Detailed Project Report for construction of berth (B.No.18) for handling bulk & containers at NMP

November 2010

1 ABBREVIATIONS

The abbreviations and terminologies used in the document have been explained below:

Civil

Cu.M	Cubic Metre
CR	Crane Rail
Engineer	Engineer Incharge
Ha	Hectare
IS	Indian Standard
IRC	Indian Road Congress
kN/mm^2	Kilo newton per square milli metre
kN/M^3	Kilo newton per cubic metre
kg/m^2	Kilo gram per square metre
kPa	Kilo Pascal
L	Litres
LPM	Litres per Minute
M	Meter
MMT	Million Metric Tonnes
MT	Metric Tones
MPa	Mega Pascals
mg/l	Milli Gram per litre
Nos	Numbers
NMPT	New Mangalore Port Trust
NMP	New Mangalore Port
N/mm^2	Newton per square milli metre
PCC	Plain Cement Concrete
RAT	Radio Active Tracer
RCC	Reinforced Cement Concrete
Sq.m	Square Meter
T/M^2	Ton per square metre
UDL	Uniformly Distributed Load

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**Source: Feasibility study for the development of Western Dock Arm by CES*

1. BACKGROUND AND SCOPE OF THE REPORT

New Mangalore Port (NMP) is an artificial lagoon port situated at latitude 12º 55' north and longitude 74º 48' east located at Panambur in Mangalore. It is located at a distance of 170 nautical miles south of Mormugao Port – Vasco – Goa and 191 nautical miles North of Cochin Port Kerala. The port has handled 36.6 MMT in FY 09 with container traffic of 28,555 TEUs. The only major port of Karnataka, strategically located between two major ports JNPT in Mumbai and Cochin port. The port has experienced a dramatic growth in container traffic with a CAGR of 44% in last 3 years supported by conscious marketing efforts of the port and facilitation of the traffic handling. The port has carried out traffic study by Rotterdam Maritime Group and Tata Consultancy Services and a feasibility study on the development of Western Dock Arm. Both the studies have emphasized the need for a dedicated container terminal in the port to capitalize the growing opportunity.

Captive traffic potential in the hinterland of Karnataka that is estimated to produce 75,000 TEUs of containers, good connectivity by road and rail has further strengthened the need for the dedicated container facility in NMP. In line with its growth plans, the port has planned to develop a container terminal through Private Public Participation (PPP) under the Build, Operate and Transfer (BOT) basis at an estimated cost of about Rs.2758.2 Mn.

The Detailed Project Report (DPR) is prepared to evaluate scope of developmental work and estimate the related cost for the major components of the project like Civil and material handling equipments. The report is based on the inputs from the previous reports on traffic, development plans, sub soil studies and the oceanographic data available with the port. The layout for the proposed container terminal with the required scope was prepared in discussion with NMPT to support the planned capacity. The cost estimates and the specifications of the equipments for the terminal were based on the detailed discussions with the port and equipment suppliers.

2. GENERAL

Mangalore, a city of coconut palms with a beautiful coast is situated on the western coast of India. The city housed an old port that had served the needs of the international trade during pre-independence era. With increasing demand for the international trade, the New Mangalore Port (NMP) was built and declared as the Ninth Major Port on 4th May 1974 and was formally inaugurated in January 1975. Proximity of the port to Iron Ore reserves attracted the investment from Kundremukh Iron Ore Company during the first phase of port's development. Mangalore refineries and Petrochemicals Limited (MRPL) and Hindustan Petroleum Corporation Limited (HPCL) also contributed to the construction and the development of the port.

The port is an artificial lagoon port situated at latitude 12º 55' north and longitude 74º 48' east located at Panambur in Mangalore. It is located at a distance of 170 nautical miles south of Mormugao Port – Vasco – Goa and 191 nautical miles North of Cochin Port Kerala.

The Port has an entrance channel of 7.5 km in length, 245 M in width and a dredged depth of 15.4 M. The tidal variation at Mangalore is around 1.5 M. The Port has land area of 2030 Acres and a water area of 320 Acres.

2.1 PORT CAPACITY

The port handles three broad cargo categories viz., Liquid Bulk, Dry Bulk and Container & General cargo. The port has handled about 22 MMT of liquid bulk and about 14 MMT of Dry Bulk in 2008 - 09. Container traffic is growing steadily with the growth registered at about 18% during the first quarter of 2009 -10.

The port has 14 berths with maximum draft of about 14.0 m in three berths. The present total capacity of the port is about 44.20 MMT.

Table 2-1 - List of berths and their capacities

Berth no.	Main commodities handled	Length (m)	Design dredged Depth (m)	Present Max. Draft (m)	Maximum size Vessel	
					LOA in m	DWT x 1000t
1	General cargo (G.C.) / Bulk	125	7.0	6.5	90	**4**
2	G.C. / Bulk / Containers	198	11.3	10.3	190	**30**
3	G.C. / Bulk / Containers	198	11.3	10.5	190	**30**
4	Liquids / G.C. / Bulk	198	11.3	9.5	190	**30**
5	Edible oil / G.C. / Bulk	198	11.3	9.5	190	**30**
6	G.C. / Bulk / Containers	198	11.3	9.5	190	**30**
7	G.C. / Bulk / Containers	198	11.3	9.5	190	**30**
8	Iron ore pellets / Bulk	300	14.0	13.0	245	**60**
9	LPG/POL	330	11.5	10.5	235	**45**
10	Crude oil/POL	320	18.2	14.0	245	**85**
11	Crude oil/POL	320	18.2	14.0	245	**85**
12	Chemicals/POL	320.	13.1	12.5	230	**50**
13	POL virtual jetty	N.A.	12.5	12.0	195	**N.A**
14	Iron ore / G.C. / Bulk	350.	17.0	14.00	280	**85**

Source: Development of business plan by NMPT – RMG & TCS study.

2.1.1 Quay Walls and Jetties

The marine territory of the port stretches from 21 km off shore to a length of 12 km along the coast. The security wall covers a land area of 885 acres including the lagoon. NMP is a lagoon port, which can be reached by a 7.5 km long channel and is protected by 2 breakwaters each of length of 770 meters. The lagoon consists of 14 berths for both dry and liquid cargo vessels. The berths 10, 11 and 14 can be deepened to accommodate larger vessels in which berth 14 is 350m long and recently constructed. Most bulk vessels calling in the port are between 25,000 and 35,000 DWT and have a LOA between 170 and 190m.

Source: Development of business plan by NMPT – RMG & TCS study.

Proposed container terminal is to be developed at Berth no 18 of Western Dock Arm

2.1.1 STORAGE FACILITY

The port offers ample storage space to store about 80,830 MT with about 38,830 MT at transit sheds/ overflow sheds and about 42000 MT covered warehouses.

Table 2-2 - Transit Sheds/ Overflow sheds in the Wharf area

Nos	Area In Sq.m(Each)	Capacity in MT
Transit sheds		
1	5574	10000
1	2380	4000
Overflow Sheds		
2	4380	16000
1	4920	8830
Total		**38830**

Table 2-3 - Covered warehouses outside Wharf area

Type	Nos	Area in Sq.m (each)	Capacity in MT
i) Warehouses owned by Port Trust	2	2190	8000
	1	2600	6000
ii) Warehouses of CWC (One is used as container Freight station)	4	2190	16000
iii) Warehouse of M/s. Consolidated Coffee Ltd.	1	2190	4000
iv) Warehouse of M/s. Coffee Board	1	2190	4000
v) Warehouse of M/s. Aspinwal &Co	1	2190	4000
Total			**42000**

Source: NMPT

2.1.3 Existing Equipments

NMP offers wharf cranes, mobile cranes and smaller equipment like forklift trucks. A list of existing equipment is shown below.

Table 2-4 Cargo handling equipment in New Mangalore Port

Type of equipment	Number	Capacity	Month and year of purchase
Mobile cranes			
a) Coles Model Husky 680S Tyre Mounted Crane with telescopic boom	1	75 t. at 3 m radius 26 t. at 6 m radius	March 1987
b) TIL Grove RT 880 Tyre Mounted Crane with telescopic boom	1	75 t. at 3 m radius 18 t. at 6 m radius	March 2000
Wharf cranes			
a) Braith Waite ELL wharf cranes	3	10 t. at 6-23 m radius	1978
Fork lift trucks			
a) Voltas High Visibility mast model DVX-30-FC-BCD	1	3 t.	March 2001
b) Godrej Low Mast model G-300 D	2	3 t.	March 1998
c) Godrej Low Mast model G-1000 D	1	10 t.	March 1995
Pay loader			
a) Hindustan 2021 front end loader	1	1.5 m^3	March 1995

Source: Business plan for NMPT – RMG & TCS study.

The electrical wharf cranes mounted on rails are located at berths 2 and 3. The rails continue from berth 2 to berth 4, but they cannot lift and drive with a container simultaneously. The cranes can only be operated at berths 2 and 3.

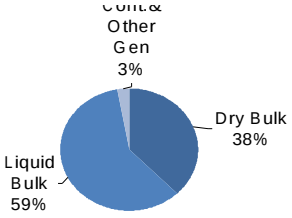
The mobile cranes have manual spreaders, which are used to lift the containers to and from the trucks and are mainly used at the container yard. The containers are also transported using normal trucks to and from the quay and within the container stacking yard.

The forklift trucks are mainly used for general cargo in and around the warehouses. The pay loader is used for several small works inside the port. One of its tasks is to clean the spills during the cargo operations, although this is done predominantly by the stevedores.

2.2 TRAFFIC THROUGHPUT AND CARGO COMPOSITION

NMP handled about 36.6 MMT in 2008-09 registering a growth of about 2% from that of 2007-08. The port has registered a traffic growth with a CAGR of 12.81% for the period of 2001 -02 to 2007 - 08, compared to the average growth of that of all major ports at 10.37 % during the same period.

The share of cargoes in 2008 - 09



Dry Bulk : Coal, Fertilizer, Lime stone, Cement, Iron Ore Fines,
Iron Ore Pellets, and Maize.
Liquid Bulk : POL – Crude and Products, LPG, Edible oil, Other Liquid Cargo.
Cont. & Other : Container cargo, Timber, Granite and others.

Source: NMPT

The port has relatively greater share of imports with about 20 MMT handled as import, slightly greater than export by about 3.2 MMT. Proximity of NMP to Iron Ore mines naturally makes Iron Ore as one of the major cargo for the traffic output. Iron Ore alone constitutes around 26 % of total traffic of FY 09. Apart from Crude oil, Thermal coal, POL, LNG are the other core cargoes that the port banks upon.

Iron ore:

The export traffic of Iron ore is around 9.2 MMT and import traffic is around 4 lakh tonnes for FY 09. KIOCL has been the major exporter of Iron Ore over the years through NMP.

Liquid Bulk - Crude oil, POL products:

Crude oil is imported for MRPL refinery located in Mangalore and it is mainly sourced from Middle East countries. The import traffic of crude oil is 12.4 million tonnes for FY 09. POL imports by oil marketing companies such as HPCL, IOC tend to increase over the next few years.

Fertilizer, Containers and Coal are the competitive cargoes that the port competes with other neighboring ports of which coal constitutes about 60% of the cargo.

Coal:

The coal is imported for Mysore paper mills, Davangere sugars, KISCO. The import traffic is around 1.9 million tonnes for FY 09.

Fertilizers:

The demand for fertilizers in Karnataka is met by MCFL, Indian Potash Ltd, IFFCO and Zuari through NMP. The import traffic is around 0.9 million tonnes for FY 09.

Containers:

From about 9650 TEUs handled in 2005 – 06, the container traffic has grown to about 28,555 TEUs, registering a CAGR of about 44%. Proactive marketing and the facilitation of container handling is making NMP an attractive destination for container shipments in western coast.

2.3 FORECAST OF CONTAINER TRAFFIC – BY RMG/TCS STUDY

A traffic study was undertaken by Rotterdam Maritime Group (RMG) and Tata Consultancy Services (TCS) as a part of the preparation of NMP Business Plan submitted in March 2007. The report is available with the port authorities and the same could be referred for further details. The executive summary of the report relevant to the traffic forecast is reproduced below under Traffic forecast.

2.3.1 TRAFFIC FORECAST

The research has led to cargo flow projections for the next 7 years by commodity group. The results are summarized as follows.

Table 2-5 Cargo flow forecast for the business plan (in MMT)

Commodity		2006/7	2007/8	2008/9	2009/10	2010/11	2011/12	2012/13
Crude Oil	Import	12.20	12.20	12.20	12.20	15.00	16.00	17.00
POL products	Import	0.60	0.60	0.65	0.70	0.75	0.80	0.85
LPG	Import	1.20	1.25	1.30	1.35	0.35	0.40	0.45
Edible Oil	Import	0.34	0.36	0.38	0.39	0.41	0.43	0.45
Other Bulk Liquids	Import	0.10	0.50	0.54	0.60	0.66	0.72	0.80
Dry Bulk (coal)	Import	0.90	1.00	1.20	1.40	3.60	4.30	5.00
Fertilizer	Import	0.90	0.78	0.90	1.03	1.19	1.37	1.57
Containers	Import / export	0.22	0.47	0.60	0.89	1.07	1.25	1.47
General cargo	Import / export	0.62	0.65	0.86	0.90	1.11	2.80	2.84
Cement	Import	0.20	0.30	0.35	0.40	0.40	0.40	0.40
Iron Ore	Export	5.80	7.30	8.40	9.80	9.50	10.20	10.90
Pellets	Export	0.40	3.50	3.50	3.50	3.50	3.50	3.50
POL Products	Export	8.50	8.50	8.50	8.50	9.00	10.00	11.00
TOTAL		**31.98**	**37.41**	**39.38**	**41.66**	**46.54**	**52.17**	**56.23**

Source: Business plan for NMPT – RMG & TCS study.

Two scenarios have been applied to the above Medium estimate to assess the sensitivity to market fluctuations, either positive or negative.

1) A LOW scenario was based on the assumption that general economic growth will fall short by 10 % from its Medium assumption, which will affect all flows of commodities. This LOW scenario results in a decrease of the total throughput by NMP of 5.6 MMT ton by 2012/13.

   This means that the total throughput by the end of the planning period will reach 50.7 MMT. The effect of this will result in a lower income to private operators and the NMP.

2) A HIGH scenario, implying an above-expectation developing growth in the Indian economy was made. This scenario included a number of constraints to developments due to production capacity limits (crude oil/POL, iron ore pellets) or known limits to demand for product (thermal coal). When all the limitations and growth trends are combined, the HIGH scenario cargo flow volume would reach 62.7 MMT by 2012/13. This represents an increase of 11.5 % over the Medium scenario.

2.4 REVIEW OF THE CONTAINER TRAFFIC FORECAST

Indian Major Ports have handled 519 MMT of cargo during 2007-08 registering a growth of about 12% compared to that of previous year. NMP has contributed about 7% of the entire traffic. The country's container traffic has grown by about 19% YOY in 2007 -08 by handling 6.6 Mn TEUs.

As per the RMG& TCS study, the majority of containers originated or was destined for the northern region. It is estimated that the southern region accounts for 18% of Indian container traffic (890,000 TEU in 2005-06). Among the southern states, Tamil Nadu accounts for about 75% followed by Karnataka that accounts for about 10% and the remaining by Andhra Pradesh and Kerala.

Further, the report states that Karnataka generates about 90,000 TEU in a year and the Inland Container Depot (ICD) at Whitefield, Bangalore is a major hub for these containers. While 43,000 TEUs were handled at ICD Whitefield, the balance were stuffed at cargo centers or consolidated at Chennai.

The ICD is well connected to various ports and the services available on the linkages are as given below.

Table 2-6 ICD Bangalore linkages to Ports and Service

Terminal	Gateway ports	Mode	Service
ICD Whitefield, Bangalore	Chennai Port	Rail	**Four times a week**
		Road	**On demand**
	Cochin Port	Rail	**Three times a week**
		Road	**On demand**
	Tuticorin Port	Rail	**On demand**
		Road	**On demand**
	Jawaharlal Nehru Port	Rail	**On demand**
		Road	**On demand**

Source: Business plan for NMPT – RMG & TCS study.

The port has already crossed the traffic of 25,000 TEUs and could attract more traffic that is west bound from the ports of Chennai and Cochin supported by the rail and road links.

Table 2-7 Container Traffic Handled In NMP in TEUs

	FY 08	FY 09
Imports	11011	14483
Exports	10449	14072
Total	21460	28555

Source: NMPT Website

Raw Cashew have constituted about 33% of the 14483 TEUs of import in 2008-09, followed by wooden logs and empty containers with a share of about 16% and 15% respectively. The main export commodities are Reefer cargo and Coffee constituting about 33% of the export cargo.

Business plan for NMPT – RMG & TCS study has listed the following factors that are considered to be absolutely essential for growth of container traffic

- Infrastructure for storage, handling, stacking and loading/unloading to/from ships;
- Ensuring availability of vessels (better frequency) i.e., attracting feeder operators to use the port

The study projects container traffic to reach 98,000 TEUs in 2012 -13. The port is upbeat about the traffic growth as the following factors could influence the traffic growth,

- Proactive marketing of the facility to the local traffic producers like Coffee, Cashew, Gherkins etc. For instance, Karnataka produces about 70% of the country's coffee production and the state is not exporting the major quantity out of the production. The traffic is diverted through Cochin, Chennai and Tuticorin ports. So with a dedicated terminal the share of the traffic Coffee could increase.

- The productive hinterland locations such as Hassan, Chikmagalur, Mysore and Bangalore could yield more cargo.

- The port enjoys a location advantage as is 22 km away from the international maritime route and is located between Jawaharlal Nehru Port Trust (JNPT) and Kochi Port Trust — two major ports that handle containers. So there is a chance of attracting the spillage of the excess cargo from these ports.

- Launch of feeder service to JNPT, the coastal movement of the container from Pipavav to NMP and the competitive rates for container handling have helped to boost the current traffic.

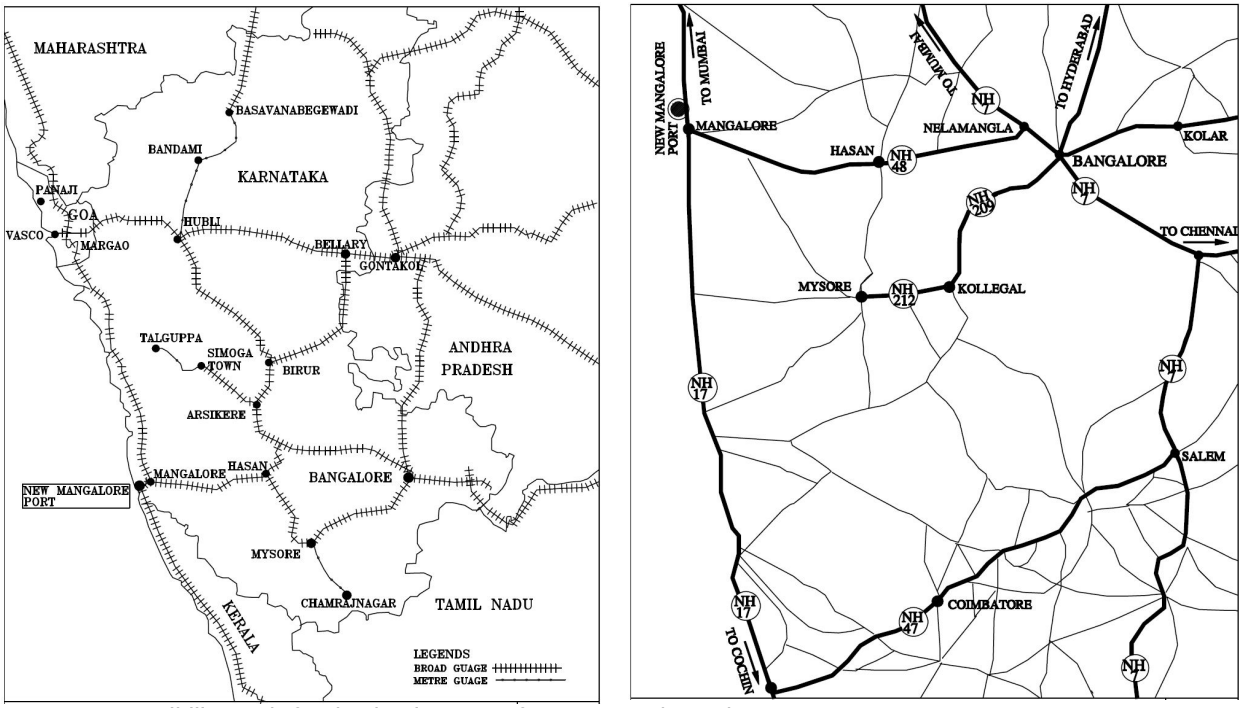
- The proposed draft of -15.1 M CD makes the port an attractive gateway for vessels up to 3rd generation vessels of 36,000 DWT with an overall length of 270 M.

- Road and rail connectivity is an important factor that could contribute to traffic growth.

    - Roads: National Highway (NH) No. 17 provides North-South connectivity to the port. NH. No. 48 connects Mangalore with the state capital, Bangalore. North-East region from Mangalore to Sholapur is connected by NH No.13. The roads pass through the hinterland of the port.

    - Rail: The railway marshalling yard in New Mangalore Port is connected to Konkan Railway network at the nearby Thokur village, providing access to Mumbai via coastal Karnataka and Goa. Rail access to Bangalore & Mysore via Hassan and Karnataka heartland is provided by South – Western railway.

Road and Rail connectivity



Source: Feasibility study for the development of Western Dock Arm by CES

The following assumptions are made by the business plan by RMG/TCS to project traffic for the period up to 2012-13.

- A 25% growth in the current container traffic that is already handled in port;
- No diverted traffic from Bangalore hub on a regular basis (only on demand service);
- The average weight per container continues to be around 15 ton per TEU;
- Necessary specialized infrastructure required for handling equipment and storage space etc will be created by NMP after the traffic grows to about 40-50,000 TEU.

Table 2-8 Forecast of container traffic through NMPT

Containers (x 1000)	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Growth in current traffic in TEU	12	16	20	24	31	38	48
Suzlon traffic		10	10	20	20	20	20
Diverted traffic from Bangalore hub	3	5	10	15	20	25	30
Total x 1000 TEU	15	31	40	59	71	83	98
Total in million tons	0.22	0.47	0.60	0.89	1.07	1.25	1.47

Source: Business plan for NMPT – RMG & TCS study.

2.5 PROPOSED WESTERN DOCK ARM (WDA) DEVELOPMENT

The feasibility of development of Western Dock Arm (WDA) at NMP was studied in detail by Consulting Engineering Services (India) Private Limited (CES) based on the traffic study done by RMG & TCS for business plan.

The study has reviewed the traffic and has assessed the developmental needs for the commodities. The study has taken the HIGH Scenario Forecast of Container traffic through NMPT by RMG & TCS study for the traffic review and phasing of traffic for WDA expansion.

Table 2-9 Container traffic forecast - HIGH scenario.

Commodity	Import/ Export	2006-07 (a)	2007-08 (a)	2008-09	2009-10	2010-11	2011-12	2012-13
Container	I/E	0.3	0.32	0.6	0.9	1.1	1.3	1.5
Cont(000TEU)		(17)	(21.6)	(50)	(74)	(89)	(104)	(123)

Source: Feasibility study for the development of Western Dock Arm by CES

The HIGH scenario has projected the container traffic forecast of about 1, 20,000 TEUs by 2012-13 as against 98,000 TEUs in 2012 – 13 in the Medium scenario. After the review, CES study has factored the further growth of container traffic to 1, 87,000 by 2012 -13. Since, the container traffic is very sensitive to the TRT (Turn Around Time), the study assumes that the competitive advantage of straight channel of 7.5KM and draft of about 14m can attract IV generation mainline container ships if proper facilities are planned and provided well in advance. As a result of the ship calls of mainline & feeder container vessels, the effective container handling at the port, including 50% incidence of transshipment, the container traffic is estimated to reach 1,30,000 TEUs in 2010-11 going up to 1,90,000 TEUs in 2012-13.

The study had proposed Berth no. 17 for the planned container berth and had assumed 350 M X 25 M berth. The major change in the proposed plan by NMP now is that the container terminal will be built in Berth No.18 with 300 M X 27 M berth.

Table 2-10 Phasing of container traffic for WDA (MMT/'000 TEUs)

Berth	Years of Cargo	2009-10	2010-11	2011-12	2012-13
B-15	Thermal Coal	1.0	1.5	2.0	3.0
B-16	Iron Ore	0.5	0.5	1.0	1.3
	Coal / Coke	0.5	0.5	1.0	1.5
	Fertilizers	0.5	0.5	0.5	0.8
	Limestone	0.3	0.3	0.5	0.6
	Total	**1.8**	**1.8**	**3.0**	**4.2**
B-17	Containers (000 TEUs)	75	134	156	187

B-18	Wind Turbine Generator parts Steel Products & other Cargo	0.3 0.7	0.5 1.0	0.6 1.3	0.9 1.5
	Total	**1.0**	**1.5**	**1.9**	**2.4**

The study had analyzed the need for the development of WDA and had proposed to initiate necessary action for development of dedicated terminal. Based on the traffic study and the subsequent feasibility study, the port is proposing to build a dedicated full fledged container terminal at the Western Dock Arm through PPP mode to capitalize the growing opportunity of container traffic in west coast.

2.6 THE COST ESTIMATE FOR THE PROPOSED CONTAINER TERMINAL

The report carries the Drawings and Specifications for the civil aspects. The estimated cost for the civil work is about Rs.1320.1 Mn and built in a total area of about 75,200 M^2

Procurement of necessary equipments like Quay Cranes, RTGCs, Reach stackers, Tractor trailers that are specified in the material handling equipment section and required provision for electrical requirements are estimated at cost of Rs.1254.8 Mn.

The total cost of the project including the proposed Civil, Material handling equipments, IT cost and other cost is Rs. 2758.2 Mn.

2.6.1 COST ESTIMATE:

Table 2-11 Total Cost estimation (INR Mn)

Particulars	Estimated cost
Civil	1320.1
Material Handling Equipments	1254.8
Other cost	152.7
IT system cost	30.5
Total	2758.2

Table 2-122 Cost estimation for Civil works (INR Mn)

Sl.No.	Particulars	Estimated Cost
1	Soil investigation, Hydrographic survey and Detailed Engineering	20.0
2	Construction of piled berth 300 X 27 m, including accessories like fenders, bollards, chain, ladders, crane track, storm anchor, stow pin etc.,	500.0
3	Construction of diaphragm wall including anchoring. Total length 375+250 = 625 m	305.0
4	Dredging in front of berth including removal of pinnacle & disposal of dredged material (750000 M3)	122.5
5	Construction of stone protection work	5.0
6	Other cost & Contingencies	95.2
7	Development of container parking yard including RTGC track, surface drainage, slot marking etc. (approx. 56,500 Sq.m)	180.0
8	Construction of buildings, electrical substation, control room, stores office, workshop, admin building, rest room, canteen and security etc.,	40.0
9	Roads, fencing, boundary wall, entrance & exit gates	18.0
10	Water supply & Sewage arrangements	15.0
11	Miscellaneous works such as fire fighting, ambulance, first aid post, green belt, & environment mitigation measures	16.0
12	Unforeseen & contingencies not exceeding 3%	3.4
	Total (A)	**1320.1**

2.7 METEOROLOGICAL PARAMETERS

The brief about oceanographic parameters have been discussed in this section. The details of the following parameters could be sought from the port for further reference.

2.7.1 WIND

The wind in the monsoon months (June, July, and August) are predominantly from SW to W, with a maximum intensity of 20 to 61 kmph. The winds in the remaining months of the year are predominantly from NW with a maximum intensity of 20 to 61 kmph. There is minor seasonal variation of the wind speed. Around Mangalore, 92% of all winds have speeds less than 19 kmph and the average wind speed in 8.4 kmph.

2.7.2 RAINFALL

The average annual rainfall recorded here is 3467mm. The rainfall is concentrated during the SW monsoon (June, July, August and September), when as much as 84 % of the total annual rainfall precipitates. The rainfall is maximum in July (1103 mm) end of February is the most dry month (with rainfall of about 2mm). The maximum rainfall recorded in a day (24 hour period) has been 270mm. The average number of rainy days in a year is 123.

2.7.3 CYCLONES

While the average frequency of cyclonic storms in the Arabian Sea is about one per year, there have been years when two or three such storms have occurred. There have also been years without any such storms. The maximum wind speed so far recorded in a cyclonic storm generally does not exceed 62 kmph (16.9 m/s), except once during 1965 when the maximum speed recorded was 97 kmph (26.9m/s).

2.8 CEANOGRAPHIC PARAMETERS

2.8.1 WAVE CLIMATE

The predominant direction of waves in the vicinity of New Mangalore Port during monsoon months (June, July and August) is West and South West where as the predominant direction during the fair months is North –West and North.
High waves are experienced only during the monsoon months. Wave observations were made by the CWPRS with the help of Dutch Wave Rider Buoys during the years 1974 and 1975.

Waves Observations

Wave data collection at “Position A” in 1974

- Period of observations : 3-7-1974 to 28-8-1974
- Latitude of position A : 12˚-55’– 43.8” N
- Longitude of position A : 74˚ -46’-0.18”E
- Location of buoy channel : 1,250 m North of approach channel

- Depth of water at the position : 13m
- No. of observations recorded : 445

Wave data collected at "Position B" in 1975

- Period of collection : 8-7-1975 to 6-11-1975
- Latitude of position B : 12˚-55'– 59" N
- Longitude of position A : 74˚ -47'-30"E
- Location of buoy channel : 1,200 m North of approach channel
- Depth of water at the buoy : 7.5m
- No. of observations recorded : 905

2.8.2 WAVE DATA COLLECTED IN 1974 AND 1975

From Observations carried out in 1974 and 1975 as mentioned above, the following information gives the range of variation of wave heights and periods:

Month	Range of Wave heights Hs (m)	Range of Wave Periods Ts (sec)	H max (m)	Corresponding Period (Sec)
July 1974	1.107-3.21	6.5-13.2	5.0	**12**
Aug 1974	1.04-2.74	6.3-10.8	5.2	**9**
July 1975	0.86-1.96	6.3-11.9	3.2	**10**
Aug 1975	0.92-3.33	6.3-13.4	5.5	**11**
Sep 1975	0.34-1.19	4.6-11.0	3.1	**9**
Oct 1975	0.34-1.19	4.6-11.0	2.3	**8**
Nov 1975	**0.40-1.06**	**5.6-8.2**	**1.8**	**7**

The analysis of 15 minutes record of 1974 indicated that the maximum significant wave height was 3.21m and the largest single wave in that wave train was 4.70m. However, in another wave train, the largest single wave height was 5.20m, in which the corresponding significant wave height was 2.55m.

The analysis of the 15 minutes record 1975 indicated that the maximum significant wave height was 3.30m and the largest single wave height in that wave train was 5.50m.

2.8.3 FREQUENCY DISTRIBUTION OF WAVE DATA AS OBTAINED IN 1974 AND 1975

The frequency distribution of the waves in the month of July 1974 shows that all of them had significant wave height less than 3.5m and corresponding significant period was between 6 to 12 sec. From the frequency distribution, it can be seen that for the month of August, 1974, 100% of the waver had significant wave heights of less that 3.0m and corresponding period was between 6 to11 sec.

2.8.4 TIDES

An automatic tide recording gauge is installed by the Survey of India National Hydrographic Office, Dehradun in the vicinity of the Oil Jetty area of the Port, inside the lagoon.

Tide particulars obtained there from are as follows:

Highest High Water Level (HHWL)	:	+ 1.68m
Mean Higher High Water (MHHW)	:	+ 1.48m
Mean Lower High Water (MLHW)	:	+ 1.26m
Mean Sea Level (MSL)	:	+0.95m
Mean Higher Low Water (MHLW)	:	+0.77m
Mean Lower Low Water (MLLW)	:	+0.26m
Lowest Low Water Level	:	+0.03m

2.8.5 CURRENT

The current along the coast during the SW monsoon (from February to September) is generally towards the South (from 160˚ to 200˚) with strength of 0.22 to 0.80 knots. During the NE monsoon (from November to January), the current is generally towards the North (from 0˚ to 40˚ and 320˚ to 360˚ bearing) with a velocity of 0.22 to 0.60 knots.

In the Port entrance channel protected by breakwater, the current direction lags 6˚ to 8˚ behind the coastal current. The current in the lagoon area further lags behind the approach channel on an average by 10˚ to 15˚. The magnitude of the current outside the lagoon area during the monsoon as experienced by pilots is about 1 to 1.5 knots.

2.8.6 LITTORAL DRIFT

The study carried out by CWPRS, Pune during 2002 has concluded as under:

- Significant littoral drift occurs between 1 and 2m depth contours, which are at a distance of about 200 to 400m from shoreline.
- Seasonal drift distribution has indicated that during North-East monsoon, Littoral drift is towards north, where as during South – west monsoon and Non-monsoon period the drift is towards South.
- The Northwards drift is comparatively less than the Southwards drift.
- The average littoral drift in the region is of the order of 0.58 lakh cubic meter towards South during S.W monsoon and North West monsoon periods and 0.08 lakhs cubic

meter towards north in NE monsoon. The average net littoral drift is 0.50 lakhs cubic meter per year towards south.

- The mathematical model studies for shoreline stability have indicated that the effect of breakwater is felt up to a distance of about 2.5 km on either side of the breakwaters. The examination of remote sensing imageries confirms these observations

2.9 SHIP CHARACTERISTICS

The structural design of the berths shall be carried out for the size of the ships up to the overall length of about 270 M with a 36,000 DWT

DWT (Ton)	Displacement (Ton)	Overall Length (m)	Length between perps (m)	Beam (m)	Draft max (m)	No. of containers	Generation
55000	77000	275	260	39.4	12.5	3900	4th
36000	51000	270	255	31.8	11.7	2000	3rd
30000	41500	228	214	31.0	11.3	1670	2nd
25000	34000	212	198	30.0	10.7	1380	2nd
20000	27000	198	184	28.7	10.0	1100	2nd
15000	20000	180	166	26.5	9.0	810	1st
10000	13500	159	144	23.5	8.0	530	1st
7000	9600	143	128	19.0	6.5	316	1st

Source: Port designers hand book by Carl A Thoresen

2.9.1 HATCH COVER

The Quay Gantry Cranes will have provision to remove the Hatch cover from the Vessel by connecting with the spreader and place the same on the common corridor till completion of operation.
Lift – away hatch covers with Longitudinal Joints types:

- Single Panel covers
- Multi Panel covers
- Single Opening abreast with Longitudinal Joints
- Multi opening abreast with Transversal Joint

Single Panel types comprise one cover for each opening i.e there are no joints. They are normally specified for bulk carriers in the case of single opening abreast and for cellular container ship in the case of multi opening abreast configurations.

Multi Panel covers comprise several separate panels for each hatch opening. They are used for cellular container ships in the case of longitudinal joints and for multipurpose cargo ships and heavy cargo tonnage in the case of transversal joints.

To open the hatch, the lift away covers are generally removed by lifting tackle or spreader using the ships or shore cranes. In the case of Single Panel Single opening abreast version, special lifting gear fitted to the legs of the gantry crane is used and in the case of single panel covers and multi panel. Covers with longitudinal joints a shore crane usually a container bridge crane) is normally used.

2.10 NAVIGATIONAL ASPECTS

2.10.1 WATER DEPTHS

Due to presence of hard rock patches in the approach channel and harbor basin, presently the dredged depth has been limited to (-) 15.1m CD (which allows ships up to a draft of 14m to be handled). The berth B14 has however been designed to have (in future) alongside dredged depth of (-) 17m CD, capable of handling ships up to 140,000 DWT (draft15.8m). This consideration was based on the fact that there is a provision in the port's future plan to deepen the harbor entrance channel and the harbor basin to (-) 17m CD – a difficult preposition through as drilling and blasting is involved in an operative port where more than 1100 ships call annually.

After discussion with NMP, it is therefore proposed that the dredged depth of the Western Dock basin be kept same as in the entrance channel and the harbor basin i.e., (-) 15.1m below CD in the initial phase.

2.10.2 DISPOSAL OF DREDGED MATERIAL BASED ON RAT STUDIES

The proposed WDA development involves about 7,50000 cubic meter of dredging. Out of this, the top layers of sandy soil, depending on the suitability after soil tests, will be used for reclamation of the backup area by constructing a diaphragm wall at the return of Berth No .18.

Remaining quantity needs to be disposed off in the deep as suitable dumping ground. The present dumping grounds of NMP are located on the southern side of the approach channel in -24 to-26m contours as shown in sketch. The location of this dumping ground has been progressively shifted towards offshore as per the development stages and deepening of the approach channel. It was observed that the length of the approach channel was required to be dredged more than the planned lengths for different stages. One of the reasons for this extra extension of approach channel is attributed to possible siltation in the reach of the approach channel, north of the dumping grounds. It is felt that there might be some movement of the disposed material from the southern dumping ground towards north into approach channel region. Considering this aspect, a new dumping ground, north of existing approach channel, has been proposed and was studied using Radio Active Tracer (RAT) studies.

The RAT studies conducted during October 2007 to January 2008 have consistently the movement of the bed material in north westerly direction. This was reported in CWPRS letters vide No. 107/76/99-PH-11 dated 08.01.08. The monthly tracking results of these studies are furnished in the report submitted to NMP by Bhabha Atomic Research Centre (BARC), Mumbai. Based on the results of the RAT studies, it was suggested to NMP to consider adopting the proposed new dumping site north of the channel for all future disposal of dredged material. Hence it is suggested to dump the proposed dredged material from the development of WDA on the northern region of the approach channel at depth contours of 24m-26m which is 10.5km from the shore line as shown in drawings.

2.10.3 TRANQUILITY

The Wave tranquility studies results for Alternative I indicated that the wave disturbances at all the four berths in proposed Western Dock Arm are within the tranquility limit of 0.5m considered for the study for all the three directions tested in the model. The measurement of wave disturbance at other location in the port basin also indicated that there is no effect on wave tranquility due to the development of WDA (Alternative The Wave tranquility study results for Alternative 2 indicated that the wave disturbances at all the proposed berths in the WDA are within 0.5m, the tranquility limit considered for the studies. At berth No.15, the wave disturbance is 0.50m for both north westerly and south-westerly incident waves. The chance of occurrence of incident wave 2.5m (which corresponds about 3.66m at deep water) is very rare from north westerly direction. However, from south western direction it may occur for about 10 days in a year. It is recommended to carry out studies for Alternative 2 to find the mooring forces and to design proper mooring devices at this berth. There is no adverse effect on wave tranquility at other region in the port basin due to the development of WDA (Alternative 2).

The wave tranquility for Alternative 3 indicates that the wave disturbances at proposed Berth Nos.16, 17, and 18 are well within the tranquility limit considered for all the three critical incident direction considered. At the southern end of the Berth No.15, the wave disturbance is equal to 0.50m for south westerly incident waves and 0.55 for the north westerly incident waves. Considering the boundary condition taken for the studies, the frequency of occurrence of tested incident waves is very rare from north westerly direction. The frequency of occurrence of south westerly tested wave is about 10 days in a year. It is therefore, recommended to conduct desk studies for finding the mooring forces and to adopt proper mooring devices at Berth No.15. Also the studies indicated that development of WDA (Alternative 3) will not have any adverse effect on wave tranquility at other regions in the port basin. The waves approach the proposed Berth No.15 at angle of about 450 -600 for the incident waves from W, WS, and NW directions. The wave approach angle at all these berth are well within the wave tranquility limit considering for the studies.

During the visit of NMP officials to CWPRS on 30th July 2008, it was informed that the NMP is finalizing the development of WDA. This proposal corresponds to Alternative 3 studies in the model and reported herewith. Here, the eastern face of WDA has been kept exactly parallel to existing eastern face of the eastern dock arm. Here, the western face will be having a total length of about 622.88m instead of 625m studied in Alternative 3, which is about 2m short. But for all practical purpose, the results of Alternative 3 are valid for this proposal.

Further, it is also anticipated to develop Berth Nos.15and 18 to start with by suitably dredging the required area and later Berth Nos .16 and 17 will be constructed by dredging the complete area. It is suggested that during the intermediate stage, i.e. after the development of Berth 15 and 18 and before developing the Berth Nos 16 and 17, care must be taken to provide sufficient slope (about 1:20) at the northern face of the WDA. This slope will be helpful in providing wave run-up and thus dissipating the Wave energy. This will improve the Wave tranquility in the WDA by reducing the reflection of wave energy from the northern face.

2.10.4 ENTRANCE CHANNEL:

The New Mangalore Port (NMP) is a major sea-port situated on the west coast of India (latitude 12 °55' N, longitude 74°48' E). The port, a lagoon type harbor is entered through a dredged channel, about 7.5 km long. The entrance is protected by two breakwaters extending to a length of 770 m (from shoreline) on either side of the channel. The dredged channel has a bottom

width of 245m, and a dredged depth of 15.4m below CD. The center line of the channel is 270° from the north. The harbor basin has a dredged depth of 15.1m below CD.

MARINE & LAND ENVIRONMENT

The port is located on an alluvial plain, about 10 km of the Gurupur and the Netravathi Rivers. The old port of Mangalore, located at the confluence of these two rivers is operational only during the fair weather season (15th September to 15th May).

TURNING CIRCLE DIAMETER

The diameter of the turning circle is 570m and as per IS 4651, where vessels turn by free interplay of the propeller and ruddler assisted by tugs , the main diameter of the turning circle shall be 1.7 to 2.0 times, (1.7 for protected location and 2 for exposed location). The length of the larger vessel has to be turned. As such 3rd generation container vessels of 270m length can be easily handled at the turning circle.

2.10.5 NAVIGATIONAL AIDS

It is assumed that existing port craft and navigational aids will be adequate to handle the additional vessels arriving at to container terminal berth no 18. Hence no navigational aids are envisaged. Any additional navigational aids, if required, will be taken up by NMP.

2.11 ENVIRONMENTAL ASPECTS

Environmental Management plan (EMP) is the key to ensure a safe and clean environment. The desired results from the environmental mitigation measures proposed in the project may not be obtained without management plans to assure proper implementation and functions. The EMP envisages the plans for the proper implementation of mitigation measures to reduce the adverse impacts arising out of the project activities. EMP has been prepared addressing the following issues:

- Environmental Management Process
- Key Players in the implementation of EMP
- Waste Management plan
- Environmental Management Action plan for Dredging Activity
- Oil Spill Contingency Plan
- Environmental Monitoring plan
- Corporate Social Responsibilities
- EMP Budget

2.11.1 WASTE DISPOSAL FROM SHIPS

Waste reception facilities to be permitted for ships arriving from the berth as per MARPOL convention.

2.11.2 SOLID WASTE DISPOSAL

Solid waste cleared from the vessel and utility area to be cleared from the container terminal and from the wharf area on daily basis.

2.11.3 DISASTER MANAGEMENT PLAN

Disaster Management Plan shall be submitted, covering possible causes of disasters

- Human Failure
- Accident
- Sabotage
- Fire accident

2.11.4 CONTAINER STUFFING, DAMAGED CONTAINERS

Container stuffing inside the terminal is not permitted. It shall be done preferably at Factory or at suitable location outside the terminal. Emptying the container within the terminal not permitted.

- Damaged and disputed containers are placed in specific area allotted.
- Provision for storing of small number of empty container is also to be made.
- Reefer containers (refrigerated containers) are placed at specified area allotted in the yard itself.

2.12 ISO CONTAINER CHARACTERISTICS

Some of the ISO container characteristics for reference are listed below.

APM MaerskContainer Dimensions	Length	Width	Height	Volume
Maersk 20' Standard	590.6 cm	235.0 cm	239.3 cm	33.2M³
	232.5 in	92.5 in	93.9 in	1172 Cu Ft
Maersk 40' Standard	1203.2 cm	235.0 cm	239.3 cm	67.7 M³
	473.8 in	92.5 in	94.1 in	2386 Cu Ft
Maersk 40' High Cube	1203.2 cm	235.0 cm	267.7 cm	76.3 M³
	473.8 in	92.5 in	106.1 in	2693 Cu Ft
Maersk 45' High Cube	1355.6 cm	235.0 cm	267.7 cm	85.9 M³
	533.7 in	92.5 in	106.1 in	3034 Cu Ft

CIVIL

3. CIVIL

3.1 SCOPE OF WORK AND THE ESTIMATED COST

Following is the general scope of work contemplated

- Construction of a Container Berth 300 m X 27 m with in situ bored piles, main and secondary beams, Crane beams and deck slab.
- Provision of CR 120 crane rails, stow pins, storm anchors etc.,
- Provision of service trench, Bollards, Fenders, Mooring rings, Ladders, Safety chains etc., and slope protection works.
- Construction of RCC diaphragm wall 1100 mm thick and 625 m long with necessary anchoring.
- Carry out capital dredging including dry excavation in front of the berth of about 7,50,000 Cu.M including removal of pinnacle, raising the ground level for container yard and disposal of surplus dredged material to the dumping site specified by NMPT
- Development of a container stacking yard with suitable concrete pavement – Approx. 56500 M^2 including marking and necessary drainage system.
- Development of all utility buildings such as Administration, Workshop, Electrical, Canteen & Customs etc.,
- Provision of Roads, Boundary walls, Fencing and Gates.
- Provision of Water supply and Sewage facilitate including Well, Over Head Tank, Under Ground Tank, Distribution lines etc.,
- Fire fighting measures including Septic tank, Monitors, Hydrants etc.,
- Environmental mitigation measures

The report carries the Drawings and Specifications for all aspects. The estimated cost for the civil work is about Rs.1255 Mn and total built up area of about 75200 M^2

Table 3-1 Estimated cost for Civil works

Sl.No.	Particulars	Estimated Cost (In Rs Mn)
1	Soil investigation, Hydrographic survey and Detailed Engineering	20.0
2	Construction of piled berth 300 X 27 m, including accessories like fenders, bollards, chain, ladders, crane track, storm anchor, stow pin etc.,	500.0
3	Construction of diaphragm wall including anchoring. Total length 375+250 = 625 m	305.0
4	Dredging in front of berth including removal of pinnacle & disposal of dredged material (750000 M3)	122.5
5	Construction of stone protection work	5.0
6	Other cost & Contingencies	95.2
7	Development of container parking yard including RTGC track, surface drainage, slot marking etc. (approx. 56,500 Sq.m)	180.0
8	Construction of buildings, electrical substation, control room, stores office, workshop, admin building, rest room, canteen and security etc.,	40.0
9	Roads, fencing, boundary wall, entrance & exit gates	18.0
10	Water supply & Sewage arrangements	15.0
11	Miscellaneous works such as fire fighting, ambulance, first aid post, green belt, & environment mitigation measures	16.0
12	Unforeseen & contingencies not exceeding 3%	3.4
	Total (A)	**1320.1**

Table 3-2 Approximate area for Civil works under various heads

S.N	Area	Length X Width in (M X M)	Area in M²
1	Container Yard	236 X 300 (Incl. RTGC´s Lanes)	67,800
2	Jetty	300 x 27	8100

3	Utility Area	240 X 25	6000
4	Road adj. to boundary wall	260 X 20	5200
5	Green Belt Area		520
6	Boundary Wall (Included)		Future
	Total area (A)		**87600**
7	Road + Common Corridor	350 x20 Road parallel to Berth.	7000
		230 x 20 Road parallel to Open Sea Side.	4600
		300 x 20 Road parallel to Railway siding.	6000
		322 x 15 Common Corridor parallel to Berth.	4830
		11 x 230 Common Corridor parallel to Open Sea Side.	2530
	Total Area (B)		**25000**
8	Rail Track Area (Future)		Future
9	Approach(Utility Road)		Future
10	14m Road Outside		Future
11	Truck Parking near Railway Siding		Future
12	Truck Parking near Railway Siding Koorikatta Gate		Future
13	Empty container yard (Outside Boundary Wall)		Future
	Total area (A+B)		**112,600**

3.2 DESIGN CRITERIA FOR STRUCTURAL CONCRETE WORKS:

3.2.1 DESIGN LOADS

1. Dead loads comprising the self weight of the structure plus superimposed loads of permanent nature shall be considered as per IS: 875 (Part-I) 1987.

2. Live Loads Uniformly distributed load to be considered on the deck and also on the fill behind

- 50 kPa except area between cope line and seaside crane rail.

- 10 kPa at the area between cope line and seaside crane rail.
- 2 high container stacking.

Live load surcharge immediately behind quay deck to be 30 kPa or 2 tier high containers stacking which ever loading governs. Back reach area to also be designed for hatch cover stacking 3 high. Hatch covers to be supported at 4 corners and assumed to be 30 tones each and measuring up to 15m in plan.

3.2.2 VEHICLE AND CRANE LOADS

The following vehicles and the corresponding loads shall be considered on the berth:

- IRC class AA or 70 R loading
- Loads due to Quay Gantry Cranes.
- Loads due to Tractor trailers.
- Load due to Reach Stacker (25% impact loading)

3.2.3 SEISMIC LOADS

The seismic loads on the structures shall be computed in accordance with the seismic code of India IS: 1893 (Part I): 2002.

Mangalore falls under Zone III and Basic horizontal seismic force coefficient -0.04 (Table 2) Important factor -1.5 (Table 4). Coefficient depending on the soil foundation system is -1.0 (Table3). The above design factors are based on IS 1893 – (1984) re - affirmed on 2003 – Criteria for earth quake design for structures.
Horizontal seismic force coefficient -0.04 x 1.50 x 1.0 = 0.06

3.2.4 WIND LOADS

For calculating wind loads on the structure a basic wind speed as per code IS 875 shall be used.

3.2.5 MOORING LOADS:

The bollard pull of 150 T shall be considered for the design of the structure.

3.2.6 BERTHING LOADS

The berthing load calculation shall be made as per IS 4651 (Part III) – 1974 reaffirmed 2002 for the design vessel.

3.2.7 BERTHING ENERGY

Considering the location of the berths from the wave tranquility point of view and the design ships to be handled at these berths, it has been assumed for the purpose of calculation of the berthing energy that the design vessel under fully loaded condition berths at an angular approach of 10˚ with a velocity 15 cm/s perpendicular to the berth. Source IS 4651 Part III table 2. Difficult condition

3.2.8 FENDERING SYSTEM

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

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 40T/m². Also for abnormal conditions, loss of control etc., it is recommended to design for 125% of normal berthing energy not to overstress the structure but this may result in damage to the fenders and the ship's hull. Based on these criteria the suitable fender system has been proposed at the berths.

3.2.9 FENDER REACTION (BERTHING FORCE)

Corresponding to the energy to be absorbed and the fender selected, the design reaction force has to be worked out.

In addition a longitudinal force equal to the 25% of transverse berthing force is also applied simultaneously on the fender point to account for the friction between the ship's hull and the fender.

3.2.10 ANALYSIS

The 3D dimensional analysis is to be carried out using STAAD Pro package or Equivalent. The load combinations are to be considered in the analysis as per IS: 4651 part iv - 1989 for limit state for collapsibility.

3.2.11 DESIGN

Maximum forces and moments are to be tabulated and percentage steel is obtained for each row of piles. Design of piles and superstructure is to be carried out using Limit State Method.

A marine growth of 100mm thick on the circumference of the piles is to be considered while assessing the wave/current forces.

Concrete for Edge Structures:

Grade

The following concrete grades for structural concrete shall be used. These grades have been chosen for durability and with reference to IS 456:2000.

Marine Structures

Reinforced concrete piles

- Cast insitu in dry M35
- Cast insitu in bentontite M35
- Cast insitu underwater M35
- Reinforced concrete retaining walls M35
- Reinforced concrete of deck including beams M40
- Insitu coping to seawalls M35
- Precast concrete block work M40

Limiting Stresses

Maximum ultimate stresses are as defined in IS 456: 2000 with appropriate partial safety factor for materials, γ_m for all loading combinations.

Durability

a. Crack width

Marine Structure

Crack widths in marine structures due to permanent loads shall be limited in accordance with clauses 35.3.2 of IS 456: 2000 as follows. Crack widths for transient loads shall be limited as detailed in the following table.

Table 3-3 Crack width

Location	Limiting Crack Width (mm)	
	Permanent load	Transient load
Below deck level	0.10	0.20
Elsewhere	0.20	0.30

Note: permanent load = dead load plus 50% of live load UDL

Transient load = dead load plus berthing, mooring and container crane or full live load UDL

Calculations

Crack widths to be calculated in accordance with IS 456: 2000 and IS 456.

Concrete Cover

Minimum concrete cover shall be in accordance with IS 456: 2000 as follows.

Table 3-4 Minimum Concrete Cover

Structure	Location	Cover(mm)
Quay deck	Top surface (unexposed)	**50**
	Below deck	
	Elsewhere	**75**
		75
Piles	Infill concrete	**75**
	Bored cast in situ piles	**75**
Seawalls	**Retaining wall**	**75**

Design Mixes

Design concrete mixes shall be in accordance with the specification.

Other Measures

Electrical continuity between reinforced of quay structure shall be provided for possible future cathodic protection system in comply with the specification requirements.

Material Properties

i. Unit weight

Reinforced concrete	25 kN/m^3
Plain concrete	24 kN/m^3

ii. Temperature effects

Coefficient of thermal expansion for concrete is taken to be 9 X 10^{-6} per ^oC according to Clause 6.2.6 of IS 456: 2000

iii. Elastic properties

For elastic analysis of structures, the instantaneous or short term elastic modules of concrete (Ec) shall be determined in accordance with clause 6.2.3 of IS 456:2000 for elastic analysis, Poisson's ratio =0.2

Reinforcement

Grade

All reinforcing steel to be high strength deformed CRS/TMT with minimum strength of Fe 415 conforming to IS 1786: 1985.

Limiting Stresses

i. Ultimate Limit State Design

Maximum stress are as defined in IS 456: 2000 with partial safety factor of material γm=1.15.

ii. Serviceability limit state

Stresses in reinforcement under un factored working loads shall be limited as necessary to ensure that modification to reinforcement requirements during design to satisfy serviceability (crack Width) requirements are minimal.

Minimum Requirements

Minimum reinforcement requirements for shrinkage and temperature effects shall be in accordance with IS 456: 2000

Material Properties

Elastic Modulus, E_s= 200 KN/mm^2
Yield stress, f_y = 415 N/mm^2

3.2.12 INDIAN STANDARD CODES REFERRED FOR CIVIL APPLICATION

1. IS 4651 – 1974 : Code of Practice for planning and design of Ports And Harbors
2. IS 2911 – 1980 : Code of practice for Design and construction of Pile foundation
3. IS 875 – 1987 : Code of Practice for Design Loads
4. IS 1893 – 2002 : Criteria for Earthquake Resistant Design of Structures
5. IS 456 – 2000 : Code of practice for plain and reinforced concrete
6. SP – 16 : IS -456 – 1978
7. IS 1786 - 1985 :Specification for HSD steel bars and wires for concrete Reinforcement. (Third Revision)

3.3 DESIGN CRITERIA FOR STRUCTURAL STEEL WORKS

3.3.1 GENERAL

The following Indian Standard Codes of Practice shall apply (except as suitably Modified, wherever necessary)

- IS: 226-1062 : Specification for Structural Steel (Standard Quality)
- IS: 800-1964 : Code of Practice for use for Structural Steel in General Building Construction
- IS: 807-1963 : Code of Practice for Design of Cranes and Hoists
- IS: 816- : Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel
- IS: 1915-1961 : Code of Practice for Steel Bridges
- IS: 2062-1962 : Specification for Structural Steel (Fusion Welding Quality)

3.3.2 DESIGN LOADS

Electrical rooms and operating
Floors with no moving machinery : 350-500 kg/m^2

3.3.3 WIND LOADS

Wind Loads on buildings as stipulated in IS: 875-1964, Cl 4.3 shall generally be used for design purpose.

The above shall be calculated on the vertically projected area of structures. For open framework, the leeward side shall be calculated as 50% of the exposed surface.

3.3.4 ALLOWABLE STRESSES

Basic unit stresses shall be as in IS: 800-1964

3.3.5 SLENDERNESS RATIO

Slenderness ratio shall be generally limited to values stipulated in IS: 800 – 1964 except where suitably modified for certain machinery components.

3.4 SOIL CHARACTERISTICS

Sub soil investigation in the Western Dock Area near Berth no. 15 was carried out by NMPT, through M/s. Fugro Geotech Ltd, during March to June 2006. Total of 37 boreholes (32 Nos on the land and 5 Nos in water up to 4m depth) were drilled up to sound rock. Penetration tests were carried out and undisturbed and disturbed samples were collected which were tested in the laboratory for their classification and determining index & engineering properties. Rock samples collected were also tested. The details are available with the Port and can be seen on request.

The boreholes carried out along the line of berth B 15 indicate that hard rock levels vary between -23m to -32m. Along a line 35 m behind the berth line of B15, the variation in hard rock levels is from -24 m and -29m.

The soil profile on the Western side of the dock arm, near to the line of B 15 indicates variation of hard rock from -12.5 m (BH -28) to -27.6 m. the shallow level of rock observed in Bore No: 28 may cause some concern. The rock appears to be a pinnacle shape. Founding of diaphragm wall and piles has to be taken deeper into the rock as per design requirements. To provide a dredged depth of -15.1 m initially, removal of rock pinnacle may be involved. The rock levels in boreholes Nos 30, 36 and 37 are -16.5m to -17.5 m respectively. The boreholes taken in the middle of the Western Dock arm show rock varying -23m to -26m.

The rock samples collected from different boreholes tested for compressive strength indicate wide variation in the values. The compressive strength varies from 19 to 139 MPa. However, in the case of BH-7, the value is very low at 2.5 MPa, even at a depth of -31m. This needs verification of the rock levels of boreholes. In general, soil profile of area consists of top layer of loose to medium, dense sand, followed by dense to very dense sand, weathered rock before finally reaching the hard rock structure. A layer of stiff to very stiff clay is also noted in most of the boreholes.

The available site bore logs show sand depth 12m to 18 m with underlying layers of sand mixed with clay and soft rock up to 30m depth. Hard Rock exists below 30m depth. The angle of internal friction of sand is 35 deg -38 deg and therefore no soil consolidation is necessary. The water table is at about 1.5m below ground.

A study of the bore logs show

1. The layers up to a depth of nearly 20 M is cohesionless with at some locations stiff to hard clay layer of 1.5 to 2 M thickness present at a depth of about 3M below ground level.
2. Where ever the silty clay layer is present it is seen to be of stiff consistency with low settlement due to consolidation.
3. The bearing capacity of the pavement laid on the top cohesionless layer computed from the minimum N value of 16 could be of the order of 15 T/M^2
4. The settlements would be considered to be essentially elastic and well within 50mm
5. Pile foundation when adopted could be designed as end bearing pile, terminating the pile in the weathered granite layer with a seating of 15 to 20 cms. The length of pile would therefore vary from 24 to 30 M. Piles could be designed as end bearing pile utilizing its full structural capacity which could be taken as 50 Kg/cm^2 for M-20 concrete.

3.5 BERTH

3.5.1 STRUCTURAL ARRANGEMENT OF BERTHS

The berth provided is required to handle containers and container handling cranes, Trailers etc. The width of the berth is 27m and length of the berth is 300m.

3.5.2 DECK ELEVATION

The deck elevation of the berth has been fixed at +4.66m.This deck elevation shall keep the crest level of the most waves during the storm below the soffit of the main longitudinal beams to prevent the slamming effect of the wave crest.

The proposed scheme consists of rows of bored cast-in-situ piles of diameter 1300mm. spaced at 7650mm c/c in the longitudinal direction and 6670m c/c in lateral direction. The piles shall be founded at a level of -30m CD. On rear side of the berth, there shall be a diaphragm wall 1100mm thick to retain the back fill that is to be provided for the entire length of berth as shown in the drawing CS-J114-002-PCT. In addition to this the diaphragm wall is to be extended by 75m on dredging slope side. Totally 375m long diaphragm walls to be provided. The founding level of diaphragm wall shall be -25m CD approximately. The diaphragm wall to be anchored by diagonal anchors spaced at 2500 mm.

In the lateral direction, main beams of size 1000mm x 2000mm are provided supported over the piles, which in turn support longitudinal beams slab elements in the transverse direction. Crane rails shall be provided in the appropriate longitudinal Cranes beams 1100x 1400 to support the Quay gantry crane. Crane beam to be designed for a wheel load of 56 ton per corner 8 wheels, wheels are spaced at a distance of 1150mm wheels are spread at a distance of 8000mm per corner. A 500mm thick deck slab partly precast and partly insuitu shall be provided supported over the intermittent longitudinal beams and 100mm thick wearing coat shall be provided over the RCC deck slab. Reference the sketch enclosed.

Bollards and High tech cell fenders shall be provided at 14.8m c/c along the berthing face. A service trench shall be provided on the berthing side to accommodate cables/utilities.

Berth shall be provided with crane rails , crane rail fixing system , crane cable slots , draw pits , tie-downs, stow-pins , bollards , fenders , ladders , power feeder pits , crane rail stopper , line marking , paintings , and numbering satisfying all the operational requirements. Slope protection to be provided under the berth soil bed as shown in the drawing CS-J114-002-PCT.

3.6 DIAPHRAGM WALL (OPEN SEA SIDE)

On the side of open sea, an 1100 mm thick and 250 m long RCC diaphragm wall to be constructed. The diaphragm wall shall be anchored with inclined anchors at regular intervals.

3.7 CONTAINER YARD

Container Yard is approximately 6 Ha, behind the 300 m berth structure where in containers are stacked as shown in the drawing CS-J114-011-PCY.

Entire Container Yard is to be developed for stacking 7296 containers, including reefer empty and damaged containers. Heavy load carrying floor shall be laid for operating Rubber Tyred Gantry Crane (RTGC) and for Trailor movement including the paint marking for locating the Container and track for RTGCs. The finished floor level of Container yard shall be + 4.66 m. A small step wall of half feet height is proposed all along the RTG's track to maintain the straightness of travel.

The containers are stacked in 4 high and in a six rows. Each 20' container weigh approx 31.5 tons. For details of the yard dimeznsions kindly refer the drawing no. CS-J114-011-PCY.

Table 3-5 Container slots

Sl.No	Columns	Rows	Container slots
1	45	6	270
2	45	6	270
3	45	6	270
4	45	6	270
5	45	6	270
6	45	6	270
7	45	6	270
8	45	6	270
	Total		2160

Total No of Slots = 2160 Slots
Total No of Containers = 2160 X 4 = 8640 Containers

The ground available is assumed to be plain ground without any rock blasting to be carried out. Plants have to be removed.

3.7.1 CONTAINER STACKING YARD

RTGCs are provided in the yard for handling containers. Wheel load of gantry crane is 16 ton for each wheel. Wheel load per corner of 64 ton is to be considered. The run way of RTGC is to be designed to take care of this load. The pavement made by providing concrete slabs strong enough to take the concentrated rolling load of 64 tons at any point.

We propose the container stacking area and internal roads inside the yard to be paved as per pavement composition indicated as under. The total pavement area shall be about 56500 m^2

The recommended pavement composition is as under

- 100 mm concrete paving blocks
- 30mm sand bed
- 490mm M15 grade concrete as base course
- 150mm granular sub- base (Gravel-sand mix)

Similar pavement without paving blocks has to be made for supporting RTGCs track except that the pavement shall consist of RCC – 500 thick instead of PCC base course.

3.8 ROAD

3.8.1 ACCESS ROAD

The sub base for the roads shall be formed by the gravel/quarry run. Pre-consolidation of the subsoil under the roads is not proposed. It is expected that the usage during construction shall provide the consolidation and any settlement at this stage would be attended immediately. It is proposed to provide flexible type pavement for the road.

The composition of the pavement shall be as under:

Table 3-6 Composition of Pavement

Layers	Thickness
Bituminous concrete surface layer	40 mm thick
Dense bituminous concrete	125 mm thick
Wet mix macadam	250 mm thick
Granular sub base cum drainage layer	200 mm thick
Total	615 mm thick

20m wide x 300 long approximately road parallel to berth.
15m wide x 300 m long approximately common corridor parallel to berth for stacking ship hatch.
20m wide x 230m long road parallel to open sea side.
11m wide x 230m long common corridor parallel to open sea side.
20m wide x 300m long road parallel to railway siding.
Connectivity Road to Terminal for Berth No: 18.

The terminal has to be connected to the Koorikatta Gate by New Road.

3.8.2 EMPTY CONTAINER YARD

It is proposed to develop a site of size 200m x 100m = 20000 sq.m area for storing empty container, outside port boundary near railway siding.

3.8.3 ROAD

A 20 m wide x 256 m long concrete road parallel to the boundary fence wall, perpendicular to Berth has been considered.

3.8.4 UTILITIES / BUILDINGS

It is proposed to construct the following utilities with the indicative area in the container terminal.

- Electrical Building 200 Sq.m
- Site Office 200 Sq.m
- Store Office 200 Sq.m
- Work shop 850 Sq.m
- Shed for Parking trucks
- Water tank with well
- Security Gate
- Customs office 1600 Sq.m
- Rest room/canteen
- Administrative Building &
- Control Room

3.8.5 ADMINISTRATIVE AND WORKSHOP BUILDINGS

The administrative, control stations related to the operation of the container handling shall be housed in a common building, having a plinth area measuring 1600 Sq.m., except for the control tower, the administrative building shall essentially be a double storied building in R.C.C. beam and slab construction and shall be partly air-conditioned and sound insulated.
36 m x 20 m portion of the administrative building shall be two stories in height, and shall form the control tower. The elevated location and all-round view from the control tower shall provide the control room supervisor with a command post from which he can visually direct and control the container handling operation while the topmost storey shall contain the master control panel including all necessary control and communication equipment for controlling the receiving and shipping operations of container handling.

3.8.6 THE GENERAL SPECIFICATIONS FOR ALL THE BUILDING WORKS SHALL BE AS FOLLOWS

- The work shall be carried out as per General Technical Specifications for Building Works of the State of Karnataka.

- The minimum grade of reinforced concrete shall be M 20 conforming to IS: 456-2000 for columns, foundations and superstructure unless otherwise specified.
- The reinforcement shall be high strength deformed bars of grade Fe415 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 (1:3:6).
- Back filling shall be done with granular soil in layers not exceeding 200mm and each layer shall be well compacted as per specifications.
- All reinforcement shall be sheared only. Flame cutting shall not be 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 mortar 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 pr Technical Specifications.
- Electrical fittings and wiring shall be provided as per specifications
- All sanitary and water supply fittings shall be provided conforming to specifications
- All R.C.C. slabs for roofing shall be provided with water proofing treatment.

3.8.7 DREDGING AND DISPOSAL

The dredging needs to be carried to a depth of -15.1 m CD from about +3 M of ground level. After a dry excavation from +3.00 M to +0.00 M, the estimated quantity of the dredging in front of container terminal is about 7,50,000 Cu.M. Based on the available borehole data of berth no. 15, it could be assessed that most of the dredged material is suitable for reclamation. The excavated/dredged material could be used advantageously for raising of ground level of the container yard area and the balance dredged material could be dumped in the dumping grounds

Based on the available data, it is assessed that no hard rock dredging shall be involved. The dredging plan is shown in the drawing number CS-J114-021-PDR.

Based on the Radio Active Tracer (RAT) studies conducted during October 2007 to January 2008, it is recommended to dispose of the dredged material during the development of WDA at northerly region of approach channel at depth contours of about 24m-26m that is 10.5 km from the shore line.

The suspended solid content anywhere in the water column measured at 200 meters from the dredging site shall not exceed 500 mg/l above the standard background level. Measurements of the suspended solid content shall be taken twice daily at locations around dredging operations, to the approval of the Engineer.

3.8.8 SITE GRADING

Present Ground Level is 0 to +3 M. above mean sea level. This has to be excavated and then dredging has to be carried out. The general ground level of container stock yard could to be raised utilizing the excavated or dredged material as discussed above.

3.8.9 ROCK BUND REMOVAL (PARTLY)

According to earlier survey done by NMPT, there exists a rock bund on open sea side. Part of the rock bund has to be replaced by new diaphragm wall at open sea side.

3.9 REMOVAL OF PINNACLE

A pinnacle is found at the location at the entrance of the berth in the dredging area and this has to be removed by controlled blasting with the approval of the competent authorities.

3.9.1 BOUNDARY WALL BETWEEN BERTH AND 17 AND 18

A boundary wall of 285 m long has to be provided between Berth No.17 and 18 with sufficient height to prevent outsiders, and ensure safety of the terminal.

3.9.2 FENCE AROUND CONTAINER YARD

Suitable steel and strong wire mesh type fencing has to be provided around the container stacking to a suitable height to ensure safety of the containers. Gates has to be provided at entry and exit location of the trailers.

3.10 SECURITY GATE

Civil construction is required for inspection gate.

3.11 RAIL FOR QUAY GANTRY CRANE

Two Nos rail of CR120 (Crane Rail) has to be provided all along the jetty, 300m long to the entire length of jetty for the Quay crane travel. These rails have to be firmly fixed with jetty floor with standard accuracy level. Four Nos of Quay crane end stoppers that are strong enough to receive the impact have to be provided.

3.12 TRAILER AND TRUCK PARKING SPACE

Area allotted for trailer and truck parking is about 50 m wide x 120m long = 6000 sq.m. Entire area has to be made with strong concrete floor for taking Trailer loads.

3.13 FOOTING FOR FLOOD LIGHT TOWER

Necessary footing strong foundation has to be provided for the required number of flood light towers as required by manufacturer's specification.

3.14 RAILWAY SIDING (FUTURE)

This facility of railway siding shall be considered in future and the space is reserved for the Railway siding. In future, the railway siding could be connected to the existing Railway siding, which has connection to Western Railway line and hinter land of Karnataka. Presently, the container movement shall be done by trailers only.

3.15 UNDERGROUND CABLE DUCTING

Power supply is taken from PSP to main substation by means of 11 KVA cable. The distance between PSP and main substation is approximately 600 m. The cable has to be buried below the ground. Cable shall be laid at a depth of not less than one meter (depending upon the soil receptivity) and with a sand cushion and PCC troughing protection. At the places, where cables have to cross the roads and in the areas where heavy equipment is likely to exert pressure during their working, RCC pipes and or box culverts shall be provided. The cable routes shall be provided with route markers.

3.16 WATER SUPPLY

A 5 m diameter Well, 50000 L capacity Over Head Tank and 1,00,000 L, Under Ground Sump has been proposed for the augmentation of water supply. Necessary distribution lines shall be provided to all buildings. A separate line shall be taken to the berth for supply to the ships if necessary.

3.17 FIRE FIGHTING

Typical Firefighting equipment recommended for berth no: 18

- 2 Nos - Tower Monitors (20 Meters Height) of 6000 LPM capacity each.
- 1 No. - Ground Monitor (03 Meters Height) of 3000 LPM capacity.
- 2 Nos- Fixed Water Monitors of 2700 LPM capacity.
- Jumbo Water curtain Nozzles of 362 LPM – 16 Nos.
- Hydrants – 15 Nos
- 60.0 Cubic Meter Foam Tank
- Water Discharge Pressure – 16 kg/cm
- Water Throw – 1000 meters
- 2 Nos – Vertical Turbine Pump of 15000 LPM capacity.
- 1 No – Motor Driven pumps for Foam Injection.
- 1 No – Engine Driven Pump for Foam Injection.
- Fire Alarm /Hooters – 02 Nos

- Manual call points – 10Nos
- Gas detection Systems -04 Nos
- Flame Detection -10Nos
- Public Address System – 7 Nos

Hydraulic line could be interconnected from Berth No: 16 to Berth No: 18 in case of failure of Hydraulic Pump of Berth No: 18

3.18 STORM / RAIN WATER DRAINAGE

Storm water drains line to be provided all along the container yard. This shall take the storm water to sea through drain with NMPT approval. Please refer the drawing enclosed.

3.19 SEWERAGE LINE

Sewerage line on the side of utility road shall be provided. All sewerage lines from utility building shall be connected to NMPT lines and the sewerage treatment plant. Sewage water discharge in the sea will not be permitted.

For any isolated building when the quantity is negligible, it is proposed to construct septic tank and connect it to the soak pits.

3.20 MATERIAL FOR CONSTRUCTION OF CIVIL WORKS

3.20.1 GENERAL

Materials to be used in the work shall conform to the specifications mentioned on the drawings, the requirements laid down in this section and specifications for relevant items of work covered under these specifications. If any material, not covered in these specifications, is required to be used in the work, it shall conform to relevant Indian Standards, if there are any, or to the requirements specified by the Engineer

3.20.2 SOURCES OF MATERIAL

A notification shall be given for the proposed sources of materials. If it is found after trial that sources of supply previously approved do not produce uniform and satisfactory products, or if the product from any other source proves unacceptable at any time, then an acceptable materials shall be furnished from other sources.

3.20.3 BRICKS

Burnt clay bricks shall conform to the requirements of IS: 1077, except that the minimum compressive strength when tested flat shall not be less than 8.4 MPa for individual bricks

and 1.5 MPa for the average of 5 specimens. They shall be uniformly burnt and free from cracks and Flaws and nodules of free lime. The brick shall have smooth rectangular faces with sharp Corners and emit a clear ringing sound when struck. The size may be according To local Practice with a tolerance of ±5 per cent

3.20.4 STONES

Stones shall be of the type specified. It shall be hard, sound, and free from cracks, decay and weathering and shall be freshly quarried from an approved quarry. Stones with round surface and flakiness shall not be used.

The stones, when immersed in water for 24 hours, shall not absorb water by more 5 per cent of their dry weight when tested in accordance with IS: 1124.

The length of stones shall not exceed 3 times its height nor shall they be less than twice its height plus one joint. No stone shall be less in width than the height and width on the base shall not be greater than three –fourth of the wall nor less than 150mm.

3.20.5 CEMENT

Cement to be used in the works shall be any one of the following types with the prior approval of the Engineer,

- Ordinary Portland Cement, 33Grade, conforming to IS: 269
- Rapid Hardening Portland Cement, conforming to IS: 8041
- Ordinary Portland cement, 43 Grade, conforming to IS: 8112
- Ordinary Portland cement, 53 Grade, conforming to IS: 12269
- Sulphate Resistant Portland cement, conforming to IS: 12330
- Portland Pozzollona Cement, conforming to IS: 1489 Part I and and II

3.20.6 AGGREGATES

For plain and reinforced cement concrete (PCC and RCC) coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone, crushed gravel, natural gravel or a suitable combination thereof or other approved inert material. They shall not consist of pieces of disintegrated stones, soft, flaky, elongated particles, salt, alkali, vegetable matter or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the steel reinforcement. Coarse aggregate having positive alkali-silica reaction shall not to be used. All coarse aggregates shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386. The maximum value for flakiness index for coarse aggregate shall not exceed 35 per cent. The coarse aggregate shall satisfy the following requirements of grading:

Table 3-7 Requirements of Coarse Aggregate

IS Sieve Size	Per cent weight	Passing the sieve	
	40mm	20mm	12.5mm
63mm	100	-	-
40mm	95-100	100	-
20mm	30-70	95-100	100
12.5mm	-	-	90-100
10mm	10-35	25-55	40-85
4.75mm	**0-5**	**0-10**	**0-10**

3.20.7 SAND/FINE AGGREGATES

For masonry work, sand shall conform to the requirements of IS: 2116. For plain and reinforced cement (PCC and RCC) concrete works, fine aggregate shall consist of clean, hard strong and durable pieces of crushed stone, crushed gravel. Or a suitable combination of natural sand crushed stone or gravel. They shall not contain dust, lumps, soft or flaky, materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Motorized sand washing machines should be used for remove impurities from sand. Fine aggregate having positive alkali-silica reaction shall not to be used. All fine aggregate shall confirm to IS: 383 and tests for conformity shall be carried out as per IS: 2386. The fineness modulus of fine aggregate shall neither be less than 2.0 nor shall greater than 3.5 Sand/fine aggregate for structural concrete confirm to the following grading requirements:

Table 3-8 Requirements of Sand/Fine aggregates

IS Sieve Size	Per cent weight	Passing the sieve	
	Zone I	Zone II	**Zone III**
10mm	100	100	**100**
4.75mm	90-100	90-100	**90-100**
2.36mm	60-95	75-100	**85-100**
1.18mm	30-70	55-90	**75-100**
600micron	15-34	35-59	**60-79**
300micron	5-20	8-30	**12-40**
150 micron	**0-10**	**0-10**	**0-10**

3.20.8 REINFORCEMENT/UNTENSIONED STEEL

For plain and reinforced cement concrete (PCC and RCC) works, the reinforcement / Intentioned steel as the case may be shall consist of the following grades of reinforcing bars.

Table 3-9 Grades of Reinforcing bars

Grade Designation	Bar Type conforming to IS Specification	Governing characteristic Strength Fy (MPa)	Elastic Modulus (GPa)
S 240	IS :432 Part I Mild steel Bar	240	200
S 415	IS : 1786 High Yield Strength Deformed bars (HYSD)	415	200

All steel shall be procured from original producers; no re-rolled steel shall be incorporated in the work. Only new steel shall be delivered to the site. Cracked ends of bars shall be discarded.

3.20.9 WATER

Water used for mixing and curing of concrete/ mortar shall be clean and free from injurious amounts of Oils, Acids, Alkalis, Salts, Sugar, Organic materials or other substances that may be detrimental to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. Mixing and curing with sea water will not be permitted. As a guide, the following concentrations represent the maximum permissible values:

- To neutralize 200ml sample of water, using phenolphthalein as an indicator, it should not require more than 2ml of 0.1 normal NAOH.
- To neutralize 200ml sample of water, using methyl orange as an indicator, it should not require more than 10ml of 0.1 normal HCL.
- The permissible limits for solids shall be as follows when tested in accordance with IS: 3025

PERMISSIBLE LIMITS (MAX):

Organic	200mg/lit
Inorganic	300mg/lit
Sulphates (SO_4)	500mg/lit
Chlorides (Cl)	500mg/lit
Suspended matter	2000mg/lit

In case of building structures, the permissible limit of chlorides may be increased up to 1000 mg/lit. All samples of water (including potable water) shall be tested and suitable measures shall be taken where necessary to ensure conformity of the water to the requirements stated herein. The PH value shall not be less than 6.

3.20.10 CONCRETE ADMIXTURES

GENERAL

Admixtures are material added to the concrete before or during mixing with a view to modify one or more of the properties of concrete in the plastic or gardened state.

Concrete admixtures are proprietary items of manufacture and shall be obtained only from established manufacturers with proven track record, quality assurance and full fledged laboratory facilities for the manufacture and testing of concrete.

The contractor shall provide the following information concerning each admixture after obtaining the same from the manufacturer:

1. Normal dosage and detrimental effects, if any, of any, of under dosage and over dosage.
2. The chemical names of the main ingredients in the admixtures.
3. The chloride content, if any, expressed as a percentage by the weight of the admixture.
4. Values of dry material content, ash content and relative density of the admixture which can be used for uniformity tests
5. Whether or not the admixture leads to the entrapment of air when used as per the manufacturer's recommended dosage, and if so to what extent.
6. Where two or more admixtures are proposed to be used in any one mix, confirmation as to their compatibility.
7. Confirmation that there would be no risk of corrosion of the reinforcement or other embedment as a result of using the admixture.

STORAGE OF MATERIAL:

General

All materials shall be stored at proper places so as to prevent their deterioration or intrusion by foreign matter and to ensure their satisfactory quality and fitness for the work. The storage space must also permit easy inspection, removal and restorage of the materials. All such materials even though stored in approved godowns /places, must be subjected to acceptance test prior to their immediate use.

Brick

Bricks shall not be dumped at site. They shall be stacked in regular tiers as they are unloaded, to minimize breakage and defacement. The supply of bricks shall be available at site at any time. Bricks selected for use in different works shall be stacked separately.

Aggregates

Aggregate stockpiles may be made on ground that is denuded of vegetation, is hard, leveled and well drained. If necessary, the ground shall be covered with 50mm plank.

Coarse aggregates, unless otherwise agreed by the engineer in writing, shall be delivered to the site in separate sizes (2 sizes when nominal size is 25mm or less and 3 sizes when the

nominal size is 32mm or more). Aggregates placed directly on the ground shall not be removed from the stockpile within 30cm of the ground until the final cleaning up of the work, and then only the clean aggregate shall be permitted to be used. In the case of line aggregates, these shall be deposited at the mixing site not less than 8 hours before use and shall have been tested and approved by the engineer.

Cement

Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground level in perfectly dry and water-tight sheds and shall be stacked not more than eight bags high. Wherever bulk storage containers are used their capacity should be sufficient to cater to the requirement at site and should be cleaned at least once every 3 to4 months.

Each consignment shall be stored separately so that it may be readily identified and inspected and cement shall be used in the sequence in which it is delivered at site. Any consignment or part of a consignment of cement which had deteriorated in any way, during storage, shall not be used in the works and shall be removed from the site by the contractor without charge to the employer.

The contractor shall prepare and maintain proper records on site in respect of delivery. Handling, storage and use of cement and these records shall be available for inspection by the engineer at all times.
The contractor shall make a monthly return to the engineer on the date corresponding to the interim certificate date, showing the quantities of cement received and issued during the month and in stock at the end of the month.

Reinforcement / Un tensioned Steel

The reinforcement bars, when delivered on the job, shall be above the surface of the ground upon platforms, skids, or other supports with well-drained surface, and shall be protected from mechanical injury and from deterioration by exposure.

Water

Water shall be stored in containers/tanks covered at and cleaned at regular intervals in order to prevent intrusion by foreign matter or growth of organic matter. Water from shallow, muddy or marshy surface will not be permitted. The intake pipe shall be enclosed to exclude silt, mud, grass and other solid materials and there shall be a minimum depth of 0.60m of water below the intake at all times.

Tests and standard of acceptance

All materials even though stored in an approved manner shall be subjected to an acceptance test prior to their immediate use.

Independent test of cement for every consignment shall be done by the contractor at site in the laboratory approved by the engineer before use. Any cement with lower quality than those shown in manufacturer's certificate shall be debarred from use. In case of imported cement, the same series of tests shall be carried out before acceptance.

Testing and approval of material

The contractor shall furnish test certificates from the manufacturer /supplier of material along with each batch of material(s) delivered to site.

The contractor shall set up a field laboratory with necessary equipment for testing of all materials, finished products used in the construction as per requirements of conditions of contract and the relevant specifications. The testing of all the materials shall be carried out by the engineer or his representative for whom the contractor shall make all the necessary arrangements and bear the entire cost.

Test which cannot be carried out in the field laboratory have to be got done at the contractor's expense at any recognized laboratory/testing establishments in India or abroad as approved by the engineer. All necessary cost for witnessing the test by engineer's representative shall have to be borne by the contractor.

Rubber for fender:

1. The rubber for manufacturing fenders shall be natural or synthetic rubber or the mixture of both. The substance shall be reinforced with carbon black for resistance to ageing, abrasion, weathering, wearing, and stability when repeatedly in contact with seawater.
2. The rubber for fenders shall be homogeneous in quality, free from foreign materials, air bubbles, pores, injuries, cracks, defective impurities and other harmful defects.
3. The rubber for fenders shall comply with specification stipulated below.

Table 3-10 Rubber for fenders

Property	Value	Test method &condition (part no. of BS 903)
Density	1100kg/m³ to 1300kg/m³	Part A1
Hardness (international rubber hardness degrees)	≤72	Part A26method N
Tensile strength	≥16 N/mm²	Part A2

Elongation change	≥350%	Part A2
After acceleration air ageing test: Hardness (increase in IRHD) Reduction in tensile strength Reduction in elongation	 ≤8% ≤20% ≤20%	Part A19 Method A at 70°C×96 hours
Oil resistance (measured by volume change percentage) Industrial gasoline Heavy oil	 ±60% ±20%	Part A19 method A at 70°C×96 hours
Compression set	≤30%	Part A6 Method A at 70°C×22 hours using type 2 test pieces
Ozone resistance	No crack visible	Part A43 at 40°c×100 hours
Tear resistance	≥60kn/m	Part A3 method C at 23°c
Abrasion resistance (volume loss at 3,000 revolution)	≤1500mm³	Part A9 method C

3.21 PILE FOUNDATION

3.21.1 DESCRIPTION

This work shall consist of construction of piles for structures in accordance with the details shown on the drawings.

The construction of pile foundations requires a careful selection of the piling system depending upon sub-soil conditions and loading characteristics and type of structure. The permissible limits of total and differential settlements, unsupported length of pile under scour, impact/entanglement of floating bodies and other special requirements of projects are also equally important criteria for selection of the piling system. The method of installing the piles, including details of the equipments shall be submitted by the contractor and got approved from the engineer. The work shall be done as per IS: 2911 except as modified herein.

Sub-Surface Investigation

The complete sub – surface investigation of strata in which pile foundations are proposed shall be carried out in advance and by in-situ pile tests as per relevant standards. Borings

should be carried up to sufficient depths so as to ascertain the nature of strata around the pile shaft and below the pile tip. However, depth of boring shall not be less than:

1. 1.5 times estimated length of pile in soil but not less than 15m beyond the probable length of pile
2. 15 times diameter of pile in weak/jointed rock but minimum 15m in such rock
3. 4 times diameter of pile in sound , hard rock but minimum 3m in such rock

The sub-surface investigation shall define adequately stratification of sub-strata including the nature and type of strata, its variation and extent and specific properties of the same. The investigation shall be adequate for estimating design capacities for different diameters and length of piles.

For piles socketed into rocks, it is necessary to determine the uni axial compressive strength of the rock and its quality.

The investigation shall also include location of ground water table and other parameters including results of chemical tests showing sulphate and chloride content and any other detrimental chemical content in soil and/ or ground water, likely to affect durability.

Materials

The basic materials shall conform to the specifications for materials. The specifications for steel reinforcement, structural concrete, and structural steel to be used in pile foundations shall be as per standards.

Concrete in Piles

Grade of concrete to be used in cast-in-situ piles shall be as specified in the drawing and the cement content shall not be less than 400 kg per cubic meter of concrete. Maximum water cement ratio shall be 0.5 for cast-in-situ piles and 0.45 for precast piles.
Concrete mix should have homogeneous mixture with required workability for the system of piling adopted of sulphate, chloride etc. it may be preferable to opt for higher grades of concrete restricting water cement ratio to 0.45. Special types of cement, such as sulphate resistant cement may be used where considered appropriate.

Test Piles

Test piles laid to determine the lengths of piles shall conform to the requirements for piling as indicated in these specifications, if they are to be incorporated on the completed structure.

Test piles that are to become a part of the completed structure shall be installed with the same type of equipment that is proposed to be used for piling in the actual structure.

Cast-In Situ Concrete Piles

Cast-in-situ concrete piles shall be installed by making a bore into the ground by removal of material. Cast-in-situ concrete piles shall be cast in metal shells liner which may remain permanently in place.

The metal casing shall be of sufficient thickness and strength to hold its original form and show no harmful distortion after it and adjacent casings have been driven and the driving core, if any has been withdrawn.

Liner or bore-hole which is improperly located or shows partial collapse that would affect the load carrying capacity of the pile, shall be rejected or repaired as directed by the Engineer at the cost of the Contractor.

Wherever practicable, concrete should be placed in a clean dry hole. Where concrete is placed in dry and there is casing present, the top 3 m of the pile shall be compacted using internal vibrators. The concrete should invariably be poured through a tremie with a funnel so that the flow is directed and concrete can be deposited in the hole without segregation. The casing of cast-in-situ piles shall not allow being withdrawn.

Care shall be taken during concreting to prevent as far as possible the segregation of the ingredients. This displacement or distortion of reinforcement during concreting shall be avoided.

The concrete shall be properly graded, shall be self-compacting and shall not get mixed with soil, excess water, or other extraneous matter. Special care shall be taken in silty clays and other soils with the tendency to squeeze into the newly deposited concrete and cause necking. Sufficient head of green concrete shall be maintained to prevent inflow of soil or water into the concrete.

The placing of concrete shall be a continuous process from the toe level to the top of the pile. To prevent segregation, a tube or tremie pipe as appropriate shall be used to place concrete in all piles.

To ensure compaction by hydraulic static heads, rate of placing concrete in the pile shaft shall not be less than 6 m (length of pile) per hour.

For bored cast-in-situ piles, casting/liner shall be driven open ended with a pile driving hammer capable of achieving penetration of the liner to the length shown on the drawing or as approved by the Engineer. Materials inside the casing shall removed progressively by air lift, grab or percussion equipment or other approved means.

For piles used in soils liable to flow, the bottom of the casting shall be kept enough in advance of the boring tool to prevent the entry of soil into the casing, thus preventing the formation of cavities and settlements in the adjoining ground. The water level in the casing should generally be maintained at the natural ground water level or the same reasons. The

joint of the casing shall be made as tight as possible to minimize inflow of water or leakage of slurry during concreting.

Boring shall be carried out using rotary or percussion type equipment. Unless otherwise approved by the engineer, the diameter of the bore-holes shall be not more than the inside diameter of the liner.

Prior to the lowering of the reinforcement cage into the pile shaft, the shaft shall be cleaned of all loose materials. Cover to reinforcing steel shall be maintained by suitable spacers.
The diameter of the finished pile shall not be less than that specified and a continuous record shall be kept by the Engineer as to the volume of concrete placed in relation to the length cast.

Before concreting under water, the bottom of the hole shall be cleaned of drilling mud and all soft or loose material very carefully. In case a hole is bored with use of drilling mud, concreting should not be taken up when the specific gravity of bottom slurry us more than 1.2. The drilling mud should be maintained at 1.5m above the ground water level.

Concreting under water for cast-in-situ concrete piles may be done either with the use of tremie method or by the use of an approved method specially designed to permit under water placement of concrete.

General requirements and precautions for concrete under water are as follows:

a) The concreting of a pile must be completed in one continuous operation. Also, for bored holes, the finishing of the bore, cleaning of the bore, lowering of reinforcement cage and concreting of pile for full height must be accomplished in one continuous operation without any stoppage.
b) The concrete should be coherent, rich in cement with high slump and restricted water cement ratio.
c) The tremie pipe should be large enough with due regard to the size of aggregate. For 20mm aggregate, the tremie pipe should be of diameter not less than 150mm and for large aggregate, larger diameter tremie pipes may be necessary.
d) The first charge of concrete should be placed with a sliding plug pushed down the tube ahead of it to prevent mixing of water and concrete.
e) The tremie pipe should always penetrate well into the concrete with an adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.

All tremie tubes should be scrupulously cleaned after use.

The minimum embedment of cast-in-situ concrete piles into the structure supported by pile shall be 150mm. Any defective concrete at the head of the completed pile shall be cut away

and made good with new concrete. The clear cover between the bottom reinforcement in structure supported by pile from the top of the pile shall not less than 25mm. The reinforcement in the pile shall be exposed for full anchorage length to permit it to be adequately bonded into the pile cap. Exposing such length shall be done carefully to avoid damaging the rest of the pile. Defective piles shall be removed or left in place as judged convenient without affecting the performance of adjacent piles or pile cap. Additional piles shall be provided to replace the defective piles.

Driving Equipment

Piles casings shall be driven with any type of drop hammer, diesel hammer or single-acting steam or compressed air hammer, provided they penetrate to the prescribed depth or attain the designed resistance without being damaged. The weight or power of the hammer should be sufficient to ensure a penetration of at least 5 mm per blow, unless rock has been reached. It is always preferable to employ the heaviest hammer practicable and to limit the stroke, so as not to damage the pile. The minimum weight of the hammer shall be 2.5t. In the case of precast concrete piles the mass of the hammer shall be not less than 30 times the mass of 300mm length of pile.

Stream or air hammers shall be furnished along with boiler or air compressor of capacity at least equal to that specified by the manufacturer of the hammers. The boiler or air compressor shall be equipped with an accurate pressure gauge at all times. The valve mechanism and other parts of steam, air or diesel hammers shall be maintained in first class condition so that the length of stroke and number of blows per minute, for which the hammer is designed, shall be obtained. Inefficient steam, air or diesel hammers shall be removed from the work.

Driving

Piles casing shall be installed from firm ground or from temporary supports or from fixed platform. The arrangement shall provide sufficient rigidity to ensure accuracy of pile casing driving under all conditions of tide, stream flow or hammer drop.

During driving the top of pile casing shall be protected by a suitable helmet of substantial steel construction. The helmet shall provide uniform bearing across the top of the pile casing and shall hole the pile casing centrally under the hammer. No pile casing shall be driven unless inspected and approved by the Engineer.

Pile casing shall be driven from a fixed frame of sufficient rigidity to ensure accuracy of driving within specified tolerances. Forces producing undue bending or torsional stresses in piles shall not be applied during driving. The force of the hammer shall be directed centrally and axially during driving.

The stroke of a single acting or drop hammer shall be limited to 1.2m unless otherwise permitted by the engineer. A shorter stroke may be necessary when there is a danger of damaging the pile casing.

Pile casing shall not be bent or sprung into position but shall be effectively guided and held on-line during the initial stages of driving. Attempts to correct any tendency for the pile to run off-line by the application of significant horizontal restraint will not be permitted. Shortly after the commencement of driving and at regular intervals throughout the driving operation, checks shall be made to ensure that the pile frame does not exert any undue lateral force on the pile due to restraint within the helmet.

If the indications are that a pile casing shall finish outside the specified tolerances, driving operations on that pile casing shall cease. The pile casing shall be withdrawn, the hole filled and the pile casing re-driven at no extra cost.

To avoid the possibility of premature "set-up" pile casing driving shall be continuous in the later stages, without any deliberate stops. (Delays of an hour or less may lead to significant "set-up" in piles i.e. resistance to further driving increases after driving is stopped).

If any pile casing is damaged in any way during driving, it shall be repaired or replaced as directed by the engineer, at no extra cost. If during driving, the head of a pile is damaged to the extent that further driving is not possible, the head shall be cut off and driving continued.

Pile casings shall be driven to level required and specified on the drawing whichever gives the lowest toe elevation. The engineer's decision in these matters shall be final.

3.21.2 PILE TESTS

General

The bearing capacity of a single pile may be determined from test loading a pile. The load test on a concrete pile may not be carried out earlier than 28 days from the time of casting of the pile.

There shall be two categories of test on piles, namely initial tests and routine tests. Initial tests should be carried out on test piles which are not be incorporated in the work. Routine tests shall be carried out as a check on working piles. The number of initial and routine tests on piles shall be as determined by the engineer depending upon the number of foundations, span length, type of superstructure and uncertainties of founding strata. In any case, the initial load tests shall not be less than 2 in number, while the routine load tests shall not be less than 2 percent of the total number of piles in the structure not less than 2 in number.

The above stipulations hold good for both vertical as well as lateral load tests on pile foundations. However, both initial and routine tests may be suitably increased for important structures or cases with large variation in the sub-surface strata.

The methodology of carrying out load tests and of arriving at safe load on piles shall conform to IS: 2911 (PART IV). In case of any doubt of workmanship or load carrying capacity of working piles not subjected to routine tests, or when ordered by the Engineer, or when provided in the contract, load tests on working piles may be supplemented by non-destructive testing. Such tests may include "Integrity Testing" of concrete in the installed pile and utilization of "Pile Driving Analyzer" which gives an indication of pile capacity in end bearing and side friction.

IMPORTANT CONSIDERATION:

Bored Cast-In-Situ Piles

While concreting uncased piles, voids in concrete shall be avoided and sufficient head of concrete is to be maintained to prevent inflow of soil or water into the concrete. It is also necessary to take precautions during concreting to minimize the softening of the soil by excess water. Uncased cast-in-situ piles not be allowed where mudflow conditions exist.

Tremie of 150mm to 200mm diameter shall be used for concreting. The tremie should have uniform and smooth cross-section inside and shall be withdrawn slowly ensuring adequate height of concrete outside the tremie pipe at all stages of withdrawal. Other recommendations for tremie concreting are:

- The sides of the bore-hole have to be stable throughout
- The tremie shall be water-tight throughout its length and have a hopper attached at its head by a water-tight connection.
- The tremie pipe shall be large enough in relation to the size of aggregates. For 20mm aggregate the tremie pipe shall be of diameter not less than 150mm and for larger size aggregate tremie pipe of larger diameter is required.
- The tremie pipe shall be lowered to the bottom of the bore-hole, allowing water or drilling mud to rise inside it before pouring concrete.
- The tremie pipe shall always be kept full of concrete and shall penetrate well into the concrete in the bore-hole with adequate margin of safety against accidental withdrawal if the pipe is surged to discharge the concrete.

For very long or large diameter piles, use of retarding plasticizer in concrete is desirable.

For large diameter piles, it may be essential to conduct non-destructive pile integrity tests to evaluate integrity of the pile.

Where possible, it may be desirable to grout the base of pile with cement slurry under suitable pressure after concrete in the pile attains the desired strength. For this purpose conduit pipes with easily removable plugs at the bottom end should be placed in the bore along with reinforcement cage before concreting.

3.21.3 TOLERANCES

Permissible Tolerances for Bored Piles

- Variation in cross-sectional dimensions : +50mm, -10mm
- Variation from vertical or specified rake : 1 in 50
- Variation in the final position of the head in plan : 50 mm
- Variation of level of top of piles : +/-25mm

Tests and standards of acceptance

The material shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

3.22 FACILITY TO BE PROVIDED / DEVELOPED BY NMPT

- Power supply at PSP point at 11 kV
- Railway Siding
- Land Preparation for Railway Siding
- Road and common Corridor adjacent to Berth
- Road adjacent to Railway Siding
- Road and Common Corridor adjacent to Open Sea Side
- Linking Road from Container Terminal to Korrikata Gate
- 14 m wide Road outside of Boundary Wall on north side
- Sewage treatment plant
- Road widening to Truck Trailer Parking Space
- Empty Container Stacking Space
- Craft for ship mooring
- Site for Damaged /Disputed Container

Time Bar Chart

Activity	Months																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
CIVIL																								
Engineering/ survey & mobilization																								
Berth construction																								
Diaphragm wall																								
Dredging																								
Container yard construction																								
Roads																								
Utilities, buildings																								
Water supply																								
Drainage system																								
Fire fighting																								
Flood light post																								
Inspection																								

*Two monsoons of each one month duration is built into above schedule