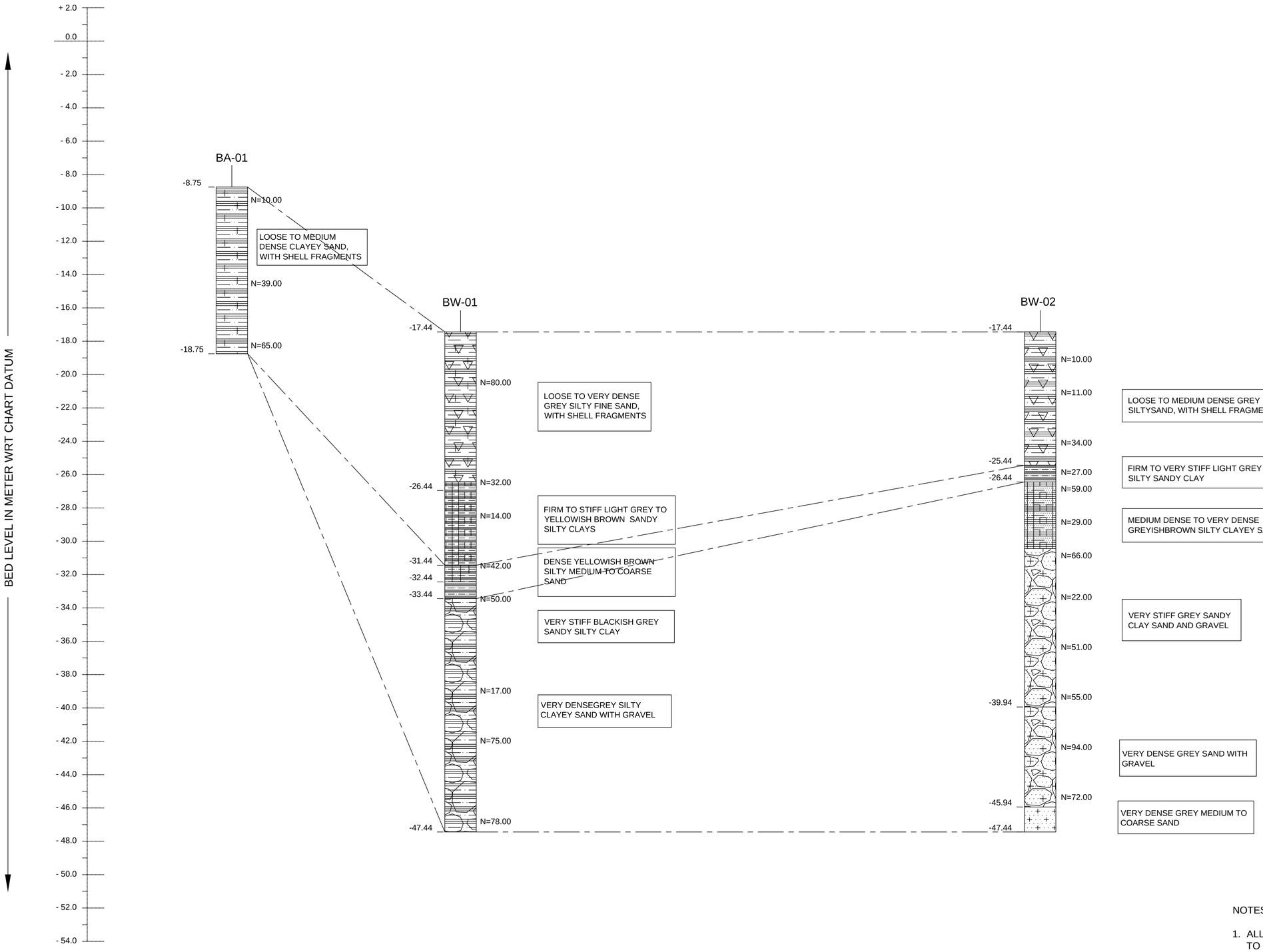
SOIL PROFILE 1

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 07-02-2014

FIGURE No. : 4.6

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm



NOTES:

1. ALL LEVELS ARE IN METRES AND ARE WITH RESPECT TO CHART DATUM.

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

SOIL PROFILE 2

AECOM India Private Limited

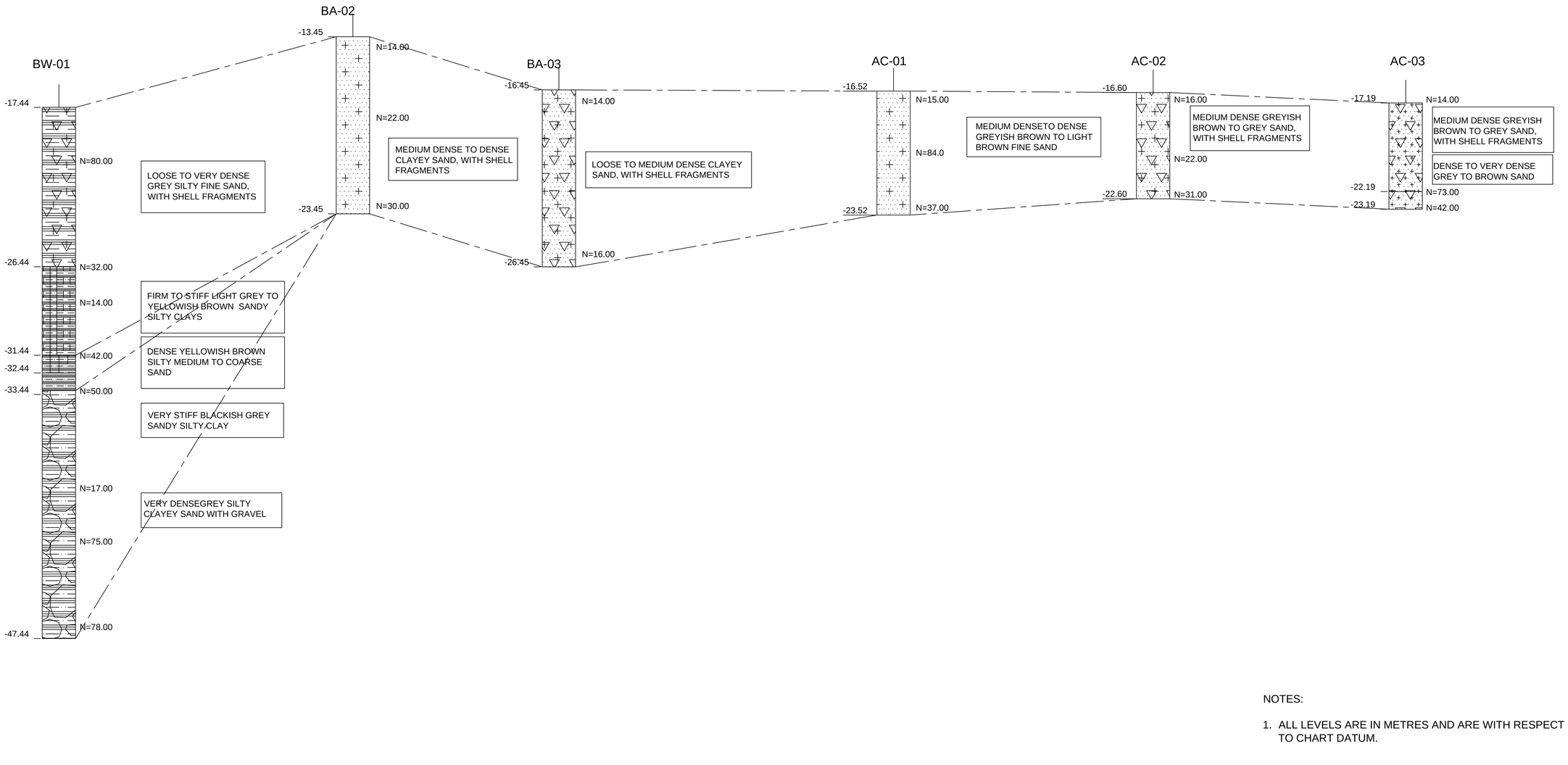
PROJECT No. : DELD12086 **DATE :** 07.02.2014

FIGURE No. : 4.7

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

BED LEVEL IN METER WRT CHART DATUM

+ 2.0
0.0
- 2.0
- 4.0
- 6.0
- 8.0
- 10.0
- 12.0
- 14.0
- 16.0
- 18.0
- 20.0
- 22.0
- 24.0
- 26.0
- 28.0
- 30.0
- 32.0
- 34.0
- 36.0
- 38.0
- 40.0
- 42.0
- 44.0
- 46.0
- 48.0
- 50.0
- 52.0
- 54.0



NOTES:

1. ALL LEVELS ARE IN METRES AND ARE WITH RESPECT TO CHART DATUM.

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

SOIL PROFILE 3

AECOM India Private Limited

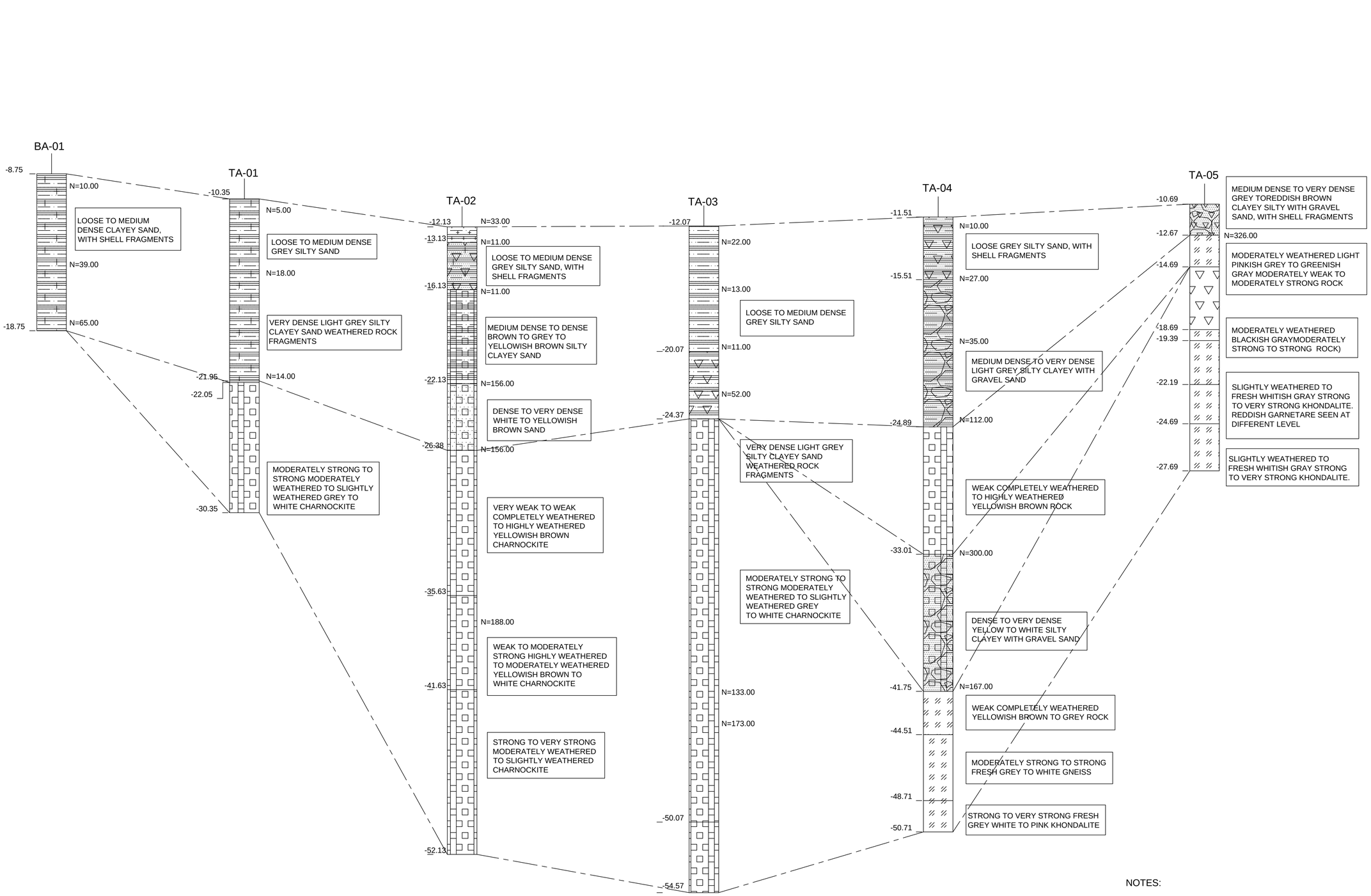
PROJECT No. : DELD12086 **DATE :** 07.02.2014

FIGURE No. : 4.8

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm

BED LEVEL IN METER WRT CHART DATUM

+ 2.0, 0.0, - 2.0, - 4.0, - 6.0, - 8.0, - 10.0, - 12.0, - 14.0, - 16.0, - 18.0, - 20.0, - 22.0, - 24.0, - 26.0, - 28.0, - 30.0, - 32.0, - 34.0, - 36.0, - 38.0, - 40.0, - 42.0, - 44.0, - 46.0, - 48.0, - 50.0, - 52.0, - 54.0



NOTES:

1. ALL LEVELS ARE IN METRES AND ARE WITH RESPECT TO CHART DATUM.

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

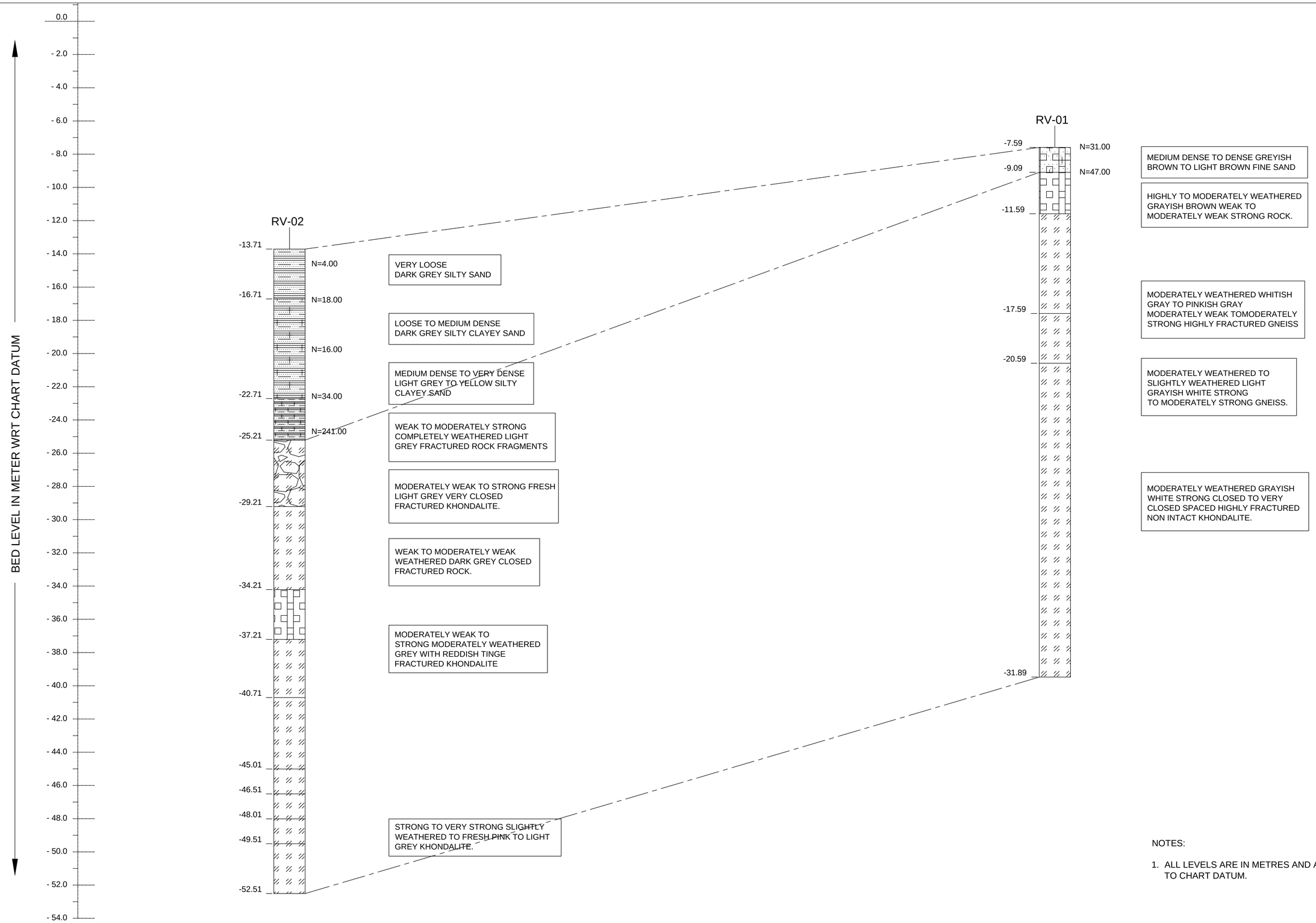
SOIL PROFILE 4

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 07.02.2014

FIGURE No. : 4.9

Project Management Initials: Designer: DK Checked: AM Approved: VA ISO A1 594mm x 841mm



NOTES:

1. ALL LEVELS ARE IN METRES AND ARE WITH RESPECT TO CHART DATUM.

PROJECT NAME : DEVELOPMENT OF VIZHINJAM PORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

SOIL PROFILE 5

AECOM India Private Limited

PROJECT No. : DELD12086 **DATE :** 07.02.2014

FIGURE No. : 4.10

Annexure 3

Drawings

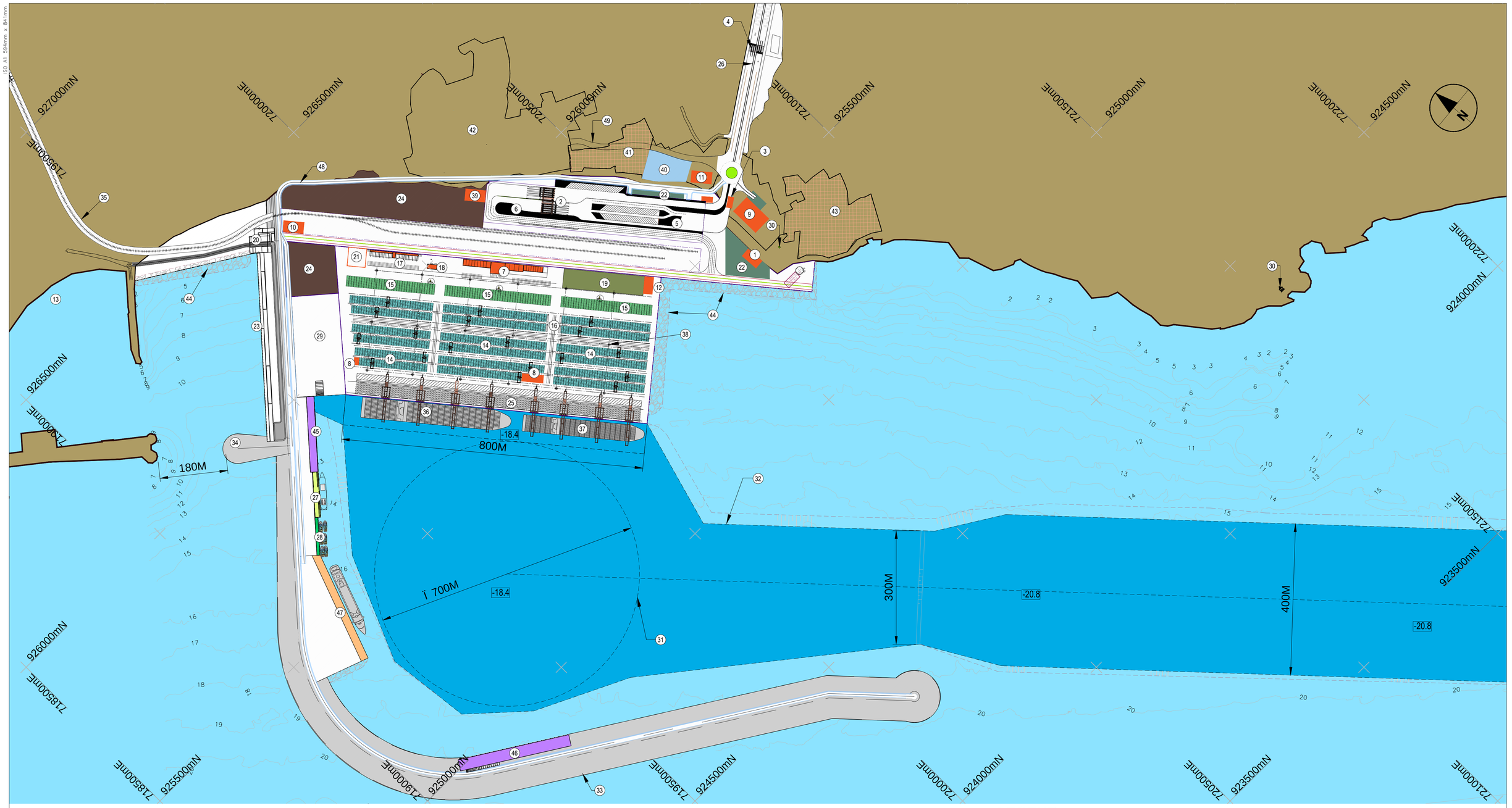
Prepared for

Vizhinjam International Seaports Limited (VISL)

Prepared by

AECOM India Private Limited

December 2014



KEY NOTES

1. ADMINISTRATION BUILDING
2. ENTRY / EXIT GATE CANOPY
3. SECURITY GUARD BOOTH
4. PRE - GATE
5. CUSTOMS BUILDING
6. GATE STAFF BUILDING
7. MAINTENANCE & REPAIR AREA AND BUILDING
8. QUAY CRANE MAINTENANCE & MARINE OPERATIONS BUILDING
9. VISL PORT ADMINISTRATE BUILDING
10. RAILWAY STATION MASTER BUILDING
11. SUB STATION & UTILITY AREA
12. YARD OPERATIONS BUILDING
13. EXISTING FISHING HARBOUR
14. LOADED BOX STORAGE
15. EMPTY BOX STORAGE
16. REEFER STORAGE
17. REEFER WASH AREA
18. REEFER SERVICE & GENSET AREA
19. EQUIPMENT STORAGE AREA
20. AUCTION HALL, NET MENDING FACILITY FOR FISH LANDING BERTHS
21. HAZARDOUS CARGO AREA
22. POV PARKING AREA
23. FISH LANDING BERTHS 500M LONG
24. FUTURE EXPANSION AREA
25. CONTAINER BERTHS 800M LONG
26. MAIN PORT ACCESS ROAD
27. COAST GUARD BERTH 120M LONG
28. PORT CRAFT BERTHS 100M LONG
29. INDIAN NAVY OPERATIONAL AREA(10 ACRES)
30. EXISTING TEMPLE
31. TURNING CIRCLE 700M DIA
32. APPROACH CHANNEL
33. BREAKWATER (2960M LONG)
34. FISHERY BERTH BREAKWATER (140M LONG)
35. PROPOSED RAIL ACCESS CORRIDOR
36. 12500 TEU CONTAINER VESSELS
37. 9000 TEU CONTAINER VESSELS
38. HIGH MAST LIGHTING POLE (TYP.)
39. FIRE STATION
40. RAIN WATER HARVESTING AREA
41. OPERATOR UTILITY AREA (PHASE - 1 & 2)
42. CRUISE TERMINAL & RESORT AREA
43. OPERATOR UTILITY AREA (FOR FUTURE)
44. REVETMENT WORK
45. INDIAN NAVY BERTH WITH LOADING RAMP 200M LONG
46. INDIAN NAVY BERTH 300M
47. CRUISE BERTH 300M
48. INDICATIVE ACCESS ROAD FOR NAVY & COAST GUARD
49. CRUISE SERVICE AREA ACCESS ROAD

LEGEND

- BUILDINGS
- POV / TERMINAL EQUIPMENTS PARKING AREA
- BREAKWATER
- LAND AREA
- SEA AREA
- FUTURE EXPANSION AREA

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 10 20 30 40
SCALE 1:5000 FULL SIZE (A1)

TRANSPORTATION (Ports & Maritime)

AECOM
9th Floor, Infinity Tower C
DLF Cyber City, DLF Phase- II
Gurgaon - 122002,
Haryana, India

www.aecom.com

Drawn By	VK
Approved By	VA
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

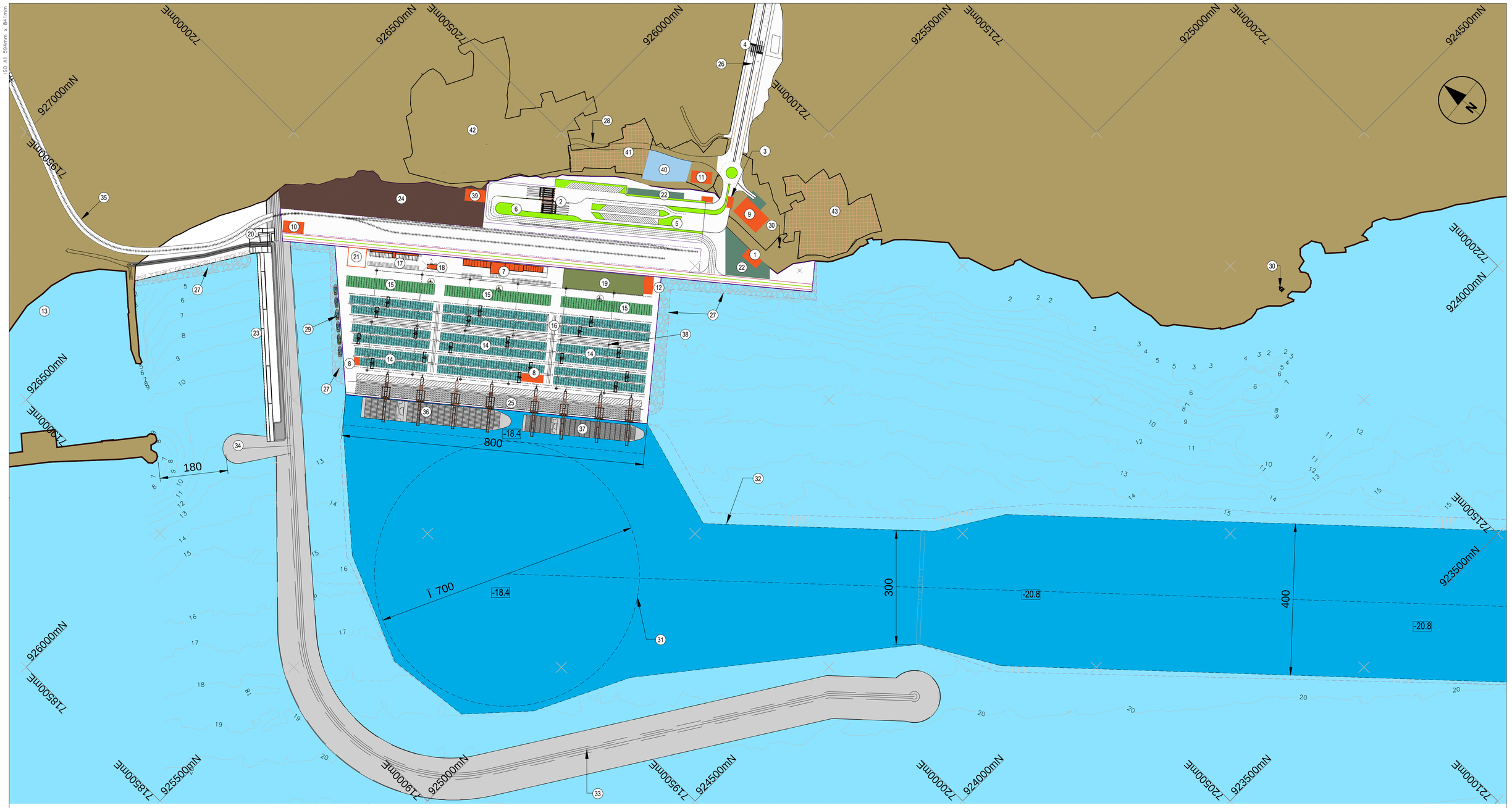
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title

PROPOSED MARINE LAYOUT OF PHASE-1 PORT DEVELOPMENT

Project Number	Sheet Number
DELD11137	1 of 1

Drawing No.
DELD11137-DRG-25-0000-CP- 1001 REV 1



KEY NOTES

1. ADMINISTRATION BUILDING
2. ENTRY / EXIT GATE CANOPY
3. SECURITY GUARD BOOTH
4. PRE - GATE
5. CUSTOMS BUILDING
6. GATE STAFF BUILDING
7. MAINTENANCE & REPAIR AREA AND BUILDING
8. QUAY CRANE MAINTENANCE & MARINE OPERATIONS BUILDING
9. VISL PORT ADMINISTRATE BUILDING
10. RAILWAY STATION MASTER BUILDING
11. SUB STATION & UTILITY AREA
12. YARD OPERATIONS BUILDING
13. EXISTING FISHING HARBOUR
14. LOADED BOX STORAGE
15. EMPTY BOX STORAGE
16. REEFER STORAGE
17. REEFER WASH AREA
18. REEFER SERVICE & GENSET AREA
19. EQUIPMENT STORAGE AREA
20. AUCTION HALL, NET MENDING FACILITY FOR FISH LANDING BERTHS
21. HAZARDOUS CARGO AREA
22. POV PARKING AREA
23. FISH LANDING BERTHS 500M LONG
24. FUTURE EXPANSION AREA
25. CONTAINER BERTHS 800M LONG
26. MAIN PORT ACCESS ROAD
27. REVETMENT WORK
28. CRUISE SERVICE AREA ACCESS ROAD
29. FACILITIES FOR PORT CRAFT
30. EXISTING TEMPLE
31. TURNING CIRCLE 700M DIA
32. APPROACH CHANNEL
33. NORTH BREAKWATER (2960M LONG)
34. FISHERY BERTH BREAKWATER (140M LONG)
35. PROPOSED RAIL ACCESS CORRIDOR
36. 12500 TEU CONTAINER VESSELS
37. 9000 TEU CONTAINER VESSELS
38. HIGH MAST LIGHTING POLE (TYP.)
39. FIRE STATION
40. RAIN WATER HARVESTING AREA
41. OPERATOR UTILITY AREA (PHASE - 1)
42. CRUISE TERMINAL & RESORT AREA
43. OPERATOR UTILITY AREA (FOR FUTURE)

LEGEND

- BUILDINGS
- POV / TERMINAL EQUIPMENTS PARKING AREA
- BREAKWATER
- LAND AREA
- SEA AREA
- FUTURE EXPANSION AREA

NOTES:

1. ALL DEPTHS ARE IN METERS AND WITH RESPECT TO CHART DATUM.
2. ALL DIMENSIONS ARE IN METERS.
3. ALL COORDINATES ARE GIVEN IN METERS RELATING TO UTM PROJECTION, SPHEROID WGS 84.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 100 200 300 400
SCALE 1:5000 FULL SIZE (A1)

TRANSPORTATION (Ports & Maritime)

AECOM
9th Floor, Infinity Tower C
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Gurgaon - 122002,
Haryana, India

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Drawn By	VK
Approved By	VA
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

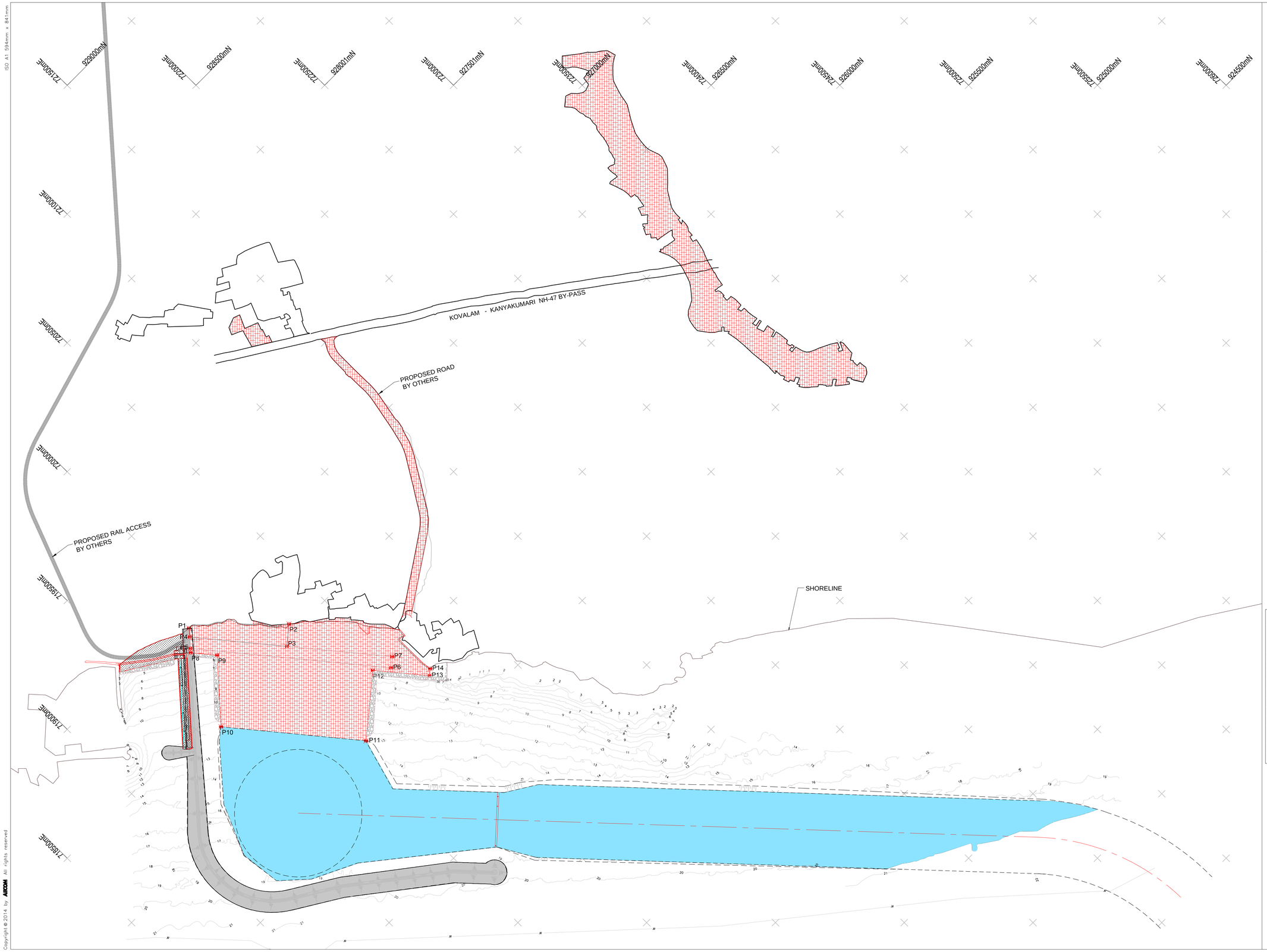
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title

RECOMMENDED MARINE LAYOUT OF PHASE-1 PORT DEVELOPMENT

Project Number	Sheet Number
DELD11137	of
Drawing No.	
DELD11137-DRG-25-0000-CP- 1002	REV 1

ISO A1 594mm x 841mm



N

LEGENDS :

LAND ALLOTTED FOR PPP WORK

FUNDED WORK :

1. BREAKWATER
2. FISHERY HARBOUR

PPP WORK :

1. DREDGING
2. CONTAINER BERTH/TERMINAL RECLAMATION, EXTERNAL CONNECTIVITY, CFS & WARE HOUSING, ELECTRIC SUB-STATION

COORDINATES			
POINTS	EASTING	NORTHING	REMARKS
P01	719865.837	926420.054	VISL AREA FOR FUTURE EXPANSION
P02	720270.156	926047.572	
P03	720174.808	925969.024	
P04	719834.441	926382.254	
P05	719792.561	926335.511	AREA FOR PROPOSED RAIL YARD
P06	720495.960	925481.598	
P07	720543.813	925521.019	
P08	719777.037	926318.166	SEA SIDE LIMIT FOR PPP WORK
P09	719869.774	926205.394	
P10	719607.177	925912.396	
P11	720115.866	925294.905	
P12	720415.947	925542.111	
P13	720614.625	925301.061	
P14	720644.751	925325.923	

NOTE:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.
3. ALL CO-ORDINATES ARE GIVEN IN METERS RELATING TO UTM PROJECTION, SPHEROID WGS 84.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 200 400 600 800

SCALE 1:10000 FULL SIZE (A1)

TRANSPORTATION (Ports & Maritime)

AECOM
9th Floor, Infinity Tower C
DLF Cyber City, DLF Phase- II
Gurgaon - 122002,
Haryana, India

www.aecom.com

Drawn By	VK
Approved By	VA
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title

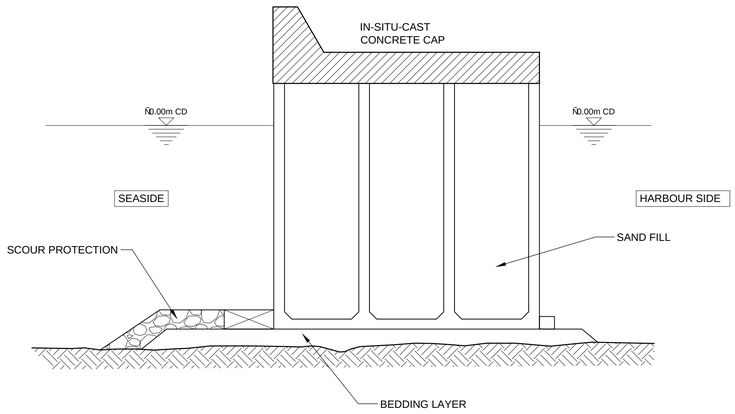
WORKS LIMITS FOR FUNDED AND PPP WORKS

Project Number	Sheet Number
DELD11137	1 of 1

Drawing No.

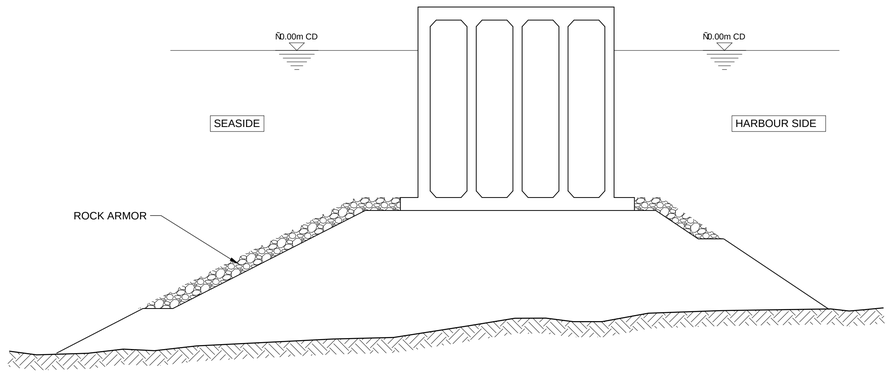
DELD11137-DRG-25-0000-CP- 1003 REV 1

ISO A1 594mm x 841mm



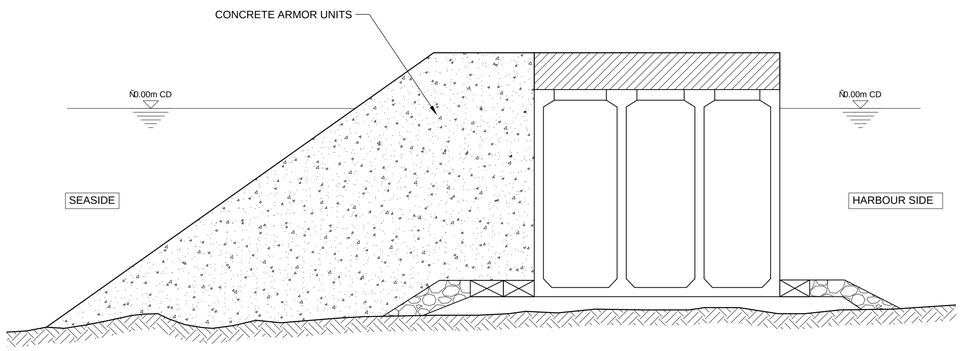
CONVENTIONAL CAISSON BREAKWATER WITH VERTICAL FRONT

SCALE 1:100



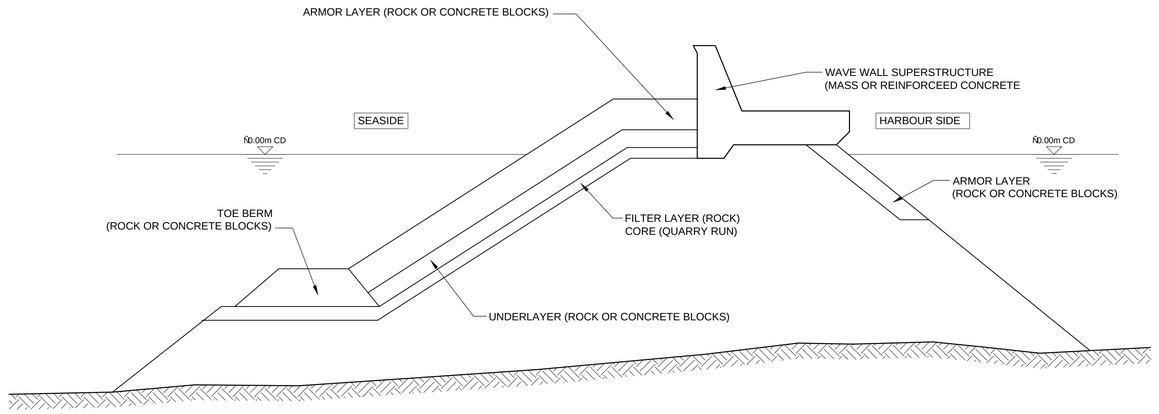
VERTICAL COMPOSITE CAISSON BREAKWATER

SCALE 1:100



HORIZONTAL COMPOSITE CAISSON BREAKWATER

SCALE 1:100



RUBBLE-MOUND BREAKWATER WITH CONCRETE SUPERSTRUCTURE

SCALE 1:100

Revision	By	Approved	Date
R1	VKM	VA	05-05-2014

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Approved By: VA
Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

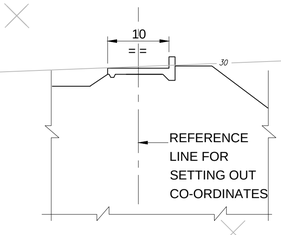
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: ALTERNATIVE BREAKWATER CROSS SECTIONS

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 2001 REV 1

ISO A1 594mm x 841mm

926500mN
926000mN
925500mN
925000mN
719500mE
719000mE
718500mE
SHORELINE
P1
P2
P3
P4
P5
P6
P7
P8
DREDGED HARBOUR BASIN
REFERENCE LINE FOR SETTING OUT CO-ORDINATES
R400.000
coral reef



TYPICAL SECTION THROUGH BREAKWATER

COORDINATES		
POINTS	EASTING	NORTHING
P1	719862.367	926420.928
P2	719411.171	925917.442
P3	719117.216	925589.421
P4	719206.344	924981.267
P5	719462.513	924824.533
P6	719950.497	924451.465
P7	720104.973	924285.618
P8	719304.341	926013.177

NOTE:

1. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.
3. ALL CO-ORDINATES ARE GIVEN IN METERS RELATING TO UTM PROJECTION, SPHEROID WGS 84.

Revision	By	Approved	Date
R1	VKM	VA	05-05-2014

50 0 50 100 150 200 250 m
SCALE 1 : 5000 FULL SIZE A1

TRANSPORTATION (Ports & Maritime)

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Approved By	VA
Date	07-02-2014
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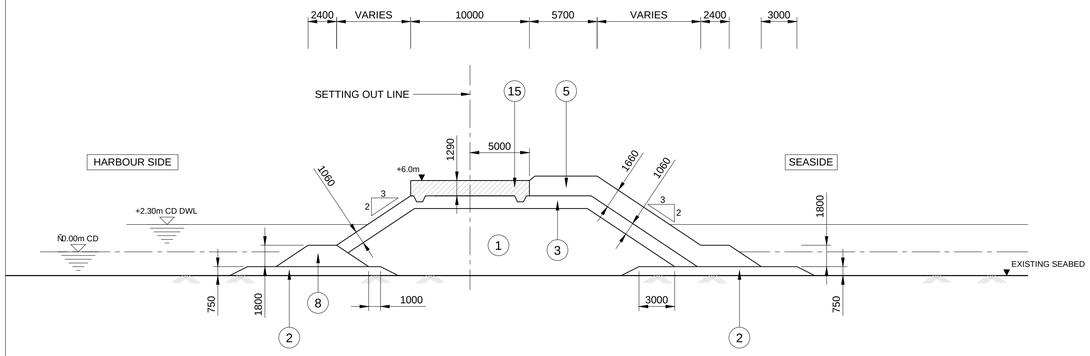
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
PROPOSED BREAKWATER LAYOUT

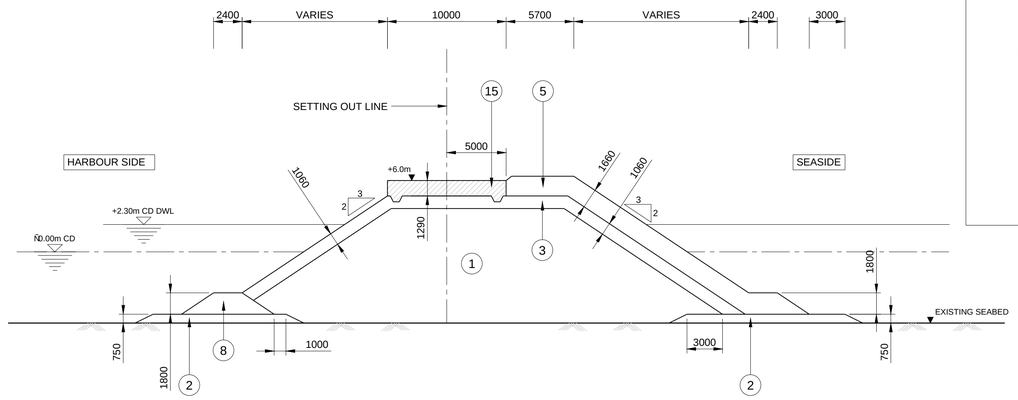
Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 2002 REV 1

ISO A1 594mm x 841mm



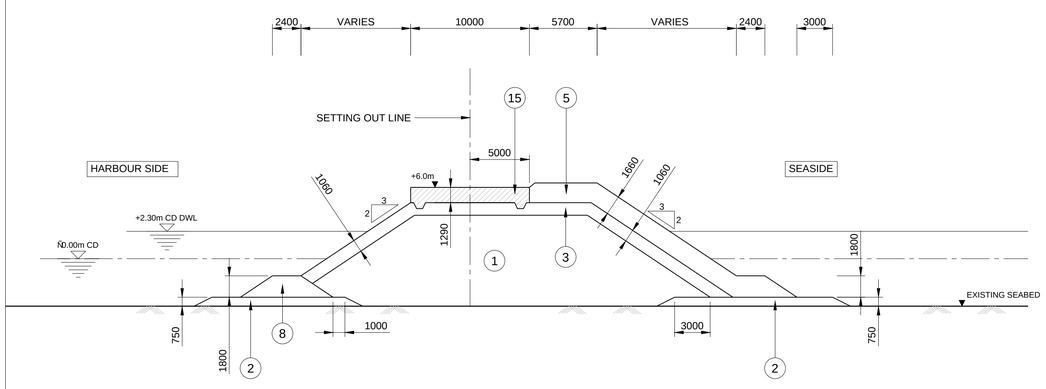
CROSS SECTION VALID FROM -0m TO -2m CD

SCALE 1:250



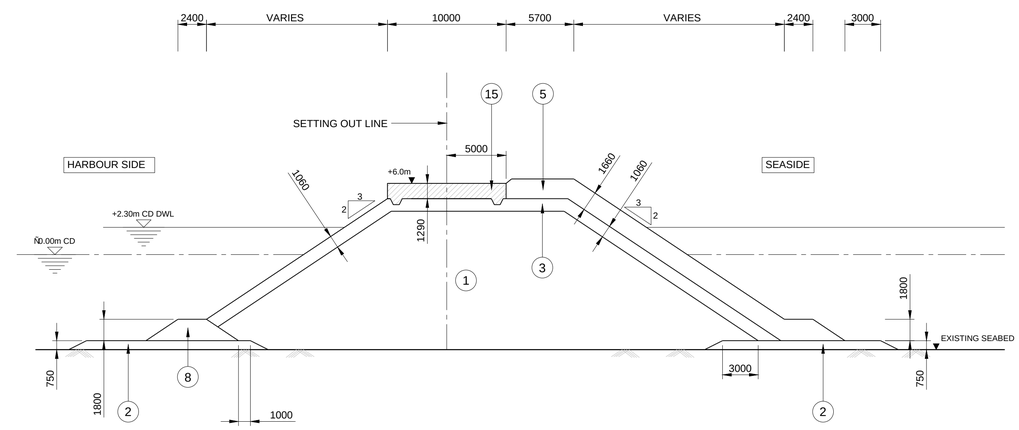
CROSS SECTION VALID FROM -4m TO -6m CD

SCALE 1:250



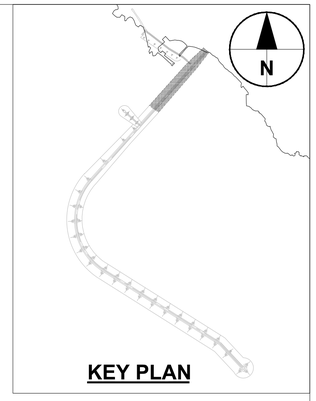
CROSS SECTION VALID FROM -2m TO -4m CD

SCALE 1:250



CROSS SECTION VALID FROM -6m TO -8m CD

SCALE 1:250



KEY PLAN

LEGEND:

1	CORE 10KG TO 0.5T
2	BEDDING LAYER 0.1T TO 0.3T
3	ROCK 0.2T TO 0.4T
4	ROCK 0.6T TO 1.4T
5	ROCK 1.0T TO 2.0T
6	ROCK 1.4T TO 2.7T
7	ROCK 2.0T TO 4.0T
8	TOE PROTECTION ROCK 1.0T TO 2.0T
9	TOE PROTECTION ROCK 2.0T TO 4.0T
10	TOE PROTECTION ROCK 2.5T TO 5.0T
11	ACCROPODE 4m^3
12	ACCROPODE 5m^3
13	ACCROPODE 6m^3
14	ACCROPODE 8m^3
15	CROWN WALL

TIDAL LEVELS:

MHHW	-	+ 0.80m
MLHW	-	+ 0.70m
MHLW	-	+ 0.40m
MLLW	-	+ 0.30m
MSL	-	+ 0.60m
HAT	-	+ 1.20m

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.

Revision	By	Approved	Date
R1	VKM	VA	05-05-2014

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Approved By	VA
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Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

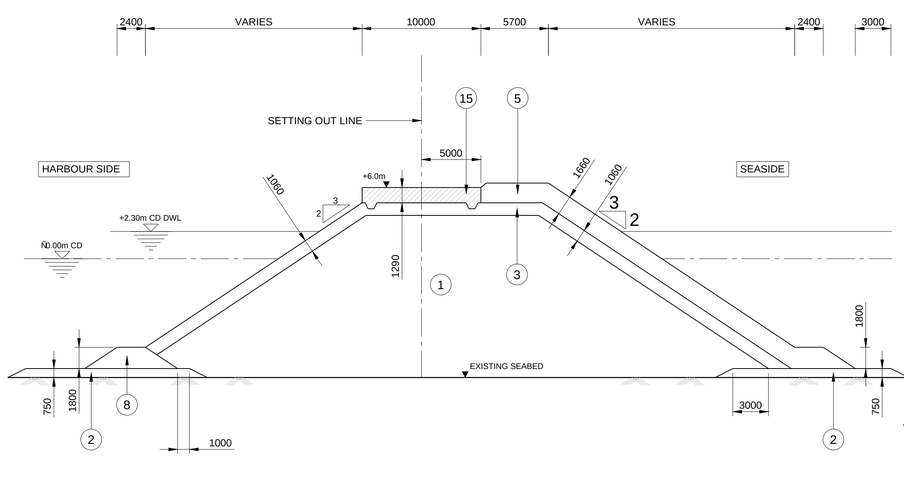
Sheet Title

BREAKWATER
CROSS SECTIONS

Project Number	Sheet Number
DELD11137	1 of 3

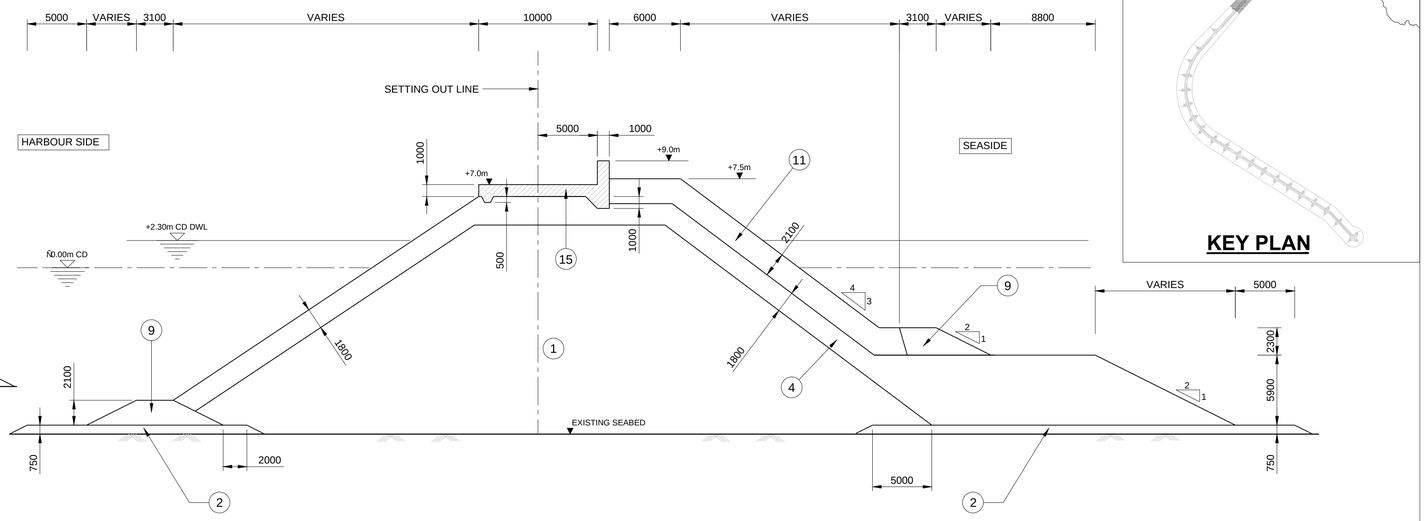
Drawing No.
DELD11137-DRG-25-0000-CP- 2003 REV 1

ISO A1 594mm x 841mm



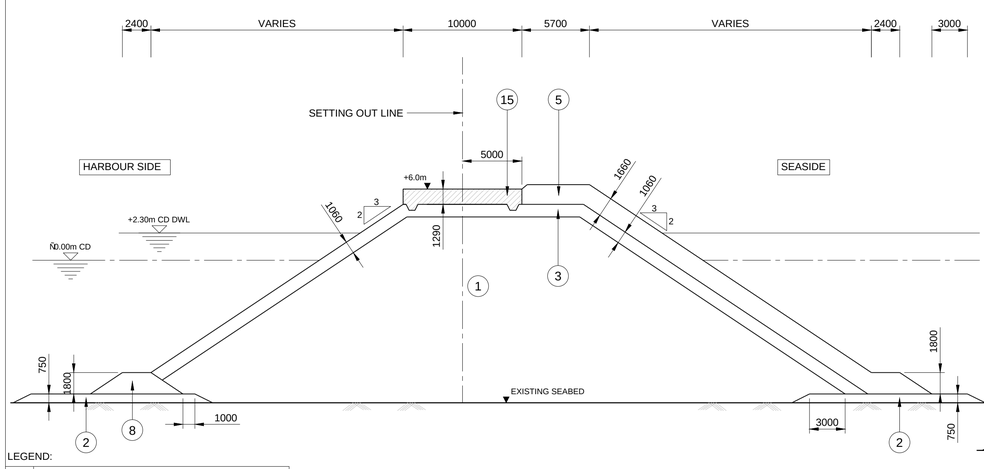
CROSS SECTION VALID FROM -8m TO -10m CD

SCALE 1:250



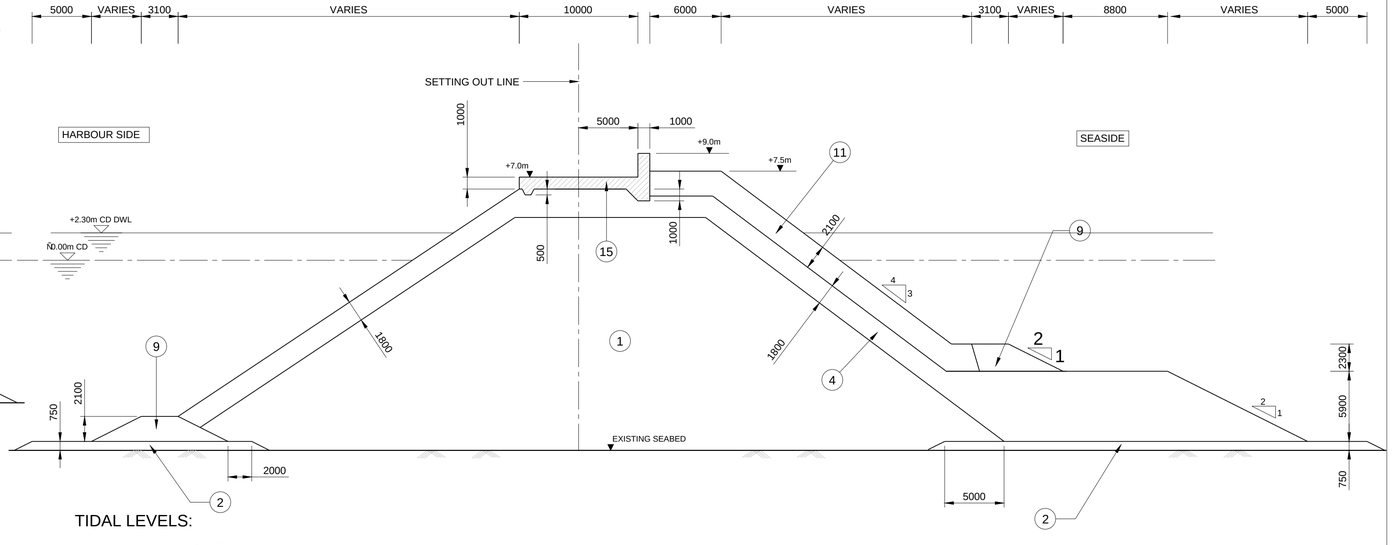
CROSS SECTION VALID FROM -12m TO -14m CD

SCALE 1:250



CROSS SECTION VALID FROM -10m TO -12m CD

SCALE 1:250



CROSS SECTION VALID FROM -14m TO -16m CD

SCALE 1:250

LEGEND:

1	CORE 10KG TO 0.5T
2	BEDDING LAYER 0.1T TO 0.3T
3	ROCK 0.2T TO 0.4T
4	ROCK 0.6T TO 1.4T
5	ROCK 1.0T TO 2.0T
6	ROCK 1.4T TO 2.7T
7	ROCK 2.0T TO 4.0T
8	TOE PROTECTION ROCK 1.0T TO 2.0T
9	TOE PROTECTION ROCK 2.0T TO 4.0T
10	TOE PROTECTION ROCK 2.5T TO 5.0T
11	ACCROPODE 4m³
12	ACCROPODE 5m³
13	ACCROPODE 6m³
14	ACCROPODE 8m³
15	CROWN WALL

TIDAL LEVELS:

MHHW	-	+ 0.80m
MLHW	-	+ 0.70m
MHLW	-	+ 0.40m
MLLW	-	+ 0.30m
MSL	-	+ 0.6 m
HAT	-	+ 1.20m

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.

KEY PLAN

Revision	By	Approved	Date
R1	VKM	VA	05-05-2014

TRANSPORTATION (Ports & Maritime)

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Date	07-02-2014
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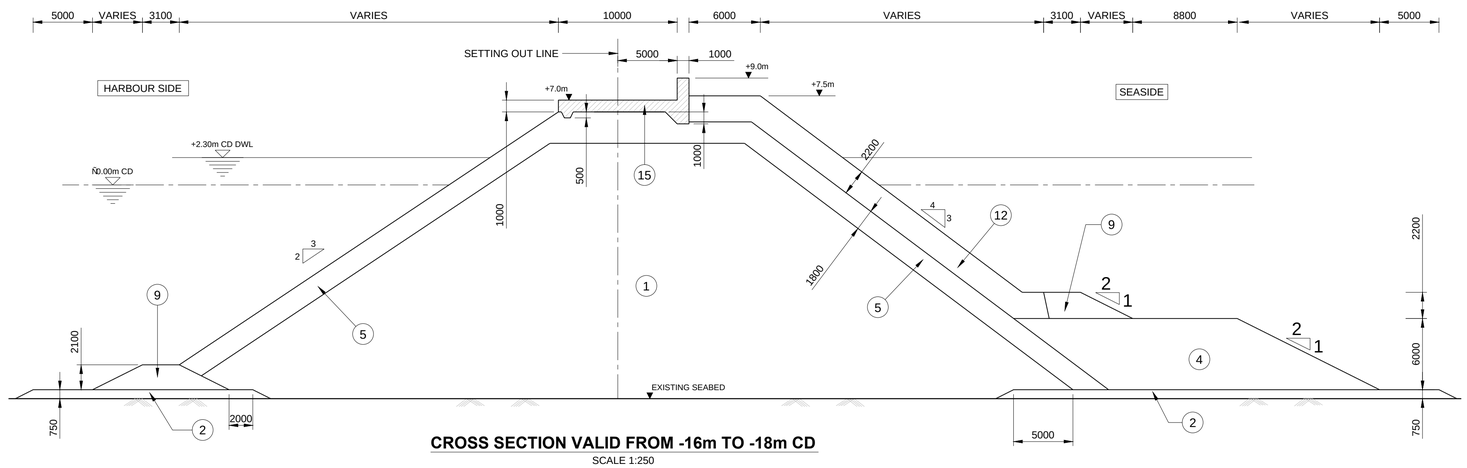
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: BREAKWATER CROSS SECTIONS

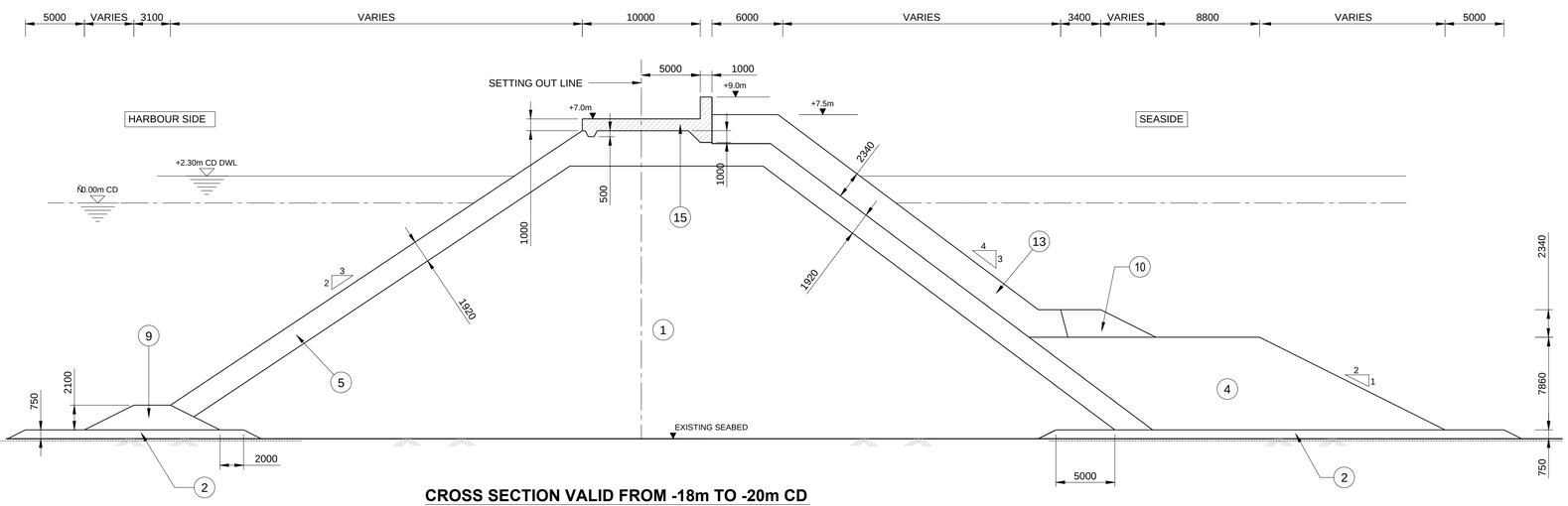
Project Number	Sheet Number
DELD11137	2 of 3

Drawing No. DELD11137-DRG-25-0000-CP- 2003 REV 1



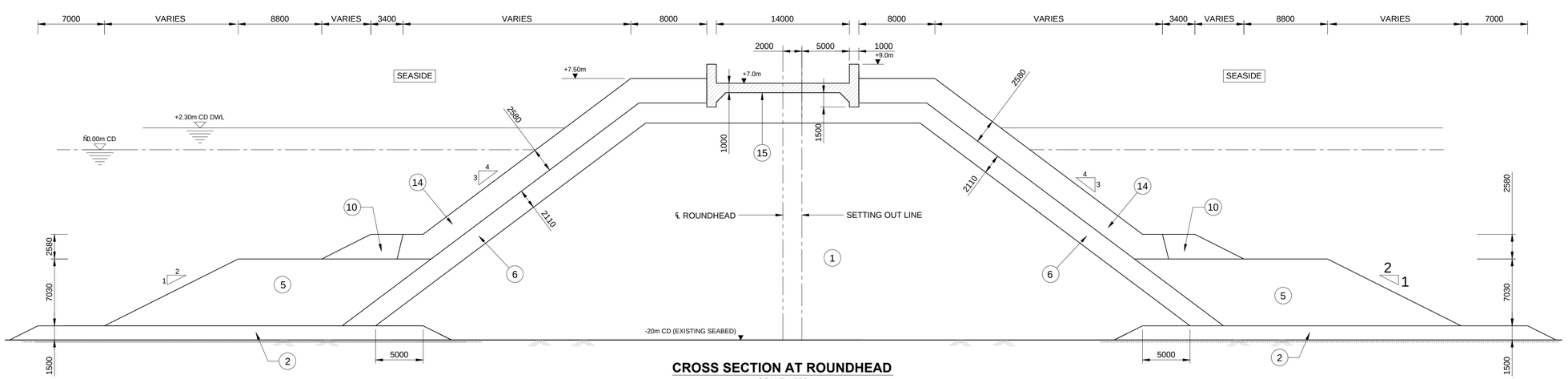
CROSS SECTION VALID FROM -16m TO -18m CD

SCALE 1:250



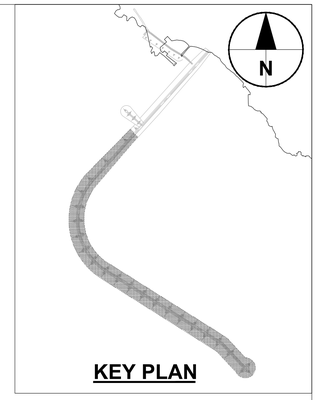
CROSS SECTION VALID FROM -18m TO -20m CD

SCALE 1:250



CROSS SECTION AT ROUNDHEAD

SCALE 1:250



KEY PLAN

LEGEND:

1	CORE 10KG TO 0.5T
2	BEDDING LAYER 0.1T TO 0.3T
3	ROCK 0.2T TO 0.4T
4	ROCK 0.6T TO 1.4T
5	ROCK 1.0T TO 2.0T
6	ROCK 1.4T TO 2.7T
7	ROCK 2.0T TO 4.0T
8	TOE PROTECTION ROCK 1.0T TO 2.0T
9	TOE PROTECTION ROCK 2.0T TO 4.0T
10	TOE PROTECTION ROCK 2.5T TO 5.0T
11	ACCROPODE 4m^3
12	ACCROPODE 5m^3
13	ACCROPODE 6m^3
14	ACCROPODE 8m^3
15	CROWN WALL

TIDAL LEVELS:

MHHW -	+ 0.80	m
MLHW -	+ 0.70	m
MHLW -	+ 0.40	m
MLLW	- + 0.30	m
MSL	- + 0.60	m
HAT	- + 1.20	m

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.

Revision	By	Approved	Date
R1	VKM	VA	05-05-2014

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Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

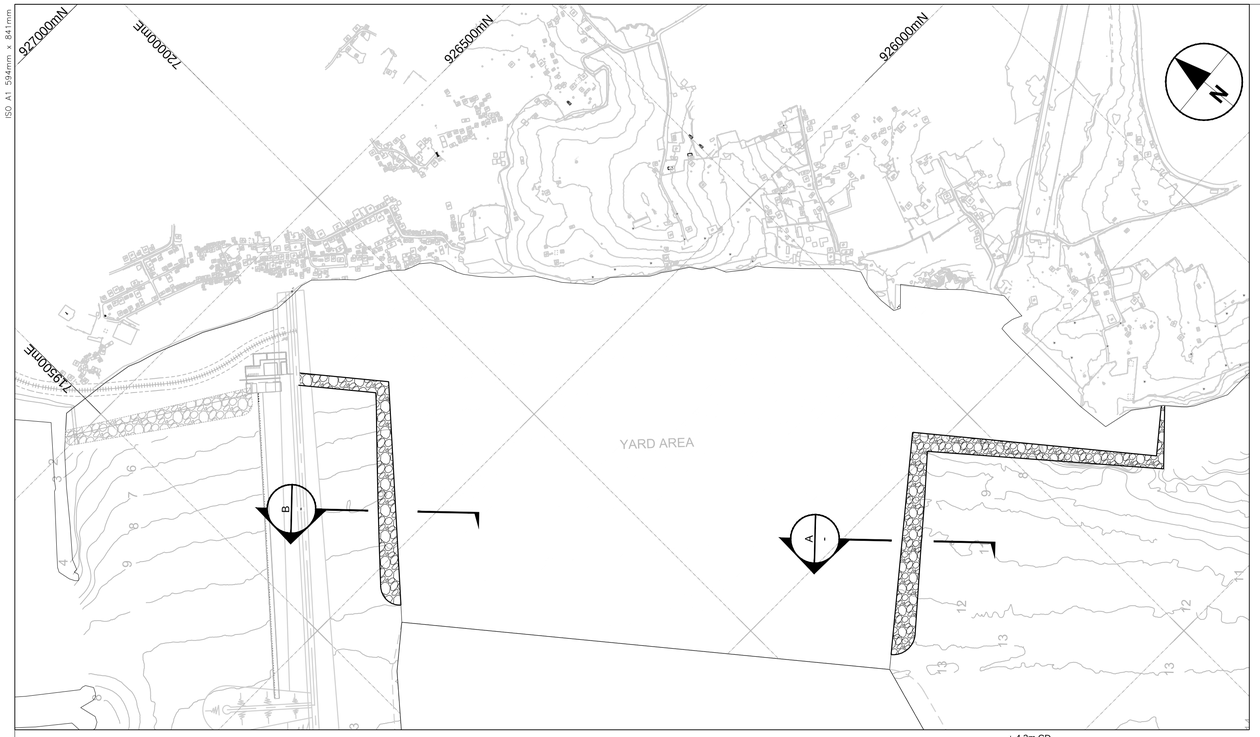
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

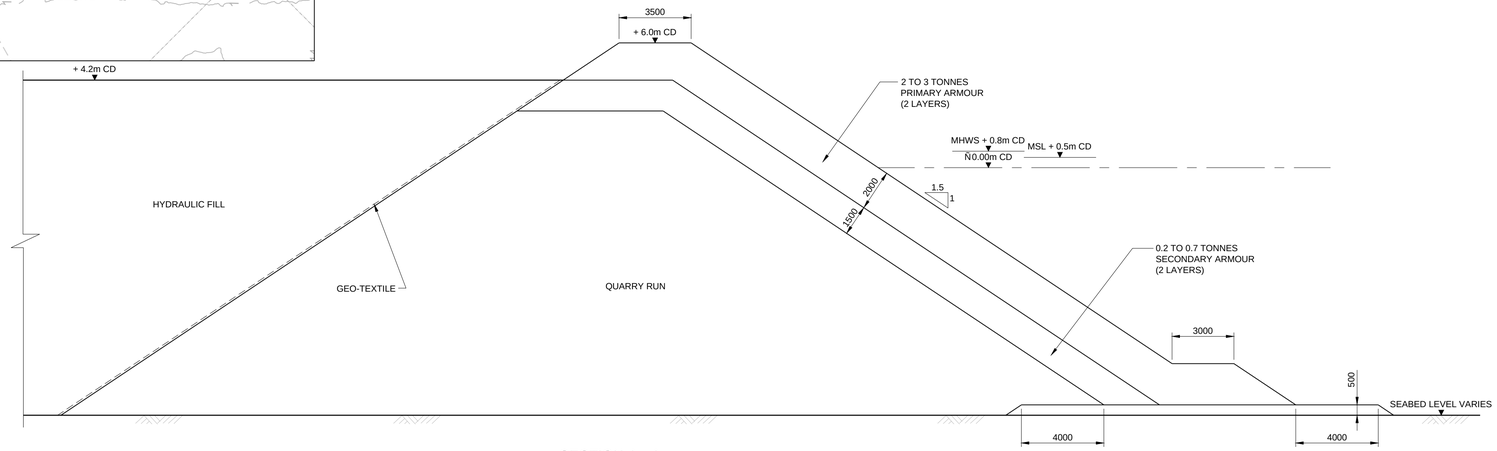
Sheet Title

BREAKWATER
CROSS SECTIONS

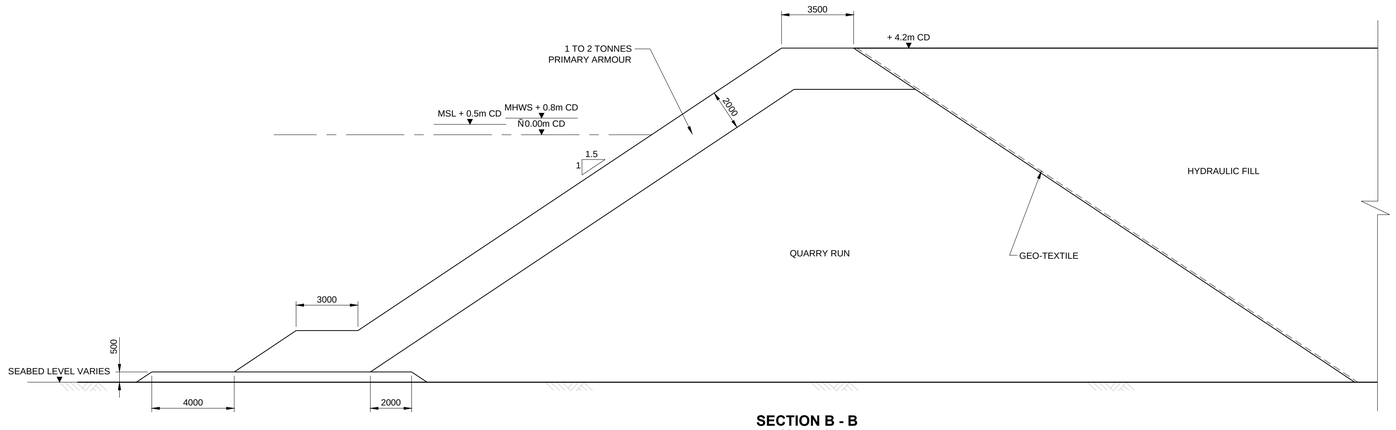
Project Number	DELD11137
Sheet Number	3 of 3
Drawing No.	DELD11137-DRG-25-0000-CP- 2003 REV 1

ISO A1 594mm x 841mm





SECTION A - A
SCALE 1:125



SECTION B - B
SCALE 1:125

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.

TIDAL LEVELS:

MHHW	-	+ 0.80m
MLHW	-	+ 0.70m
MHLW	-	+ 0.40m
MLLW	-	+ 0.30m
MSL	-	+ 0.60m
HAT	-	+ 1.20m

Revision	By	Approved	Date
R1	VKM	VA	05-05-2014

50 0 50 100 150 200 250 m
SCALE 1 : 5000 FULL SIZE A1

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Approved By	VA
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
LAYOUT AND CROSS SECTION OF SHORE PROTECTION BUND

Project Number	Sheet Number
DELD11137	1 of 1

Drawing No.
DELD11137-DRG-25-0000-CP- 2004 REV 1

ISO A1 594mm x 841mm

720000mE 926500mN 720500mE 926000mN 721000mE 925500mN 721500mE 925000mN 722000mE 924500mN

927000mN

SHORELINE

722000mE 924000mN

926500mN 719000mE

-18.4

800

60

926000mN 718500mE

-18.4

-20.8

-20.8

925500mN 718500mE 925000mN 719000mE 924500mN 720000mE 924000mN 720500mE 923500mN 721000mE

721500mE 923500mN

30

LEGEND

CONTAINER BERTH

NOTES:

1. ALL DEPTHS ARE IN METERS AND WITH RESPECT TO CHART DATUM.
2. ALL DIMENSIONS ARE IN METERS.
3. ALL COORDINATES ARE GIVEN IN METERS RELATING TO UTM PROJECTION, SPHEROID WGS 84.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 100 200 300 400

SCALE 1:5000 FULL SIZE (A1)

TRANSPORTATION (Ports & Maritime)

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Drawn By	VK
Approved By	VA
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

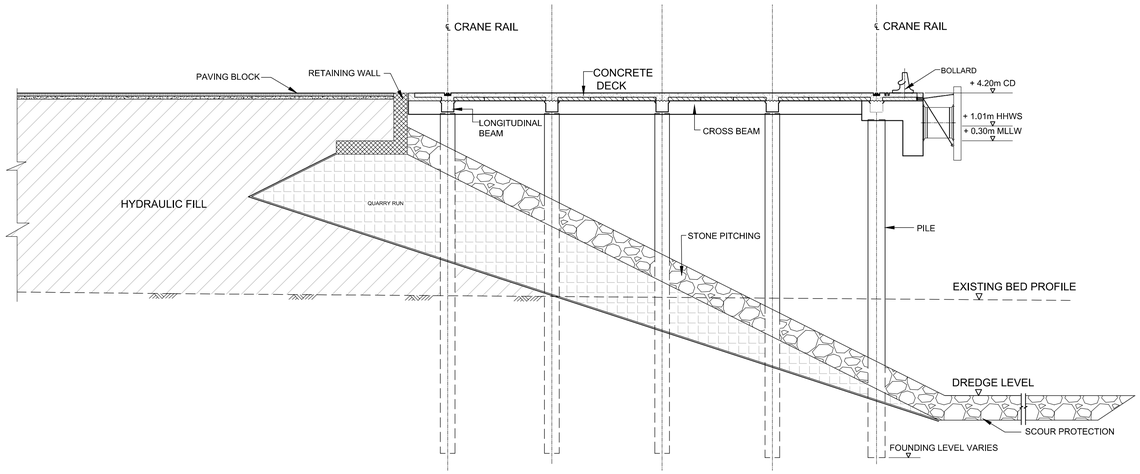
Sheet Title

GEOMETRIC REQUIREMENTS FOR THE QUAY STRUCTURE

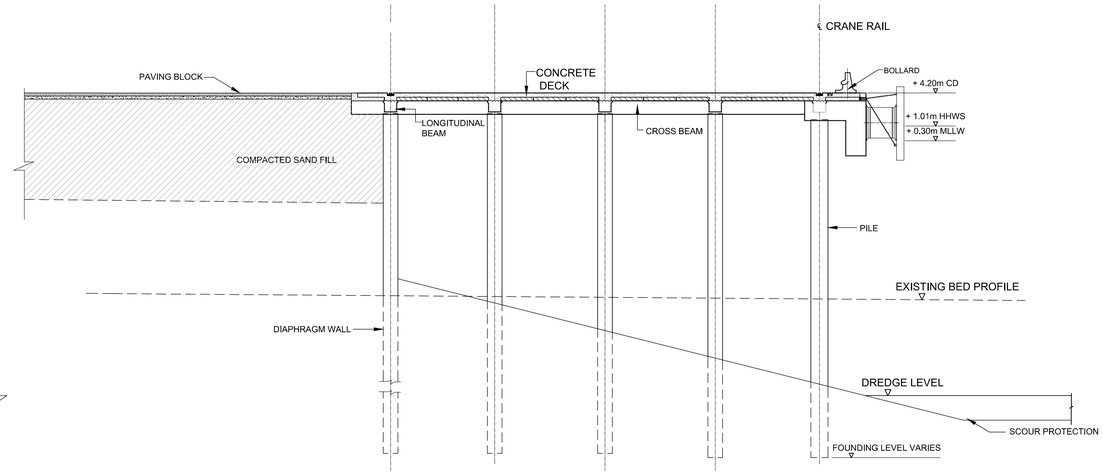
Project Number	Sheet Number
DELD11137	of

Drawing No.
DELD11137-DRG-25-0000-CP- 3001 REV 1

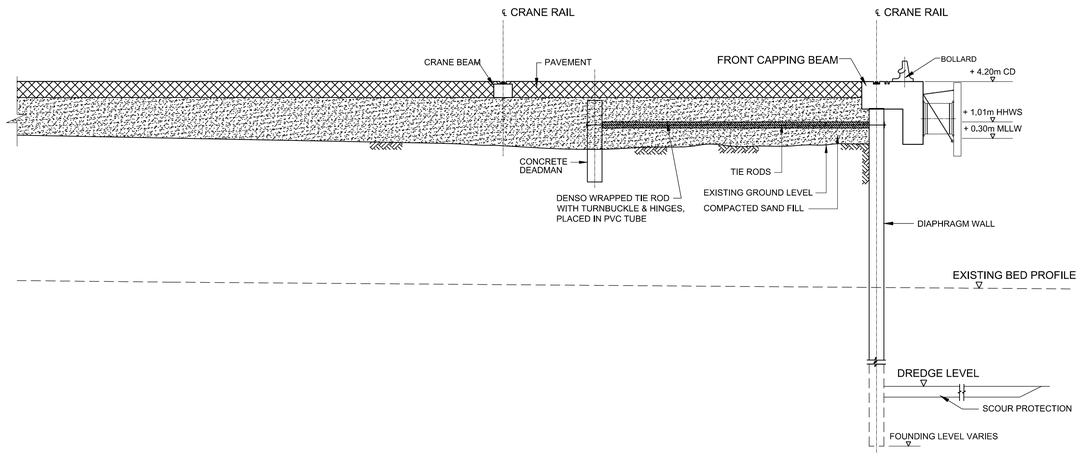
ISO A1 594mm x 841mm



ALTERNATIVE-1 : BERTH SUPPORTED ON PILES WITH RETAINING WALL AT REAR



ALTERNATIVE-2 : BERTH SUPPORTED ON PILES WITH DIAPHRAGM WALL AT REAR



ALTERNATIVE-3 : BERTH SUPPORTED ON DIAPHRAGM WALL

NOTES:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO LOCAL CHART DATUM.
2. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE MENTIONED.

Revision	By	Approved	Date
R1	VKM	VA	05-05-2014
R2	VK	VA	09-10-2014

0m 50 100 150 200
SCALE 1:250 FULL SIZE (A1)

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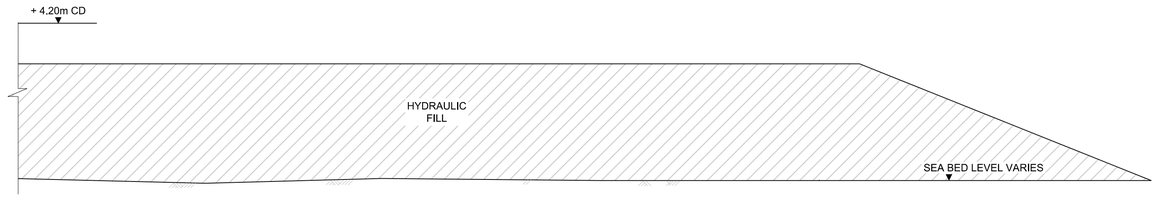
Approved By: VA
Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

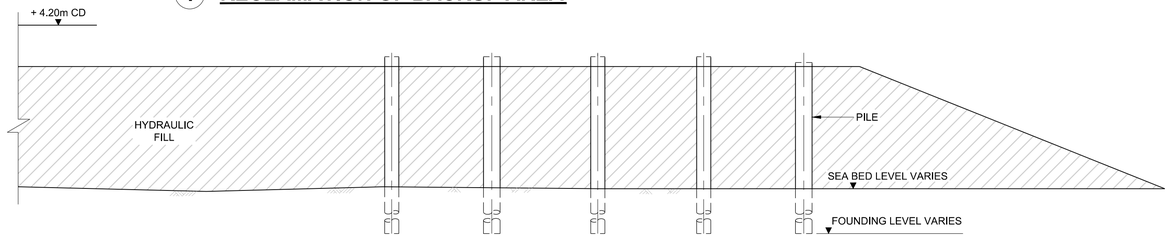
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: ALTERNATIVE BERTH STRUCTURE OPTIONS

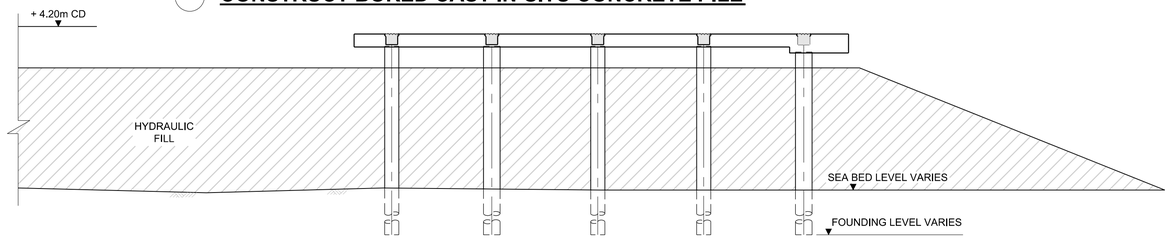
Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 3002 REV 2



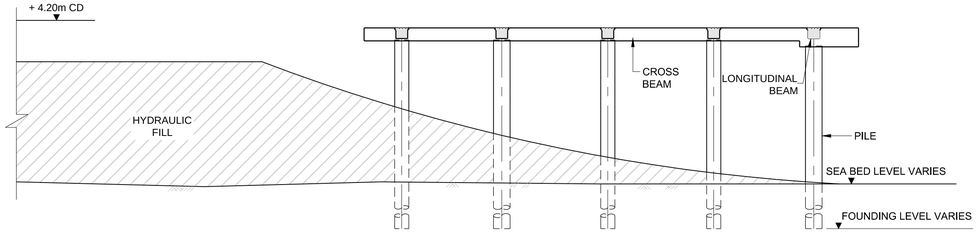
1 RECLAMATION OF BACKUP AREA



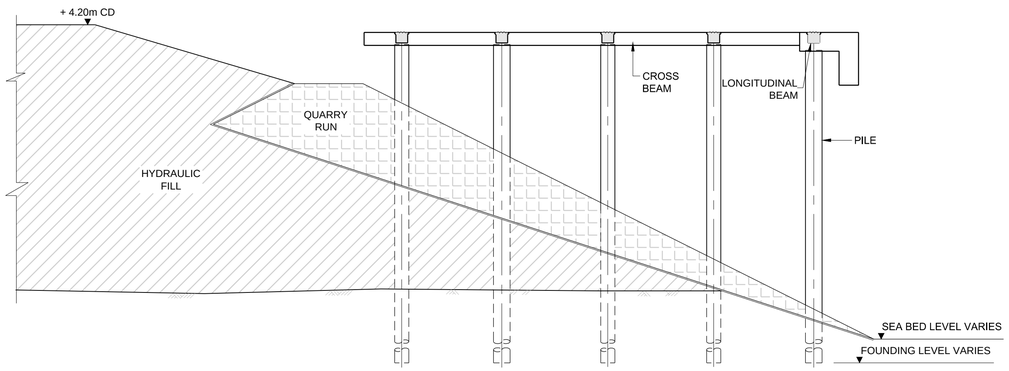
2 CONSTRUCT BORED CAST IN-SITU CONCRETE PILE



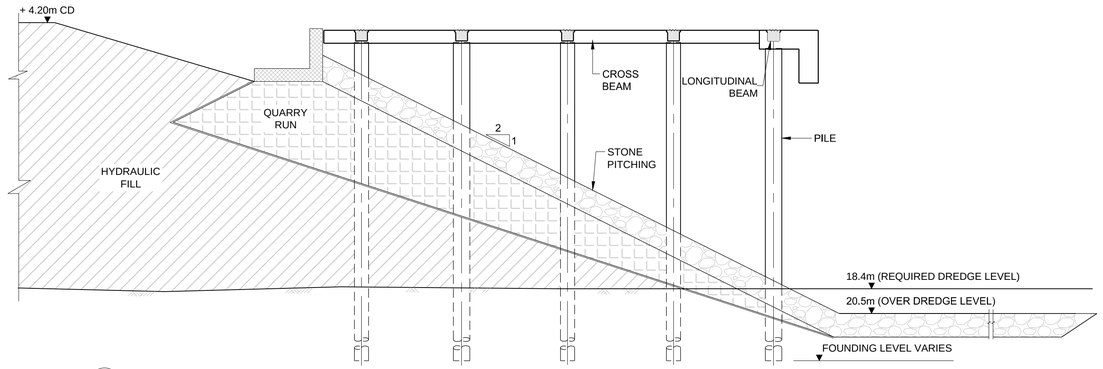
3 ERECTION OF LONGITUDINAL & TRANSVERSE BEAM



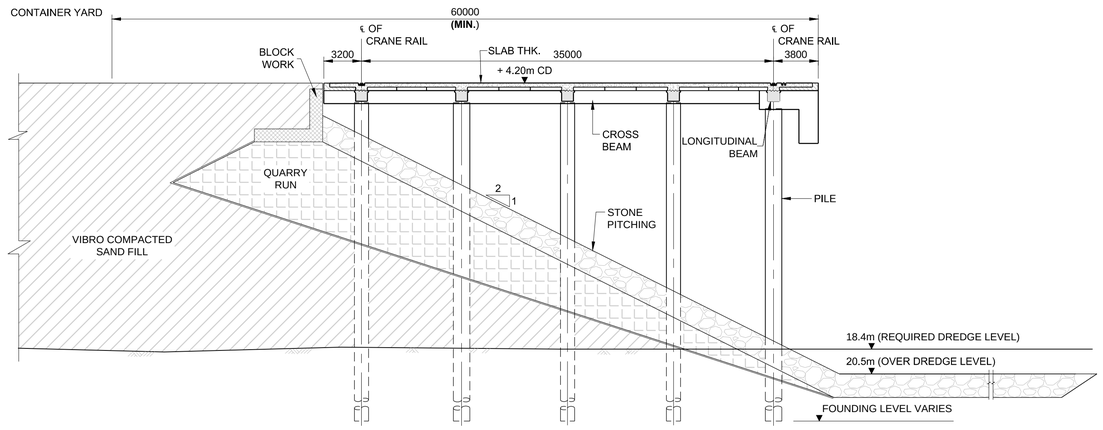
4 DREDGING IN FRONT OF BERTH TO ULTIMATE DREDGED LEVEL



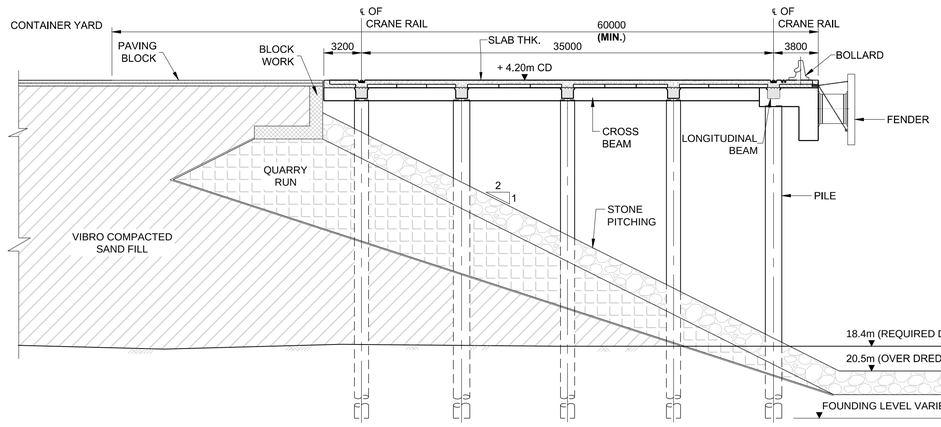
5 PLACING OF QUARRY STONE



6 PLACE STONE PITCHING UNDERNEATH THE DECK, CONSTRUCT RETAINING WALL



7 CONSTRUCT DECK & FILL RECLAMATION BEHIND BERTH



8 BERTH FIXTURES & YARD PAVEMENT

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE NOTED.
2. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.

Revision	By	Approved	Date
R1	VKM	VA	05-05-2014

TRANSPORTATION (Ports & Maritime)

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Drawn By: VKM
Approved By: VA
Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

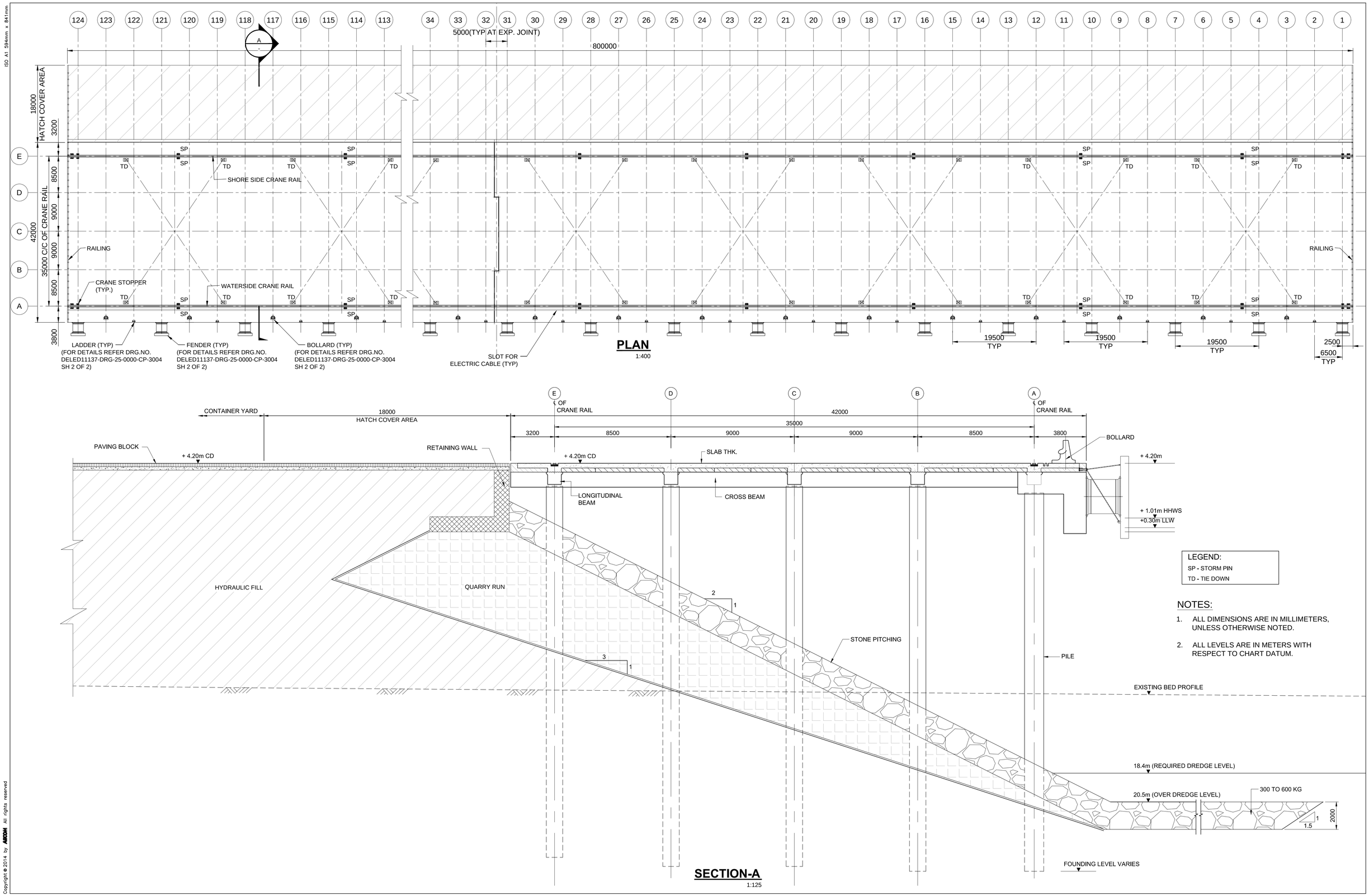
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: SEQUENCE OF CONSTRUCTION FOR CONTAINER BERTH

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 3003 REV 1

ISO A1 594mm x 841mm



PLAN
1:400

SECTION-A
1:125

LEGEND:
SP - STORM PIN
TD - TIE DOWN

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE NOTED.
2. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.

Revision	By	Approved	Date
R0	VKM	VA	07-02-2014
R1	VKM	VA	05-05-2014

0m 100 200 300 400
SCALE 1:5000 FULL SIZE (A1)

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Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

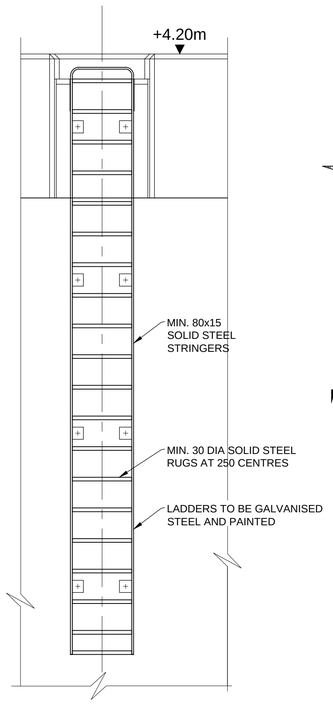
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

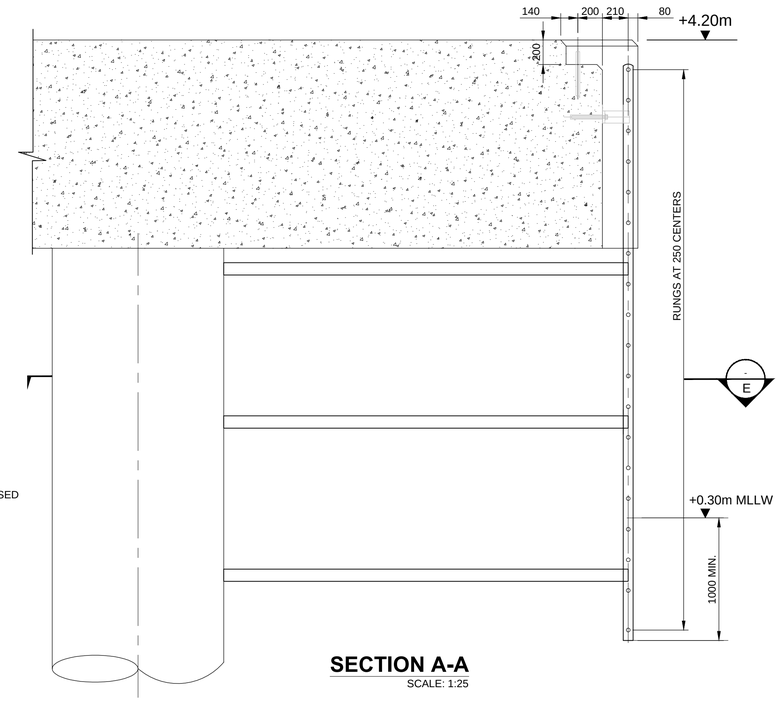
Sheet Title
GENERAL ARRANGEMENT AND CROSS SECTION OF THE CONTAINER BERTHS

Project Number	DELD11137
Sheet Number	1 of 2
Drawing No.	DELD11137-DRG-25-0000-CP- 3004 REV 1

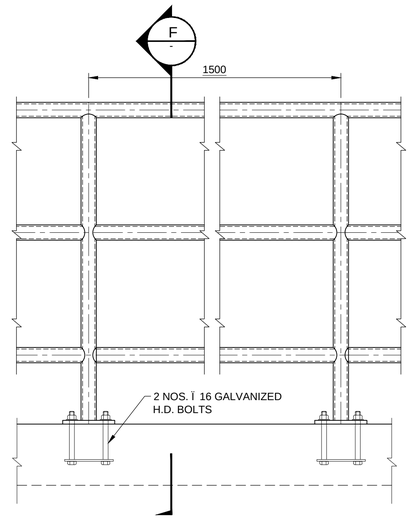
ISO A1 594mm x 841mm



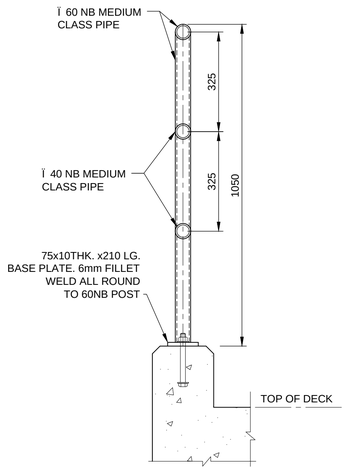
LADDER ELEVATION
SCALE: 1:25



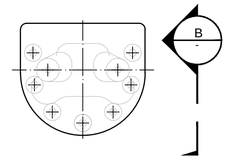
SECTION A-A
SCALE: 1:25



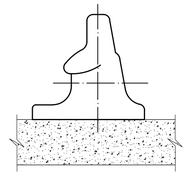
TYPICAL ELEVATION OF HANDRAIL
SCALE: 1:10



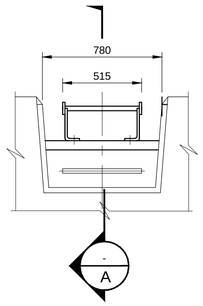
SECTION F-F
SCALE: 1:10



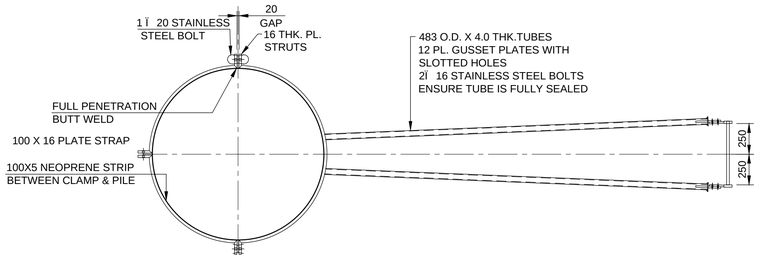
200T BOLLARD PLAN
SCALE: 1:25



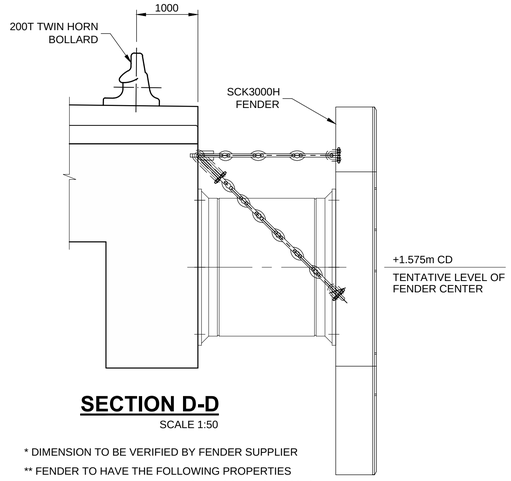
SECTION B-B
SCALE: 1:25



LADDER PLAN
SCALE: 1:20



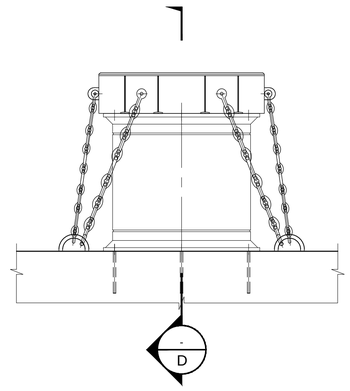
SECTION E-E
SCALE: 1:25



SECTION D-D
SCALE 1:50

* DIMENSION TO BE VERIFIED BY FENDER SUPPLIER

** FENDER TO HAVE THE FOLLOWING PROPERTIES
1. MINIMUM RATED ENERGY ABSORPTION: 3624 kNm
2. MAXIMUM RATED REACTION: 3668kN



PLAN (TYP. DETAIL OF FENDER)
SCALE 1:50

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE NOTED.
2. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.

Revision	By	Approved	Date
R0	VK	VA	07-02-2014
R1	VK	VA	05-05-2014

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(Ports & Maritime)

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DLF Cyber City, DLF Phase- II
Gurgaon - 122002,
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Drawn By: VK
Approved By: VA
Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: GENERAL ARRANGEMENT AND CROSS SECTION OF THE CONTAINER BERTHS (MISCELLANEOUS DETAILS)

Project Number: DELD11137
Sheet Number: 2 of 2
Drawing No.: DELD11137-DRG-25-0000-CP- 3004 REV 1

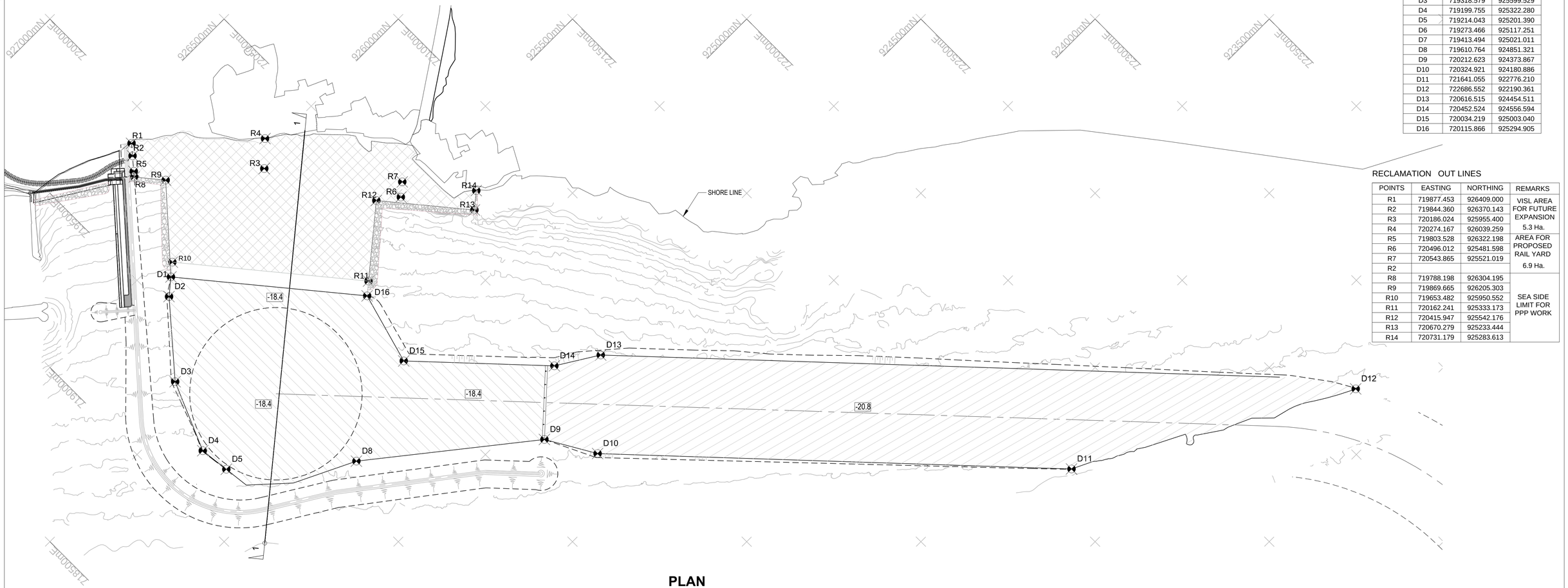
ISO A1 594mm x 841mm

DREDGING OUT LINES

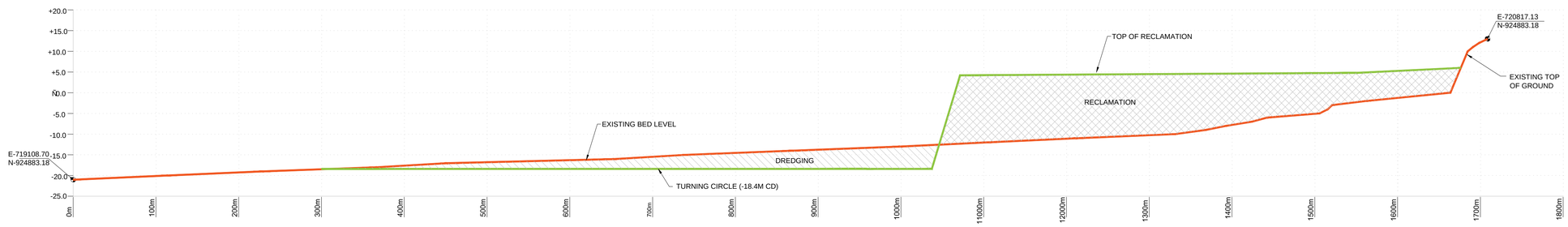
COORDINATES		
POINTS	EASTING	NORTHING
D1	719607.170	925912.407
D2	719545.243	925861.408
D3	719318.579	925599.529
D4	719199.755	925322.280
D5	719214.043	925201.390
D6	719273.466	925117.251
D7	719413.494	925021.011
D8	719610.764	924851.321
D9	720212.623	924373.867
D10	720324.921	924180.886
D11	721641.055	922776.210
D12	722686.552	922190.361
D13	720616.515	924454.511
D14	720452.524	924556.594
D15	720034.219	925003.040
D16	720115.866	925294.905

RECLAMATION OUT LINES

POINTS	EASTING	NORTHING	REMARKS
R1	719877.453	926409.000	VISL AREA FOR FUTURE EXPANSION 5.3 Ha.
R2	719844.360	926370.143	
R3	720186.024	925955.400	
R4	720274.167	926039.259	
R5	719803.528	926322.198	AREA FOR PROPOSED RAIL YARD 6.9 Ha.
R6	720496.012	925481.598	
R7	720543.865	925521.019	
R2			
R8	719788.198	926304.195	SEA SIDE LIMIT FOR PPP WORK
R9	719869.665	926205.303	
R10	719653.482	925950.552	
R11	720162.241	925333.173	
R12	720415.947	925542.176	
R13	720670.279	925233.444	
R14	720731.179	925283.613	



PLAN



SECTION 1-1

LEGENDS :

RECLAMATION AREA

DREDGING AREA DEPTH BELOW -18.4 C.D.

DREDGING AREA DEPTH BELOW -20.8 C.D.

BOUNDARY LOCATION POINT

NOTE:

1. ALL LEVELS ARE IN METRES AND ARE WITH RESPECT TO CHART DATUM.
2. DREDGING LINES SHOWN IN THE DRAWING REPRESENTS DREDGED BOTTOM LINE.
4. DREDGING DEFINED HERE IS BASED ON NAVIGATION & MATHEMATICAL MODEL STUDIES DONE.CONCESSIONAIRE MAY REDEFINE THE LIMITS BASED ON HIS OWN DESIGN / STUDIES.
5. CONCESSIONAIRE SHALL DESIGN THE STABLE SIDE SLOPE.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

80 0 80 160 240 320 400 m
SCALE 1 : 8000 FULL SIZE A1

TRANSPORTATION (Ports & Maritime)

AECOM
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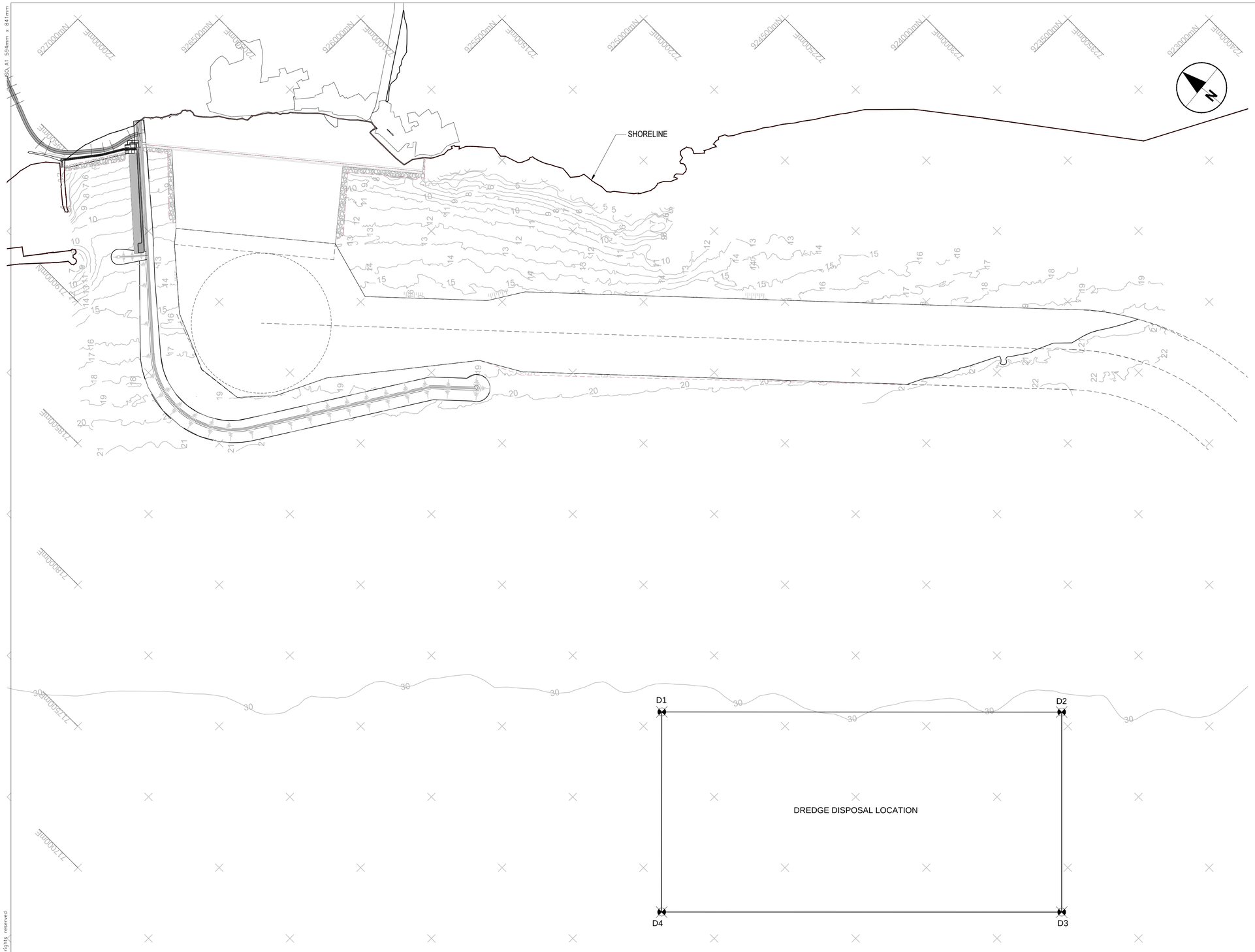
Drawn By: VK
Approved By: VA
Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: LAYOUT & CROSS SECTION OF DREDGING AND RECLAMATION

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 4001 REV 1



COORDINATES		
POINTS	EASTING	NORTHING
D1	719615.310	922485.680
D2	721028.340	921071.670
D3	720321.280	920364.410
D4	718907.250	921778.760

NOTE:

1. ALL LEVELS ARE IN METRES AND ARE WITH RESPECT TO CHART DATUM.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

100 0 100 200 300 400 500 m
SCALE 1 : 10000 FULL SIZE A1

TRANSPORTATION (Ports & Maritime)

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Drawn By	VK
Approved By	VA
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

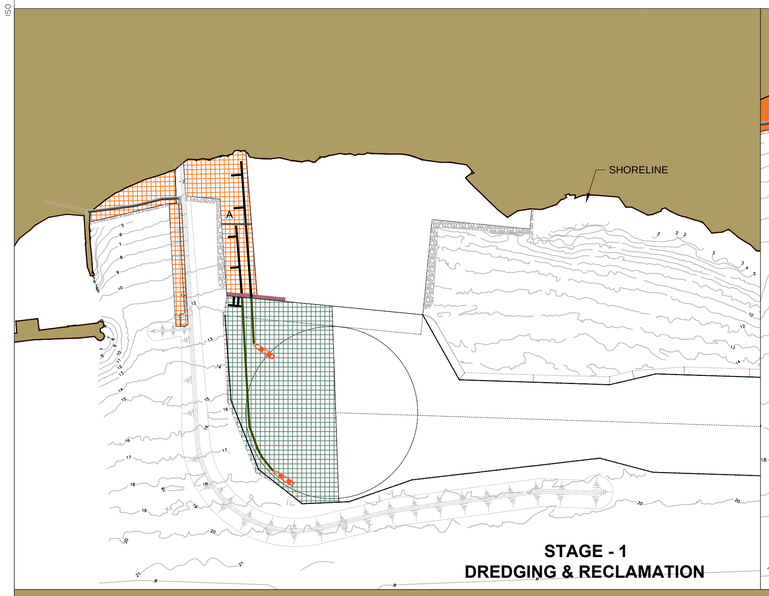
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

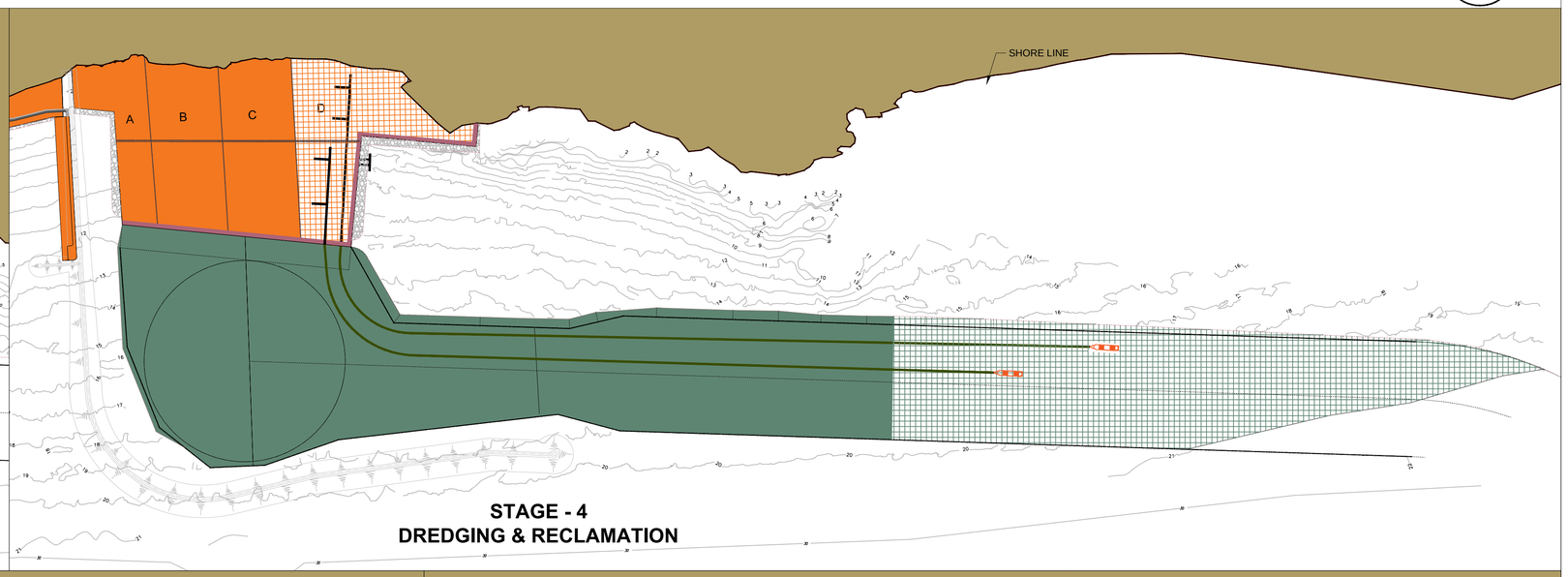
Sheet Title
DREDGED MATERIAL DISPOSAL SITE LOCATION

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 4002 REV 1

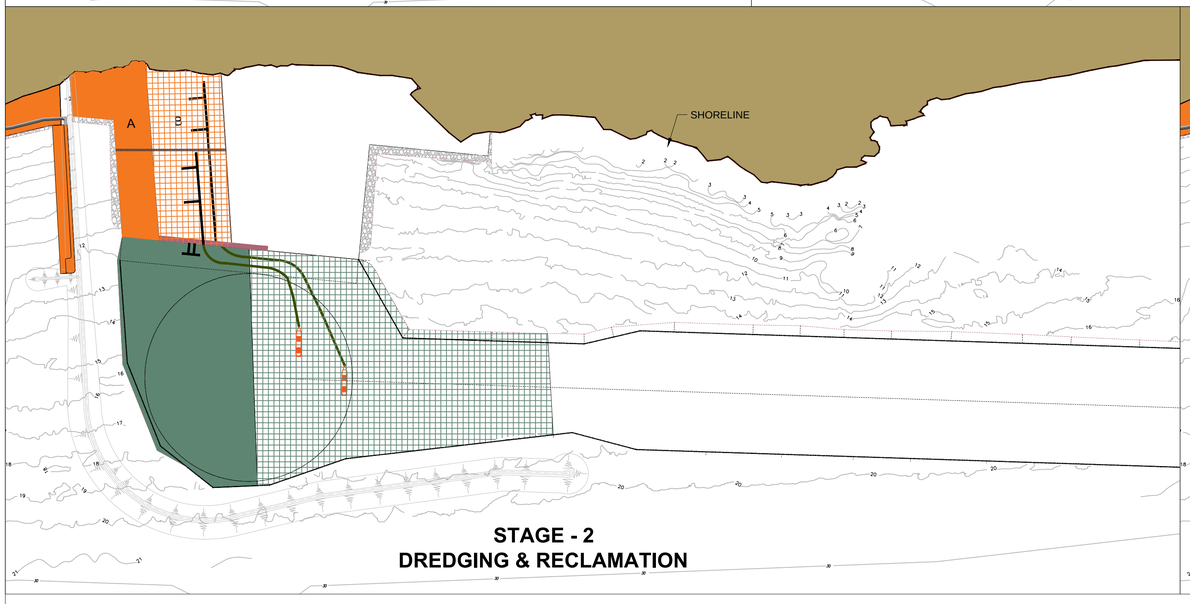
ISO A1 594mm x 841mm



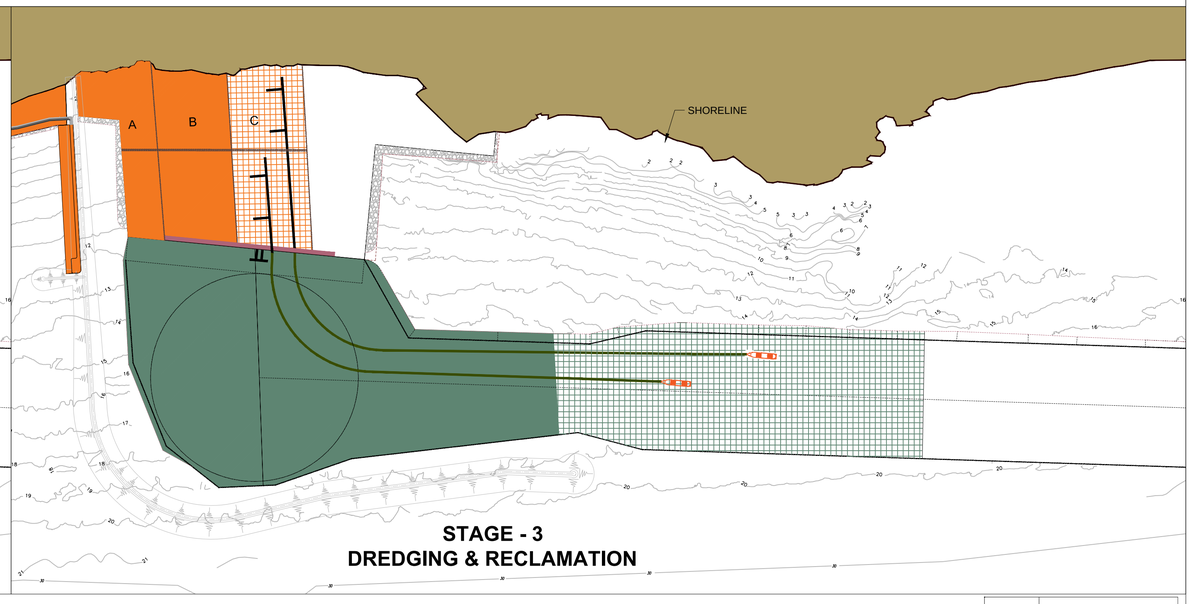
STAGE - 1
DREDGING & RECLAMATION



STAGE - 4
DREDGING & RECLAMATION



STAGE - 2
DREDGING & RECLAMATION



STAGE - 3
DREDGING & RECLAMATION

LEGEND	LEGEND
	ONSHORE PIPELINE
	MARINE PIPELINE
	WEIR BOX
	DREDGER
	TEMPORARY BUND
	RECLAIMED AREA
	DREDGED AREA
	RECLAMATION AREA
	DREDGING AREA

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 100 200 300 400
SCALE 1:5000 FULL SIZE (A1)

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Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

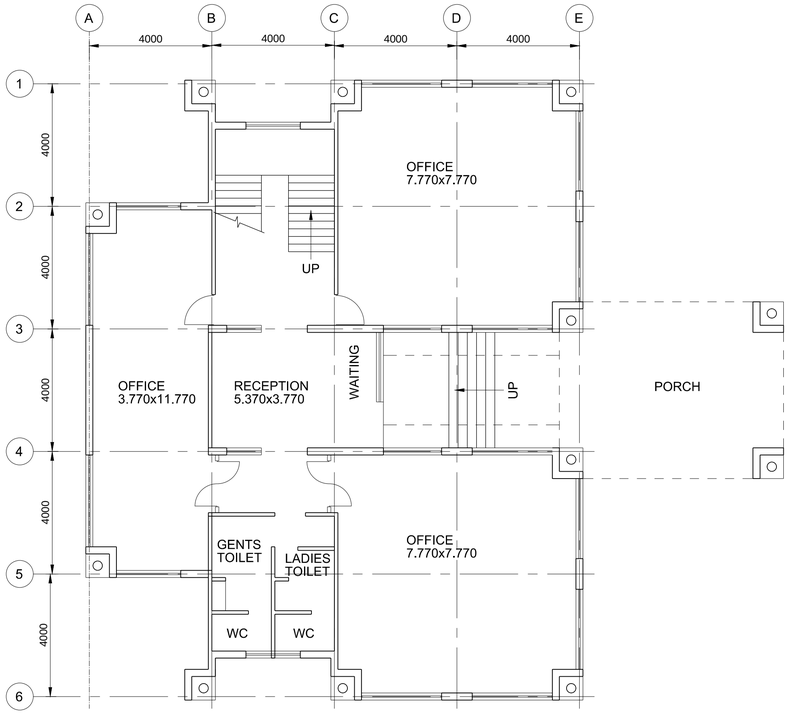
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
WORK SEQUENCE FOR
DREDGING AND RECLAMATION

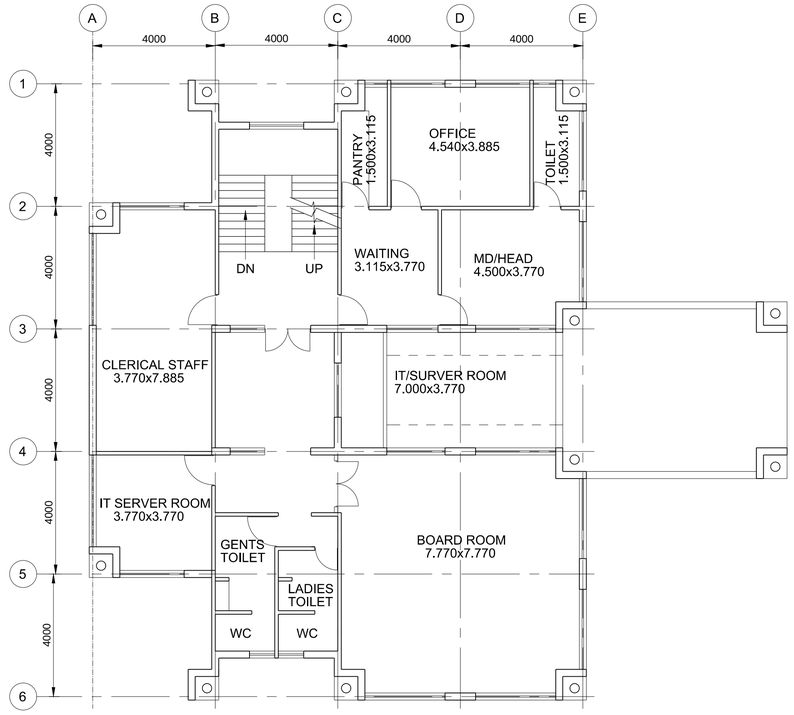
Project Number	Sheet Number
DELD11137	1 of 1

Drawing No.
DELD11137-DRG-25-0000-CP- 4003 REV 1

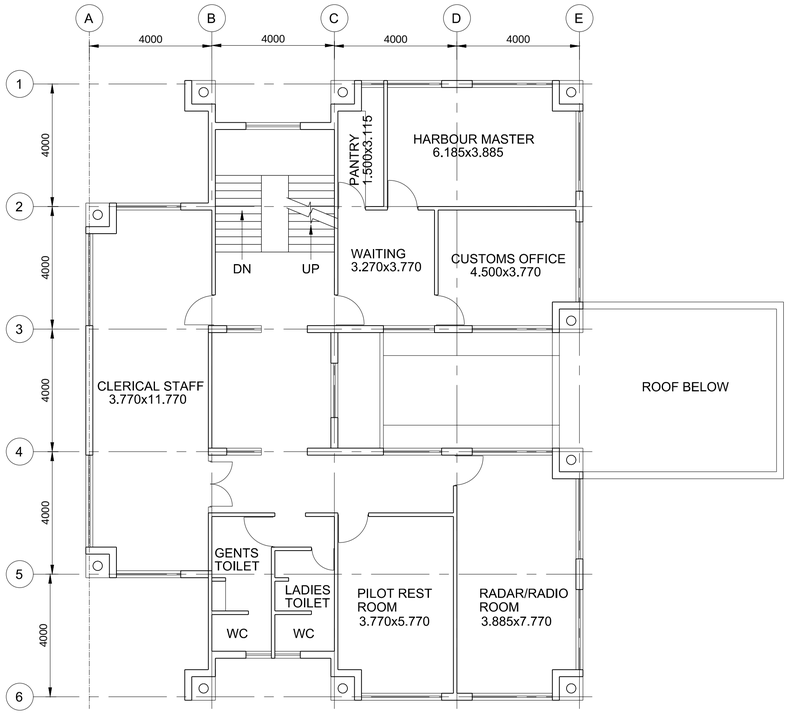
ISO A1 594mm x 841mm



GROUND FLOOR PLAN



FIRST FLOOR PLAN



SECOND FLOOR PLAN

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014
R2	VK	VA	09-10-2014

0m 2 4 6 8
SCALE 1:100 FULL SIZE (A1)

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Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
TYPICAL ADMINISTRATIVE BUILDING (LANDLORD FACILITY)

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 5001 REV 2

ISO A1 594mm x 841mm

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 40 80 120 160
SCALE 1:20000 FULL SIZE (A1)

TRANSPORTATION
(Ports & Maritime)

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Drawn By	VK
Approved By	VA
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

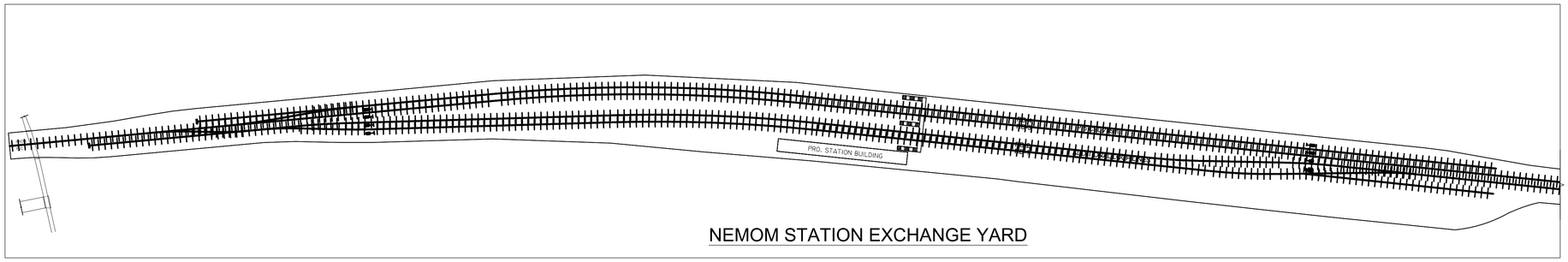
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
PROPOSED RAIL LINES AND ASSOCIATED RAIL FACILITIES

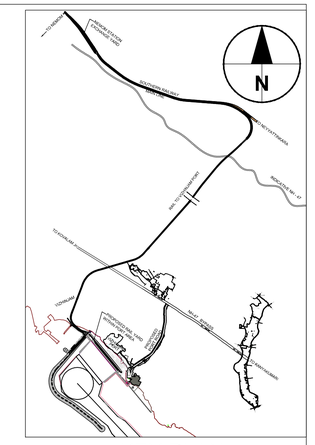
Project Number	Sheet Number
DELD11137	1 of 2

Drawing No.
DELD11137-DRG-25-0000-CP- 6001 REV 1

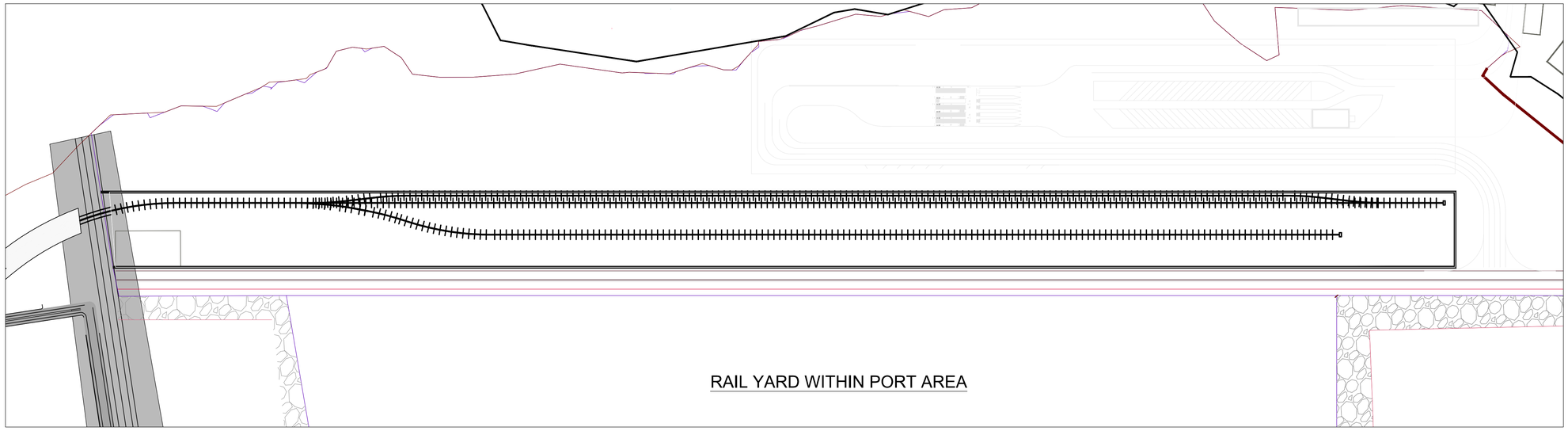
ISO A1 594mm x 841mm



NEMOM STATION EXCHANGE YARD



KEY PLAN



RAIL YARD WITHIN PORT AREA

Revision	By	Approved	Date
R0	VK	VA	07-02-2014
R1	VK	VA	05-05-2014

0m 4 8 12 16
SCALE 1:2000 FULL SIZE (A1)

TRANSPORTATION (Ports & Maritime)

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Meeting: BASIC ENGINEERING REPORT

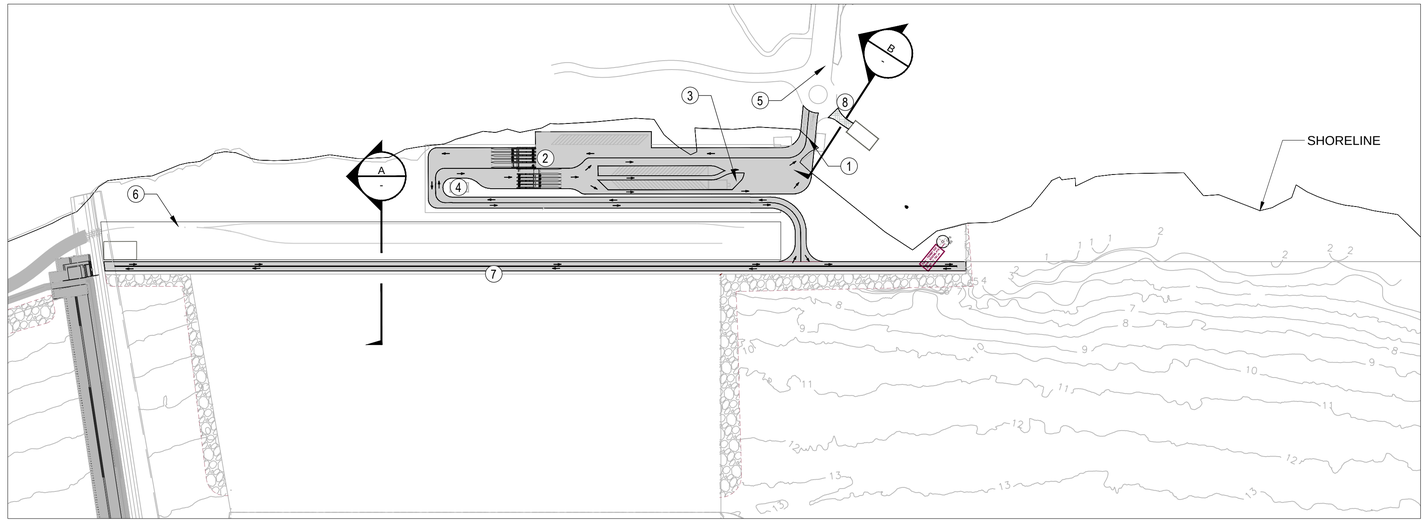
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

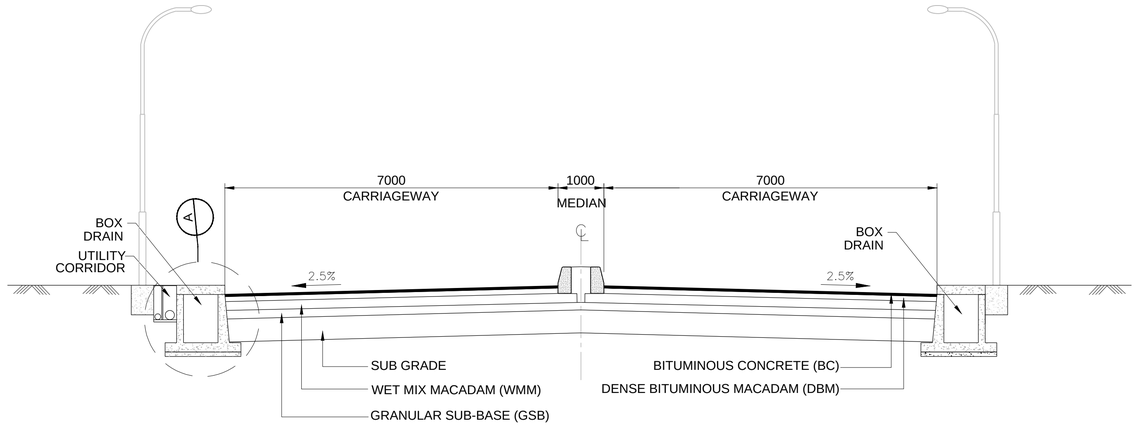
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: PROPOSED RAIL LINES AND ASSOCIATED RAIL FACILITIES

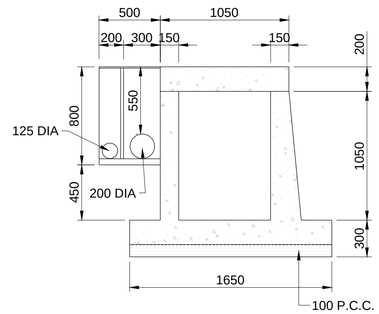
Project Number: DELD11137
Sheet Number: 2 of 2
Drawing No.: DELD11137-DRG-25-0000-CP- 6001 REV 1

ISO A1 594mm x 841mm

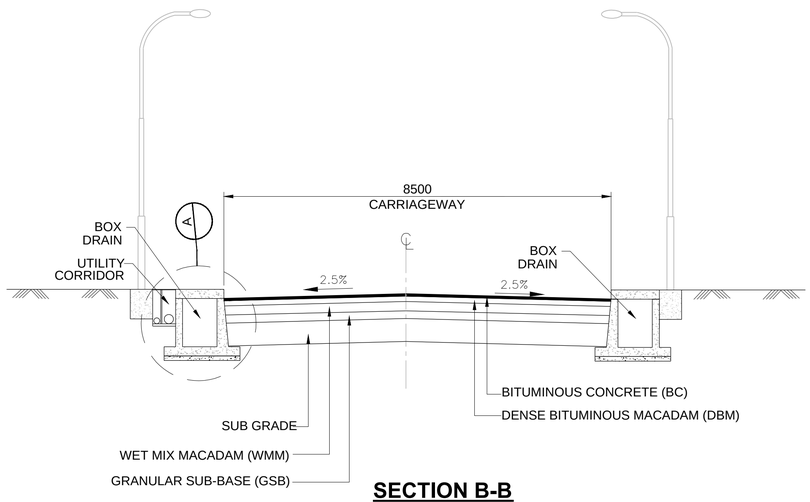




SECTION A-A
Scale 1:15



DETAIL - A
SCALE 1:25



SECTION B-B
Scale 1:15

KEY NOTES

1. SECURITY GUARD BOOTH
2. ENTRY / EXIT GATE CANOPY
3. CUSTOMS BUILDING
4. GATE STAFF BUILDING
5. CONNECTING ROAD WITH NH47 & YARD AREA
6. RAIL YARD AREA WITH IN PORT
7. PPP WORK
8. FUNDED WORK

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE NOTED.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014
R2	VKM	VA	09-10-2014

0m 100 200 300 400
SCALE 1:5000 FULL SIZE (A1)

TRANSPORTATION (Ports & Maritime)

AECOM
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Haryana, India

www.aecom.com

Drawn By	VK
Approved By	VA
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

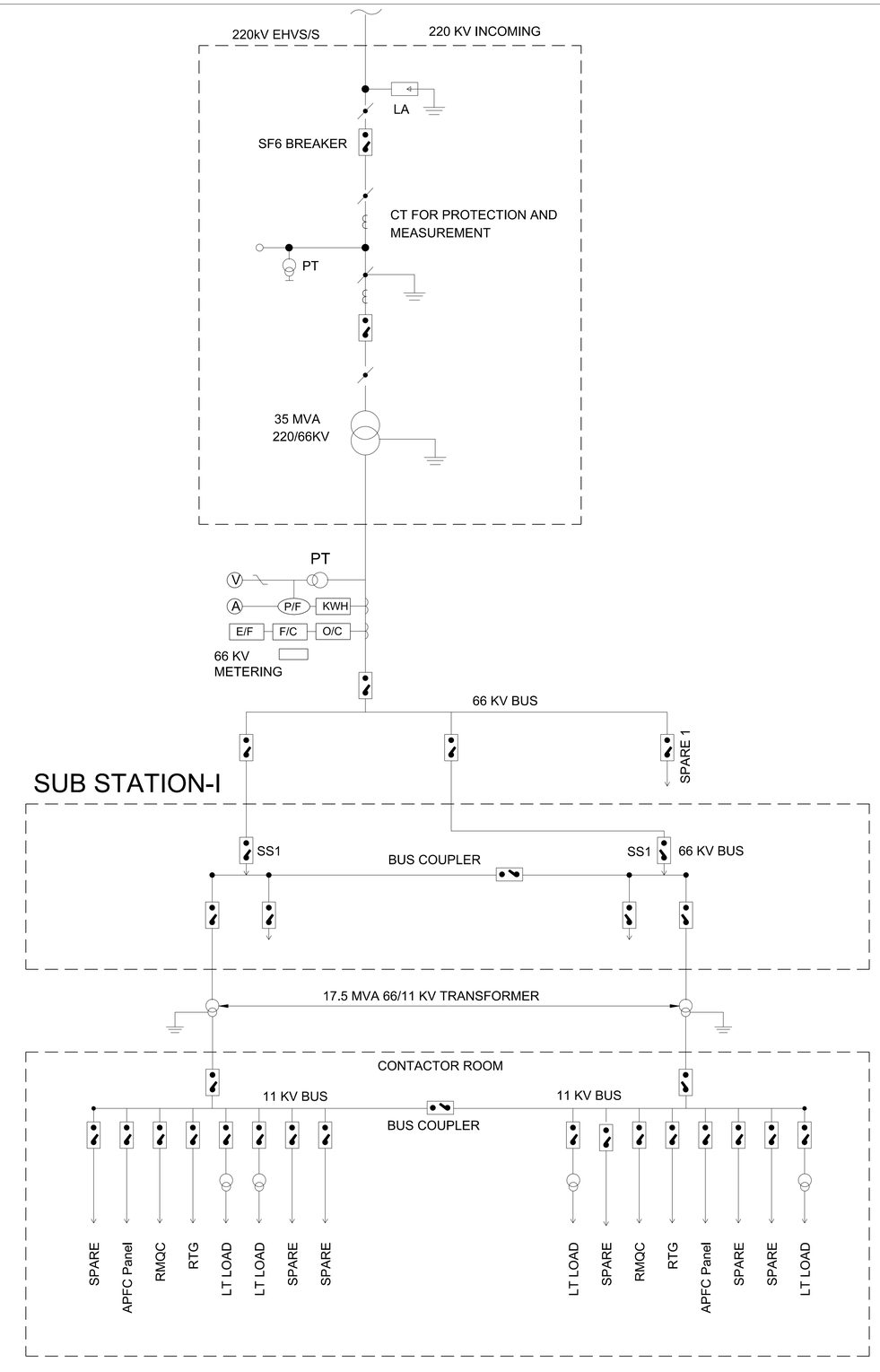
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
PROPOSED INTERNAL ROAD FOR TRAFFIC FLOW WITHIN THE PORT

Project Number	Sheet Number
DELD11137	1 of 1

Drawing No.
DELD11137-DRG-25-0000-CP- 6002 REV 2

ISO A1 594mm x 841mm



LEGEND

- LIGHTNING ARRESTOR
- DISCONNECTER SWITCH
- BUS COUPLER
- TRANSFORMER
- PT — POTENTIAL TRANSFORMER

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

TRANSPORTATION (Ports & Maritime)

AECOM
9th Floor, Infinity Tower C
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Drawn By: VK
Approved By: VA
Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

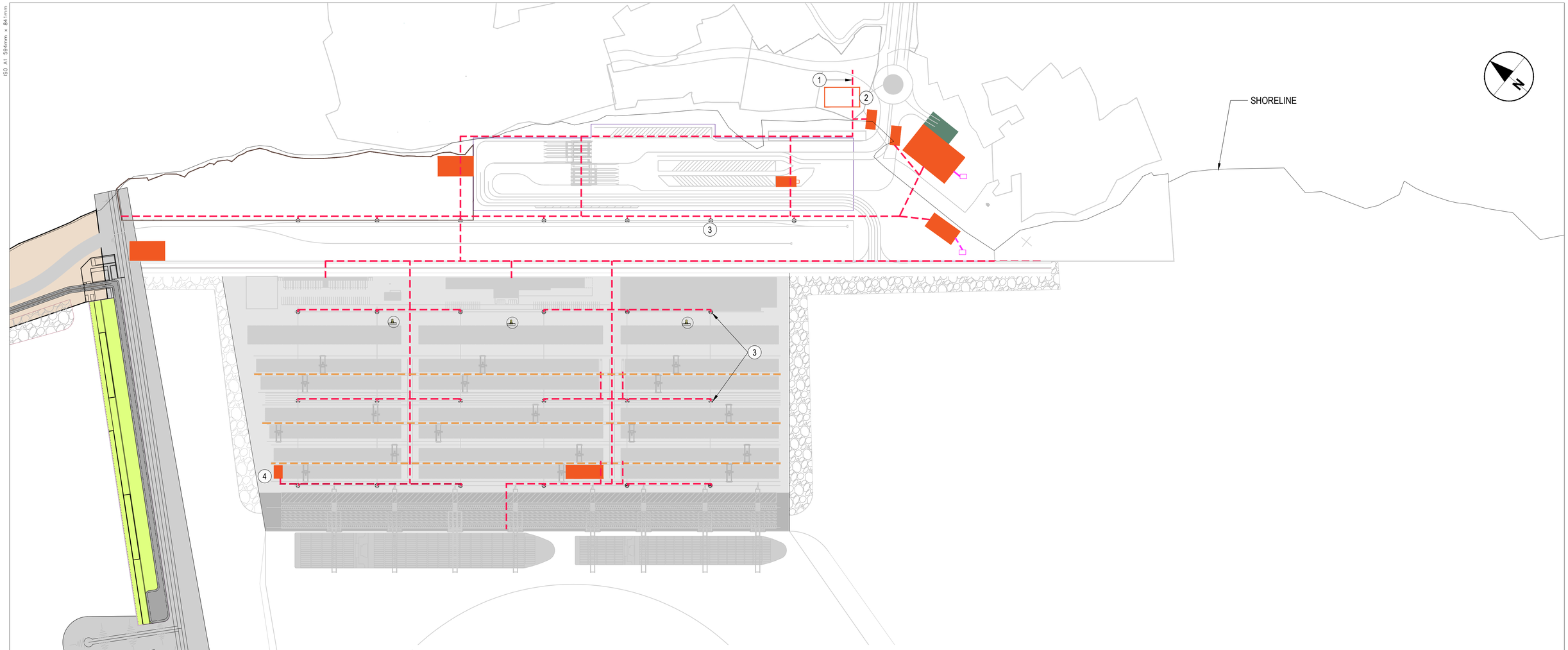
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
SCHEMATIC DIAGRAM OF ELECTRICAL REQUIREMENT

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 7001 REV 1

ISO A1 594mm x 841mm



KEY NOTES

1. MAIN POWER FEED FROM 220KV SUB STATION
2. MAIN PORT SUBSTATION
3. HIGH MASS LIGHT POLES W/ FIRE HYDRANTS

LEGEND

ELECTRICAL SERVICE
- ALL TERMINAL LIGHTING
- GATE COMPLEX
  ENTRY / EXIT GATE POWER AND LIGHTING
- MAINTENANCE AREA
  SERVICE BUILDINGS POWER AND LIGHTING
- CONTAINER AREA
  REEFER STACK SUBSTATIONS
  REEFER STACK SERVICE PLATFORMS
- QUAY AREA
- QUAY MAINTAINANCE BUIDINGS

ELECTRICAL SERVICE FOR POTENTIAL ERTG BUS BAR SYSTEM

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 60 120 180 240

SCALE 1:3000 FULL SIZE
1:6000 HALF SIZE

TRANSPORTATION (Ports & Maritime)

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Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
CONCEPTUAL LAYOUT OF UTILITY REQUIREMENT (ELECTRICAL SERVICES)

Project Number	Sheet Number
DELD11137	1 of 1

Drawing No.
DELD11137-DRG-25-0000-CP- 7002 REV 1

ISO A1 594mm x 841mm

100ï

OVERHEAD WATER TANK
CENTRALISED 200 CUM

BY GRAVITY TO ALL USAGE POINTS 100ï

ADMINISTRATION BUILDING
WORKSHOP, WASHROOMS
CANTEEN
PORT OPERATION BUILDING
CUSTOM OFFICE
LANDSCAPING ETC.

P3

FIRE HYDRANTS

P1
P1

TREATED (POTABLE) WATER 1200cum

RAW WATER TANK 400 cum

SEA WATER

SEA WATER PUMP
HOUSE FOR FIRE FIGHTING

WTP

150ï

P2

30 CUM CAPACITY
RAW WATER TANK FOR WORKSHOP EQUIPMENT.
AND REEFER CONTAINER WASHING

VELLAYANI
LAKE

LEGEND

P1	TREATED WATER SUPPLY PUMPS
P2	RAW WATER SUPPLY PUMPS
P3	POTABLE WATER LIFT PUMPS TO OHT

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

TRANSPORTATION
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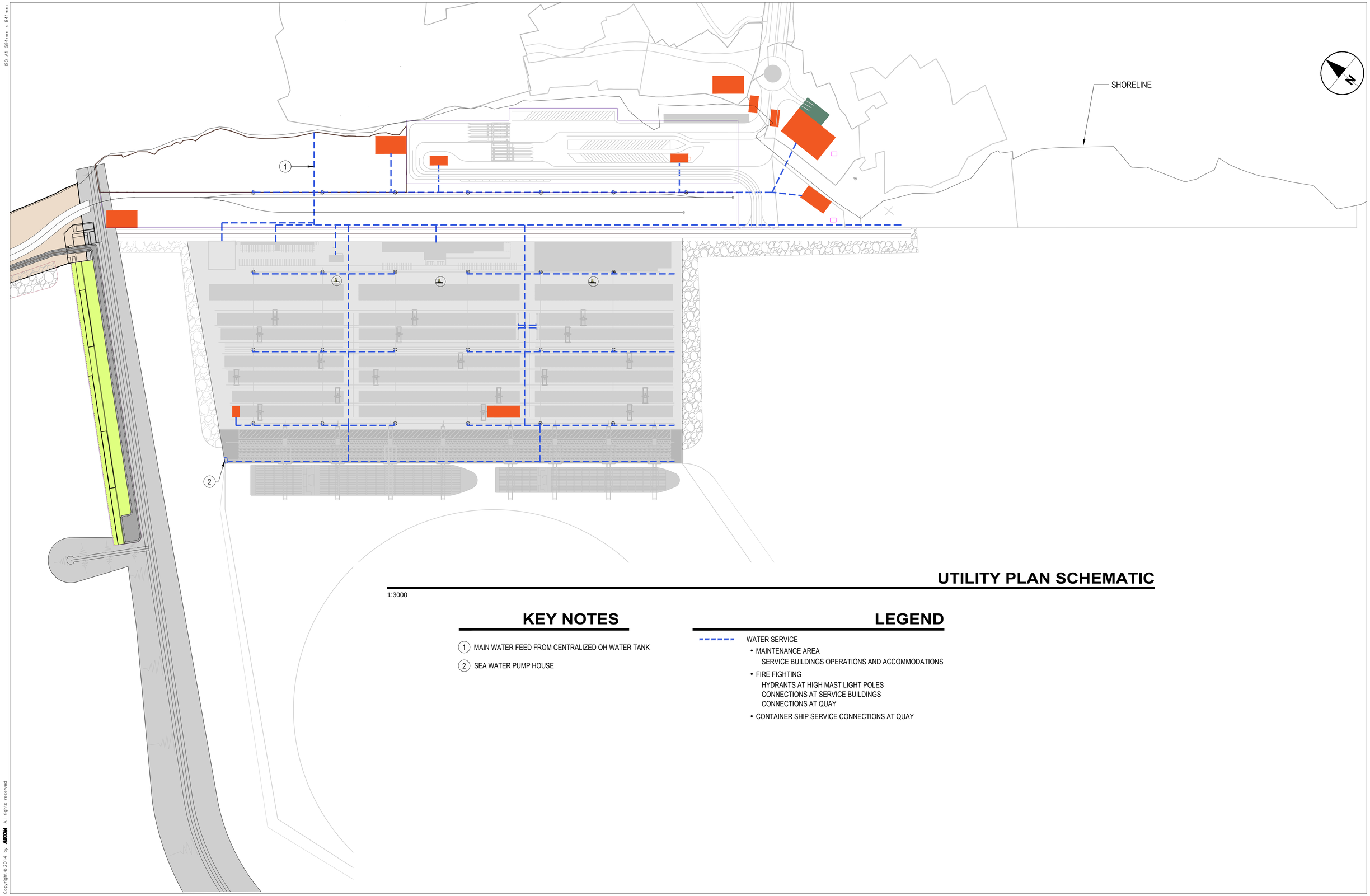
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: SCHEMATIC DIAGRAM OF WATER SUPPLY

Project Number: DELD11137
Sheet Number: 1 of 2
Drawing No.: DELD11137-DRG-25-0000-CP- 7003 REV 1

ISO A1 594mm x 841mm



UTILITY PLAN SCHEMATIC

1:3000

KEY NOTES

1. MAIN WATER FEED FROM CENTRALIZED OH WATER TANK
2. SEA WATER PUMP HOUSE

LEGEND

WATER SERVICE

- MAINTENANCE AREA
  SERVICE BUILDINGS OPERATIONS AND ACCOMMODATIONS
- FIRE FIGHTING
  HYDRANTS AT HIGH MAST LIGHT POLES
  CONNECTIONS AT SERVICE BUILDINGS
  CONNECTIONS AT QUAY
- CONTAINER SHIP SERVICE CONNECTIONS AT QUAY

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 60 120 180 240

SCALE 1:3000 FULL SIZE
1:6000 HALF SIZE

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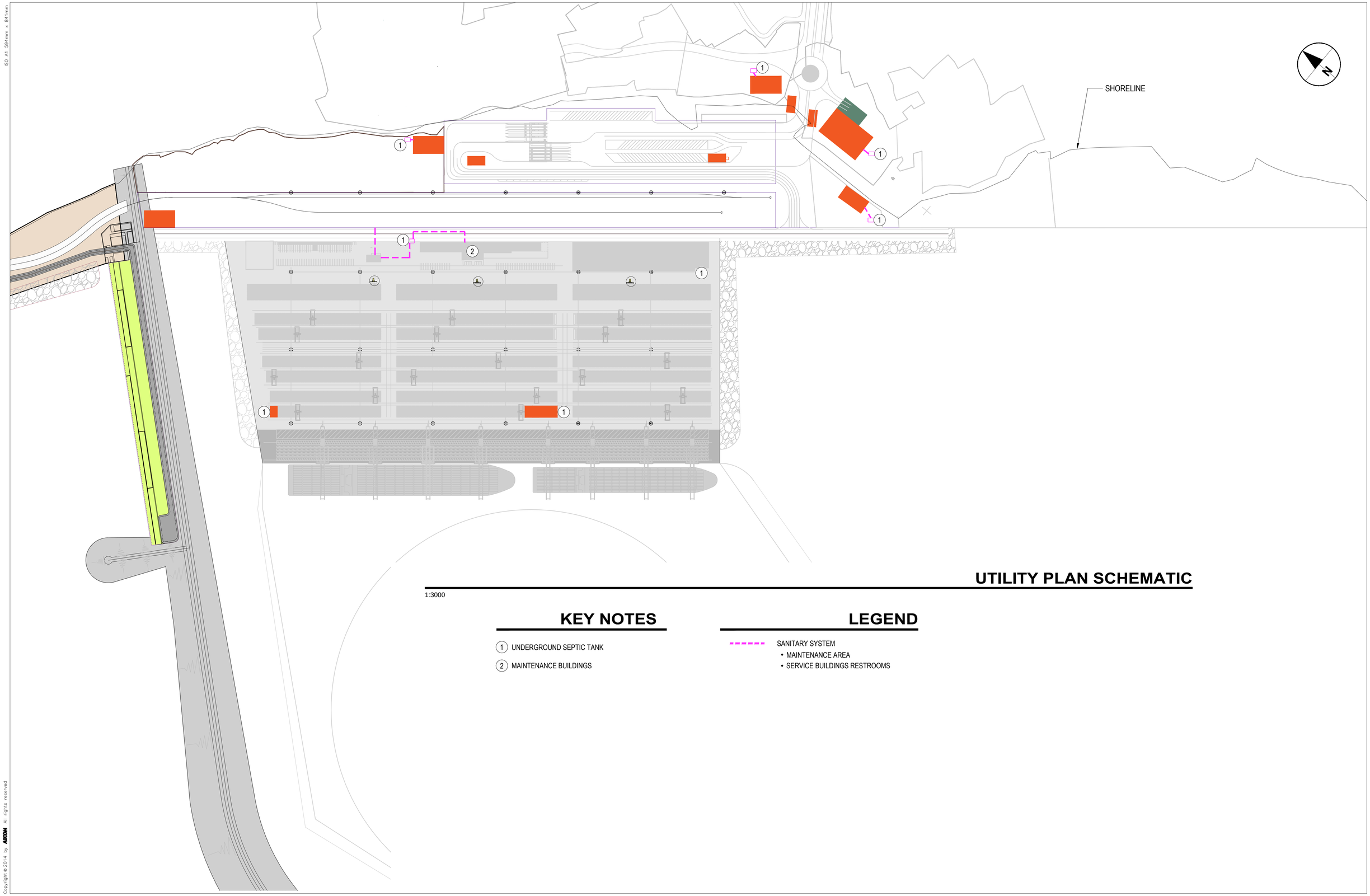
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: CONCEPTUAL LAYOUT OF UTILITY REQUIREMENT (WATER SUPPLY)

Project Number: DELD11137
Sheet Number: 2 of 2
Drawing No.: DELD11137-DRG-25-0000-CP- 7003 REV 1

ISO A1 594mm x 841mm



UTILITY PLAN SCHEMATIC

1:3000

KEY NOTES

1. UNDERGROUND SEPTIC TANK
2. MAINTENANCE BUILDINGS

LEGEND

SANITARY SYSTEM
- MAINTENANCE AREA
- SERVICE BUILDINGS RESTROOMS

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 60 120 180 240

SCALE 1:3000 FULL SIZE
1:6000 HALF SIZE

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Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: CONCEPTUAL LAYOUT OF UTILITY REQUIREMENT (SANITARY SYSTEM)

Project Number: DELD11137

Sheet Number: 1 of 1

Drawing No.: DELD11137-DRG-25-0000-CP- 7004 REV 1

ISO A1 594mm x 841mm

UTILITY PLAN SCHEMATIC

1:3000

LEGEND

TRENCH DRAINS

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 60 120 180 240

SCALE 1:3000 FULL SIZE
1:6000 HALF SIZE

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Date: 07-02-2014
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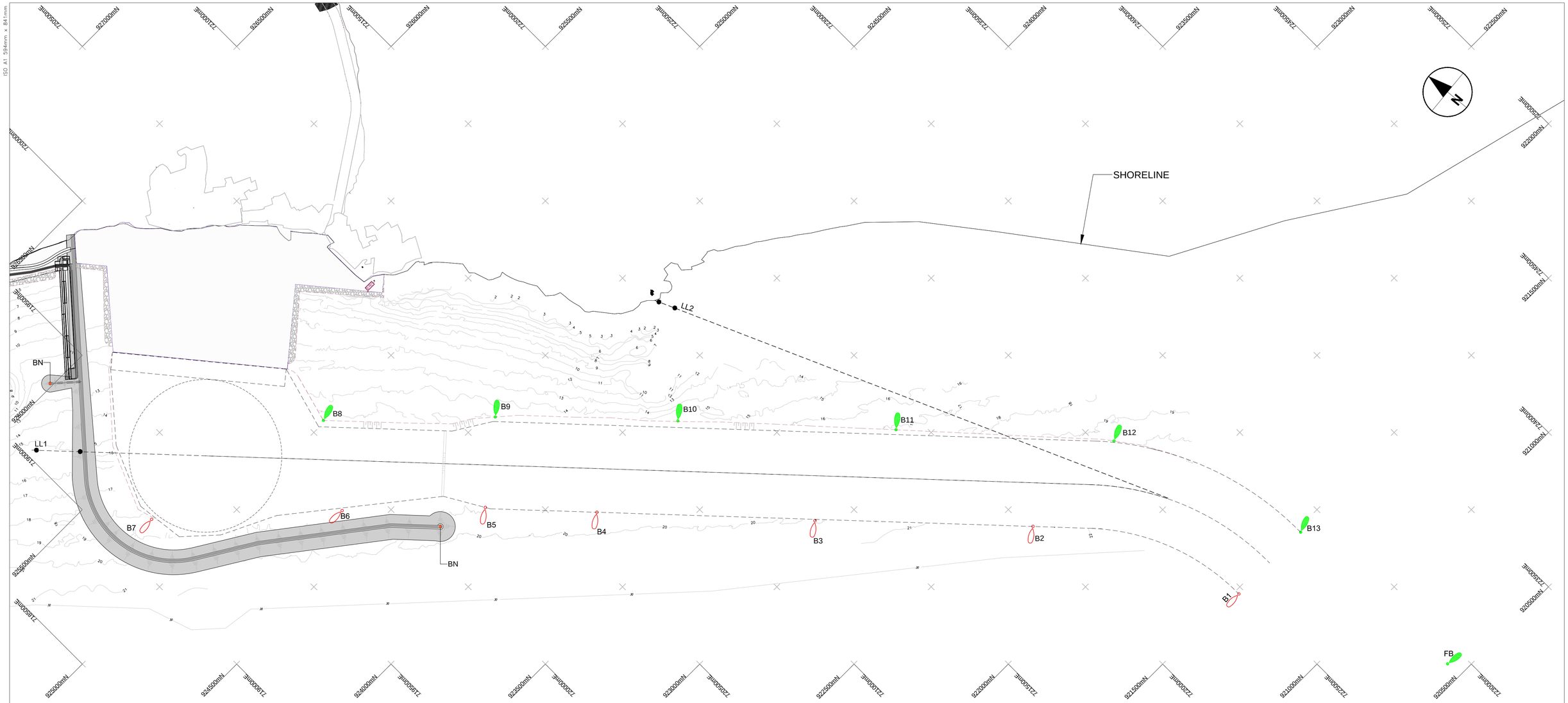
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: CONCEPTUAL LAYOUT OF UTILITY REQUIREMENT (STORM WATER TRENCHES)

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 7005 REV 1

ISO A1 594mm x 841mm



KEY NOTES

B1.....	CHANNEL MARKING BUOY
FB	FAIRWAY BUOY
BN	BEACON
LL	LEADING LIGHT

LEGEND

- PORT SIDE BUOY
- STAR BOARD SIDE / BUOY
- BEACON
- LEADING LIGHT

Revision	By	Approved	Date
R1	VB	VA	05-05-2014

0m 80 160 240 320
SCALE 1:8000 FULL SIZE (A1)

TRANSPORTATION (Ports & Maritime)

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Drawn By	VB
Approved By	VA
Date	07-02-2014
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VIZHINJAM INTERNATIONAL SEAPORT LIMITED

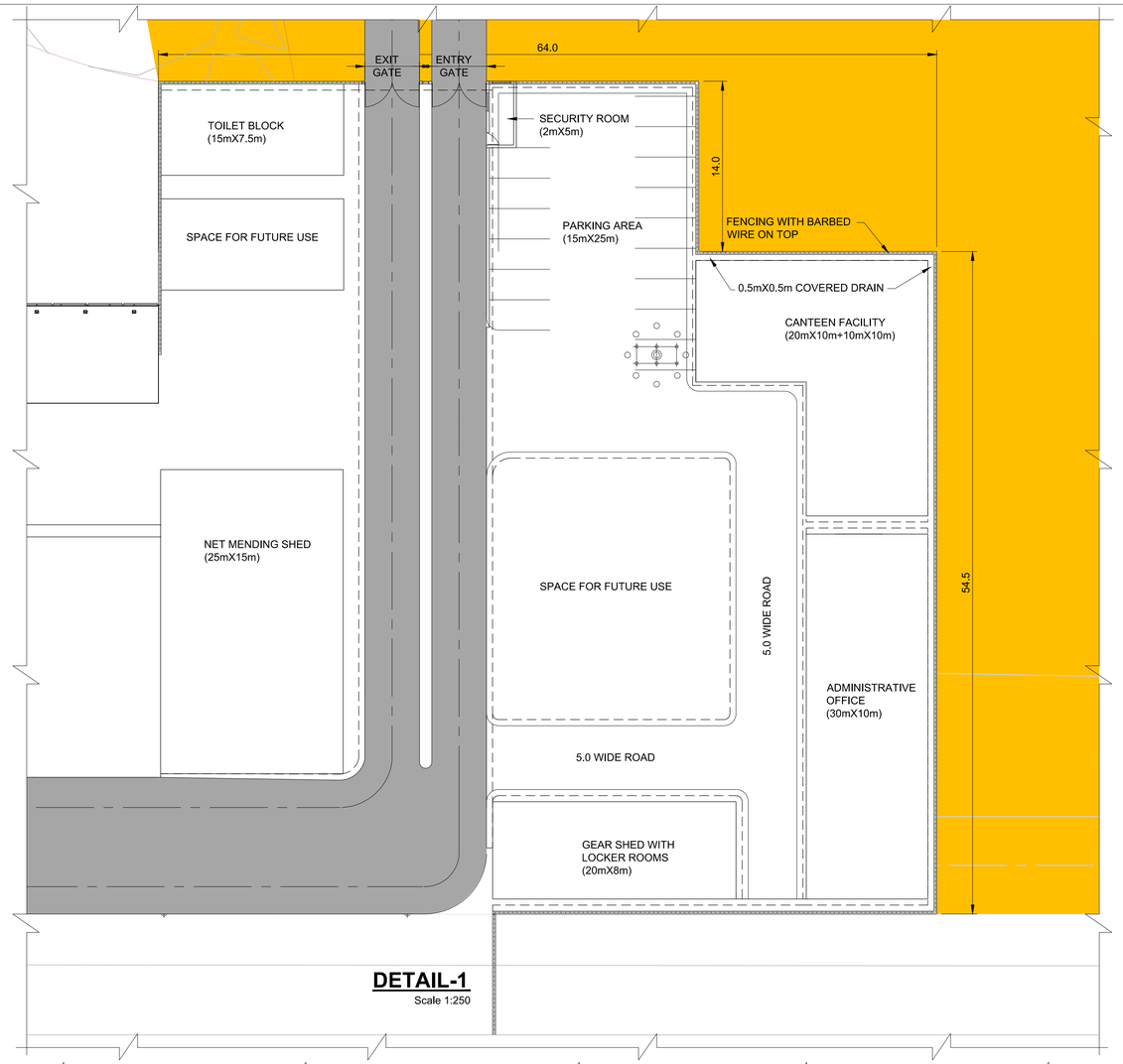
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
LAYOUT OF AIDS TO NAVIGATION FOR VIZHINJAM PORT

Project Number	Sheet Number
DELD11137	1 of 1

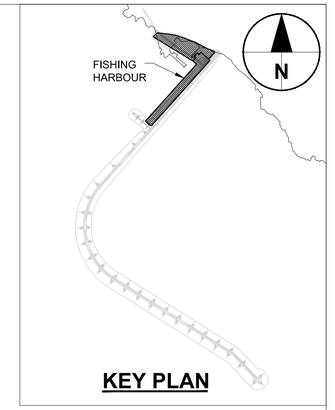
Drawing No.
DELD11137-DRG-25-0000-CP- 8001 REV 1

ISO A1 594mm x 841mm



DETAIL-1

Scale 1:250



KEY PLAN

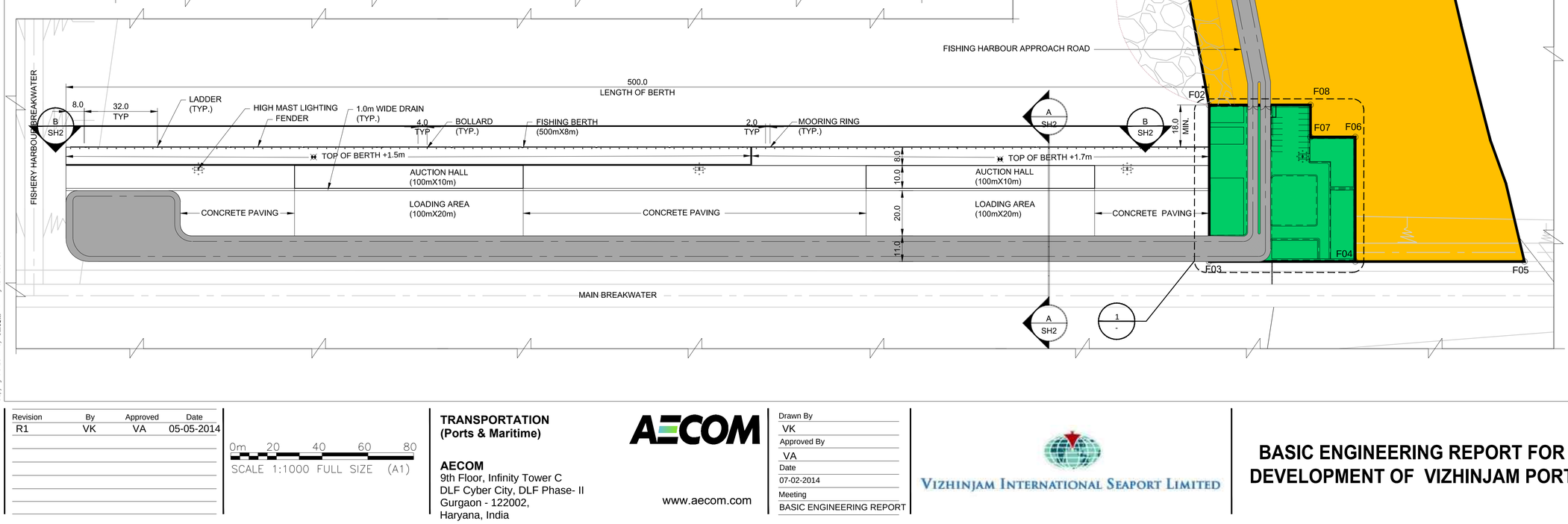
COORDINATES		
POINTS	EASTING	NORTHING
F01	719432323.640	926514903.764
F02	719692098.051	926355882.833
F03	719743081.569	926310194.186
F04	719785780.169	926357841.140
F05	719835179.339	926412965.195
F06	719745222.728	926394186.506
F07	719732160.917	926379613.448
F08	719721736.078	926388955.621

LEGEND

- RECLAIMED SEA BEACH AREA (RECLAIMED LEVEL +1.50m CD)
- FISHERY HARBOUR-BUILDING AREA (RECLAIMED LEVEL +1.70m CD)

NOTE:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.
2. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE MENTIONED.
3. ALL CO-ORDINATES ARE GIVEN IN METERS RELATING TO UTM PROJECTION , SPHEROID WGS 84.



Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 20 40 60 80
SCALE 1:1000 FULL SIZE (A1)

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Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title

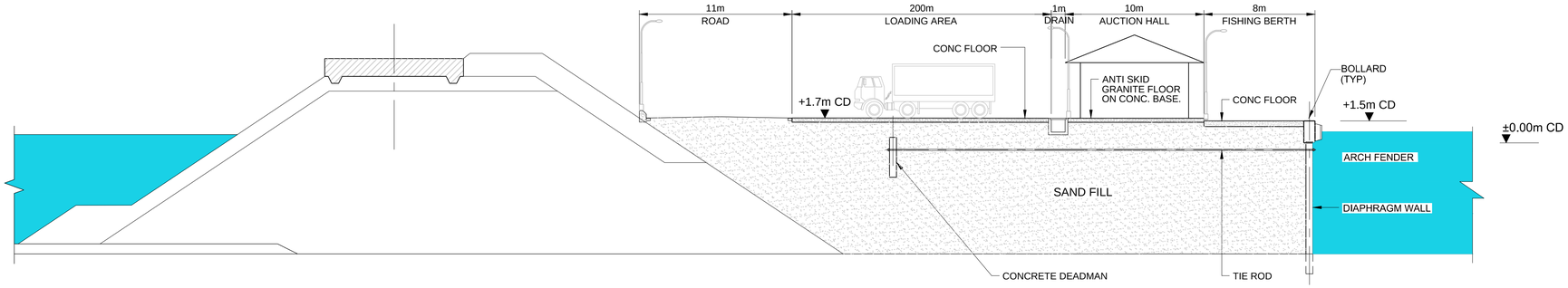
LAYOUT OF FISHERY HARBOUR

Project Number: DELD11137

Sheet Number: 1 of 2

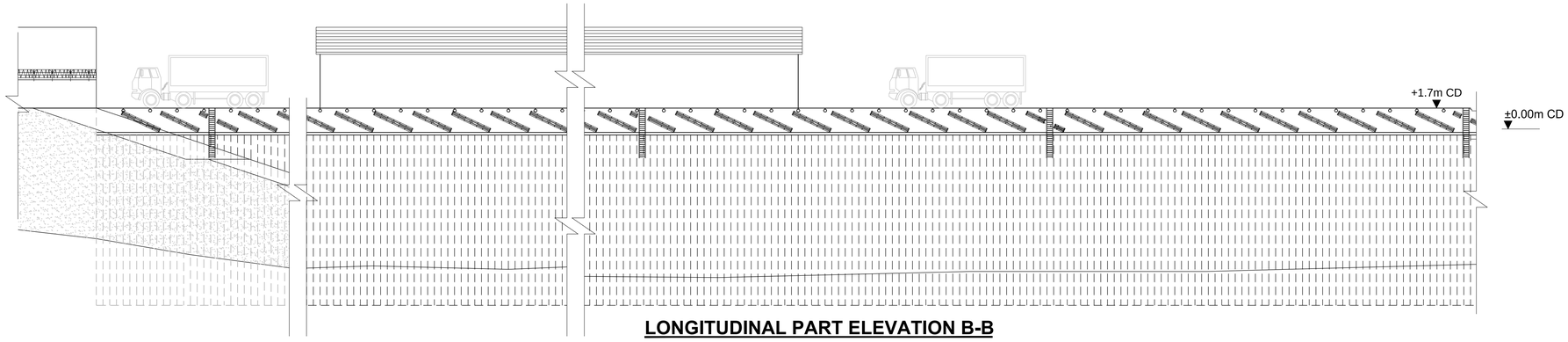
Drawing No.: DELD11137-DRG-25-0000-CP- 9001 REV 1

ISO A1 594mm x 841mm

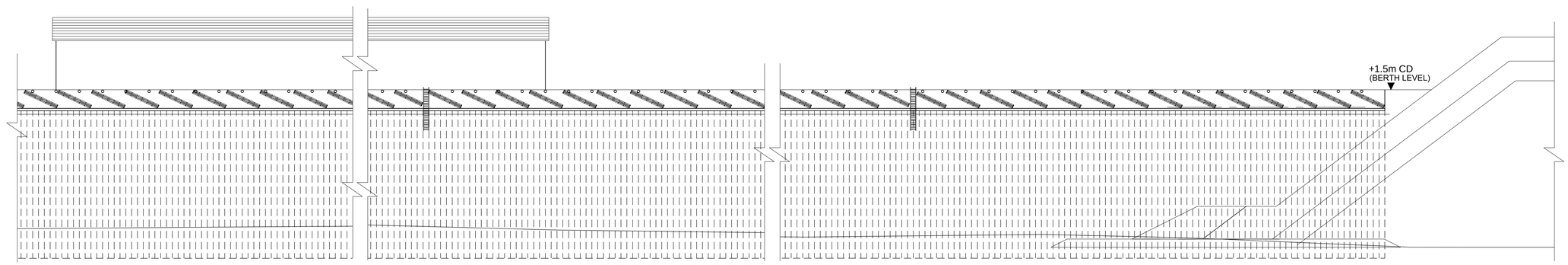


SECTION A-A

Scale 1:200



LONGITUDINAL PART ELEVATION B-B



LONGITUDINAL PART ELEVATION B-B

NOTES:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO LOCAL CHART DATUM.
2. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE MENTIONED.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 4 8 12 16
SCALE 1:200 FULL SIZE (A1)

TRANSPORTATION (Ports & Maritime)

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Drawn By: VK
Approved By: VA
Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

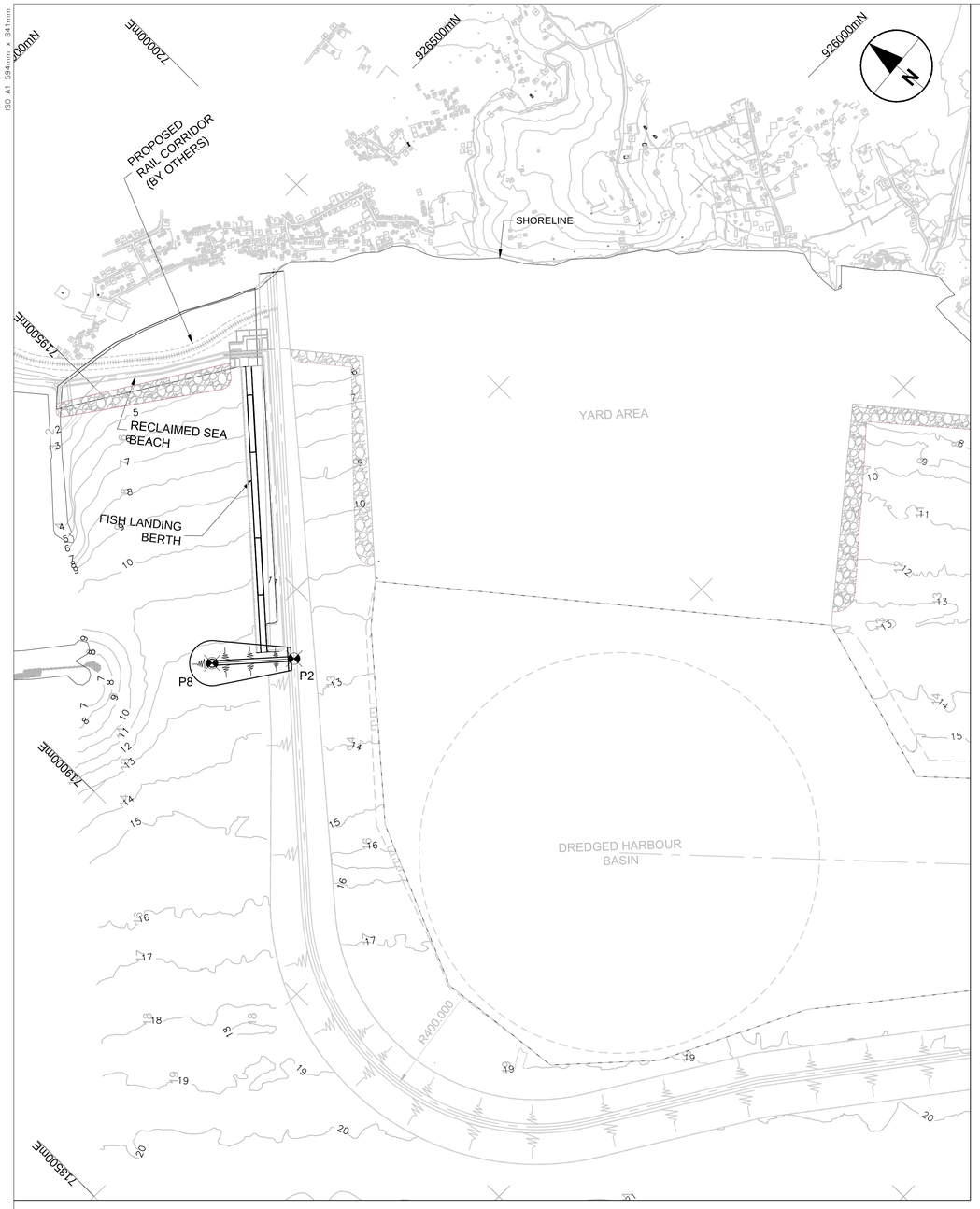
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

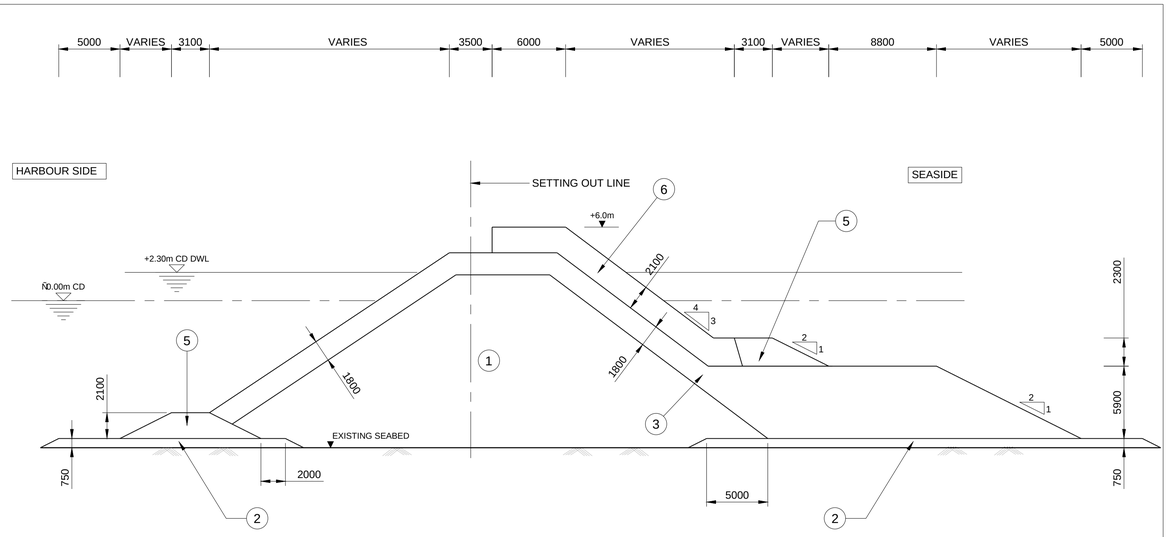
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: LAYOUT OF FISHERY HARBOUR (CROSS SECTION & LONGITUDINAL SECTION)

Project Number: DELD11137
Sheet Number: 2 of 2
Drawing No.: DELD11137-DRG-25-0000-CP- 9001 REV 1

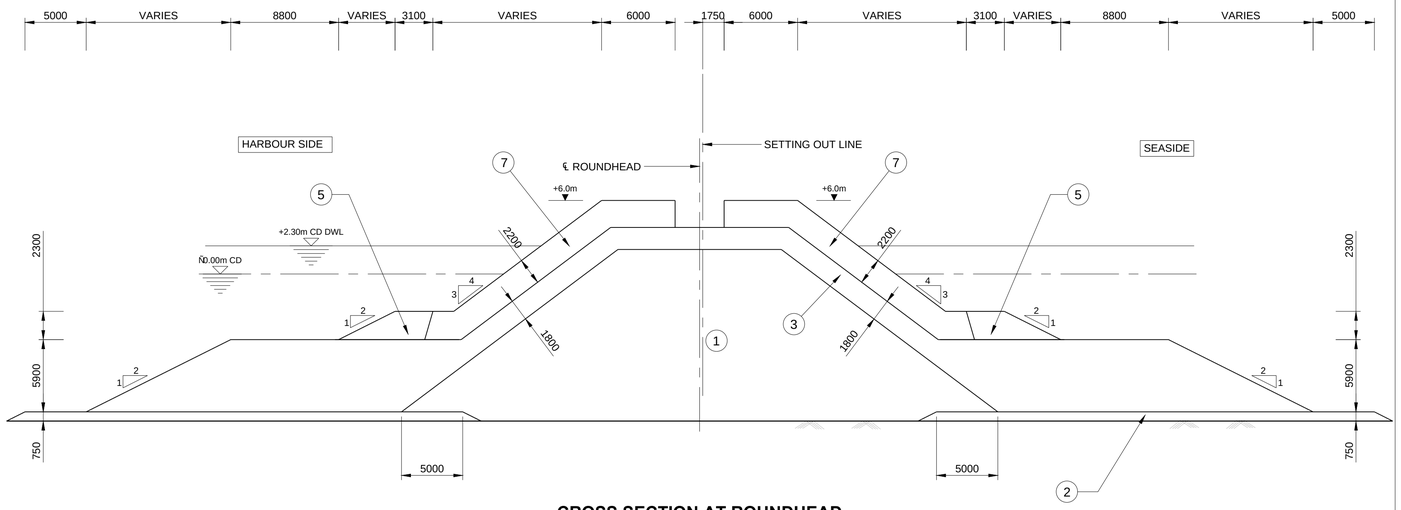
ISO A1 594mm x 841mm





CROSS SECTION ALONG -12m CD CONTOUR

SCALE 1:250



CROSS SECTION AT ROUNDHEAD

SCALE 1:250

COORDINATES		
POINTS	EASTING	NORTHING
P2	719411.171	925917.442
P8	719304.341	926013.177

LEGEND:

1	CORE 10KG TO 0.5T
2	BEDDING LAYER 0.1T TO 0.3T
3	ROCK 0.6T TO 0.4T
4	ROCK 1.4T TO 2.7T
5	TOE PROTECTION ROCK 2.0T TO 4.0T
6	ACCROPODE'4m
7	ACCROPODE'5m

TIDAL LEVELS:

MHHW	-	+ 0.80m
MLHW	-	+ 0.70m
MHLW	-	+ 0.40m
MLLW	-	+ 0.30m
MSL	-	+ 0.60m
HAT	-	+ 1.20m

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SPECIFIED.
2. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.
3. ALL CO-ORDINATES ARE GIVEN IN METERS RELATING TO UTM PROJECTION, SPHEROID WGS 84.

Revision	By	Approved	Date
R1	VKM	VA	05-05-2014

SCALE 1 : 5000 — 50 0 50 100 150 200 250 m — FULL SIZE A1

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Meeting	BASIC ENGINEERING REPORT

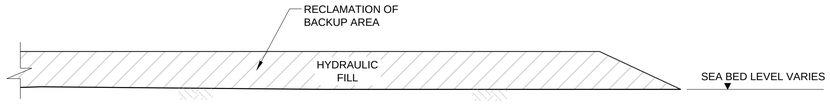
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

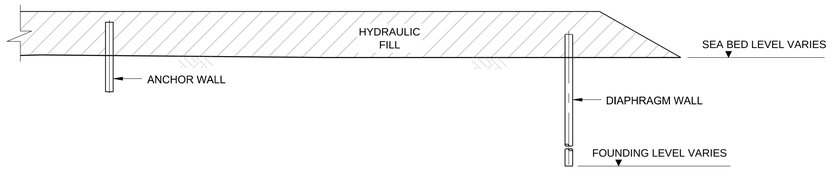
Sheet Title: FISHERY HARBOUR BREAKWATER LAYOUT AND CROSS SECTIONS

Project Number	Sheet Number
DELD11137	1 of 1

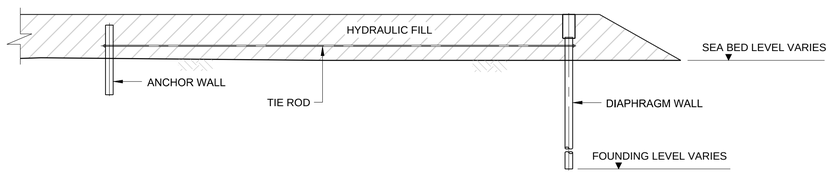
Drawing No. DELD11137-DRG-25-0000-CP- 9002 REV 1



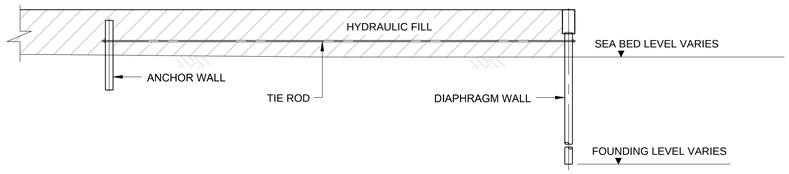
1 RECLAMATION OF BACKUP AREA



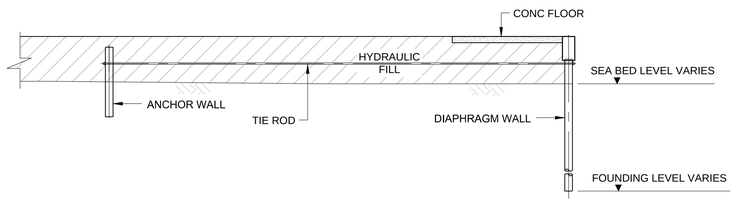
2 CONSTRUCT DIAPHRAGM WALL AND ANCHOR WALL



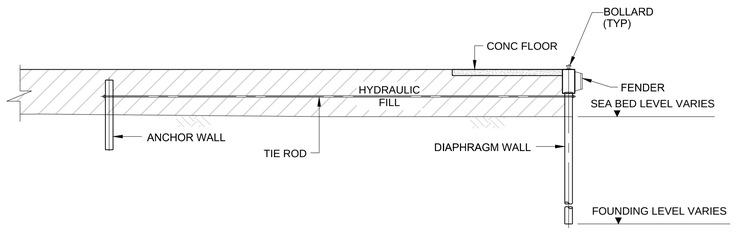
3 CONSTRUCT LONGITUDINAL BEAM & INSTALL TIE-ROD



4 REMOVAL OF EXTRA FILL MATERIAL IN-FRONT OF BERTH



5 CONSTRUCT BERTH SLAB



6 INSTALLATION OF BERTH FIXTURE

NOTES:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.

Revision	By	Approved	Date
R1	VKM	VA	05-05-2014
R2	VK	VA	09-10-2014

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Meeting: BASIC ENGINEERING REPORT

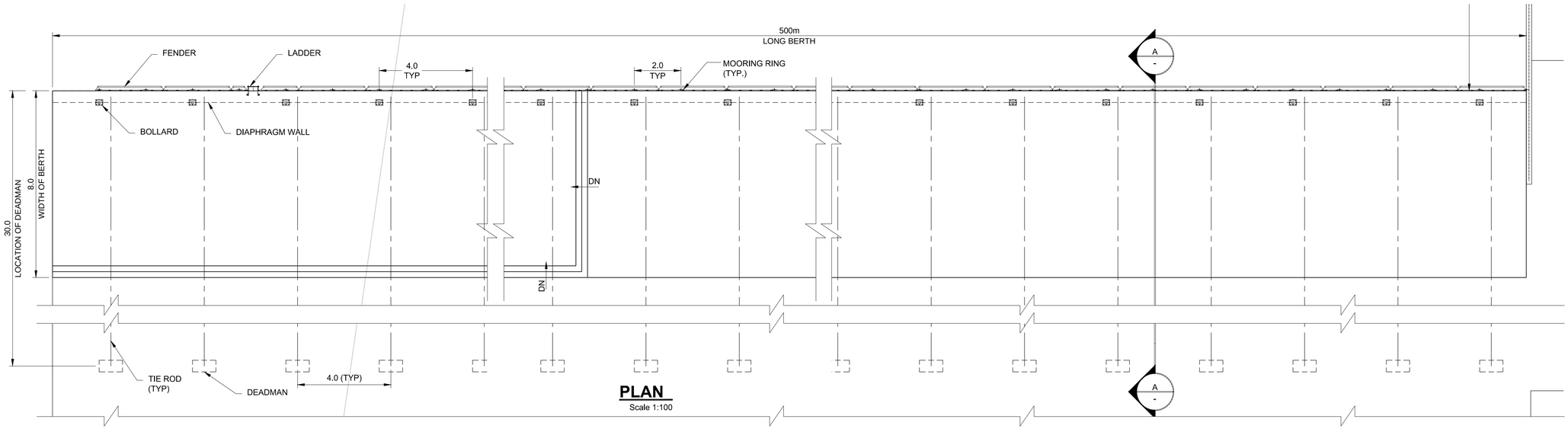
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

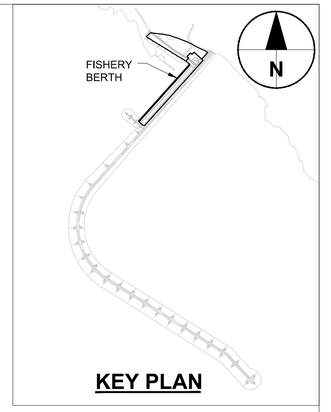
Sheet Title: SEQUENCE OF CONSTRUCTION FOR FISHERY BERTH

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 9003 REV 2

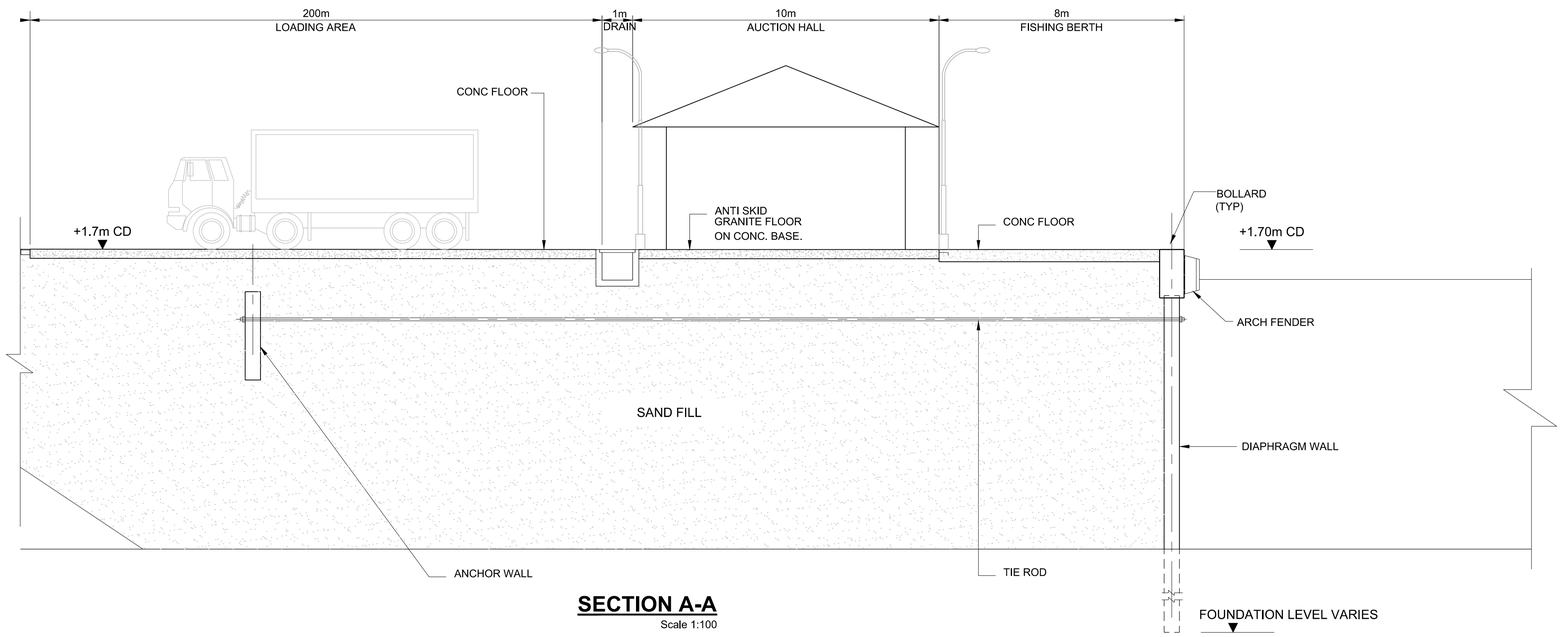
ISO A1 594mm x 841mm



PLAN
Scale 1:100



KEY PLAN



SECTION A-A
Scale 1:100

NOTE:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO LOCAL CHART DATUM.
2. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE MENTIONED.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014
R2	VK	VA	09-10-2014

0m 2 4 6 8
SCALE 1:100 FULL SIZE (A1)

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Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

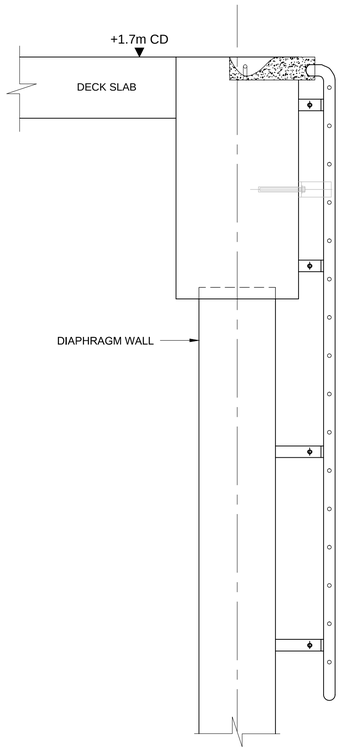
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
STRUCTURAL ARRANGEMENT AND CROSS SECTION OF FISHERY BERTH

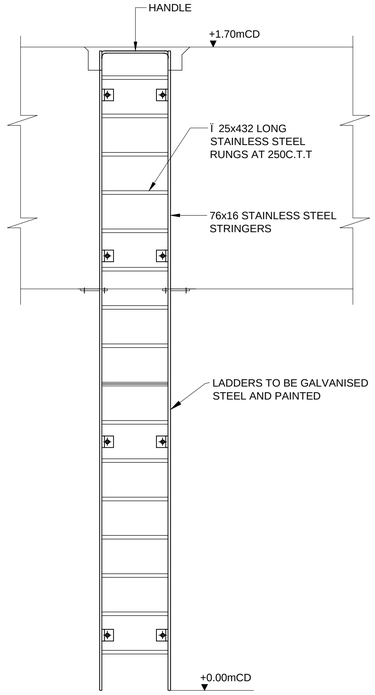
Project Number	Sheet Number
DELD11137	1 of 2

Drawing No.
DELD11137-DRG-25-0000-CP- 9004 REV 2

ISO A1 594mm x 841mm



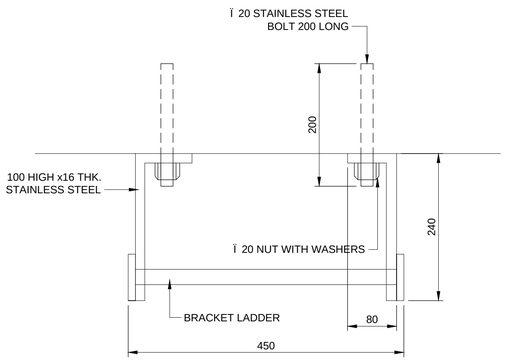
SIDE ELEVATION



ELEVATION

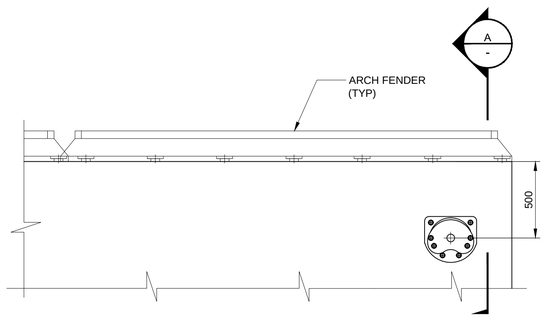
TYPICAL DETAIL OF LADDER

Scale 1-20



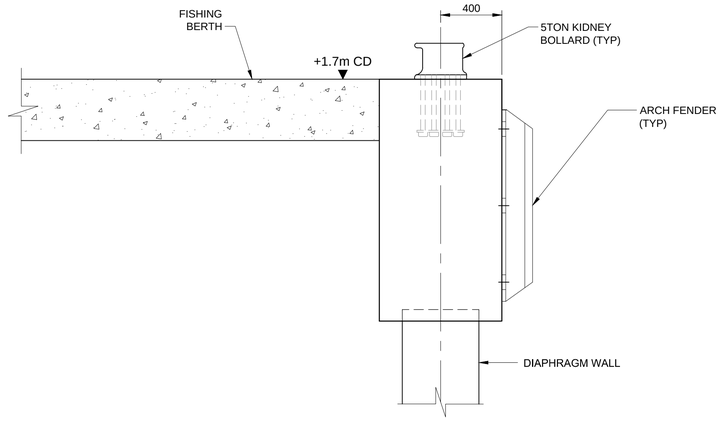
TYPICAL FIXING DETAIL OF LADDER

Scale 1-5



TYPICAL PLAN KIDNEY BOLLARD

Scale 1-20



SECTION A-A

Scale 1-20

NOTE:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO LOCAL CHART DATUM.
2. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE MENTIONED.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014
R2	VK	VA	09-10-2014

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Drawn By: VK
Approved By: VA
Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

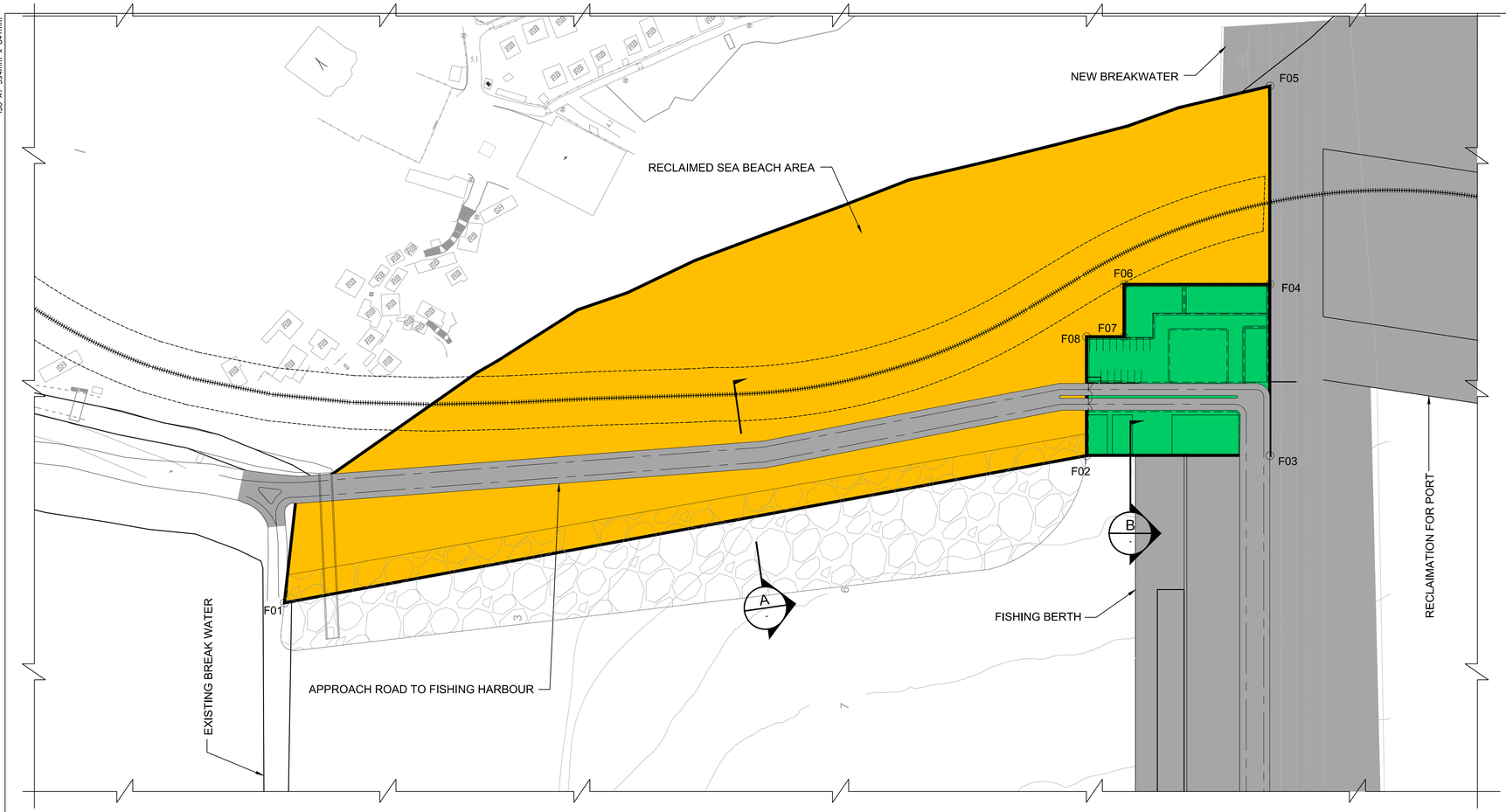
Sheet Title: GENERAL ARRANGEMENT AND CROSS SECTION OF THE FISHERY BERTH (MISCELLANEOUS DETAILS)

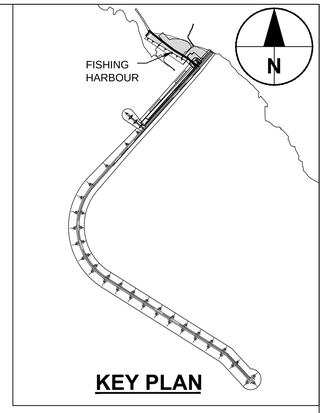
Project Number: DELD11137

Sheet Number: 2 of 2

Drawing No.: DELD11137-DRG-25-0000-CP- 9004 REV 2

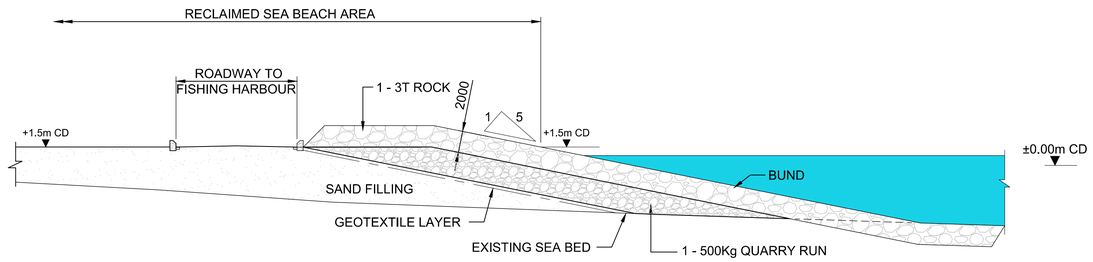
ISO A1 594mm x 841mm





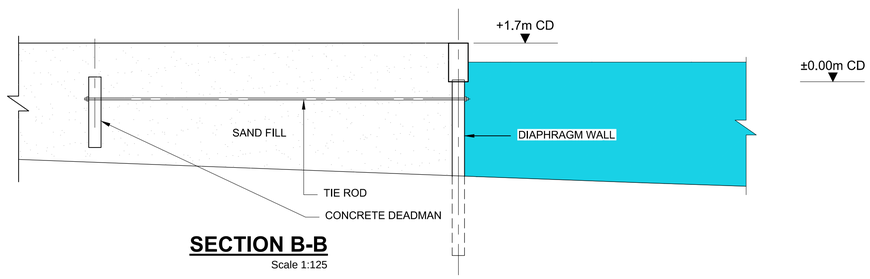
KEY PLAN

PLAN OF RECLAIMEND SEA BEACH AREA



SECTION A-A

Scale 1:250



SECTION B-B

Scale 1:125

COORDINATES		
POINTS	EASTING	NORTHING
F01	719432.324	926514.904
F02	719692.098	926355.883
F03	719743.082	926310.194
F04	719785.783	926357.844
F05	719835.179	926412.965
F06	719745.232	926394.024
F07	719732.167	926379.608
F08	719721.735	926388.954

LEGEND

- RECLAIMED SEA BEACH AREA (RECLAIMED LEVEL +1.00m CD)
- FISHERY HARBOUR-BUILDING AREA (RECLAIMED LEVEL +1.70m CD)

NOTES:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO LOCAL CHART DATUM.
2. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE MENTIONED.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 2 4 6 8
SCALE 1:1000 FULL SIZE (A1)

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VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

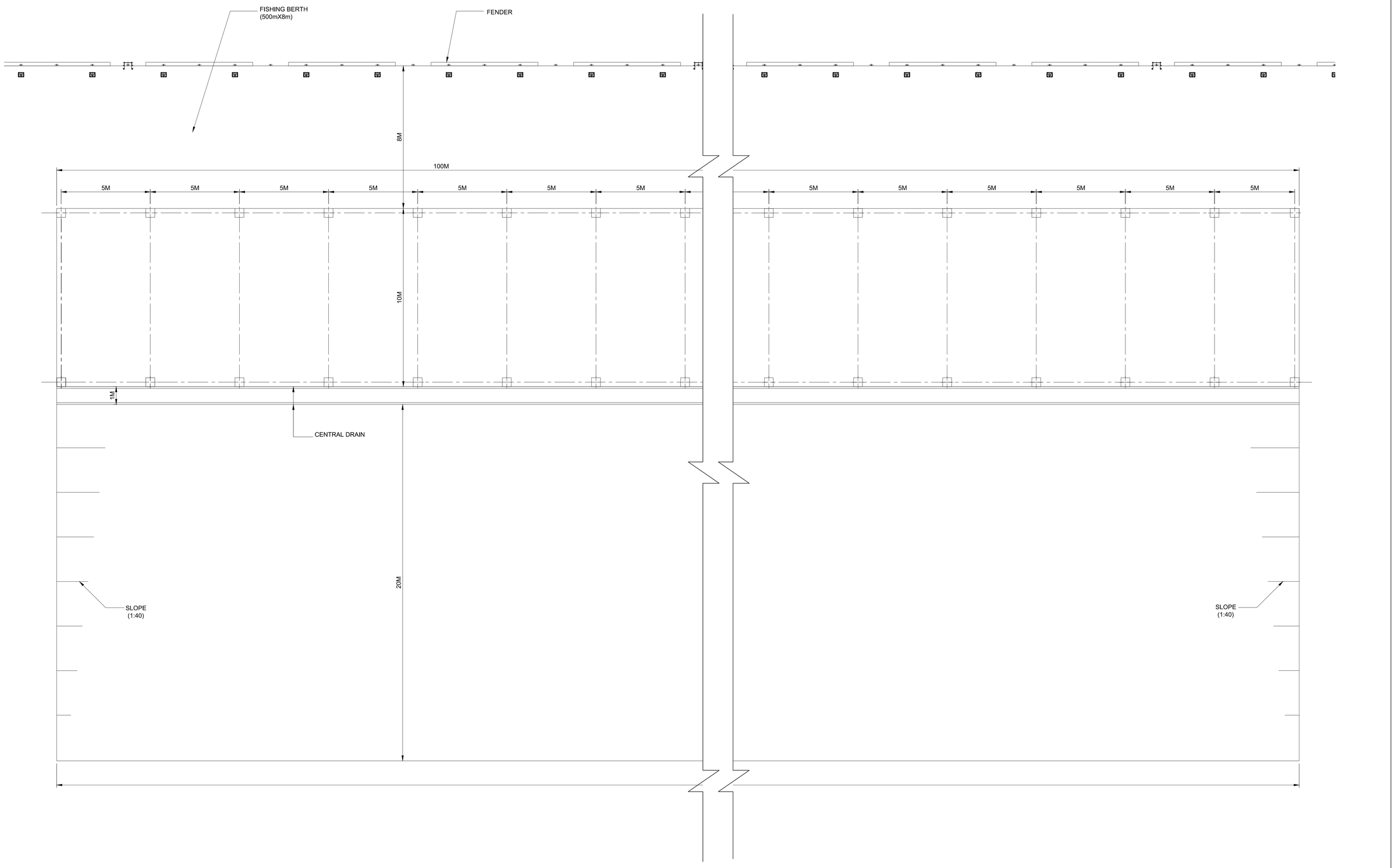
Sheet Title

SHORE PROTECTION BUND FOR SEA BEACH AREA

Project Number	Sheet Number
DELD11137	1 of 1

Drawing No.
DELD11137-DRG-25-0000-CP- 9005 REV 1

ISO A1 594mm x 841mm



Revision	By	Approved	Date
R1	VB	VA	05-05-2014

0m 2 4 6 8

SCALE 1:100 FULL SIZE (A1)

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Approved By	VA
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

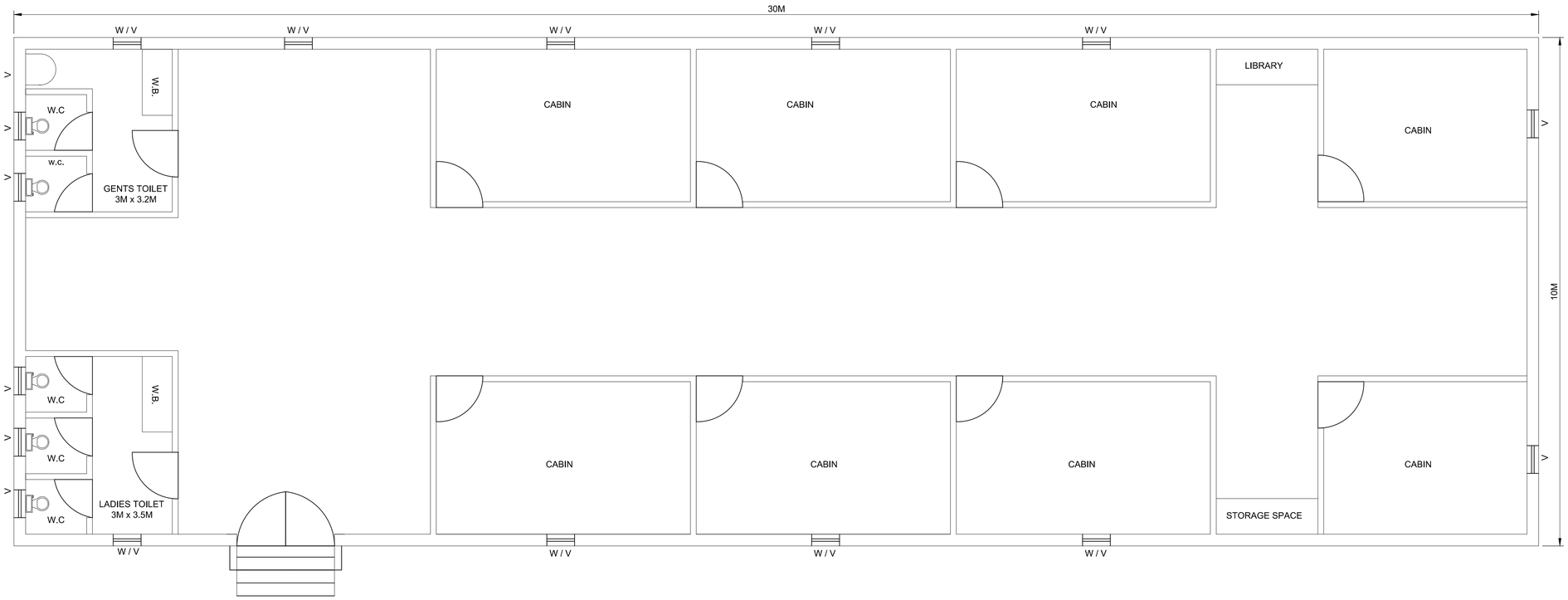
Sheet Title

GENERAL ARRANGEMENT OF AUCTION HALL & LOADING AREA

Project Number	Sheet Number
DELD11137	1 of 1

Drawing No.
DELD11137-DRG-25-0000-CP- 9006 REV 1

ISO A1 594mm x 841mm



Revision	By	Approved	Date
R1	VB	VA	05-05-2014

0m 1 2 3 4

SCALE 1:50 FULL SIZE (A1)

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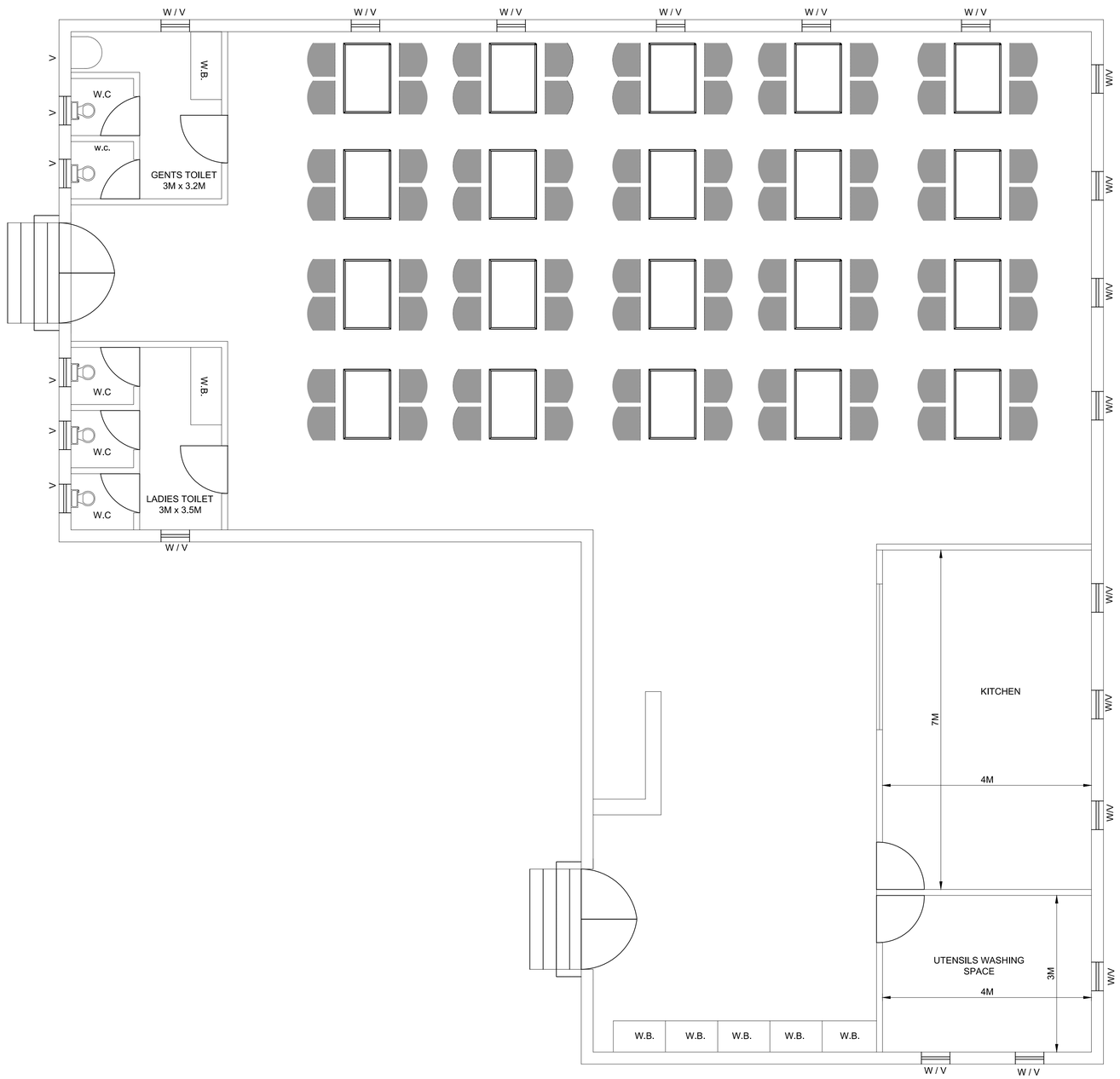
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
GENERAL LAYOUT OF ADMINISTRATIVE BUILDING

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 9007 REV 1

ISO A1 594mm x 841mm



Revision	By	Approved	Date
R1	VB	VB	05-05-2014

0m 1 2 3 4
SCALE 1:50 FULL SIZE (A1)

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Drawn By	VB
Approved By	VA
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

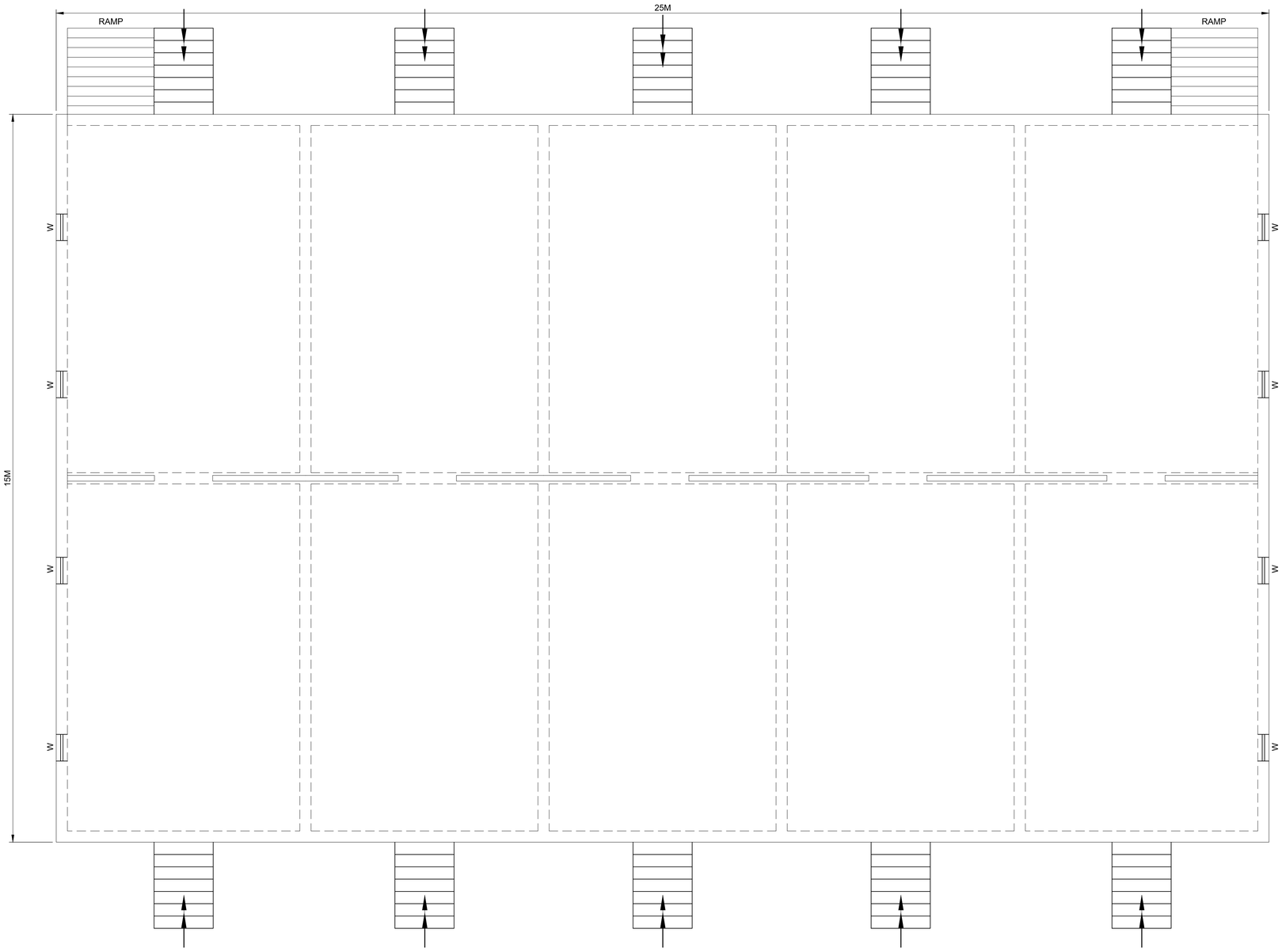
Sheet Title

GENERAL LAYOUT OF CANTEEN BUILDING

Project Number	Sheet Number
DELD11137	1 of 1

Drawing No.
DELD11137-DRG-25-0000-CP- 9008 REV 1

ISO A1 594mm x 841mm



Revision	By	Approved	Date
R1	VB	VB	05-05-2014

0m 1 2 3 4
SCALE 1:50 FULL SIZE (A1)

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Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

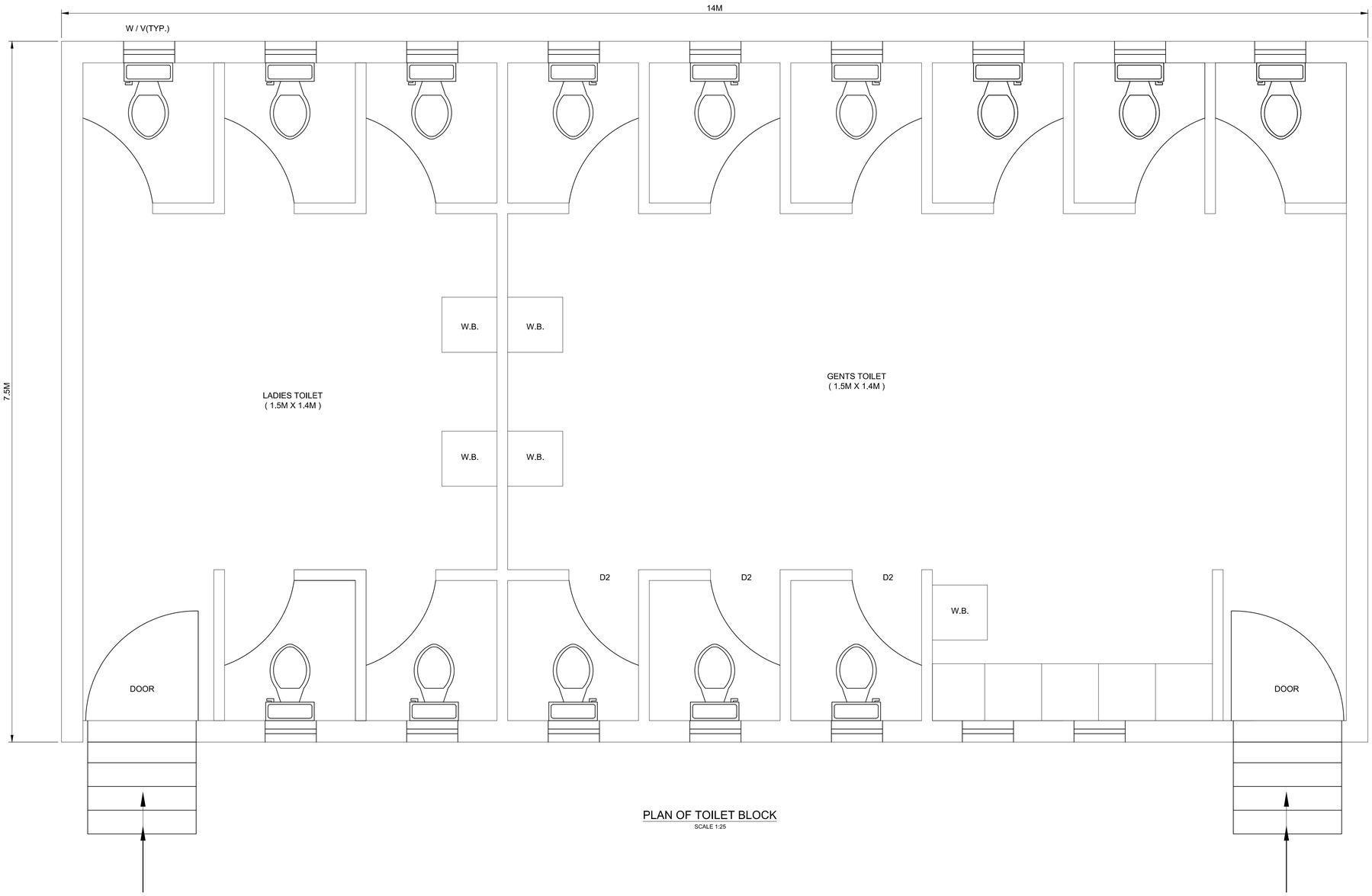
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
GENERAL LAYOUT OF NET MENDING SHED

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 9009 REV 1

ISO A1 594mm x 841mm



PLAN OF TOILET BLOCK

SCALE 1:25

Revision	By	Approved	Date
R1	VB	VA	05-05-2014

0m 100 200 300 400

SCALE 1:5000 FULL SIZE (A1)

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Date: 07-02-2014
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VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

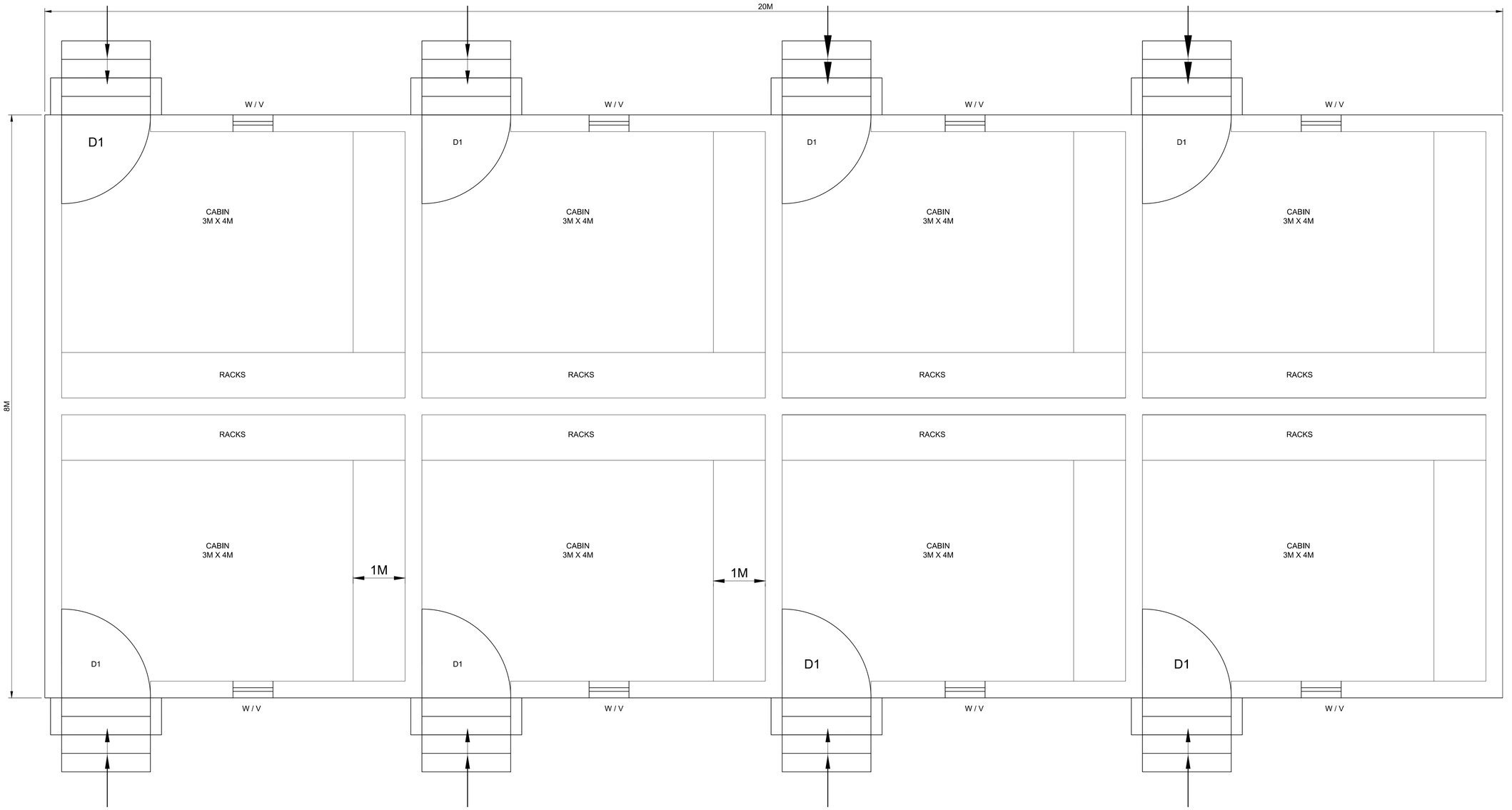
Sheet Title: GENERAL LAYOUT OF TOILET BLOCK

Project Number: DELD11137

Sheet Number: 1 of 1

Drawing No.: DELD11137-DRG-25-0000-CP- 9010 REV 1

ISO A1 594mm x 841mm



Revision	By	Approved	Date
R1	VB	VA	05-05-2014

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Approved By: VA
Date: 07-02-2014
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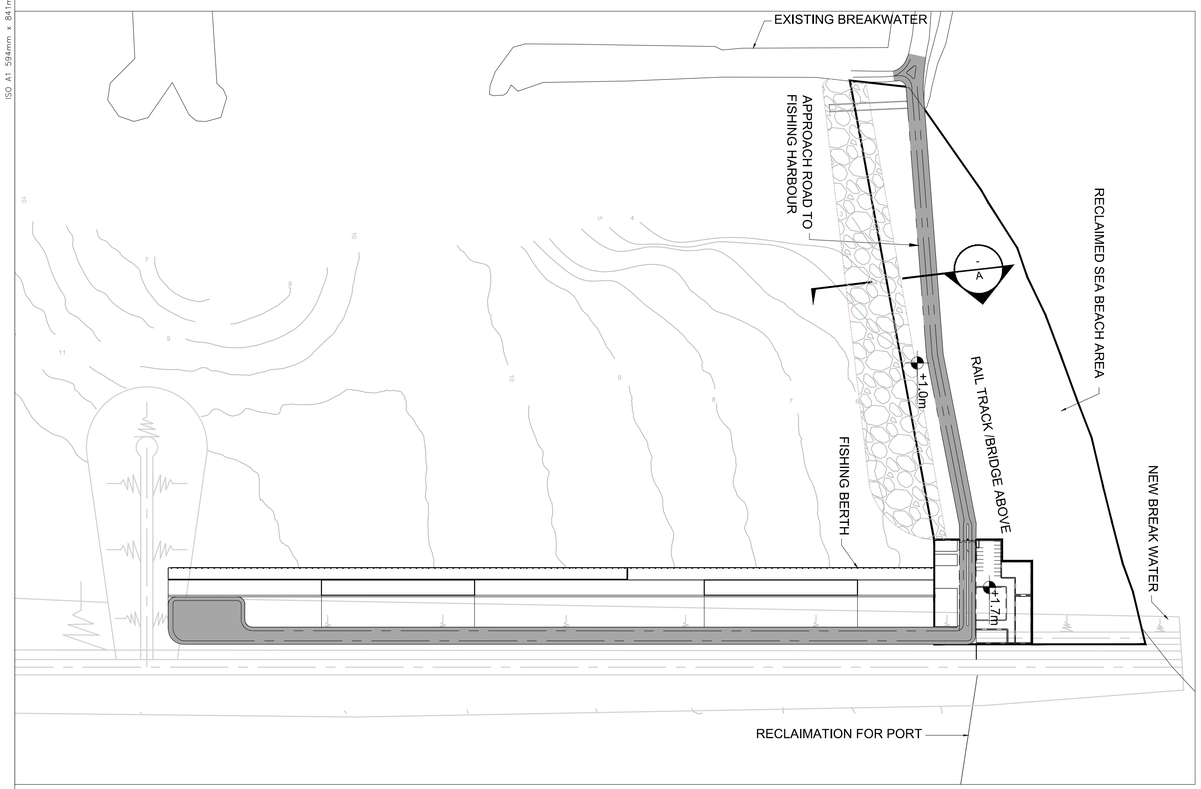
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

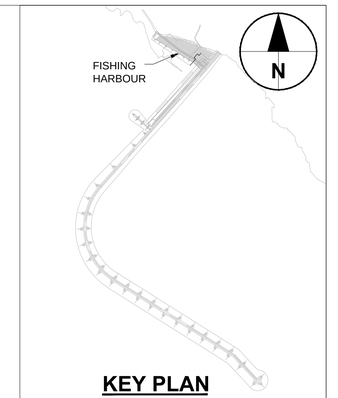
Sheet Title
GNERAL LAYOUT OF
GEAR SHED FOR LOCKER ROOM

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 9011 REV 1

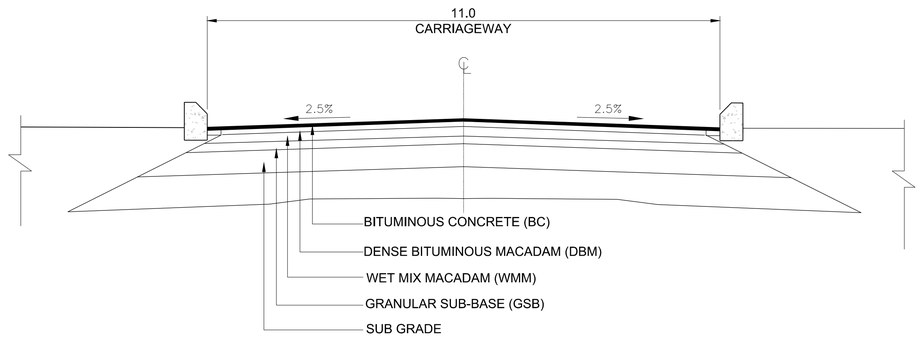
ISO A1 594mm x 841mm



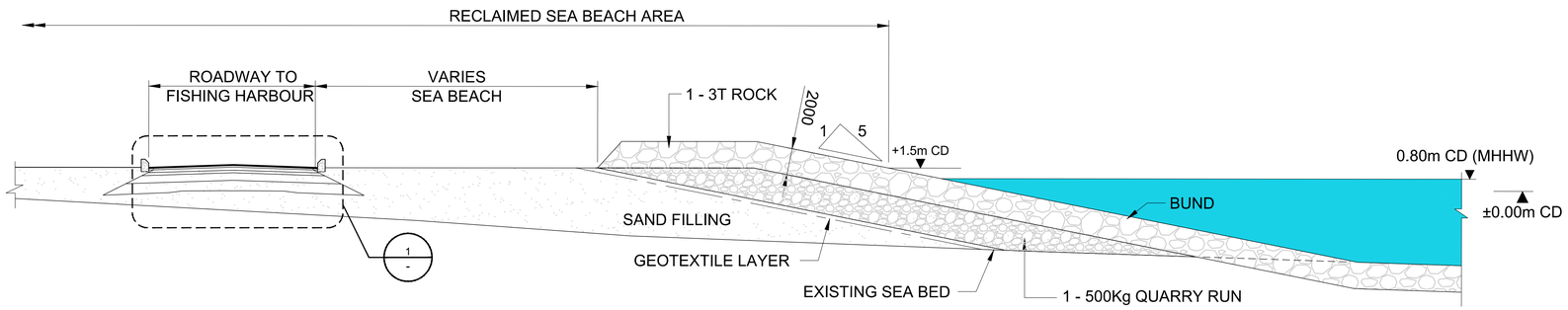
PLAN
SCALE 1:2000



KEY PLAN



DETAIL - 1
SCALE 1:15



SECTION A-A
SCALE 5:1

NOTES:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO LOCAL CHART DATUM.
2. ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE MENTIONED.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014
R2	VK	VA	09-10-2014

0m 2 4 6 8
SCALE 1:1000 FULL SIZE (A1)

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Date: 07-02-2014
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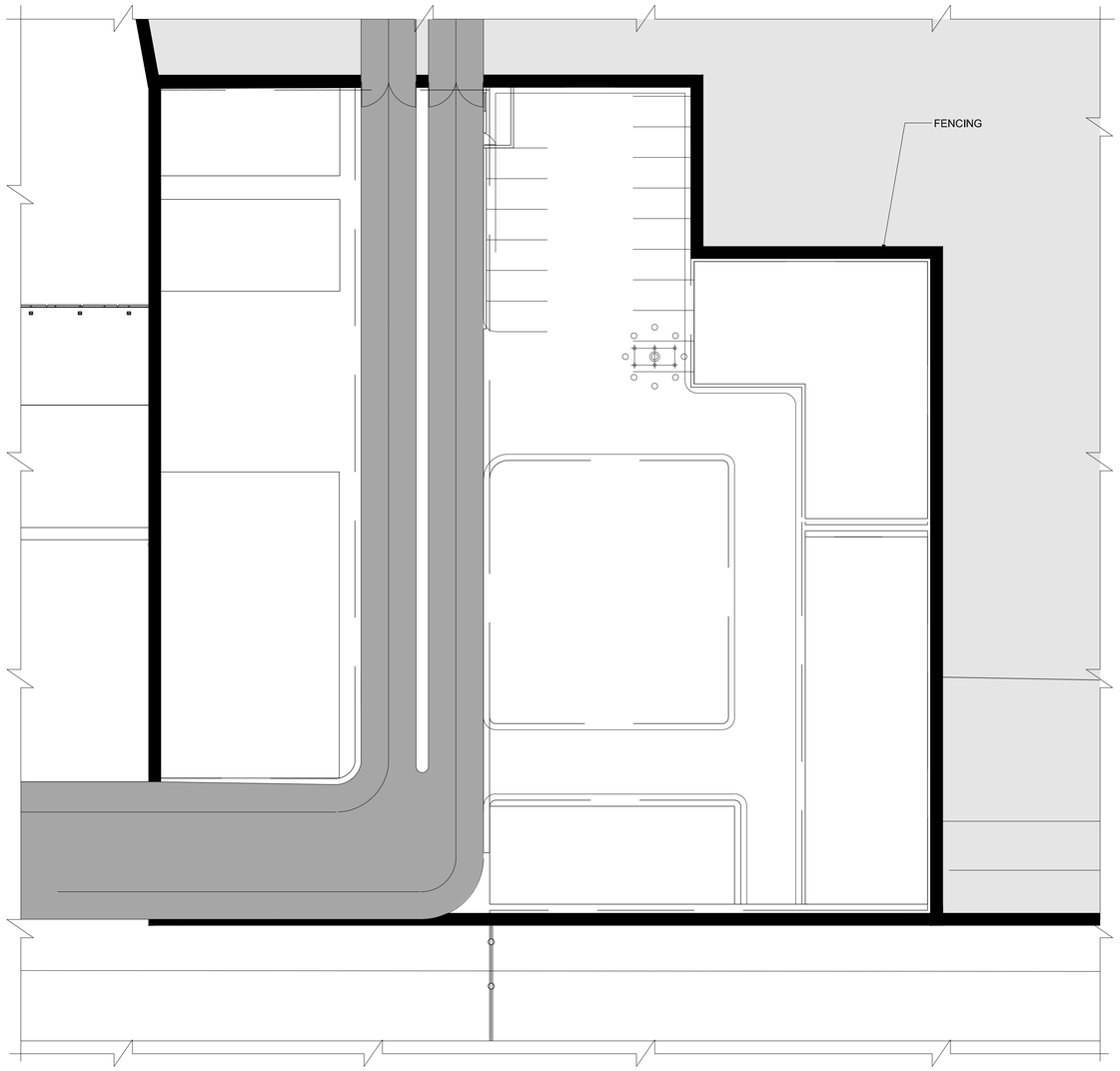
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

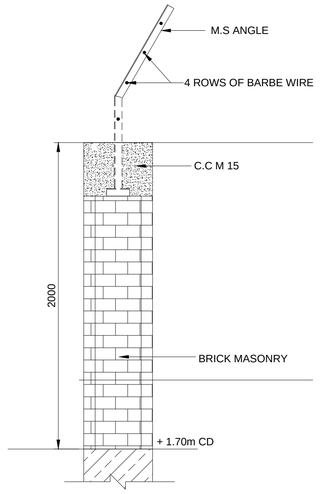
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: INTERNAL ROAD FOR FISHERY HARBOUR

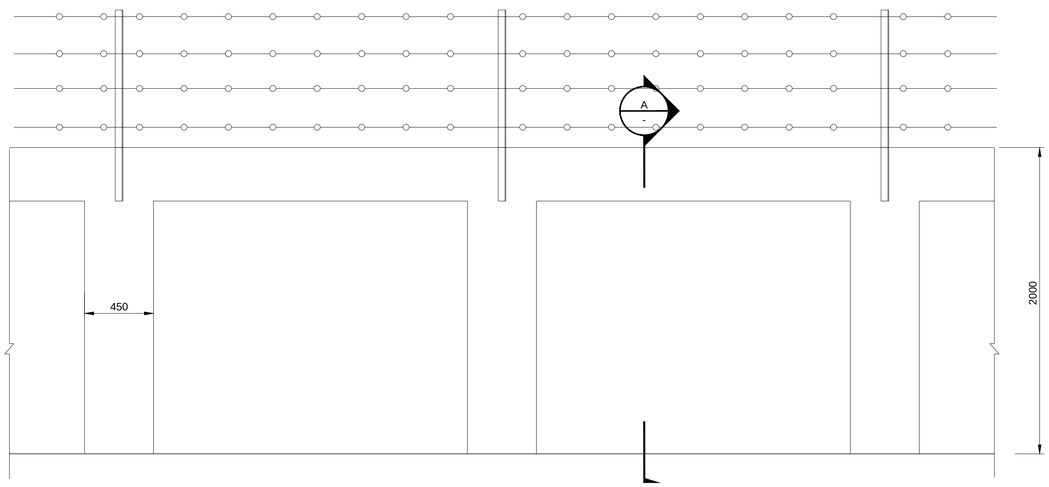
Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 9012 REV 2

ISO A1 594mm x 841mm





SECTION A A



LONGITUDINAL SECTION OF FENCING WALL

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE NOTED.
2. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.

Revision	By	Approved	Date
R1	VB	VA	05-05-2014

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Approved By: VA
Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: FISHERY HARBOUR FENCING ARRANGEMENT

Project Number: DELD11137
Sheet Number: 1 of 1
Drawing No.: DELD11137-DRG-25-0000-CP- 9013 REV 1

ISO A1 594mm x 841mm

KEY NOTES

1. INDIAN NAVY BERTH 1 (200M LONG)
2. INDIAN NAVY BERTH 2 (300M LONG)
3. COAST GUARD BERTH (120M LONG)
4. PORT CRAFT BERTH (100M LONG)
5. CRUISE BERTH (300M LONG)

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 10 20 30 40
SCALE 1:5000 FULL SIZE (A1)

TRANSPORTATION (Ports & Maritime)

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Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

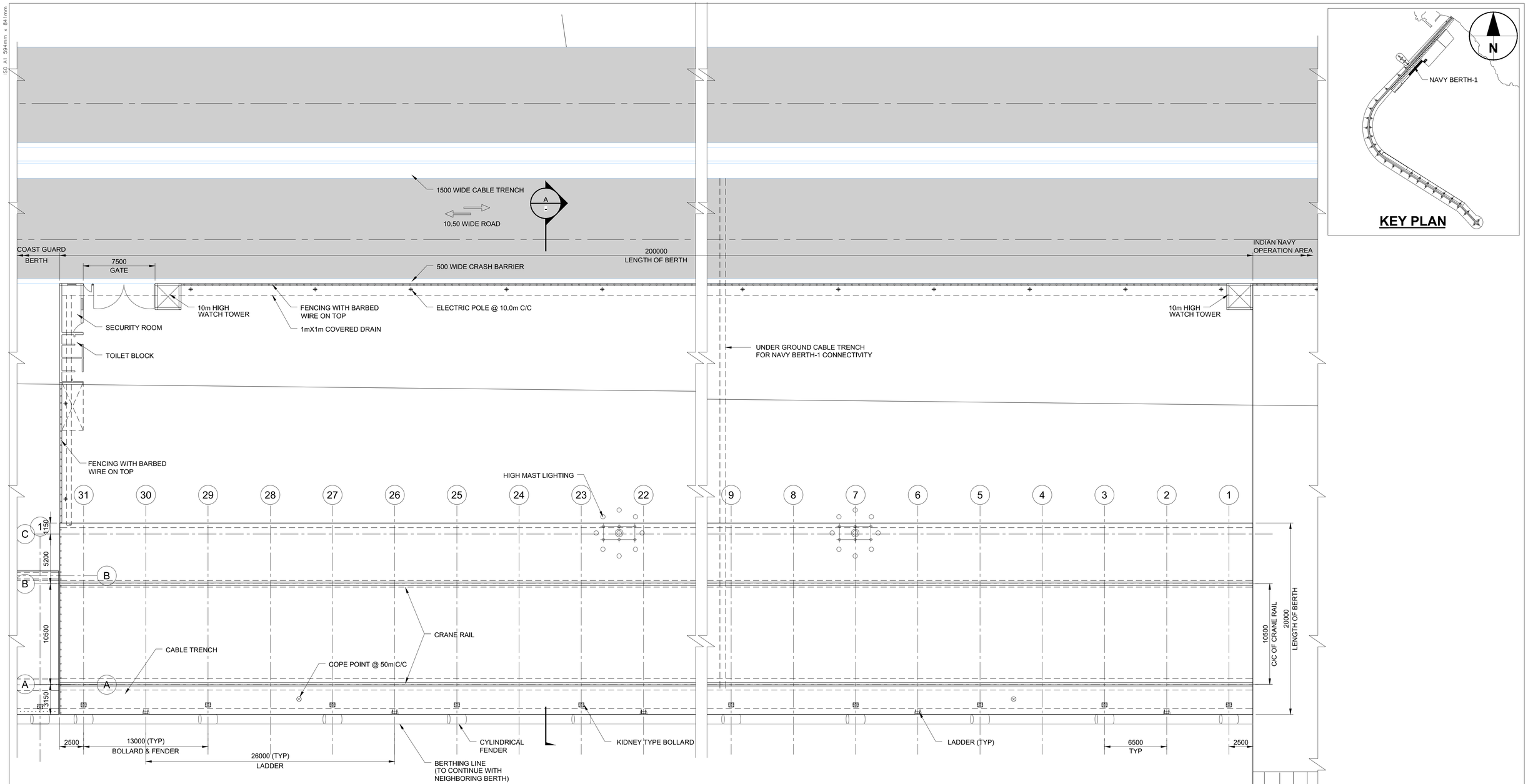
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
GEOMETRIC REQUIREMENTS
FOR INDIAN NAVY, COASTGUARD,
CRUISE CUM MULTIPURPOSE BERTHS

Project Number	Sheet Number
DELD11137	1 of 1

Drawing No.
DELD11137-DRG-25-0000-CP- A001 REV 1

ISO A1 594mm x 841mm



PLAN OF NAVY BERTH-1

LIST OF REQUIREMENTS FROM NAVY :-

1. FENDER - SCN 900 E2.1 - 18 NOs.
2. CRANE - RAIL MOUNTED 30 TONNES RATED AT 30 m
3. BOLLARD - 80T - 18 NOs.
4. HIGH MAST LIGHTING - 30m HIGH WITH 8 LAMPS @100m C/C
5. WATCH TOWER - 10m HIGH - 2 NOs.
6. GATE - 1 NO.
7. BOUNDARY WALL- 3m HIGHT WITH BARBED WIRE ON TOP
8. ELECTRIC POLE - @ 10m C/C NEXT TO ROAD/BOUNDARY WALL
9. SENTRY POST - NEXT TO GATE OF SIZE 5m X 2m WITH TOILET & REST ROOM
10. TOILET BLOCK - SEPARATE BATH & TOILET IN ONE BUILDING WITH UNDER GROUND SEPTIC TANK
11. COVERED DRAIN - 1m X 1m (STROM WATER ONLY) - TO BE DISPOSED TO SEA
12. COPE POINT - @ 50m C/C ALONG THE BERTH FACE

NOTES:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO WITH CHART DATUM.
2. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE MENTIONED.
3. TOTAL YARD AREA BEHIND BERTH = 4983m²

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 4 8 12 16
SCALE 1:200 FULL SIZE (A1)

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Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

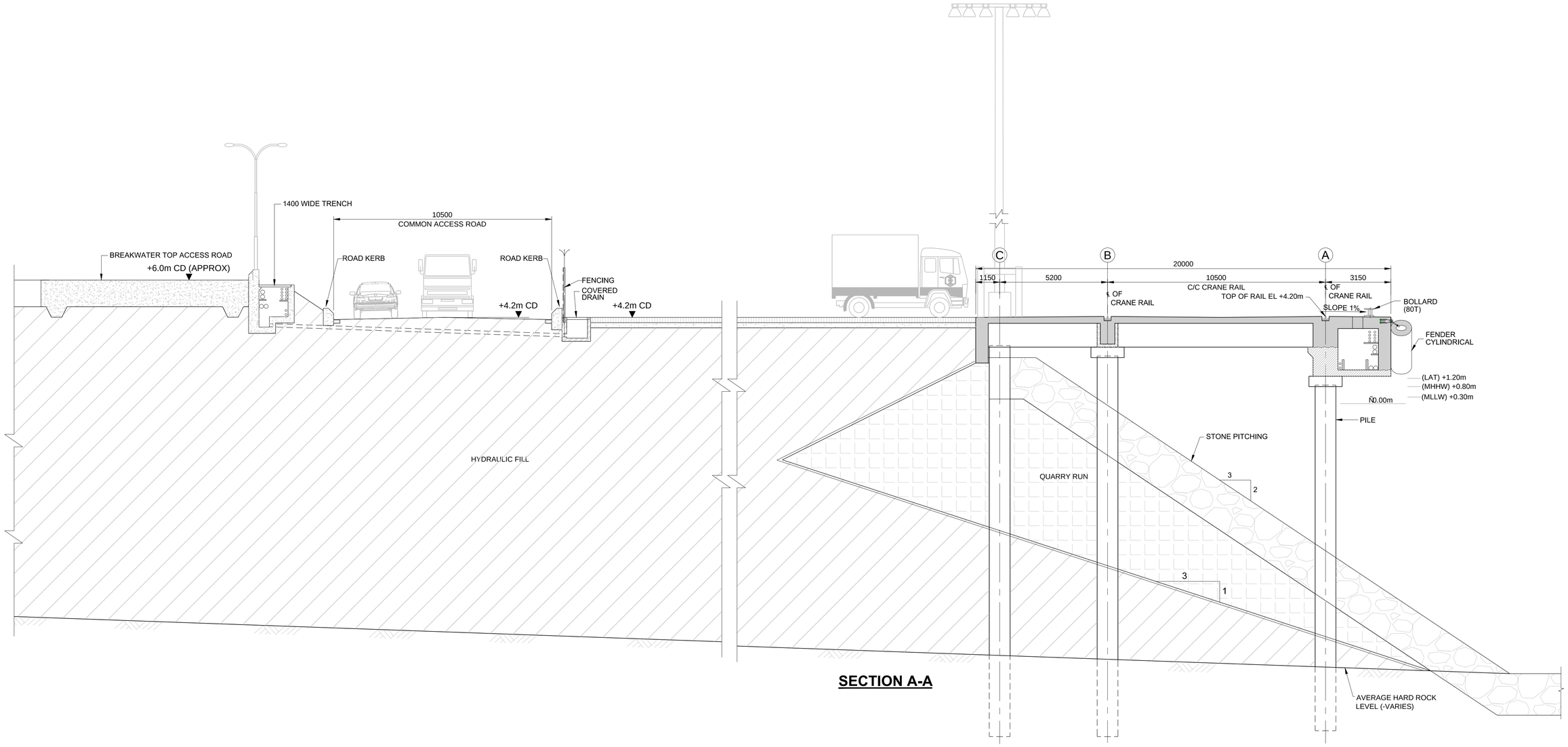
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: GENERAL ARRANGEMENT OF NAVY BERTH-1

Project Number: DELD11137
Sheet Number: 1 of 2
Drawing No.: DELD11137-DRG-25-0000-CP- A002 REV 1

ISO A1 594mm x 841mm



SECTION A-A

NOTES:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO LOCAL CHART DATUM.
2. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE MENTIONED.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 2 4 6 8
SCALE 1:100 FULL SIZE (A1)

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Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

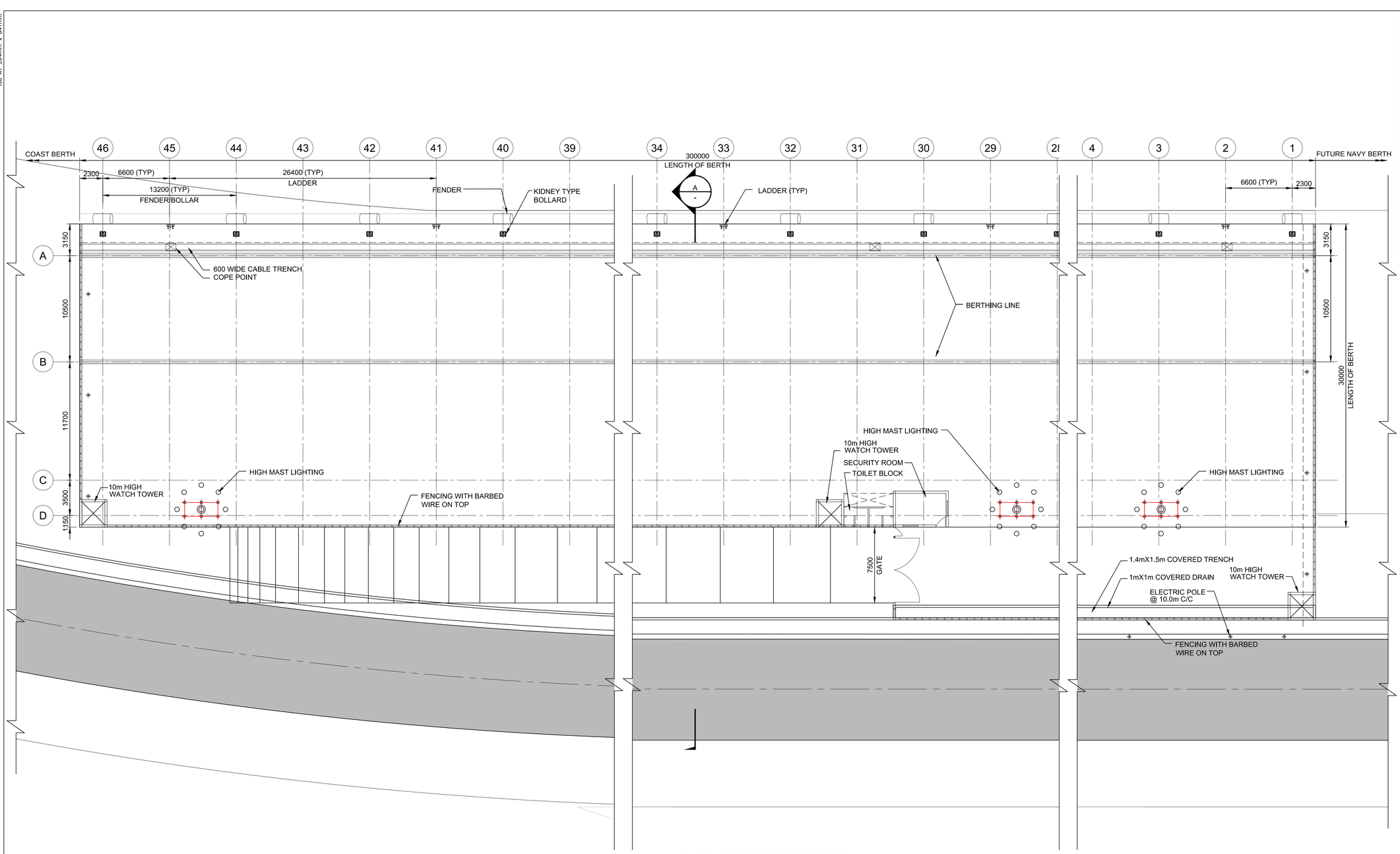
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

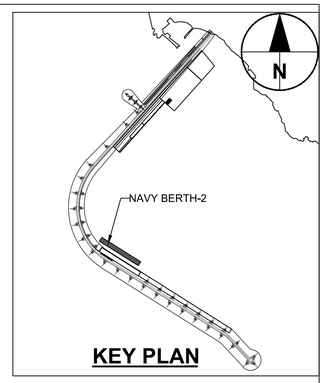
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
GENERAL ARRANGEMENT OF NAVY BERTH-1 (CROSS SECTION)

Project Number: DELD11137
Sheet Number: 2 of 2
Drawing No.: DELD11137-DRG-25-0000-CP- A002 REV 1

ISO A1 594mm x 841mm





KEY PLAN

PLAN OF NAVY BERTH-2

LIST OF REQUIREMENTS FROM NAVY :-

1. FENDER - SCN 1100 E0.9/SCK 1450H E1.0 - 26 NOs.
2. CRANE - RAIL MOUNTED 30 TONNES RATED AT 30 m
3. BOLLARD - 100T - 26 NOs.
4. HIGH MAST LIGHTING - 30m HIGH WITH 8 LAMPS @100m C/C
5. WATCH TOWER - 10m HIGH - 2 NOs.
6. GATE - 1 NO.
7. BOUNDARY WALL- 3m HIGHT WITH BARBED WIRE ON TOP
8. ELECTRIC POLE - @ 10m C/C NEXT TO ROAD/BOUNDARY WALL
9. SENTRY POST - NEXT TO GATE OF SIZE 5m X 2m WITH TOILET & REST ROOM
10. TOILET BLOCK - SEPARATE BATH & TOILET IN ONE BUILDING WITH UNDER GROUND SEPTIC TANK
11. COVERED DRAIN - 1m X 1m (STROM WATER ONLY) - TO BE DISPOSED TO SEA
12. COPE POINT - @ 50m C/C ALONG THE BERTH FACE

NOTES:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.
2. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE MENTIONED.
3. TOTAL YARD AREA BEHIND BERTH = 2158m²

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 4 8 12 16
SCALE 1:200 FULL SIZE (A1)

TRANSPORTATION (Ports & Maritime)

AECOM
9th Floor, Infinity Tower C
DLF Cyber City, DLF Phase- II
Gurgaon - 122002,
Haryana, India

www.aecom.com

Drawn By	VK
Approved By	VA
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

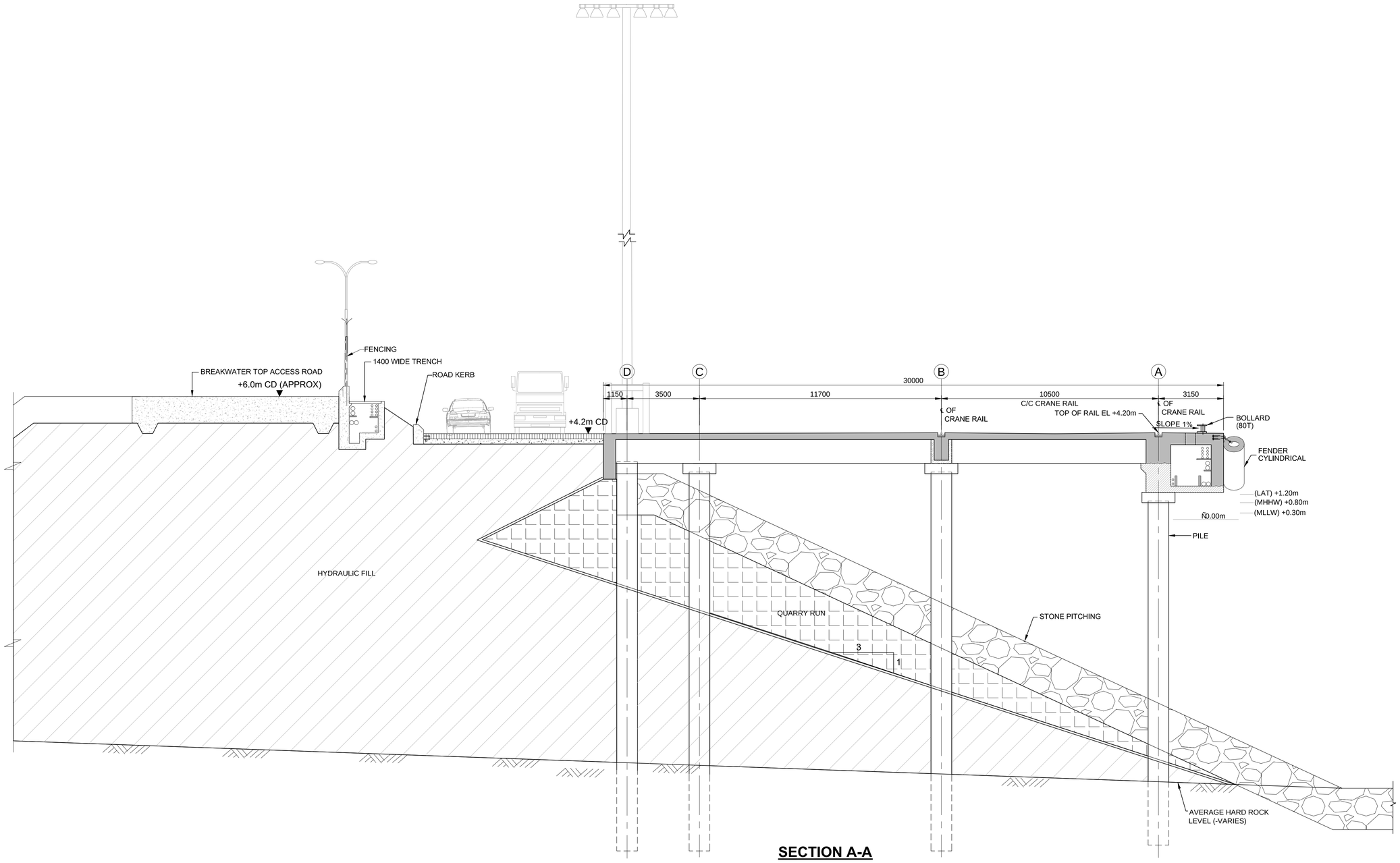
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
GENERAL ARRANGEMENT OF NAVY BERTH-2

Project Number: DELD11137
Sheet Number: 1 of 2
Drawing No.: DELD11137-DRG-25-0000-CP- A003 REV 1

ISO A1 594mm x 841mm



SECTION A-A

NOTES:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO CHART DATUM.
2. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE MENTIONED.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 2 4 6 8
SCALE 1:100 FULL SIZE (A1)

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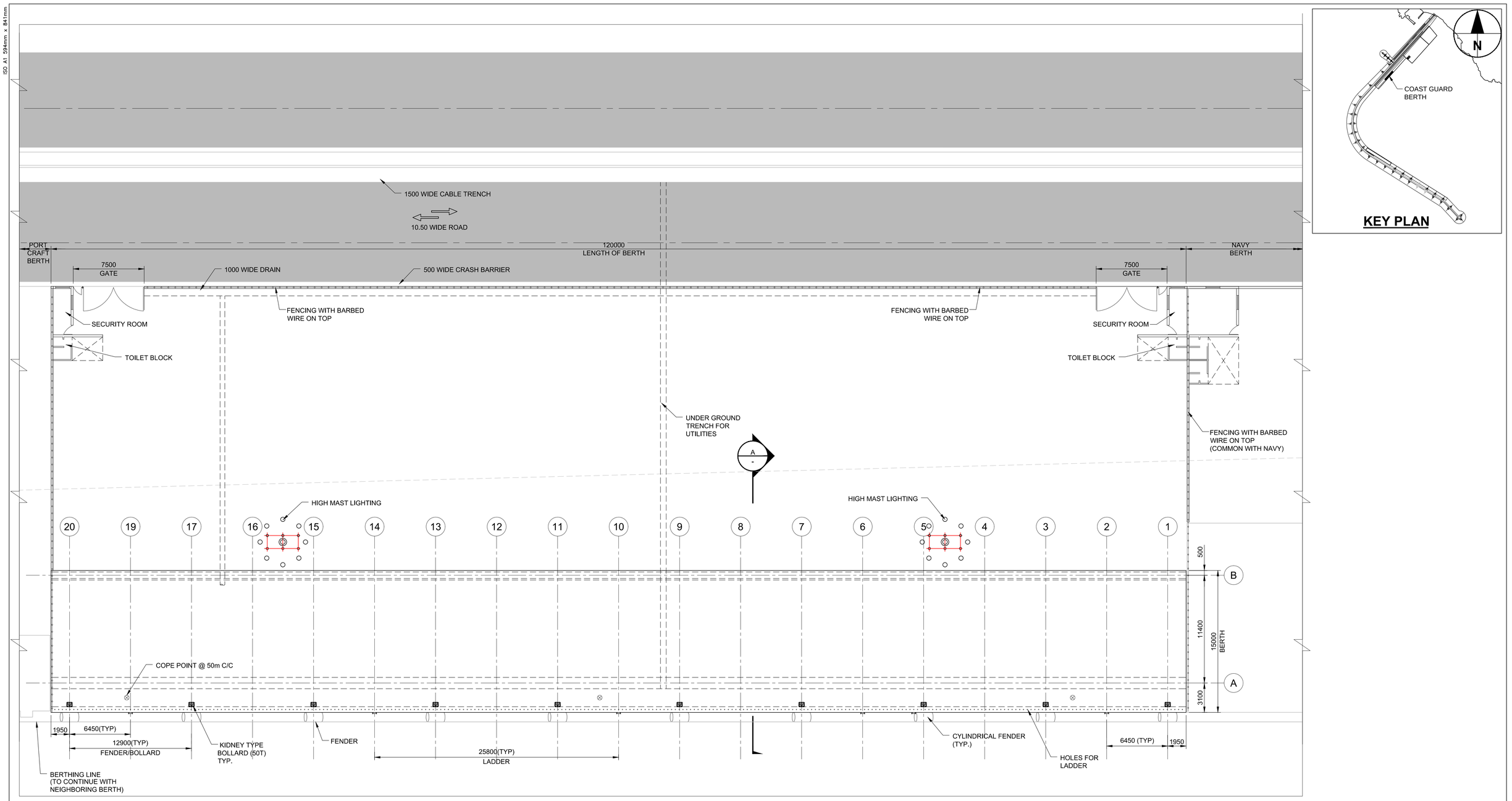
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
GENERAL ARRANGEMENT OF NAVY BERTH-2 (CROSS SECTION)

Project Number: DELD11137
Sheet Number: 2 of 2
Drawing No.: DELD11137-DRG-25-0000-CP- A003 REV 1

ISO A1 594mm x 841mm



KEY PLAN

LIST OF REQUIREMENTS FROM COAST GUARD

1. BOLLARD - 50T - 8 NOS.
2. HIGH MAST LIGHTING 2 NOS. 30 m HIGH WITH 8 LAMPS @100m C/C
3. GATE - 2 NO.
4. FENCING WITH BARBED WIRE ON TOP
5. SENTRY POST - NEXT TO GATE OF SIZE 5m X 2m WITH TOILET & REST ROOM
6. COVERED DRAIN - 1m X 1m (STORM WATER ONLY) - TO BE DISPOSED TO SEA
7. COPE POINT - 6 NOS ALONG THE BERTH FACE

NOTES:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO WITH CHART DATUM.
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Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 4 8 12 16
SCALE 1:200 FULL SIZE (A1)

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VIZHINJAM INTERNATIONAL SEAPORT LIMITED

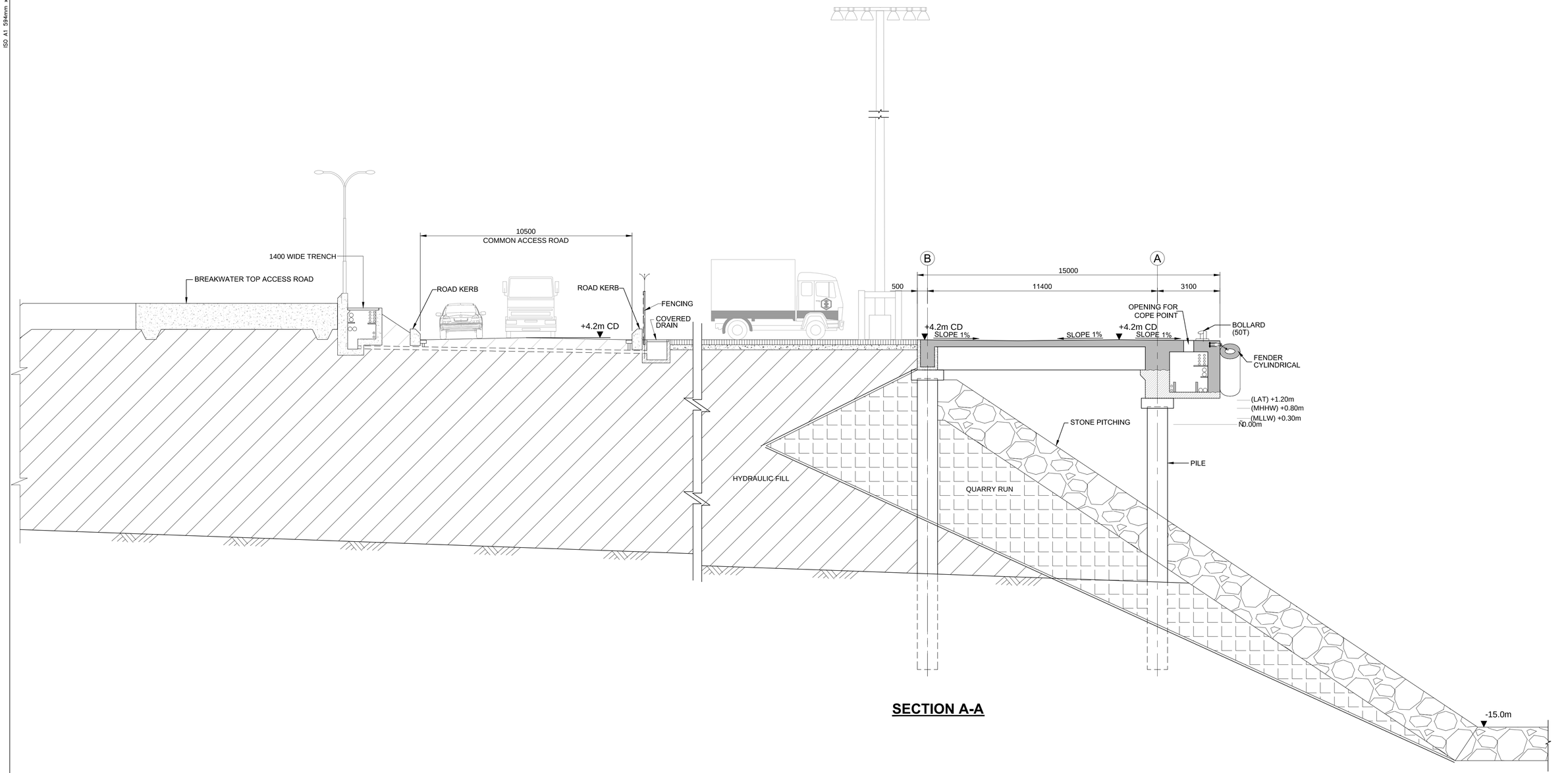
BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title
GENERAL ARRANGEMENT OF COAST GUARD BERTH

Project Number	Sheet Number
DELD11137	1 of 2

Drawing No.
DELD11137-DRG-25-0000-CP- A004 REV 1

ISO A1 594mm x 841mm



SECTION A-A

NOTES:

1. ALL LEVELS ARE IN METERS WITH RESPECT TO WITH CHART DATUM.
2. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE MENTIONED.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

0m 2 4 6 8
SCALE 1:100 FULL SIZE (A1)

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Drawn By: VK
Approved By: VA
Date: 07-02-2014
Meeting: BASIC ENGINEERING REPORT

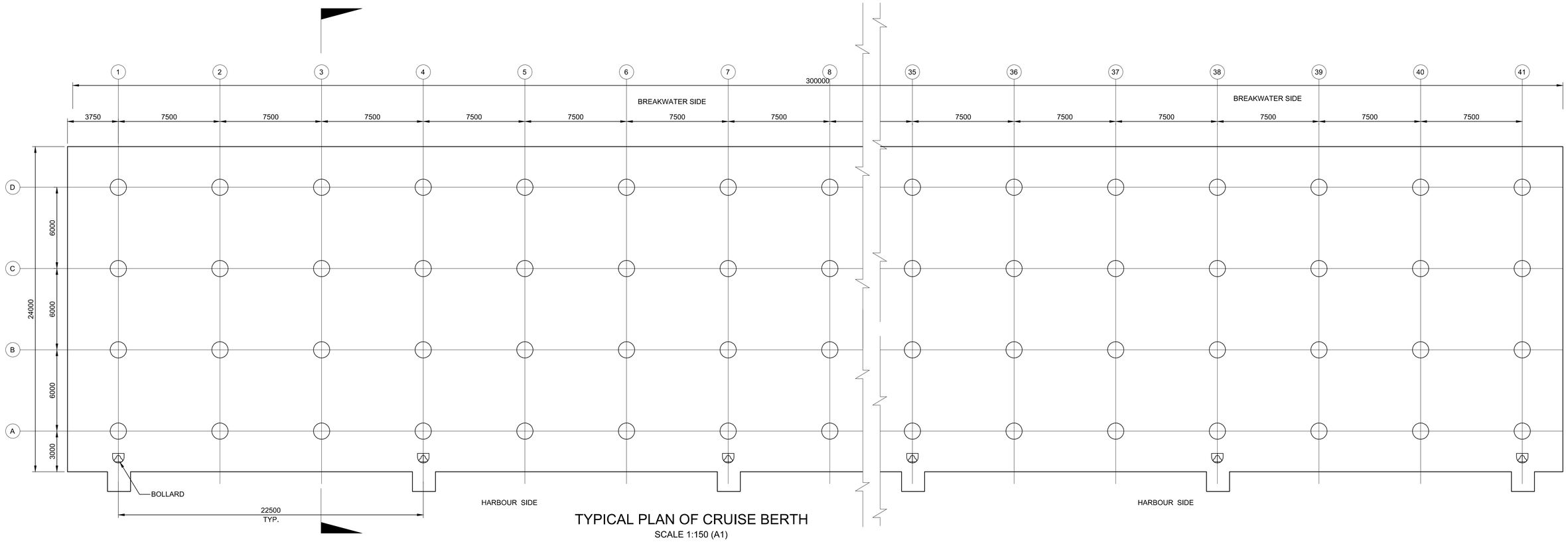
VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title: GENERAL ARRANGEMENT OF COAST GUARD BERTH (CROSS SECTION)

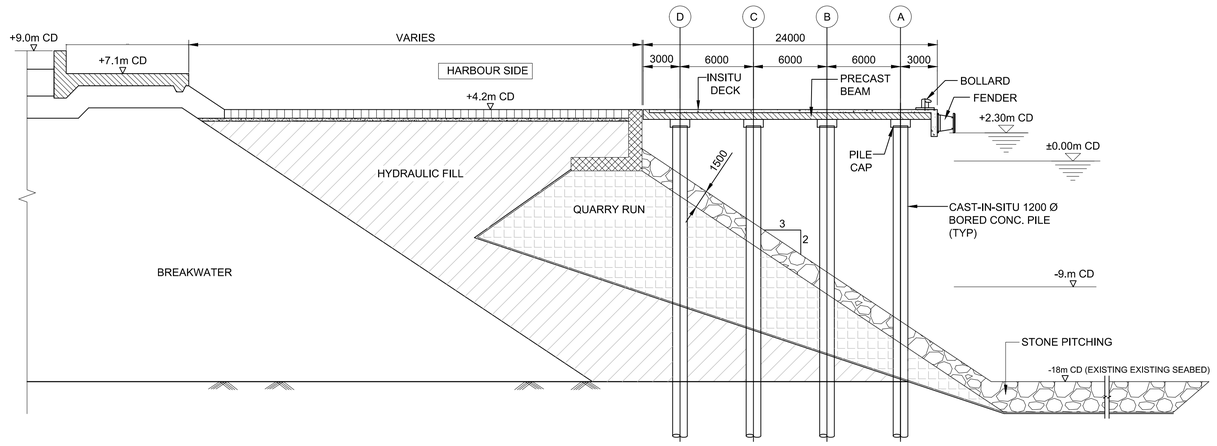
Project Number: DELD11137
Sheet Number: 2 of 2
Drawing No.: DELD11137-DRG-25-0000-CP- A004 REV 1

ISO A1 594mm x 841mm



TYPICAL PLAN OF CRUISE BERTH

SCALE 1:150 (A1)



TYPICAL CROSS SECTION OF CRUISE BERTH

SCALE 1:250 (A1)

NOTES:

1. ALL LEVELS ARE IN METRES AND ARE WITH RESPECT TO CHART DATUM.
2. ALL DIMENSIONS ARE IN MILLIMETERS.

Revision	By	Approved	Date
R1	VK	VA	05-05-2014

TRANSPORTATION (Ports & Maritime)

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Approved By	AM
Date	07-02-2014
Meeting	BASIC ENGINEERING REPORT

VIZHINJAM INTERNATIONAL SEAPORT LIMITED

BASIC ENGINEERING REPORT FOR DEVELOPMENT OF VIZHINJAM PORT

Sheet Title

GENERAL ARRANGEMENT OF CRUISE CUM MULTIPURPOSE BERTH

Project Number	Sheet Number
DELD11137	1 of 1

Drawing No.
DELD11137-DRG-25-0000-CP- A005 REV 1

Annexure 4

Detailed Cost Estimates

Prepared for

Vizhinjam International Seaports Limited (VISL)

Prepared by

AECOM India Private Limited

December 2014

Annexure 4: Detailed Capital Cost Estimates - Basic Engineereing Report (2014 Price Level)

S. No.		ITEM	QUANTITY PHASE 1	UNIT	RATE (INR)	AMOUNT (INR) PHASE 1
1.		**PROJECT PRELIMINARIES AND SITE DEVELOPMENT**				
	1.1	Project Studies and Surveys		LS		5,00,00,000
	1.2	Preliminary and Preoperative Expenses		LS		5,00,00,000
	1.3	Site Clearing		LS		2,00,00,000
	1.4	Temporary Construction Fencing		LS		1,00,00,000
	Total (1)					**13,00,00,000**
2.		**DREDGING AND RECLAMATION**				
	2.1	Dredging & Reclmation of Sand	66,32,668	Cum	550	3,64,79,67,125
	2.2	Dredging & Reclmation from Marine Borrow Area	-	Cum	550	-
	2.3	Reclamation bund (Sand Fill - Dredge Spoils)	5,35,000	Cum	275	14,71,25,000
	2.4	Shore Protection Bund				
		Geofabric filter layer	28,133	Sqm	180	50,63,877
		upto 500 kg	3,48,350	Cum	1,782	62,07,60,146
		0.2 to 0.7 t stones	30,851	Cum	2,376	7,33,02,570
		0.7 to 1.5 t stones (Pitching)	21,934	Cum	3,024	6,63,29,323
		2 to 3 t stones (Primary)	44,607	Cum	3,996	17,82,49,572
	2.5	Ground Improvement (Gross Reclaimed Area)	59	Ha.	1,00,00,000	59,00,00,000
	2.6	Reclamation for Fishery Harbour	3,26,070	Cum	550	17,93,38,500
	2.7	Reclamation Bund for Fishing Harbour	350	m	3,33,960	11,68,86,000
	Total (2)					**5,62,50,22,113**
3.		**BREAKWATERS (Mob-Demob Cost included in material cost)**				
	3.1	Breakwater (Length in meters)	3,100			
		a. ACCROPODE (m^3 units)				
		8	490	No.	85,000	4,16,57,685
		6	11,337	No.	75,000	85,02,94,725
		5	2,818	No.	67,000	18,88,05,998
		4	4,385	No.	60,000	26,30,85,780
		b. Rock				
		2.5 to 5 T	22,986	Cum	5,022	11,54,34,742
		2.0 to 4.0 T	49,756	Cum	3,996	19,88,25,491
		1.4 to 2.7 T	8,417	Cum	3,510	2,95,45,299
		1 to 2 T	7,13,692	Cum	3,024	2,15,82,03,308
		0.6 to 1.4 T	1,36,603	Cum	3,024	41,30,85,993
		0.2 to 0.4 T	89,826	Cum	2,376	21,34,27,436
		c. Core and Bedding				
		0.1 to 0.5 T stones (core)	28,08,149	Cum	1,782	5,00,41,22,263
		0.1 to 0.3 T stones (bedding)	1,38,380	Cum	1,782	24,65,94,018
		d. Crown Wall	43,434	Cum	15,700	68,19,09,659
	Total (3)					**10,40,49,92,397**
4.		**BERTHS**				
	4.1	Container Berths (Quay Length in meters)	800	m		
		a. Piled Foundation				
		Concrete In-Situ Piles	620	No.	27,89,828	1,72,96,93,562
		b. RCC in Superstructure	33,440	Sqm	20,409	68,24,89,477
		c. Fixtures and Accessories				
		Fenders	39	No.	25,00,000	9,75,00,000
		Bollards	39	No.	2,80,000	1,09,20,000
		Other Miscellaneous Fixtures	1	LS.	11,91,29,000	11,91,29,000
		d. Retaiining Wall behind the berth	2,400	Cum	13,760	3,30,24,000
		e. Stone pitching underside the berth				
		Geofabric filter layer	52,000	Sqm	180	93,60,000
		upto 500 kg	1,77,600	Cum	1,782	31,64,83,200
		Armour 0.5 to 1 T	1,25,600	Cum	3,024	37,98,14,400

S. No.	ITEM			QUANTITY PHASE 1	UNIT	RATE (INR)	AMOUNT (INR) PHASE 1
	4.4	Fishery Berth (Quay Length in meters)		500	m		
		a. 0.5 m thick Diaphragm Wall		500	m	2,40,000	12,00,00,000
		b. Tie Rods, Fixtures, turn buckles etc		500	No.	18,000	90,00,000
		c. Concrete dead man		625	Cum	25,000	1,56,25,000
		d. Pavement		4,000		2,850	1,14,00,000
		e. Fixtures and Accessories					
		Rubber Fenders		64	No.	20,000	12,80,000
		Bollards		126	No.	15,000	18,90,000
		Mooring rings, Ladder, Handrails Misc. etc.		1	LS	13,02,000	13,02,000
	Total (4)						**3,53,89,10,639**
5.	**BUILDINGS**						
	5.1	Administrative Buildings					-
		a. Port Users Administrative Building		800	Sqm	30,000	2,40,00,000
		b. Private Operator Administrative Building		800	Sqm	30,000	2,40,00,000
	5.2	Port Marine Operations Building		630	Sqm	30,000	1,89,00,000
	5.3	Yard Operations Building		300	Sqm	30,000	90,00,000
	5.4	Crane Maintenance Building		830	Sqm	25,000	2,07,50,000
	5.5	Maintenance & Repair Building		3,400	Sqm	25,000	8,50,00,000
	5.6	Trouble Kiosk & Restrooms		60	Sqm	15,000	9,00,000
	5.7	Quay Workers Restrooms		60	Sqm	15,000	9,00,000
	5.8	Railway Master Building		200	Sqm	15,000	30,00,000
	5.9	Reefer Shop w/ Genset		330	Sqm	35,000	1,15,50,000
	5.10	Canteen		100	Sqm	15,000	15,00,000
	5.11	Fire station		100	Sqm	25,000	25,00,000
	5.12	Utility Building		400	Sqm	25,000	1,00,00,000
	5.13	Electrical Sub Stations		400	Sqm	30,000	1,20,00,000
	5.14	Security Booth - Entry Gate		30	Sqm	20,000	6,00,000
	5.15	Security Booth - Exit Gate		30	Sqm	20,000	6,00,000
	5.16	Other Misc. Buildings		200	Sqm	20,000	40,00,000
	5.17	Fuel Station		100	Sqm	30,000	30,00,000
	5.18	Fish Landing Center Buildings					
		a	Auction Hall	2,000	Sqm	10,000	2,00,00,000
		b.	Fishery Administrative Office	300	Sqm	16,000	48,00,000
		c.	Canteen	300	Sqm	18,000	54,00,000
		d.	Net Mending Shed	300	Sqm	18,000	54,00,000
		e.	Gear Shed	375	Sqm	12,000	45,00,000
		f.	Cold Storage	160	Sqm	15,000	24,00,000
		g.	Toilet Block	375	Sqm	25,000	93,75,000
		h.	Gate house	113	Sqm	12,000	13,50,000
	Total (5)						**28,54,25,000**
6.	**CONTAINER YARD**						
	6.1	Yard Pavement					
		Precast paving blocks on 25mm sand bed		2,79,720	Sqm	800	22,37,76,000
		Grade M45 in-situ concrete		1,11,888	Cum	8,200	91,74,81,600
		Granular sub-base for road		1,11,888	Cum	1,800	20,13,98,400
	6.2	RTGS Beams					
		HYSD Reinforcement for Structures above 16mm dia		1,728	T	72,000	12,44,16,000
		Grade M30 in-situ concrete		17,280	Cum	5,500	9,50,40,000
		Pavement Type-1 (PCC)		160	Cum	1,500	2,40,000
		Granular sub-base for RTGC Runway		480	Cum	1,800	8,64,000
		Striping & Signage		20,000	m	200	40,00,000
	6.3	Miscellaneous items			LS.		2,00,00,000
	6.4	Terminal Fencing wall		1,600	m	12,000	1,92,00,000
	6.5	Excavation & Disposal		17,280	Cum	300	51,84,000
	Total (5)						**1,61,16,00,000**

S. No.		ITEM	QUANTITY PHASE 1	UNIT	RATE (INR)	AMOUNT (INR) PHASE 1
7.	**EQUIPMENTS**					
	7.1	Container Terminal				
		a. RMQC	8	No.	75,44,00,000	6,03,52,00,000
		b. Reach Stackers	2	No.	3,31,20,000	6,62,40,000
		c. RTG (Yard)	24	No.	9,30,00,000	2,23,20,00,000
		d. Empty Container Handler	6	No.	2,30,00,000	13,80,00,000
		e. ITVs	55	No.	69,00,000	37,95,00,000
		g. Maintenance Vehicles	2	No.	15,00,000	30,00,000
		h. Workshop Equipments		LS		5,00,00,000
	7.2	Spares @ 5%				44,51,97,000
	Total (7)					**9,34,91,37,000**
8.	**UTILITIES AND OTHERS**					
	8.1	Electric Supply and Distribution lines		LS		40,00,00,000
	8.2	Lighting & Earthing		LS		1,00,00,000
	8.3	Fire Fighting		LS		4,00,00,000
	8.4	Water Supply & Distribution System		LS		6,00,00,000
	8.5	Drainage and Sewerage		LS		5,00,00,000
	8.6	Communication and IT		LS		5,00,00,000
	8.7	Workshop equipment		LS		1,50,00,000
	8.8	High mast lighting	27	No.	20,00,000	5,40,00,000
	8.9	Rail line within port boundary	2,870	m	35,000	10,04,50,000
	8.10	Terminal Security		LS		1,50,00,000
	8.11	Utilities for Fish Landing Center (Electric, Water & Drainage)		LS		93,00,000
	Total (8)					**80,37,50,000**
9.	**PORT CRAFTS AND AIDS TO NAVIGATION**					
	9.1	Port Crafts				
		a. Tug Boats	4	No.	70,00,00,000	2,80,00,00,000
		b. Pilot-cum-Survey Launches	1	No.	6,50,00,000	6,50,00,000
		c. Mooring Launch	2	No.	2,00,00,000	4,00,00,000
	9.2	Aids to Navigation				
		a. Channel Marking Buoy	10	No.	10,00,000	1,00,00,000
		b. Fairway Buoy	1	No.	20,00,000	20,00,000
		c. Manoeuvring Area buoys	3	No.	14,00,000	42,00,000
		d. Leading and Transit Lights	2	sets	80,00,000	1,60,00,000
		e. Breakwater Lights	2	No.	10,00,000	20,00,000
		f. Racon	1	No.	60,00,000	60,00,000
		g. VTMS	1	Unit	11,00,00,000	11,00,00,000
	9.3	Aids to Navigation in Fishing Harbour				
		a. Fish Landing channel buoys	-	Unit	0	-
		b. Breakwater Light	2	Unit	1,00,000	2,00,000
	Total (9)					**3,05,54,00,000**
10.	**GATES COMPLEX & ROAD DEVELOPMENT**					
	10.1	Road (Customs + Terminal Area 4 Lane road)	63,000	Sqm	2,800	17,64,00,000
	10.2	External Approach Road from NH 47 bypass to Port Boundary	2	km	30,00,00,000	60,00,00,000
	10.3	Inspection/Canopy (Entry + Exit Gate)	2,400	Sqm	20,000	4,80,00,000
	10.4	Gate Staff & Customs Building	900	Sqm	20,000	1,80,00,000
	10.5	Weigh Bridge (Entry + Exit Gate) for Trains	1	No.	11,00,000	11,00,000
	10.6	Weigh Bridge (Entry + Exit Gate) for Trucks	6	No.	7,00,000	42,00,000
	10.7	Fish Landing Center approach road	5,200	Sqm	2,500	1,30,00,000
	10.8	Fish Landing Center Parking area	375	Sqm	2,500	9,37,500
	Total (10)					**86,16,37,500**

S. No.	ITEM	QUANTITY PHASE 1	UNIT	RATE (INR)	AMOUNT (INR) PHASE 1
	Total				**35,66,58,74,649**
	Allowable for variation in physical & price contingencies @ 15%				5,34,98,81,197
	Engineering and Project Management @ 5%				1,78,32,93,732
	GRAND TOTAL				**42,79,90,49,578**

Disclaimer

The capital cost estimates prepared for the present assignment has been arrived at based upon site information, appropriate assumptions, wherever required, and the database available with the AECOM for the similar projects. These site information and assumptions are subject to many factors that are beyond the control of the AECOM and AECOM thus make no representations or warranties with respect to these estimates and disclaim any responsibility for the accuracy of these estimates.