# INLAND WATERWAYS AUTHORITY OF INDIA

(Ministry of Shipping, Government of India)

## Detailed Feasibility Study for Capacity Augmentation of National Waterway-1 and Detailed Engineering for its Ancillary Works and Processes between Ghazipur to Allahabad (Jal Marg Vikas Project)

# Detailed Project Report
# Varanasi Multimodal Terminal

**September**
**2018**


HOWE ENGINEERING PROJECTS (INDIA) PVT. LTD.
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**HOWE INDIA HOUSE, 81 NEHRU PLACE, NEW DELHI–110019, INDIA**
Phone : +91(011) 49508000 ; Fax : +91(011) 26467557 ; E-Mail : howe@howeindia.com
**Web : www.howeindia.com**

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| | **INLAND WATERWAYS AUTHORITY OF INDIA**<br>(Ministry of Shipping, Government of India) |
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# EXECUTIVE SUMMARY

## 1 INTRODUCTION

Inland Waterways Authority of India (IWAI), an autonomous organization under Ministry of Shipping (MoS), Govt. of India was constituted for development and regulation of inland waterways of the country.

IWAI has appointed M/s Howe Engineering Projects (India) Pvt. Ltd. (HOWE) as Consultant for carrying out detailed feasibility study for capacity augmentation of NW-1 and detailed engineering for its ancillary works and processes between Haldia to Allahabad (Jal Marg Vikas Project). The present submission deals with the Detailed Project Report (DPR) of the proposed facilities for Multimodal Terminal (MMT) at Varanasi.

## 2 PROJECT LOCATION

The Site is located on the eastern side of Ganges at a distance of 9 km up stream of Malviya road cum Railway Bridge connecting Varanasi to Mughalsarai at Latitude 25°15'12.4" North and Longitude 83°01'50.3" East at Varanasi in Uttar Pradesh. Proposed IWT terminal at the bank of Ganga River in Ramnagar Municipal Board of Varanasi district which is south of Viswa Sundari Setu (NH-2) Viaduct is 650 meters from existing National Highway -7 and existing Airport at Babatpur lies at 30 Kms of aerial distance from the proposed site.


**Figure 1-1: Location of Site for Varanasi Multimodal IWT Terminal**

# 3 TRAFFIC POTENTIAL

The traffic potential of Varanasi MMT as provided by M/s Hamburg Port Consulting GmBH, the traffic consultant is presented below.

Table 1-1: Varanasi MMT - 2020 to 2045 cargo forecast by cargo type (tons)

| Cargo | 2020 | 2025 | 2035 | 2045 |
|---|---|---|---|---|
| Bagged | 1.40 | 1.50 | 3.31 | 3.37 |
| Container | 0.16 | 0.17 | 0.19 | 0.21 |
| Dry Bulk | 0.14 | 0.15 | 4.25 | 4.34 |
| General Cargo | 0.66 | 0.69 | 0.74 | 0.75 |
| Neo-Bulk | 1.13 | 1.23 | 1.27 | 1.29 |
| Ro-Ro | 0.05 | 0.05 | 0.35 | 0.36 |
| Liquid Bulk | 0.01 | 0.01 | 0.01 | 0.01 |
| Total | 3.55 | 3.82 | 10.12 | 10.32 |

Source: HPC report on Infrastructure requirement of individual terminals along National Waterways 1, 26th April 2016.

# 4 TARGETED TRAFFIC AND TERMINAL CAPACITY

Considering the restriction in the availability of water front, maximum of five berths can be developed. However, for Phase 1 development two berths are planned. Therefore, alternate layouts have been worked out based on various discussion held with IWAI, the following commodities has been considered as the targeted cargoes and the individual berth capacities for handling the targeted commodities have been worked out as described below:

## 4.1 Bagged and General Cargo

Bagged and General Cargo like food grains, vegetables, agricultural produce, jute, cloths, cement etc. will come to the terminal by barges and unloaded by MHC cranes into trucks and transported to the covered shed. Then it will be loaded to trucks and transported to the hinterland by trucks or rail.

## 4.2 Bulk Cargo

Natural aggregates like Sand, Stone Chips, Soil, consumer goods etc. will come to the terminal by barges and unloaded by MHC cranes into trucks hopper / mobile hopper and transported to the storage yard by conveying system / trucks. Then it will be loaded to trucks by pay loader and transported to the hinterland by trucks or rail.

### 4.3 Container

Containers will come to the terminal by barges and unloaded by MHC cranes into trucks and container yard. Then it will be loaded to trucks by reach stacker and transported to the hinterland by trucks or rail.

### 4.4 Berth Capacity

Following table shows the berth capacities considered for phase wise development:

**Table 1-2: Phase wise Total Traffic**

| Commodity | Phase 1a | | Phase 1b | | Final Phase | |
|---|---|---|---|---|---|---|
| | No. of berths | Traffic in MTPA | No. of berths | Traffic in MTPA | No. of berths | Traffic in MTPA |
| Construction Material Bulk | 2 | 0.21 | 2 | 0.31 | 5 | 1.53 |
| Construction Material Bagged | | 0.21 | | 0.31 | | 1.53 |
| Consumer goods Bulk | | 0.08 | | 0.14 | | 0.17 |
| Containers | | 0.04 | | 0.06 | | 0.08 |
| Food and food stuff Bagged | | 0.25 | | 0.36 | | 0.44 |
| Project Cargo | | 0.06 | | 0.08 | | 0.10 |
| Total | 2 | 0.84 | 2 | 1.26 | 5 | 3.85 |

## 5 DESIGN VESSEL SIZE

The principal dimension of the design vessel considered to be handed at Varanasi multimodal terminal is mentioned below:

**Table 1-3 : Design Vessel Size**

| Vessel Type | Vessel Size (DWT) | LOA (m) | Beam (m) | Loaded Draft (m) |
|---|---|---|---|---|
| Barge | 3000 DWT | 95 | 15 | 2.5 |
| Barge | 2,000 DWT | 80 | 11 | 2.5 |
| Barge | 75 TEU | 80 | 11 | 2.5 |

Though a range of vessels are mentioned in the table above can be handled at Varanasi Terminal, at present available maximum draft at the location is only 1.5m, accordingly the design shall be made.

The following water levels have been considered for planning of the terminal at the Site.

| | |
|---|---|
| High Flood Level (HFL) | RL +73.90 M |
| Low Water Level (LWL) | RL +58.22 M |

## 6 PHASE -1A LAYOUT OF VARANASI MMT


**Figure 1-2: Varanasi MMT - Layout Plan of Terminal Facilities during Phase 1A Development**

# 7 PHASE -1B LAYOUT OF VARANASI MMT

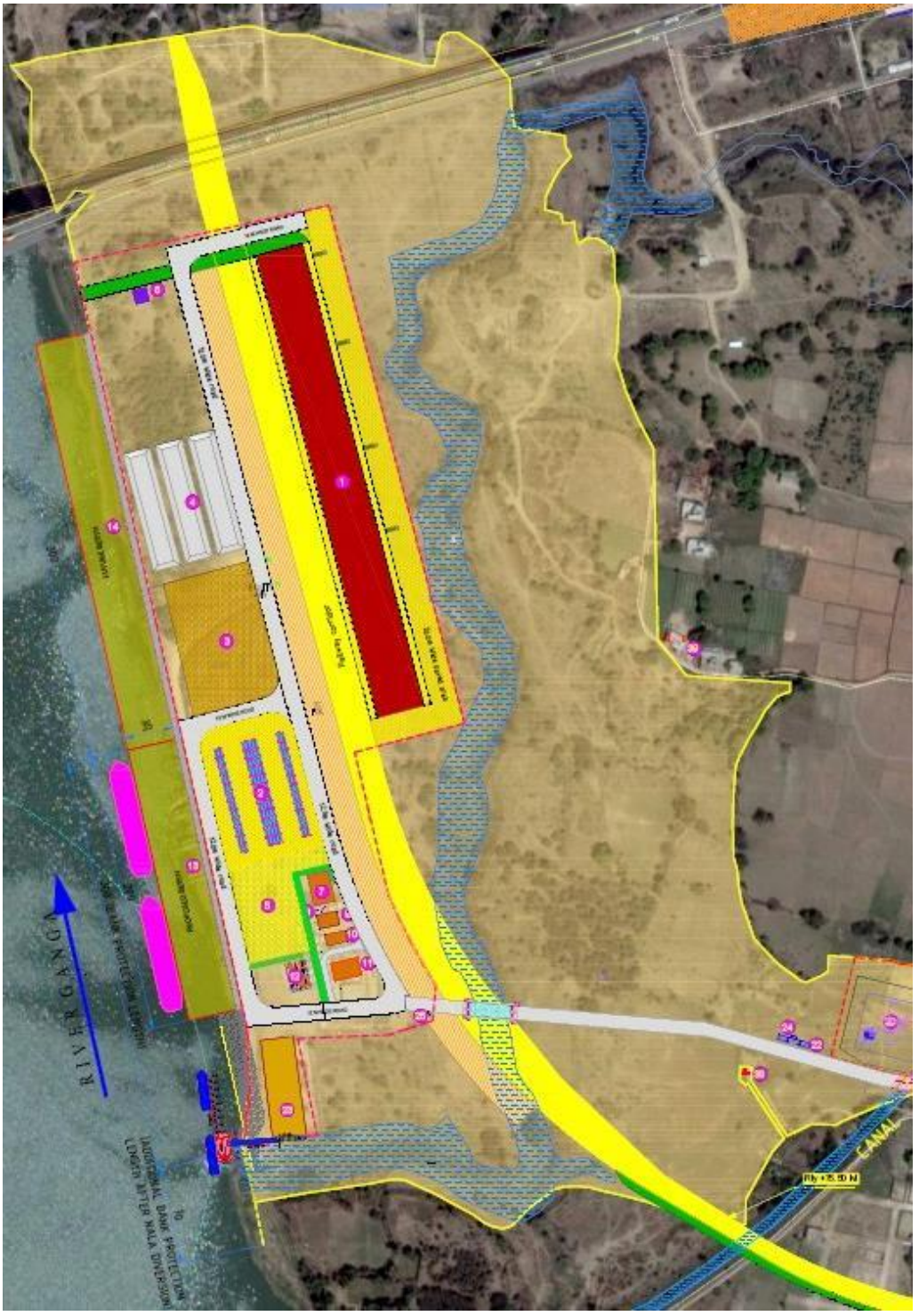



**Figure 1-3: Varanasi MMT - Layout Plan of Terminal Facilities during Phase 1B Development**

# 8 MASTER PLAN LAYOUT OF VARANASI MMT


**Figure 1-4: Varanasi MMT - Layout Plan of Terminal Facilities during Final Phase Development**

# 9 DEVELOPMENT PLAN – MARINE FACILITIES

Considering IWAI's requirement, it is proposed to take up the proposed development in Phase-1 (1a & 1b) and Final Phase.

## 9.1 Berths

### 9.1.1 Phase 1A + 1B

It is proposed to develop berth 1 as multi-cargo berth for handling bagged food, consumer bulk cargo, project cargo and containers. The length of berth-1 is 200m and width is 35 m. The berth will be continuous with backup yard with a slope protection under the berth.

### 9.1.2 Final Phase

In final phase and additional berth is proposed to cater for the future traffic requirement. The dimension of the proposed additional berth is 300m length and 35m in width.

## 9.2 Manoeuvring Area & Approach Channel

The manoeuvring area for development of terminal comprises of approach channel, turning circle and berthing area. It is proposed that the barges will move in 45 m wide channel, with 2.2m LAD. To enable continuous operations of the terminal, the approach channel, turning circle and berth pockets will be dredged to 2.5m depth from LWL. The diameter of the turning circle is 190 m.

# 10 DEVELOPMENT PLAN – ONSHORE FACILITIES

## 10.1 Storage Areas

### 10.1.1 Phase 1A + 1B

It is proposed to have one number covered storage shed for storing bagged cargo. For storing the Bulk construction, consumer goods & project cargo open stockyard is proposed. Containers will be stored in open container yard.

### 10.1.2 Final Phase-(Master Plan)

It is proposed to have second covered storage shed for storing bagged cargo. For storing the Bulk construction, consumer goods & project cargo open stockyard along with Mechanised stockyard is proposed. Containers will be stored in open container yard.

## 10.2 Buildings

Buildings to be developed in Phase-1A

- Worker's amenity building & Septic tank and sock pit
- Electrical substation building - 1
- Pump Room

Buildings to be developed in Phase-1B

- Terminal administration building
- Security office, boundary wall and fencing
- Godown / storage Shed – 1 (Part-1)
- Water tank & Pump house
- Weigh bridge control room-1 (1 nos)

Buildings to be developed in Master Plan

- Electrical substation building – 2
- Godown / storage Shed – 1 (Part-2)
- Godown / storage Shed – 2
- Gate house (2 nos)
- Jal Yatri Niwas (Guest House)
- Banarasi Haat
- Shops/ Kiosks
- Canteen and Toilet Block
- Weigh bridge control room-1 (1 nos)
- Toilet block -(2 nos)

### 10.3 Onshore Utilities

Onshore facilities such as roads, drainage, sewerage, water supply, communication system will be developed in phase wise manner as shown in drawing.

### 10.4 Mechanical Equipment

The mechanical equipment proposed in phases are as follows:

Equipment except Mobile Harbour crane, Weigh Bridge & control cabin, conveying system, rail mounted stacker and Mobile hopper with feeder to be arranged by O&M contractor managing the terminal in working stage.

**Table 8 Phase wise additional requirement of Mechanical Equipment**

| S. No. | Equipment | No. of Equipment | No. of Equipment | No. of Equipment |
|---|---|---|---|---|
| | | Phase 1A | Phase 1B | Final Phase (Master Plan) |
| 1. | Mobile Harbour Crane | 2 | 2(Phase 1a) + 1 | 3(Phase 1a & 1b) +4 |
| 2. | Truck Loading Hopper | 2 | 2(Phase 1a) + 0 | - |
| 3. | Front end loaders | 1 | 1(Phase 1a) + 0 | 1(Phase 1a & 1b) +3 |
| 4. | Dumper Trucks | 1 | 1(Phase 1a) + 0 | 1(Phase 1a & 1b) +0 |
| 5. | Reach stacker | 2 | 2(Phase 1a) + 0 | 2(Phase 1a & 1b) +0 |
| 6. | Weigh Bridge & Control cabin | 1 | 1(Phase 1a) + 0 | 1(Phase 1a & 1b) +1 |
| 7. | Flatbed Truck Trailers / Trucks | 3 | 3(Phase 1a) + 2 | 5(Phase 1a & 1b) +7 |
| 8. | Conveying system (1000TPH) | - | - | 1 Lot |
| 9. | Mobile hopper with feeder | - | - | 2 |
| 10. | Rail mounted stacker 1000 TPH (20m boom) | - | - | 1 |

## 10.5 External Road Connectivity

A two lane road of 650m length is proposed in Phase-1A, which is proposed to be widened to four lane road in Master Plan. An additional four lane road is also proposed in Master Plan on the other side of the Railway track to provide better accessibility to the terminal.

## 10.6 Rail Connectivity

The terminal has a good connectivity with railway network too. The nearest railway station is Jeonathpur Railway Station, which is about 3.75 Kms by road. Mughal Sarai Junction and Varanasi Junction are about 14 kms and 17 kms by road respectively from the proposed site of the terminal. The site with respect to railway network is shown in below figure.


**Figure 1-5 Rail connectivity for Varanasi Multimodal IWT Terminal**

The layout shall allow the provision of rail line inside the terminal such that rail connectivity to the nearest rail head can be achieved suitably.

In order to transport the large quantities of bulk cargo through rail, it is proposed have rail connectivity with in their IWT premises, taking off from DFC (Eastern) corridor with proposed new Jeonathpur cabin and connectivity to IR at Jeonathpur station, Mughalsarai-Allahabad section in Allahabad division of north central railway. Length of rail connectivity line from take off from DFC near Jeonathpur to IWT terminal is 5.1Km and to R&D yard beyond the takeoff is 2km.

The proposed alignment crosses the through agricultural lands, irrigation canal, village roads some stretch of built up area and NH-7.

The total approximate capital cost for connectivity including civil engineering, signalling & Telecommunication, OHE and general electrical works are around 80.98 Cr. (Ref : Railway DPR).

### 10.7 Air Connectivity

The nearest airport is Lal Bahadur Shastri International Airport, Babatpur in Varanasi which is about 37 kms by road from the project site.

## 11 IMPLEMENTATION SCHEDULE

The time frame for implementation of Phase-1A is 24 months.

The time frame for implementation of Phase-1B is 16 months.

# 12 COST ESTIMATES

## 12.1 Capital Costs

The capital cost estimates for Phase-1A of the Terminal considering the base year rate is worked out to be Rs. 181 crores , Phase-1B of the Terminal considering the base year rate is worked out to be Rs. 87 crores & Final Phase of the Terminal considering the base year rate is worked out to be Rs. 406 crores. The above cost is excluding the cost paid for land acquisition and cost to be paid to the local authorities for obtaining electrical & water supply connection. The dredging cost for terminal and approach channel along with navigational aids is included in the overall cost of fairway development and therefore not included under this terminal cost.

## 12.2 Operation and Maintenance Costs

As the entire Operation and maintenance of Terminal will be outsourced to O&M operator, cost of O&M for IWAI will be nil.

# 13 FINANCIAL AND ECONOMIC ANALYSIS

## 13.1 Financial Analysis

Based on the capital cost and operating expenditure, the financial analysis has been carried out considering 30 years of operation. The financial IRR is worked out to be positive – 12.24% for overall development including Phase IA, Phase IB and Master Plan.

## 13.2 Economic Analysis

The economic analysis for Varanasi MMT is carried out considering various economic factors from the projects and the economic IRR is worked out as **41%** for overall development including Phase IA, Phase IB and Master Plan.

# 1 INTRODUCTION

## 1.1 Project Background

Inland Waterways Authority of India (IWAI), an autonomous organization under Ministry of Shipping (MoS), Govt. of India was constituted for development and regulation of inland waterways of the country.

Till an year ago, five waterways namely (i) the Ganga-Bhagirathi-Hugli river system from Haldia to Allahabad (1620 km), (ii) the Brahmaputra from Dhubri to Sadiya (891 km), (iii) West Coast canal from Kottapuram to Kollam along with Champakara and Udyogmandal canals (205 km), (iv) Kakinada-Pondicherry canals integrated with rivers Godavari and Krishna (1095 km) and (v) East Coast canals along with river Brahmani and Mahanadi (621 km), have been declared as National Waterway No. 1, 2, 3, 4 & 5 respectively. During 2016, the government of India have notified 106 more rivers as National Waterways. Thus, now there are 111 waterways.

In this connection, IWAI has appointed M/s Howe Engineering Projects (India) Pvt. Ltd. (HOWE) as Consultant for carrying out detailed feasibility study for capacity augmentation of NW-1 and detailed engineering for its ancillary works and processes between Haldia to Allahabad (Jal Marg Vikas Project).

The present submission deals with the Detailed Project Report (DPR) of the proposed facilities for Multimodal Terminal (MMT) at Varanasi.

## 1.2 Need of the Project

An efficient transport sector is vital for development of the economy of any country and to stimulate competitive business environment. Indian transport system comprises various modes, viz. Railways, Roadways, Inland Waterways, Coastal Shipping and Airways. The main modes of transport are rail and road which are overburdened and experiencing congestion.

India has large number of inland waterways consisting of rivers, canals, backwaters, creeks, and lakes etc. which have the potential for development of efficient waterways transport network. Inland Water Transport (IWT) is a fuel efficient, environment friendly and cost effective mode of transport having potential to supplement the overburdened rail and congested roads. Hence, it is proposed to develop inland water ways and terminals at certain locations for loading and unloading of cargo.

With the above background the development of a multimodal terminal at Varanasi has been initiated by IWAI.

## 1.3 Scope of Work

The broad scope of work for the project is to carry out a technical analysis together with Front-end Engineering and Design work, economic and financial analysis, procurement assessment, operation & management and monitoring & evaluation guideline.

The scope for preparation of the Detailed Project Report is as follows:

- Collection and review of the available data / reports.
- Undertake surveys to ensure adequacy and completeness of data and record details after physical verification, wherever necessary.
- Prepare detailed multimodal terminal layout plan, shore side infrastructure plan, bank protection work, land development plan along with design and structural drawings, specifications, cost estimates for all structures like berthing jetty, approach jetty, covered and open storage along with all allied structures / buildings / facilities like Administrative Buildings, Residential Accommodation, security office, customs enclosure, bunkering of fuel, water supply, electricity supply, firefighting including lighting, requirement of power, water supply, emergency and standby power supply, communication system, Drainage & Sewerage system, boundary wall, fencing, gates, internal roads, etc. Layout developed should permit expansion of terminals to cater to projected traffic beyond the assessed value for the projected time frame.
- Every estimate shall be duly supported by the justification of rates adopted / basis of rates adopted like CPWD rates / market rates / lowest offers / rates received etc.
- Preparation of realistic construction schedule for the ancillary structures indicating the sequence of activities duly considering the river characteristics in different seasons and priority and phasing of work along with phasing of expenditure.
- Preparation of specifications, bill of quantities, estimates and tender documents containing General condition of contract, special condition of contract, technical specification and NIT etc. to facilitate implementation of works after the finalization of Detailed Project Report.
- Work out cost benefit analysis, Financial Internal Rate of Return (FIRR) and Economic Internal Rate of Return (EIRR) of the project based on current Indian/International norms including SWOT analysis with detailed back up calculations, basis, assumption, justification etc. along with their source of information.

# 2 PROJECT SITE ENVIRONMENT

This chapter provides information on location, meteorological, hydrographical parameters, connectivity and existing features to have a complete understanding on the site conditions and to enable proper planning and design of terminal facilities.

## 2.1 Project Location

The Site is located on the eastern side of Ganges at a distance of 9 km up stream of Malviya road cum Railway Bridge connecting Varanasi to Mughalsarai at Latitude 25°15'12.4" North and Longitude 83°01'50.3" East at Varanasi in Uttar Pradesh. Proposed IWT terminal at the bank of Ganga River in Ramnagar Municipal Board of Varanasi district which is south of Viswa Sundari Setu (NH-2) Viaduct is 650 meters from existing National Highway -7 and existing Airport at Babatpur lies at 30 Kms of aerial distance from the proposed site.

The bye pass bridge is on NH2 which is also a part of the Delhi-Kolkata part of Golden Quadrilateral. The site will have connectivity from NH7 via proposed access road.

Location on Google image of the proposed terminal is shown in the figure below:


**Figure 2-1 Location of Site for Varanasi Multimodal IWT Terminal**

## 2.2 Land Availability

The multi-cargo Inland Water Transport (IWT) terminal is proposed in an area of about 81 acres (32 Ha). The land belongs to both govt and private parties and is under acquisition for the project. In the entire 32.0 ha, there are no houses or built structures.

## 2.3 Infrastructure at the Project Site

The infrastructure near the project site is as follows:

### 2.3.1 Road Connectivity

The terminal has a good connectivity with national highway network. The nearest national highway from the terminal is NH-7, which runs parallel to the river on the eastern side. Another national highway is NH-2 which connects Allahbad to Aurangabad through Varanasi. The site lies at the intersection of these two national highways. The terminal is about 650 m (proposed access road) from NH-7. Further to the east NH-2 connects the terminal to Buxar, Ballia, Chhapra, Sonepur and Patna. The site location with respect to National Highways is shown in below figure. The by-pass bridge is on NH2 which is also a part of the Delhi-Kolkata part of Golden Quadrilateral.


**Figure 2-2 Road connectivity for Varanasi Multimodal IWT Terminal**

### 2.3.2 Rail Connectivity

The terminal has a good connectivity with railway network too. The nearest railway station is Jeonathpur Railway Station, which is about 3.75 Kms by road. Mughal Sarai Junction and Varanasi Junction are about 14 kms and 17 kms by road respectively from the proposed site of the terminal. The site with respect to railway network is shown in below figure.


**Figure 2-3 Rail connectivity for Varanasi Multimodal IWT Terminal**

The layout shall allow the provision of rail line inside the terminal such that rail connectivity to the nearest rail head can be achieved suitably.

In order to transport the large quantities of bulk cargo through rail, it is proposed have rail connectivity with in their IWT premises, taking off from DFC (Eastern) corridor with proposed new Jeonathpur cabin and connectivity to IR at Jeonathpur station, Mughalsarai-Allahabad section in Allahabad division of north central railway. Length of rail connectivity line from take off from DFC near Jeonathpur to IWT terminal is 5.1Km and to R&D yard beyond the takeoff is 2km.

The proposed alignment crosses the through agricultural lands, irrigation canal, village roads some stretch of built up area and NH-7.

The total approximate capital cost for connectivity including civil engineering, signalling & Telecommunication, OHE and general electrical works are around 80.98 Cr. (Ref : ARVEE Associate DPR).

### 2.3.3 Air Connectivity

The nearest airport is Lal Bahadur Shastri International Airport, Babatpur in Varanasi which is about 37 kms by road from the project site.

### 2.3.4 Nearest Towns

The nearest towns are Ramnagar and Varanasi which are in vicinity of the project site. The nearest village is Bhitti Village.

## 2.4 Meteorological Parameters

The meteorological data of the project site has been obtained from the Climatological Handbook of India, 1971 to 2000 published by Indian Meteorology Department. The nearest IMD observatory to project site was at the Sanskrit University. Surrounding area is plain with numerous trees in all directions. The river Ganga is to the southeast about 3 kms. away from the observatory and the river Baruna is to the north within 1 km. Wind instruments on wooden platform on the top of the College building.

### 2.4.1 Temperature

The temperature details at Varanasi are shown in Table below. The table gives the mean of daily maximum, minimum, highest and lowest and extreme highest and lowest temperatures. The month of January is the minimum and May is maximum of mean of daily temperature. Mean of highest temperature recorded in the month of May is 44.3°C and the mean lowest temperature recorded in the month of January is 5.3°C. The extreme highest and lowest temperature recorded 47.2°c and 1.7°C for the month of May and February respectively. The minimum temperature slumped down to 1.7° C.

**Table 2-1 Recorded Mean Daily and Extreme Temperatures**

| Month | Recorded Temperature ($^{o}$C) | | | | Extreme | |
|---|---|---|---|---|---|---|
| | Mean Daily Maximum | Mean Daily Minimum | Highest Maximum | Lowest Minimum | Highest | Lest |
| January | 23.1 | 9.6 | 27.4 | 5.3 | 31.1 | 2.5 |
| February | 26.8 | 12.0 | 32.0 | 7.2 | 36.1 | 1.7 |
| March | 33.1 | 17.1 | 38.3 | 12.1 | 41.1 | 6.7 |
| April | 38.7 | 22.8 | 42.4 | 18.0 | 44.4 | 11.1 |
| May | 41.1 | 26.4 | 44.3 | 22.2 | 47.2 | 17.3 |
| June | 38.7 | 27.8 | 43.7 | 23.7 | 47.2 | 20.6 |
| July | 33.7 | 26.2 | 38.2 | 23.4 | 45.0 | 20.0 |
| August | 32.7 | 25.8 | 35.9 | 23.4 | 40.1 | 22.1 |
| September | 32.8 | 24.9 | 35.8 | 22.5 | 38.5 | 17.8 |
| October | 32.8 | 21.1 | 35.3 | 16.6 | 39.4 | 11.7 |
| November | 29.1 | 14.3 | 32.5 | 10.5 | 36.0 | 5.0 |
| December | 24.5 | 10.2 | 28.0 | 6.4 | 32.8 | 2.2 |

*Source: IMD*

### 2.4.2 Wind

The mean wind speed recorded by the observatory nearest to the project site is Varanasi which is found to be in the range of 1.9 m/s to 4.9 m/s. As per IS 875 Part-3, the basic wind speed at Varanasi is 47.0m/s.

### 2.4.3 Relative Humidity

The humidity is moderate to high throughout the year with the mornings being more humid than evenings. The mean relative humidity for each month of the year measured during mornings and evenings is as tabulated below:

**Table 2-2 Mean Relative Humidity**

| Month | Mean Relative Humidity (%) | |
|---|---|---|
| | Morning (0530 hrs) | Evening (1730 hrs) |
| January | 75 | 51 |
| February | 64 | 39 |
| March | 49 | 28 |
| April | 40 | 24 |
| May | 47 | 27 |
| June | 62 | 47 |
| July | 82 | 72 |
| August | 85 | 78 |
| September | 82 | 73 |
| October | 71 | 57 |
| November | 65 | 50 |
| December | 73 | 53 |

*Source: IMD*

### 2.4.4 Rainfall

The area is dominated by south-west monsoon during June to October rather than north-east monsoon during December to March. The area received almost 90 % of the rainfall during south-west monsoon. The average annual rainfall in the region is about 1003.3 mm. The month-wise distribution of the average rainfall recorded for each month of the year is as follows:

**Table 2-3 Annual Rainfall Data**

| Month | Monthly Total (mm) | Number of Rainy Days | Heaviest Fall in 24 Hours (mm) | Year |
|---|---|---|---|---|
| January | 20.3 | 1.8 | 69.6 | 1984 |
| February | 12.5 | 1.1 | 67.1 | 1990 |
| March | 10.4 | 1.0 | 37.1 | 1982 |
| April | 4.3 | 0.5 | 40.0 | 1993 |
| May | 11.5 | 0.9 | 31.6 | 1990 |
| June | 85.6 | 4.5 | 159.5 | 1999 |
| July | 303.8 | 12.5 | 288.3 | 1990 |
| August | 281.3 | 13.3 | 321.6 | 1988 |

| Month | Monthly Total (mm) | Number of Rainy Days | Heaviest Fall in 24 Hours (mm) | Year |
|---|---|---|---|---|
| September | 214.9 | 9.4 | 349.5 | 1987 |
| October | 39.8 | 2.2 | 138.9 | 1996 |
| November | 15.5 | 0.3 | 161.5 | 1995 |
| December | 3.4 | 0.3 | 53.1 | 1995 |
| Total | 1003.3 | 47.8 | 1761.8 | |

*Source: IMD*

### 2.4.5 Thunders and Dust Storms

The area is located far from the sea coasts and hence is not prone to cyclones. On an average about 13 days in a year the area faces thunders and dust storms. Rest of the year remains calm. It is evident that fog is very less in this region except in the month of January. Thunder rains occur generally only in the month of July and August. In other months thunders and rains are less. So it is quite suitable for navigation at Varanasi.

### 2.4.6 Visibility

The visibility in the project area is generally good throughout the year, except for a few days during the winter season and during periods of heavy rain. On an average, the visibility is less than 4 km for about 65 days in a year.

## 2.5 Hydrographical / River Conditions

### 2.5.1 Water Levels

The following water levels have been considered for planning of the terminal at the Site.

**Table 2-4 Water Levels**

| | |
|---|---|
| High Flood Level (HFL) | RL +73.90 M |
| Low Water Level (LWL) | RL +58.22 M |

### 2.5.2 Current

The currents in the river are significant and vary season to season. It may be as high as 4.0 m/s during high flood and as low as 0.5 m/s during low flow.

### 2.5.3 Discharge

Average and annual monthly discharge data as available between 1971 and 1989 and also for the year 2000 at Varanasi is shown in Table 2.5.

**Table 2-5 Details of discharge at Varanasi in $m^3$ /sec**

| Month | Discharge at Varanasi in $m^3$ /sec | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ave 71-82 | Ave 84-87 | Ave 85-88 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 2000 |
| Jan | 472 | - | 469.54 | - | 562.98 | 514.34 | 511.48 | 289.36 | 481.98 | 754.3 |
| Feb | 464 | - | 406.37 | - | 366.46 | 650.93 | 326.45 | 281.63 | 359.88 | 580.8 |
| Mar | 417 | - | 333.22 | - | 261.30 | 432.21 | 352.29 | 287.06 | 229.76 | 486.0 |
| April | 370 | - | 274.91 | - | 214.89 | 374.00 | 237.26 | 273.50 | 231.03 | 374.0 |
| May | 319 | - | 220.59 | - | 164.78 | 295.20 | 237.42 | 184.95 | 160.80 | 332.0 |
| June | 586 | - | 217.74 | 540.70 | 169.77 | 318.28 | 212.05 | 170.84 | 404.82 | 1273.0 |
| July | - | - | - | 2643.84 | 2018.52 | 10295.96 | 1192.26 | 6031.45 | 1144.7 | - |
| Aug | - | - | - | 11097.87 | 15782.52 | 18971.47 | 3035.65 | 16769.75 | 4447.0 | - |
| Sep | - | - | - | 13706.63 | 9283.33 | 5323.57 | 14921.42 | 4609.81 | 6882 | - |
| Oct | - | - | - | 1739.03 | 13825.34 | 2164.20 | 2430.52 | 3285.18 | 1259 | - |
| Nov | 1071 | 1287.05 | - | 897.23 | 2493.41 | 892.15 | 829.42 | 884.55 | 568.11 | - |
| Dec | 625 | 340.31 | - | 410.36 | 811.63 | 612.41 | 256.90 | 486.59 | 365 | - |

*(Source: CWC, Varanasi)*

Table 2.6 shows the maximum flood discharge at Varanasi between 1959 and 1976.

**Table 2-6 Data on floods at Varanasi in m3/sec (Source: CWC, Varanasi)**

| Sl. No. | Year | Gauge | Q Max (Cumecs) |
|---|---|---|---|
| 1. | 1959 | 70.71 | 32,590 |
| 2. | 1960 | 70.96 | 29,401 |
| 3. | 1961 | 70.00 | 21,169 |
| 4. | 1962 | 70.78 | 25,050 |
| 5. | 1963 | 69.84 | 23,451 |
| 6. | 1964 | 69.71 | 24,008 |
| 7. | 1965 | 68.85 | 18,220 |
| 8. | 1966 | 69.01 | 18,062 |
| 9. | 1967 | 72.81 | 30,736 |
| 10. | 1968 | 68.98 | 19,850 |
| 11. | 1969 | 71.01 | 34,702 |
| 12. | 1970 | 71.11 | 34,890 |
| 13. | 1971 | 72.69 | 46,186 |
| 14. | 1972 | 64.43 | 24,700 |

| | | | |
|---|---|---|---|
| 15. | 1973 | 71.03 | 30.451 |
| 16. | 1974 | 69.441 | 21,975 |
| 17. | 1975 | 69.42 | 23,662 |
| 18. | 1976 | 69.84 | 20,234 |
| 19. | 1977 | 72.16 | 30,362 |
| 20. | 1978 | 67.64 | - |
| 21. | 1979 | - | - |

The maximum discharge varied between a minimum of 18,062 m3/sec in 1966 and maximum of 46,186 m3/sec in 1971.

### 2.5.4 Morphological condition

This site is located on what is presently a deep channel with more than 2.5m of water depth close to the shoreline. The river has no meandering tendency in this reach. The bank has been stable for so many years as can been seen in the past 10 years of imagery. It is to mention here the bridge on river Ganga for NH-2 is acting as a control point to keep the river in position.

2008

2010

2012

2014

2016

2017

## 2.6 Natural Hazards

### 2.6.1 Seismicity

The terminal falls under the seismic Zone III as per IS: 1893 – 2000.

# 3 FIELD SURVEYS AND INVESTIGATIONS

The secondary data on the topography of the terminal site, landside as well as riverside geotechnical data and bathymetric data of the river was not available. These details were collected by carrying out field surveys and investigations.

## 3.1 Topographic Surveys

The topographic survey of site was carried out during August 2015 by the agency appointed by M/s. HOWE (JV), namely M/s Ocean Science and Surveying Pvt. Ltd.

- The proposed site for the terminal is relatively plain and the existing Ground level varies from around (+) 69 m to (+) 78 m from MSL.
- There exists a Nallah within the proposed land for the terminal. The Nallah is a natural drain which originates around 4.5 Kms from the site. The Nallah comes under Bhitti Gram Panchayat. In the master plan it is proposed to divert this nallah. Average ground level of nallah varies from around (+) 59 m to (+) 65 m from MSL.

The topographic survey data is enclosed as **Drawing I-525-VTR-201**.

## 3.2 Geotechnical Investigations

A Geotechnical investigation for the proposed site was undertaken by M/s CENGRS Geotechnica Pvt. Ltd. and detailed report was submitted in 2003. Two boreholes on land (BH-2 & BH-4) were drilled up to 20.0m below EGL and two boreholes in river (BH-1 & BH-3) were drilled up to 40.0m below EGL to get the understanding on the subsurface profile. The Geotech report indicates that the average ground level is around RL (+) 76.0m for land side and average bed level is around RL (+) 52.0m for river side.

**Land Boreholes (BH-2 & BH-4)**

The substrata encountered on the land boreholes are found to be consistent in both the Boreholes. The sub-soil profile is found to be uniform in both the boreholes consists of hard clayey silt with SPT N values greater than 30 up to termination of boreholes.

Average SPT N values are presented in tabular form below

| Stratum No. | Stratum Description | Soil Classification | Average Standard Penetration Test (N) Value | Thickness of Stratum |
|---|---|---|---|---|
| I | Hard Clayey SILT | MI | > 30 | 20m |

**River Boreholes (BH-1 & BH-3)**

The substrata encountered on the river boreholes are found to be consistent with varying thicknesses. The top soil is observed to be Hard Clayey SILT with traces of gravel followed by very dense Sandy Silt which is then underlain by dense to very dense silty SAND up to termination of boreholes.

Average SPT N values are presented in tabular form below

| Stratum No. | Stratum Description | Soil Classification | Average Standard Penetration Test (N) Value | Approximate Thickness of Stratum |
|---|---|---|---|---|
| I | Hard Clayey SILT with gravel mixture | MI | > 30 | 27.0m |
| II | Very Dense Sandy Silty | CL | > 50 | 3.0m |
| III | Dense to very dense silty SAND | SM | > 50 | 10.0m |

Based on the review of geotechnical data (Reference: Report on geotechnical investigations at Varanasi terminal– 2003). The existing ground level varies from RL 62.0 and RL 78.0 and finished ground level is proposed to be at approximate RL 75.0m. Thus filling of approximately 6.0 to 10.0 m above Existing ground level and cutting of 2.0m to 3.0m below EGL is expected.

**Land Side (BH-2 & BH-4)**

1. Shallow foundation is proposed for lightly loaded structure like administration building, substation and other facilities. The net safe bearing capacity shall be considered as 125 kPa for design. The minimum embedment depth for the footing shall be 1.5m below finished ground level.

2. However the net safe bearing capacity shall be considered as 80kPa for the foundations resting on filled up soil. It has been assumed that the filling shall be carried out using well graded soil and % of passing through 0.075mm (i.e. fines) shall not be more than 20%. The filling material shall be placed in layers of uniform thickness; each layer shall not exceed 250 mm compacted thicknesses.

3. The permissible settlement shall be 50mm for isolate footings and 75mm for raft foundations.

4. For Stack Yard locations, the heap may be laid on the finished ground level. No soil replacement is envisaged.

**River Side (BH-1 & BH-3)**

Berths and Approach trestle proposed for river side will have deep foundations. Bored cast in-situ pile foundation shall be provided to support the super structure loads. The following pile capacities are estimated for different diameters for preliminary design purpose.

| Pile Diameter | Pile Termination level | Embedded length of pile below Cut-off level | Vertical Capacity of Pile | Uplift Capacity of Pile |
|---|---|---|---|---|
| (mm) | (RL m) | (m) | (kN) | (kN) |
| 1000 | 32 | 43.0 | 1410 | 820 |
| 1200 | 32 | 43.0 | 1770 | 980 |
| 1000 | 30 | 45.0 | 1630 | 960 |
| 1200 | 30 | 45.0 | 2060 | 1160 |
| 1000 | 26 | 49.0 | 2060 | 1260 |
| 1200 | 26 | 49.0 | 2630 | 1530 |
| 1000 | 24 | 51.0 | 2280 | 1430 |
| 1200 | 24 | 51.0 | 2900 | 1740 |

Pile Cut-off level has been assumed as RL 75m.

Scour level has been assumed as RL 50m.

## 3.3 Bathymetry Survey

The topographic survey of site was carried out during August 2015 by the agency appointed by M/s. HOWE (JV), namely M/s Ocean Science and Surveying Pvt. Ltd. The existing river bed depth near the proposed terminal varies from (-) 4.0 m to (-) 12.0 m below LWL. The bathymetric survey data is enclosed as **Drawing I-525-VTR-202**.

# 4 TRAFFIC FORECAST

IWAI has appointed M/s Hamburg Port Consulting, GmBH and M/s Universal Transport Consulting, GmBH as consultants for carrying out market analysis of Multi-modal terminal at Varanasi.

On the basis of the collected origin-destination pairs (O/D-pairs), the Consultants forecasted the traffic for Varanasi (Ramnagar) MMT from base year 2015 until 2045 as mentioned in the below table.

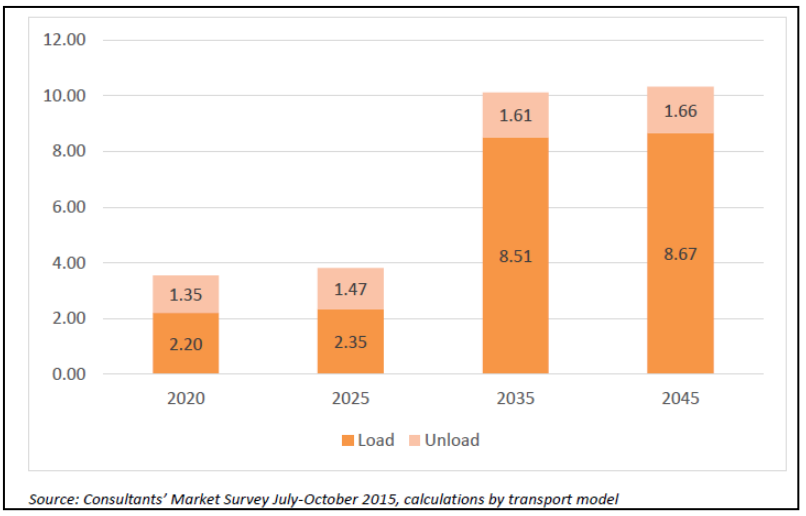
**Table 4-1 Varanasi MMT - 2020 to 2045 cargo forecast by cargo type (million tons)**

| Cargo | 2020 (MT) | 2025 (MT) | 2035 (MT) | 2045 (MT) |
|---|---|---|---|---|
| Bagged | 1.40 | 1.50 | 3.31 | 3.37 |
| Container | 0.16 | 0.17 | 0.19 | 0.21 |
| Dry Bulk | 0.14 | 0.15 | 4.25 | 4.34 |
| General Cargo | 0.66 | 0.69 | 0.74 | 0.75 |
| Neo-Bulk | 1.13 | 1.23 | 1.27 | 1.29 |
| Ro-Ro | 0.05 | 0.05 | 0.35 | 0.36 |
| Liquid Bulk | 0.01 | 0.01 | 0.01 | 0.01 |
| Total | 3.55 | 3.82 | 10.12 | 10.32 |

Source: HPC report on Infrastructure requirement of individual terminals along National Waterways 1, 26th April 2016.

Summary of Loaded and Unloaded traffic at the Terminal as forecasted in HPC report is shown in below figure:

**Figure 4.1 Loaded versus Unloaded Cargo 2020 to 2045**




## 4.1 Traffic to be handled

Considering the restriction in the availability of water front, maximum of five berths can be developed. Therefore, alternate layouts have been worked out based on various discussion held with IWAI, the following commodities has been considered as the targeted cargoes and the individual berth capacities for handling the targeted commodities have been worked out as described below:

### 4.1.1 Bagged and General Cargo

Bagged construction material and bagged food /food stuff will come to the terminal by barges and unloaded by MHC cranes into trucks and transported to the covered shed. Then it will be loaded to trucks/rail and transported to the hinterland by trucks or Rail.

### 4.1.2 Bulk Cargo

Construction material and consumer goods will come to the terminal by barges and unloaded by MHC cranes into loading hopper and transported to the storage yard by conveying system/trucks. Then it will be loaded to trucks/rail by pay loader and transported to the hinterland by trucks/Rail.

### 4.1.3 Containers

Containers will come to the terminal by barges and unloaded by MHC cranes into trucks and transported to the container yard. Unloading from trucks will by reach stacker. Then it will be loaded to trucks/rail by reach stacker and transported to the hinterland by trucks/rail

**Table 4-2 Phase wise Total Traffic**

| Commodity | Phase 1a | | Phase 1b | | Final Phase | |
|---|---|---|---|---|---|---|
| | No. of berths | Traffic in MTPA | No. of berths | Traffic in MTPA | No. of berths | Traffic in MTPA |
| Construction Material Bulk | | 0.21 | 2 | 0.31 | 5 | 1.53 |

| Commodity | Phase 1a | | Phase 1b | | Final Phase | |
|---|---|---|---|---|---|---|
| | No. of berths | Traffic in MTPA | No. of berths | Traffic in MTPA | No. of berths | Traffic in MTPA |
| Construction Material Bagged | 2 | 0.21 | | 0.31 | | 1.53 |
| Consumer goods Bulk | | 0.08 | | 0.14 | | 0.17 |
| Containers | | 0.04 | | 0.06 | | 0.08 |
| Food and food stuff Bagged | | 0.25 | | 0.36 | | 0.44 |
| Project Cargo | | 0.06 | | 0.08 | | 0.10 |
| Total | 2 | 0.84 | 2 | 1.26 | 5 | 3.85 |

# 5 VESSEL SIZES

The size of vessels that would call at any terminal will generally be governed by the following aspects:

- The trading route
- Availability of a suitable vessel in the market
- Available facilities mainly navigational channel and manoeuvring areas including the draft
- The available facilities for loading & unloading
- Volume of annual traffic to be handled and the likely parcel size as per the requirements of the user agency.

The following main cargo commodities for proposed terminal at Varanasi have been identified:

- Construction material
- Food and Food stuff
- Consumer Goods
- Project Cargo
- Container

## 5.1 Vessel Sizes

The size of vessels calling at the proposed IWT terminal at Varanasi is restricted by the availability of draft in the navigation channel of National Waterway-1. Based on the LAD of 2.5 m in the navigational channel, self-propelled barges of sizes presented in table below can ply in the inland waterways.

**Table 5-1 Vessels that can Ply in Inland Waterways with LAD of 3.0 m**

| Tonnage (T) | Length (m) | Beam (m) | Draft (m) |
|---|---|---|---|
| 650 - 1000 | 60 - 80 | 8.20 | 2.20 |
| 1000 - 1500 | 80 - 85 | 9.50 | 2.20 |
| 1500 - 3000 | 85 - 95 | 15.00 | 2.50 |

## 5.2 Design Vessel Size

As per the proposed plan, the LAD at Varanasi shall be 2.5m, the design vessel is considered as 3000 DWT but it shall be partially loaded up to maximum of 2000 DWT.

**Table 5-2 Design Vessels Size**

| Vessel Type | Vessel Size (DWT) | LOA (m) | Beam (m) | Loaded Draft (m) |
|---|---|---|---|---|
| Design vessel size proposed at Varanasi terminal | 3,000 | 95 | 15.00 | 2.5 |

However, IWAI is getting the model vessel designed and details are yet to be made available.

# 6 FACILITY REQUIREMENT

The marine infrastructure and shore based infrastructure shall be planned and developed to cater to the cargo forecast. Development of the terminal infrastructure shall also be suitably phased in such a way that the initial phases integrate well with subsequent phases.

## 6.1 Traffic to be handled

As the IWT sector is in a nascent stage, the diversion of traffic to IWT would depend on the government policies and several other factors. Hence on a conservative side, the traffic projection for the base case as arrived at in the traffic report by M/s Hamburg Port Consulting GmBH and M/s Universal Transport Consultancy GmBH has been adopted. This is given in chapter 4. The projected Cargo govern in the HPC report has been reduced due to site constraints which have also been discussed in Chapter 4.

## 6.2 Marine infrastructure

The marine infrastructure comprises of jetties and manoeuvring areas like approach channels, turning circle, berthing pockets, holding area, etc.

### 6.2.1 Navigational and Operational requirements

The basic navigational and operational requirements to service the vessels calling at a port / terminal are:

- Sufficient depth in manoeuvring area and at the berths
- Sufficient depth and width in approach channel
- Adequate berthing infrastructure including berth fixtures like fenders
- Mooring system
- Navigational aids

Dimensions of navigable water ways generally comply with guidelines provided in the BIS Code of Practice IS: 4651– 1980 “Code of Practice for Planning and Design of Ports and Harbours - Part V - Layout and Functional Requirements” and as per PIANC guidelines for Design guidelines for Habour approach channels.

#### *6.2.1.1 Design Vessels*

The dimensions of manoeuvring areas are dependent on the design vessels arriving at the terminal and details of the same is presented in Table 5.2.

#### *6.2.1.2 Channel Length*

Since the depth availability is sufficient at Terminal location, no separate approach channel is required.

#### *6.2.1.3 Channel Depth*

The proposed depth of the approach channel is 2.5 m from LWL excluding any siltation allowances.

#### *6.2.1.4 Channel Width*

The channel width for a one way channel is arrived based on the following considerations as per PIANC guidelines:

**Table 6-1 Considerations for Channel Width**

| | |
|---|---|
| Basic manoeuvring lane | 1.5 B |
| Bank Clearance (both sides sloping) | 2 x 0.3 B |
| Allowance for currents | 0.7 B |
| Allowance for depth | 0.1 B |
| Allowance for channel bottom | 0.1 B |
| Total | 3.0 B |

Based on the above, the channel width in the straight leg of the channel for 3,000 DWT vessel is 45m.

### 6.2.2 Turning circle dimensions and depth at Berth

#### *6.2.2.1 Turning Circle*

The turning circle, required to swing and berth the vessels, is very important and must have proper configuration, dimensions and access. As per IS: 4651 (Part V) – 1980, the minimum diameter of the turning circle should be 1.7 to 2.0 times (1.7 for protected locations and 2.0 for exposed locations) the length of the largest vessel.

Keeping these requirements in view, the dimension of the turning circle would be as 190m. Since the depth & width available is sufficient at Terminal location, no separate turning circle is required.

#### *6.2.2.2 Depth at Berths*

Based on table 6.1, the dredge depth at berth location is 2.5m from LWL.

In order to work out the berth requirements to meet the projected traffic, it is necessary to define the following governing parameters:

- Average parcel size
- Cargo handling arrangement
- Cargo handling rates
- Number of operational days per year

- Number of working hours per day
- Effective working hours per day
- Time required for peripheral activities

Each of the above parameters is discussed below.

#### *6.2.2.3 Average Parcel Size*

Though the design vessel size is the guiding parameter in arriving at the dimensions of the navigable water ways, in actual practice vessels of various sizes will arrive at the IWT terminal. For ascertaining the requirement of number of berths, it is prudent to consider the average parcel size for each commodity and details of the same are presented below.

**Table 6-2 Average Parcel Size**

| Commodity | Average Parcel Size (T) |
|---|---|
| Bulk and Bagged Cargo | 1000 |
| Containers | 75 TEU |

#### *6.2.2.4 Cargo Handling Arrangements*

For estimating the required number of berths, the handling arrangements assumed for various commodities of the IWT terminal at Varanasi are described below:

6.2.2.4.1 Bagged Cargo

Bagged Cargo like food grains, vegetables, agricultural produce, jute, cloths, cement etc. will come to the terminal by barges and unloaded by MHC cranes into trucks and transported to the covered shed. Then it will be loaded to trucks/rail and transported to the hinterland by trucks/rail.

6.2.2.4.2 Bulk Cargo

Bulk material consumer goods will come to the terminal by barges and unloaded by MHC cranes into trucks and transported to the storage yard. Then it will be loaded to trucks/rail by pay loader and transported to the hinterland by trucks/rail. Bulk material Stone Chips, will come to the terminal by barges and unloaded by MHC cranes into Mobile hopper and transported to the storage yard by conveying system in final phase. Then it will be loaded to trucks/rail by pay loader and transported to the hinterland by trucks / rail.

6.2.2.4.3 Containers

Containers will come to the terminal by barges and unloaded by MHC cranes into trucks and transported to the container yard. Unloading from trucks will by reach stacker. Then it will be loaded to trucks/rail by reach stacker and transported to the hinterland by trucks/rail.

#### *6.2.2.5 Cargo Handling Rates*

Based on the above cargo handling arrangements for various commodities, the cargo handling rates assumed are presented in table below:

**Table 6-3 Cargo Handling Rates**

| S. No. | Cargo | Handling Rate (TPD) | Handling Rate (TPD) | Handling Rate (TPD) |
|---|---|---|---|---|
| | | Phase 1A | Phase 1B | Final Phase (Master Plan) |
| 1. | Bulk Construction Material | 4615 | 4615 | 4615 |
| 2. | Bulk Consumer Goods | 2609 | 2609 | 2609 |
| 3. | Bagged Construction Material | 2609 | 2609 | 2609 |
| 4. | Bagged food and food stuff | 2609 | 2609 | 2609 |
| 5. | Containers | 277 TEU | 290 TEU | 340 TEU |
| 6. | Project Cargo | 1304 | 1304 | 1304 |

#### *6.2.2.6 Number of Operational Days*

It is assumed that Varanasi Terminal will work seven days a week, which brings the effective number of working days to 315 days per year, allowing for 50 non-operational days due to weather and other reasons.

#### *6.2.2.7 Number of Operational Hours*

The productive cargo handling hours on an average in a day when the vessels are at berth has been taken as 20 hours to account for shift changes, equipment position changes and for any unplanned stoppages.

#### *6.2.2.8 Time Required for Peripheral Activities*

Apart from the actual time for loading / unloading cargo, additional time is required for other activities such as berthing, de-berthing and other incidental activities, for which 1 hour has been considered per barge.

#### *6.2.2.9 Allowable Levels of Berth Occupancy*

Berth occupancy is expressed as the ratio of the total number of days per year that a berth is occupied by a vessel (including the time spent in peripheral activities) to the number of terminal operational days in a year. High levels of berth occupancy will result in bunching of vessels resulting in undesirable pre-berthing detention. For limited number of berths and with random arrival of vessels, the berth occupancy levels have to be kept low to reduce this detention. The norms generally followed for planning the number of berths, in ports worldwide and in Indian ports are indicated in the table below:

**Table 6-4 Norms for Berth Occupancy**

| No. of Berths | International Standards | Indian Practice | |
|---|---|---|---|
| | | Bulk Cargo | General Cargo |
| 1 | 40 % | 60 % | 70 % |
| 2 | 50 % | 70 % | 70 % |
| 3 | 55 % | 70 % | 70 % |
| 4 | 60 % | 70 % | 75 % |
| 5 | 65 % | 70 % | 75 % |
| 6 and above | 70 % | 70 % | 75 % |

*Source: UNCTAD Publication*

In the IWT, random arrival of vessels can be reduced by regulation of the vessel movements. The following berth occupancy factors are recommended while planning of Varanasi Terminal:

**Table 6-5 Recommended Berth Occupancy Factors for Varanasi Terminal**

| No. of berths | Recommended Berth Occupancy (%) |
|---|---|
| 1 | 75 |
| 2 or more | 75 |

#### *6.2.2.10 Berth Requirements*

Based on the considerations discussed above, the requirements of cargo handling berths for Varanasi Terminal in final Phase have been calculated as shown in tables below.

**Table 6-6 Requirement of Berths for Phase-1A**

| Commodities to be Handled | Import (I) / Export (E) | Handling Rate TPD | Average Parcel Size T | Phase - IA | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Annual Throughput MTPA | Ship Calls/ Annum | Berth Days Required | Berths Provided | Combined Berth Occupancy |
| Bulk constru. Material | **I** | 4615 | 1,000 | 0.21 | 205 | 44 | **2** | **49%** |
| Bagged Constru.Material | **I** | 2,609 | 1,000 | 0.21 | 205 | 79 | | |
| Bulk Consum. Goods | **I/E** | 2,609 | 1000 | 0.08 | 83 | 32 | | |
| Bagged Food/ Food stuff | **I** | 2,609 | 1000 | 0.25 | 245 | 94 | | |
| Containers | **I/E** | 277 TEU | 75TEU | 0.04 | 44 | 12 | | |
| Project Cargo | **I** | 1304 | 500 | 0.06 | 120 | 46 | | |

**Table 6-7 Requirement of Berths for Phase-1B**

| Commodities to be Handled | Import (I) / Export (E) | Handling Rate TPD | Average Parcel Size T | Phase - IB | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Annual Throughput MTPA | Ship Calls/ Annum | Berth Days Required | Berths Provided | Combined Berth Occupancy |
| Bulk constru. Material | **I** | 4615 | 1,000 | 0.306 | 306 | 67 | **2** | **73%** |
| Bagged Constru.Material | **I** | 2,609 | 1,000 | 0.306 | 306 | 117 | | |
| Bulk Consum. Goods | **I/E** | 2,609 | 1000 | 0.14 | 140 | 54 | | |
| Bagged Food/ Food stuff | **I** | 2,609 | 1000 | 0.364 | 364 | 140 | | |
| Containers | **I/E** | 290 TEU | 75TEU | 0.06 | 66 | 17 | | |
| Project Cargo | **I** | 1304 | 500 | 0.084 | 168 | 65 | | |

**Table 6-8 Requirement of Berths for Final Phase (Master Plan)**

| Commodities to be Handled | Import (I) / Export (E) | Handling Rate TPD | Average Parcel Size T | Final Phase – (Master Plan) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Annual Throughput MTPA | Ship Calls/ Annum | Berth Days Required | Berths Provided | Combined Berth Occupancy |
| Bulk constru. Material | **I** | 4615 | 1,000 | 1.53 | 1530 | 332 | **5** | **79%** |
| Bagged Constru.Material | **I** | 2,609 | 1,000 | 1.53 | 1530 | 587 | | |
| Bulk Consum. Goods | **I/E** | 2,609 | 1000 | 0.168 | 168 | 65 | | |
| Bagged Food/ Food stuff | **I** | 2,609 | 1000 | 0.44 | 440 | 169 | | |
| Containers | **I/E** | 340 TEU | 75TEU | 0.08 | 93 | 21 | | |
| Project Cargo | **I** | 1304 | 500 | 0.10 | 200 | 77 | | |

#### *6.2.2.11 Length of the Berths*

The requirement of the berth length for various commodities is estimated below:

Maximum length of the vessel is 95 M, assuming 2 vessels of length 95 and 65 the total length of the jetty is 200m (10+95+20+65+10) in Phase 1A & 1B. Similarly in final phase, the development of Jetty works out to be 300m.

## 6.3 Shoreside Infrastructure

The shore based infrastructure comprises of cargo storage areas, terminal buildings, road and rail networks, conveyor and pipeline networks, utilities and services such as power and water supply, drainage, nallah diversion, sewerage, etc.

### 6.3.1 Storage Area Requirements

As per industry practice and UNCTAD guidelines, the storage capacity at terminal for a particular commodity should at least cater to the higher of the following:

- 22 days storage (6% of the annual cargo throughput); or
- 1.5 times the maximum parcel size.

Other factors to be taken into account in determining the size of the terminal storage areas are material densities, angle of repose, average stacking height, etc.

**Table 6-9 Storage Area Requirement for Varanasi Terminal**

| S. No. | Commodity | Storage Area for Phase 1A (in SqM) | Storage Area for Phase 1B (in SqM) | Storage Area for Final Phase (in SqM) |
|---|---|---|---|---|
| 1 | Bagged Cargo – Construction Material | ~ 4928 | ~ 7,269 | ~ 28,463 |
| 2 | Bulk Cargo – Construction Material | ~ 5250 | ~ 9,000 | ~ 24,150 |
| 3 | Container | ~2310 | ~3,360 | ~4,830 |
| 4 | Project Cargo | ~ 2,145 | ~ 3,000 | ~ 3,578 |
| 5 | Bulk Cargo – Consumer Goods | ~ 3000 | ~ 6,000 | ~ 6,000 |
| 6 | Bagged Cargo – Food and food stuff | ~ 13300 | ~ 19,675 | ~ 18,996 |
| | Total | 30,931 | 48,304 | 86,017 |

The above storage areas duly account for the circulation space within the storage area for effective stacking/removal of cargo.

### 6.3.2 Utilities and Services

#### *6.3.2.1 Buildings*

Various buildings envisaged in the terminal are as follows:

Buildings under construction in Phase-1A

- Worker's amenity building & Septic tank and sock pit
- Electrical substation building - 1
- Pump Room

Buildings to be developed in Phase-1B

- Terminal administration building
- Security office, boundary wall and fencing
- Godown / storage Shed – 1 (Part-1)

- Water tank & Pump house
- Weigh bridge control room-1 (1 nos)

Buildings to be developed in Master Plan

- Electrical substation building – 2
- Godown / storage Shed – 1 (Part-2)
- Godown / storage Shed – 2
- Gate house (2 nos)
- Jal Yatri Niwas (Guest House)
- Banarasi Haat
- Shops/ Kiosks
- Canteen and Toilet Block
- Weigh bridge control room-1 (1 nos)
- Toilet block -(2 nos)

#### *6.3.2.2 Bunkering*

It is proposed to have fuel bunkering facility at terminal for vessels and vehicles. Required storage space and corridor for the piping from storage to jetty has been provided. Facility and space provision for vehicles to fill the fuel is also given in the master plan.

#### *6.3.2.3 Communications*

IWT terminal will be provided with modern telecommunication system consisting of telephone, telefax, e-mail etc.

#### *6.3.2.4 Water Supply*

Total water demand is broadly classified in the following categories:

- Potable water for consumption of terminal personnel.
- Potable water for vessels calling at the terminal.
- Water for canteen and truck drivers visiting the terminal.
- Water for truck washing
- Water for fire-fighting.
- Other uses like greenery etc.

Water supply system details are provided in Chapter 9.

#### *6.3.2.5 Power Supply*

The power is required at the terminal for the following activities:

- Mechanised cargo handling equipment and other equipment
- Lighting of the terminal area
- Offices and transit sheds
- Miscellaneous

Based on the above requirements the power demand is calculated and presented in Chapter 11. The power is to be drawn from the nearest substation to the terminal and internal electrical distribution system has been planned according to required HT and LT supply.

#### *6.3.2.6 Road Network*

As the mode of transport of the commodities to / from the terminal is by road, a well-developed internal and external road network is required. Adequate area is provided for internal road network running throughout the whole terminal. Ref. drawing No.: I-525/VTR-204, I-525/VTR-205 & I-525/VTR-206.

#### *6.3.2.7 Green Belt*

Green Areas have been proposed at various locations according to the Master Plan such as along the diverted nallah, between road and rail corridor and buildings.

#### *6.3.2.8 Storm Water Drainage*

A network of covered storm water drain will be provided. Run off from the storage areas will be routed through collection pits (Please refer 9.11).

#### *6.3.2.9 Sewerage System*

Sewerage from toilets, bathrooms, kitchens etc. will be collected and treated in sewage treatment plant (Please refer 9.14).

#### *6.3.2.10 Nallah Diversion*

As mentioned earlier, there exists a natural drain within the identified land for the project. The storm water of the upstream catchment is getting collected and discharged in to the River Ganga. The existing alignment and slope of the Nallah is naturally formed with unprotected sides and non-uniform section through the length.

It is proposed to divert this nallah. Alignment of the proposed diversion is along the Vishwasundari Setu through the project site. The alignment is shown in the master plan.

The energy needs to be dissipated before the water falls in river Ganga, for which the structure at confluence point is proposed and its details are given in Drawing No.: I-525/VTR-230.

**Proposed Diversion**

Cross Section of the diversion is designed as per the existing cross section of the nallah at the point where nallah enters the project site as shown in the below figures:

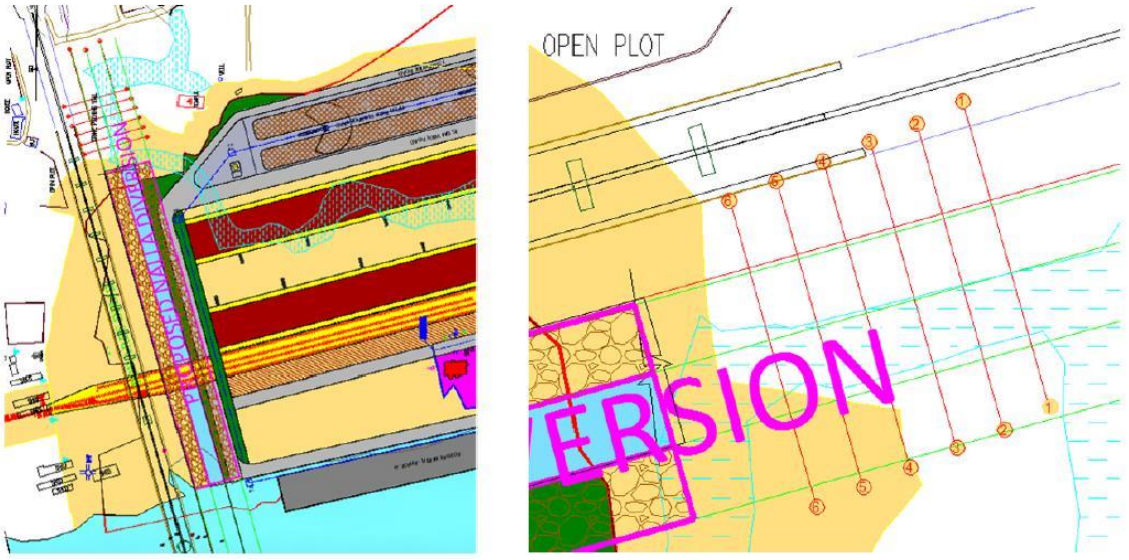



**Figure 6-1 Diversion point of the nallah**

Based on the existing cross section at diversion point the new cross section as per the FGL is generated which will have higher discharge capacity compare to existing cross section as shown in cross section 1 to cross section 6 (Figure 5 & 6)

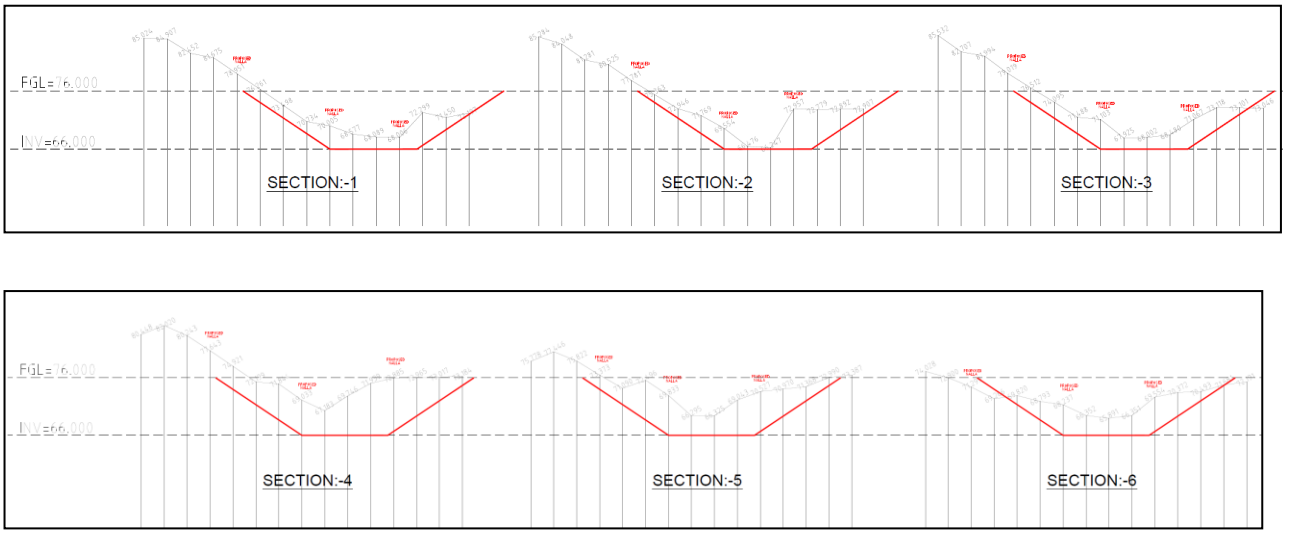



**Figure 6-2 Various Cross Sections of the Nallah (Existing and Proposed)**

The bed slope of the diversion shall be 1:2000 towards the river. The Proposed Nallah at the mouth of the River shall be of bell mouthed to dissipate the flow energy by providing scouring protection arrangements. Proposed nallah diversion as described will have Trapezoidal cross section with 1V:1.5H side slopes.

As the proposed terminal development is bisecting the natural flow path of storm water towards river, a trapezoidal boundary drain is proposed along the plot boundary to collect the storm water between the catchment area (approx. 33 hectares) of NH-7 and plot boundary, which will further discharge in the proposed nallah diversion. Below google earth image in Figure 5.3 with land profile shows the flow path towards the river.

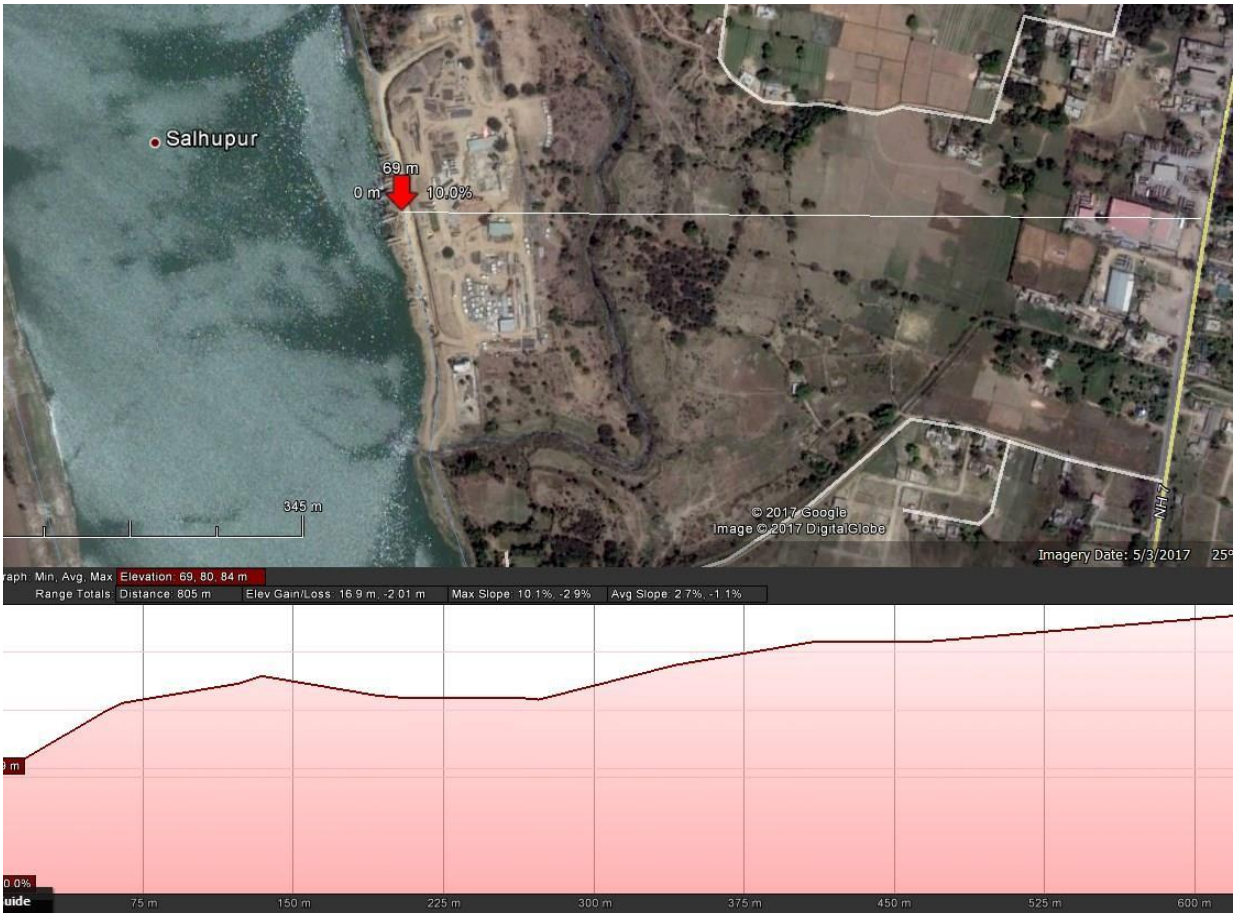



**Figure 6-3 Catchment Area profile for drainage plan.**

# 7 ALTERNATIVES

The proposed layouts of Phase 1A, Phase 1B and Master Plan have evolved based on various discussions with IWAI, traffic projections and site constraints. Hence no other alternatives were prepared.

The layout of various phases of the terminal is presented in **Drawing I-525/VTR/204, I-525/VTR/205 & I-525/VTR/206.**

# 8 DEVELOPMENT PLAN

This chapter describes the plan for development of the terminal infrastructure in various phases.

## 8.1 Marine Facilities

### 8.1.1 Berths

Considering IWAI's requirement, it is proposed to take up the proposed development in two stages Phase-1 (Phase 1a & 1b) and final phase.

#### *8.1.1.1 Phase-1A & 1B*

It is proposed to develop two multi-cargo berth for handling containers, natural aggregates, bagged & general cargo. The cumulative length of both the berths is 200 m and width is 35 m. The berth will be directly connected to land.

#### *8.1.1.2 Final Phase*

In final phase, additional berth is proposed to cater for the future traffic requirement. The dimension of the proposed additional berth is 300m length and 35m in width.

### 8.1.2 Manoeuvring Area & Approach Channel

The manoeuvring area for development of terminal comprises of approach channel, turning circle and berthing area. It is proposed that the barges will move in 45 m wide channel, with 2.5 m LAD. To enable continuous operations of the terminal, the approach channel, turning circle and berth pockets will be dredged to 2.5 m from LWL. The diameter of the turning circle is 190 m.

## 8.2 Onshore Facilities

### 8.2.1 Storage Areas

It is proposed to have a covered storage shed for storing bagged & cargo. For storing the Bulk Cargo open stockyard is proposed. Storage areas of the terminal are mentioned in Table 6.9.

### 8.2.2 Fuel Bunkering

Storage space, filling station and pipeline corridor provision for fuel bunkering has been considered at the terminal.

### 8.2.3 Buildings

The buildings envisaged in the onshore area of the terminal are mentioned in clause 6.3.2.

### 8.2.4 Onshore Utilities

Onshore facilities such as roads, drainage, sewerage, water supply, communication system will be developed in phase-wise manner.

### 8.2.1 Mechanical Equipment

The mechanical equipment proposed phase wise are as follows:

**Table 8-1 Phase wise additional requirement of Mechanical Equipment**

| S. No. | Equipment | No. of Equipment | No. of Equipment | No. of Equipment |
|---|---|---|---|---|
| | | Phase 1A | Phase 1B | Final Phase (Master Plan) |
| 1. | Mobile Harbour Crane | 2 | 2(Phase 1a) + 1* | 3(Phase 1a & 1b) +4 |
| 2. | Truck Loading Hopper | 2 | 2(Phase 1a) + 0 | - |
| 3. | Front end loaders | 1 | 1(Phase 1a) + 0 | 1(Phase 1a & 1b) +3 |
| 4. | Dumper Trucks | 1 | 1(Phase 1a) + 0 | 1(Phase 1a & 1b) +0 |
| 5. | Reach stacker | 2 | 2(Phase 1a) + 0 | 2(Phase 1a & 1b) +0 |
| 6. | Weigh Bridge & Control cabin | 1 | 1(Phase 1a) + 0 | 1(Phase 1a & 1b) +1 |
| 7. | Flatbed Truck Trailers / Trucks | 3 | 3(Phase 1a) + 2 | 5(Phase 1a & 1b) +7 |
| 8. | Conveying system (1000TPH) | - | - | 1 Lot |
| 9. | Mobile hopper with feeder | - | - | 2 |
| 10. | Rail mounted stacker 1000 TPH (20m boom) | - | - | 1 |

* Note: The third crane in phase 1B will be procured based on increase in traffic and cargo handling requirment.

## 8.3 Layout Plan

The layout plan of Phase-1A, Phase-1B and Final Phase is enclosed as **Drawing I-525/VTR/204, I-525/VTR/205 & I-525/VTR/206 respectively**.

# 9 PRELIMINARY ENGINEERING – CIVIL WORKS

## 9.1 Berthing Facilities

The design criteria for berthing facilities are provided in the following sections.

### 9.1.1 Deck Elevation

The deck of the jetty should be high enough so that during normal conditions it would be possible to inspect and repair the structural elements like deck and beams at all water levels.

HFL at the proposed location is 73.9m. It is therefore proposed to keep the deck elevation at RL +75.0 M and back up yard level is kept same as deck level i.e. +75.0M.

### 9.1.2 Design vessel and required water Level

The maximum design vessel and the minimum required water level for the operation of vessel at the berths are given in table below. However for the design of structure scour at the location to be considered as per IRC-78: 2000.

**Table 9-1: Design Vessel Parameters**

| S.No. | Design Vessel Size (DWT) | Design Vessel Dimensions (m) | | | LWL (m) | Max. Draft (m) | Desired UKC including swat (m) | Required min water level (m) |
|---|---|---|---|---|---|---|---|---|
| | | LOA | Beam | Loaded Draft | | | | |
| 1. | 3,000 | 95 | 15 | 2.5 | +58.22 | 2.5 | 0.5 | +55.22 M |

### 9.1.3 Geotechnical Criteria for Design of Berths Piles

Geotechnical Design of the marine piles has been carried out in accordance with the recommendations given in IS 2911, IS 14593 and IRC 78. The following safety factors are used to establish the safe geotechnical working load capacities of the piles given in table below:

**Table 9-2: Safety Factors**

| | |
|---|---|
| End Bearing | SF = 2.5 |
| Skin Friction on compression piles | SF = 2.5 |
| Skin Friction on tension piles | SF = 3.0 |
| Lateral Load | SF = 2.0 |

### 9.1.4 Loads Considered for Design of Jetty

The major loads considered for the design of the various components of the jetty are:

i. Dead Load

ii. Live Load

iii. Berthing Load

iv. Mooring Load

v. Current Load

vi. Wind Load

vii. Temperature Load

viii. Earthquake Load

ix. Wave load

x. Slamming forces (if any)

#### *9.1.4.1 Dead Load*

The dead load comprising the self-weight of the structure plus superimposed loads of permanent nature are considered as per IS: 875 (Part-I) 1987. Following unit weights are used to assess the self-weights of the structural elements in design

- Reinforced Concrete : 25.0 kN/m
- Mass Concrete : 24.0 kN/$m^3$
- Structural Steel : 78.5 kN/$m^3$

#### *9.1.4.2 Live Load*

The live load to be considered on the deck of jetty includes the following loads:

- Uniform distributed Live load of 3.5 T/m2.
- IRC class A/AA /70 R vehicles.
- Loads due to Rail mounted LPS 180 and Tyre mounted LHM 180 with a 320 T lifting capacity at maximum outreach of 22 m from waterside rail

#### *9.1.4.3 Berthing Load*

9.1.4.3.1 Berthing Energy

The design vessels are assumed to approach the berths under moderate wind, swell and moderate berthing condition (IS 4651 Part III – Cl 5.2.1.1, Table 2) at an angular approach of $10^o$. Based on this criterion the approach velocity perpendicular to the berth has been calculated to arrive at the design berthing energy for various design vessels.

Berthing loads are considered as per IS: 4651 Part III-1989. The Berthing energy calculated for 3,000 DWT vessel using IS: 4651 as per details in table below:

**Table 9-3: Berth Load Parameters for 3000 DWT vessel**

| | |
|---|---|
| Dead Weight Tonnage (DWT) | 3,000 |
| Displacement Tonnage (DT ) | 3,990 |
| Overall Length, LOA (m) | 95 |
| Beam Width, B (m) | 15 |
| Loaded Draft, d (m) | 2.5 |
| Berthing Velocity (m/s) | 0.45 |
| Approach angle | $20^{o}$ |

At present, available draft at the stretch near project location is 1.5m. Accordingly vessels will be brought partial loaded to suite available water depths.

The design berthing energy works out to 59 Tm considering required safety factors.

9.1.4.3.2 Fendering System

Considering the level variation in the water level of 15.7m between high water level and low water levell at the site and also the variation in the sizes of vessels to be handled at the jetty, the fendering system should be designed such that sufficient contact area between the hull of the vessel and the fender face is ensured at all water levels.

It is required to provide a suitable fendering system not only to absorb the design berthing energy of the vessel but also to keep the vessel's hull pressure within the limits as specified in PIANC 2002. For general cargo vessels with DWT less than or equal to 20,000, hull pressure may be limited to 50 $T/m^2$ and for container vessel it shall be limited to 40 $T/m^2$.

9.1.4.3.3 3000 DWT vessel

Based on these criteria, arch fenders of AN 800, grade E3.0 of Trellborg make or equivalent are proposed at each fender pile.

### *9.1.4.4 Mooring Load*

Mooring force of 30 T, as per Table-4, IS: 4651- Part III shall be applied at any of the bollard location.

### *9.1.4.5 Current Load*

The current loads on the structure shall be applied on the submerged parts of the structure as per IS: 4651 - Part III.

#### *9.1.4.6 Wind Load*

The wind load on structure shall be considered as follows

1. Operating wind speed shall be 18.0m/s
2. Extreme basic wind speed ($V_b$) shall be 47m/s as per IS: 875-Part III.

#### *9.1.4.7 Temperature Load*

- Berth shall be designed for temperature variation of (± $15^0$ C)
- Coefficient of thermal expansion for RCC structure is taken as $11.7x10^{-6}$/ °C.
- In temperature analysis, long term elastic modulus of the concrete is taken as half the instantaneous elastic modulus of the concrete.

#### *9.1.4.8 Earthquake Load*

Earthquake load shall be considered in design as applicable for the site as per IS 1893-2002. The design horizontal seismic coefficient αh is calculated based on the following parameters:

$\alpha_h$ = Z I (Sa/g) / (2R), where

Z = Zone factor = 0.16

I = Importance factor = 1.5

R = Response reduction factor = 3 for RCC structures

$S_a/g$ = Average response acceleration coefficient, which depends on Time Period of

The Time Period, T of the structure will be evaluated by STAAD Analysis considering Dead Load and 50% Live Load.

#### *9.1.4.9 Wave Load*

During the operation and storm condition the design wave height shall be considered as 0.10m and 0.3m respectively.

#### *9.1.4.10 Slamming forces*

The wave slamming forces are nothing but the uplift force experienced by the submerged horizontal member due to oscillatory wave action. The same shall be calculated based on the Coastal Engineering Manual.

$F_U = C_U A_Z \gamma_w w^2 / 2g$, where

$F_U$ = Uplift force

$C_U$ = Laboratory derived slamming co-efficient

$A_Z$ = Projected area of solid body in the horizontal plane

$\gamma_w$ = Density of sea water

w = Vertical component of flow velocity at level of object

### 9.1.5 Load Combinations

The above loads with appropriate load combinations, as per IS 4651-Part IV have been applied on the different components of the jetty.

### 9.1.6 Reinforced Concrete Design

#### *9.1.6.1 MATERIAL*

- Concrete Grade

Concrete grade M40 will be used for all the structural elements like pile, pile muff, beams, deck slab etc.

- Reinforcement

Low alloy steel reinforcement bars of grade Fe 500 D confirming to IS:1786 will be used for the design of deck slab, beam and piles.

#### *9.1.6.2 PILE DESIGN PARAMETERS*

- Pile Diameter

Bored cast-in-situ RC piles are proposed for the marine facilities. The pile configuration including diameter, founding depth and spacing has been arrived based on soil parameters.

- Depth of fixity

Pile fixity depth below scour level has been calculated as per IS-2911 guidelines.

#### *9.1.6.3 MINIMUM COVER*

The minimum cover to the steel reinforcing bars of different members (as per Table 16, IS 456:2000) shall be as follows unless stated otherwise:

a) Slabs

- Top : 50 mm
- Bottom : 75 mm

b) Beams

- Top : 75 mm
- Bottom : 75 mm
- Sides : 75 mm

c) Piles muff : 75 mm

d) Piles : 75 mm

### 9.1.7 Design Life

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

- Jetty and approach trestle - 50 years
- Fenders - 8 years
- Bollards and ladders - 15 years

### 9.1.8 Materials and Material Grades

The specifications are given below:

**Table 9-4 : Material specification**

| | |
|---|---|
| Structural Concrete | M-40 |
| Wearing coat | M-40 grade wearing course of 75 mm average thickness shall be provided on the jetty.<br>and Minimum Reinforcement for the wearing course shall be 25 kg\m$^3$. |
| Reinforcement | Low alloy steel reinforcement of grade equivalent to Fe 500 D in accordance with IS 1786. |
| Cement | For plain and reinforced concrete works cement shall be of any of the following types:<br>1. 43 Grade OPC Ordinary Portland cement conforming to IS 8112<br>2. Portland slage cement conforming to IS 455<br>3. Portland Pozzolana Cement (Fly ash based) conforming to IS 1489 (Part -1)<br>4. Portland Pozzolana Cement (Calcined based) conforming to IS 1489 (Part -2)<br>For marine structures , the above mention types of cement shall also confirm to IS 4651 Part 4.<br>Chlorides in the concrete |

Whenever there is chlorides in concrete there is an increased risk of corrosion of embedded metal. The higher the chloride content or if subsequently exposed to warm moist conditions, the greater the risk of corrosion. All constituents may contain chlorides and concrete may be contaminated by chlorides from the external environment. To minimise the chance of deterioration of concrete from harmful chemical salts, the levels of such harmful salts in concrete materials, that is, cement, aggregates, water and admixtures, as well as by diffusion from the environment should be limited. The total amount of chloride content (as Cl) in the concrete at the time of placing shall be as given below.

Limits of Chloride Content of Concrete

| Sl. No | Type or Use of Concrete | Maximum Total Acid soluble Chloride Content Expressed as kg/m3 of Concrete |
|---|---|---|
| 1 | Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete | 0.4 |
| 2 | Reinforced concrete or plain concrete containing embedded metal | 0.6 |
| 3 | Concrete not containing embedded metal or any material requiring protection form chloride | 3.0 |

The total acid soluble chloride content should be calculated from the mix proportions and the major chloride contents of each of the constituents. Whenever possible the total chloride content of the concrete should be determined as per the approval of the Engineer-in-Charge.

Sulphates in concrete:

Sulphates are present in most cements and in some aggregates; excessive amounts of water –soluble sulphate from these or other mix constituents can cause expansion and disruption of concrete. To prevent this, the total water-soluble sulphate content of the concrete mix, expressed as SO3, should not exceed 4 per cent by mass of the cement in the mix. The sulphate content should be calculated as the total from the various constituents of the mix as per the approval of the Engineer-in-Charge.

The 4 percent limit does not applied to concrete made with super sulphated cement complying with IS 6909 or as approved by the

| | |
|---|---|
| | Engineer-in-Charge. |
| Corrosion Inhibiting Admixture | Corrosion of reinforcement bars in RCC by sea water, aqueous corrosion, is electrochemical process. Sea water, by virtue of its chloride content, is a most efficient electrolyte. The omni-presence of oxygen in marine atmospheres, sea spray and splash zones at the water-line, and sometimes at much greater depths, increases the aggressiveness of salt attack and in turn reduces the durability of concrete.<br><br>Chlorides and sulphates do not present a favourable environment to the embedded RCC. Therefore a key consideration in proposing a corrosion prevention strategy is to ensure that the rebars remain protected in a heavily chloride and sulphate saturated environment thus allowing us to maximize the service life of the structure.<br>Leaving aside the strategy of preventing corrosion through better concrete, the solution of choice has been to coat the rebars. Such coatings have ranged from cement slurries to epoxies and zinc. Coatings suffer from the obvious disadvantage that they may be physically damaged or electrochemically penetrated so that the base steel is again vulnerable to the usual corrosion process.<br>Not only are these coatings systems are prohibitively expensive but due to unavoidable damage several disasters have been attributed to failure of such systems all over the world. In comparison polydentate, bipolar, migratory, non-nitrite base concrete penetrating corrosion inhibiting admixture becomes not only effective in performance but also cost effective at about 50% of the cost of such coating systems. No calcium nitrite based admixture shall be used for the project'.<br><br><u>Item Description for corrosion protection of reinforcement bars</u>-<br><br>Admix polydentate, bipolar, migratory, non-nitrite base concrete penetrating corrosion inhibiting admixture at a dosage of 3 Kg per cu.m. of concrete. Corrosion Inhibiting admixture should pass JIS Z 1535 (Accelerated corrosion test), ASTM G1 (Immersion test for 720 hrs with results rebar weight loss less than 5 mpy), ASTM G3 (Polarization test by Tafel test Rebar weight loss results in less than 5 mpy ), ASTM G-109-2005 (Long term corrosion test with results of a corrosion rate of zero coulombs) IS 9103-2005 (No Adverse effect on Compressive strength of concrete), pH- 10-12, Specific Gravity- 1.01 to 1.04. Manufacturer should submit all the test reports (short term as well as long term) during initial approval stage only. All the test reports submitted by manufacturer should be minimum 6-7years old and product should have a track record of minimum 10 years. |
| Structural Steel | As per IS:2062 (Grade-A) with minimum thickness of 10 mm |
| Protective coating to structural steel | Minimum DFT of 240 micron after sand blasting to SA 2.5 grade. |

### 9.1.9 Proposed Structural Arrangement Of Berth

The proposed jetty having two berths of 500m (200m + 300m) for handling multi-cargo is aligned parallel to the river bank. The jetty is connected to yard at the end to have access to the bank for operations and maintenance.

Drawings **I-525/VTR/209** presents the general arrangement and cross section of jetty with bank protection.

The width of the jetty, keeping in view the operational requirement should be about 35 m. The total length of jetty provided is 500m.

In phase-1 initially jetty is proposed with well foundation, subsequently the it is converted to pile jetty. Piled foundation is considered as best option for the structural system.

The proposed structural arrangement consists of six rows of vertical bored cast-in-situ piles of 1.2 m diameter and one row of fender piles of 1.0 m diameter, spaced at 6.5 m c/c in the longitudinal direction.

In the transverse direction, cross beams are provided supported over the piles, which in turn support main beams in the longitudinal direction. A 500 mm thick deck slab will be provided supported over the longitudinal and cross beams.

## 9.2 Dredging

No dredging is required, as the available natural depths at the project location is more than the required depth of +55.22m.

## 9.3 Bank Protection Work

The Bank protection works are generally adopted on the river bank against erosive action of river. It is therefore, proposed to provide stone pitching in crates on the slope of river bank. In phase-1A, the length of protection work is 370 m and in phase-2 the length of bank protection work is 350 m. Model Studies shall be carried out by selected contractor to access the quantum of bank protection works and shall also include the effects of overtopping of river discharge and construction of proposed berth and approach trestle on stability of bank.

Typical details of Bank Protection Works are shown in Drawing I-525/VTR/210.

## 9.4 Storage Areas

### 9.4.1 Stockyard for Bulk & Project Cargo

In phase-1B, the stockyard shall be provided for stockpiling of bulk cargo such as consumer goods, construction material and project cargo. The stockyard shall be developed by compacting top 2 m soil in layers of 225 mm with road roller; in which the top layer of the

ground is then compacted with stone aggregate of specified sizes in uniform thickness by a vibratory roller to proper grade and camber.

In Master Plan Phase of terminal, the stacker tracks for construction material are proposed to be supported on precast concrete sleepers resting on a flexible foundation made of stone ballast and typical details are shown in the Drawing I-525/VTR/218.

### 9.4.2 Stockyard for containers (Phase-1B)

In phase 1B, the Stockyard for containers shall be provided to facilitate stockpiling of 4 fully loaded containers plus 1 empty container stacking load.

In Final Phase, the area for container stockyard shall be further increased to cater the additional traffic.

## 9.5 Paved Area

In phase 1B, the paved area for Railway yard and 20m wide area adjacent to Godown 1 shall be provided to facilitate handling of bagged cargo.

In Final phase, the paved area for bagged cargo shall be further increased to cater the additional traffic.

### 9.5.1 Storage Sheds

Bagged cargo cannot be stored in open atmosphere and requires covered storage sheds. The sheds shall be mainly built using structural steel for the frames and galvanised sheets for roofing and cladding. Grade slab are provided for maintaining the finished floor level so as to give a plinth height of not less than 1200 mm above Finished Ground level. Retaining wall of adequate height shall be provided around the shed for optimising the storage capacity.

Based on the review of geotechnical data (Reference: Report on geotechnical investigations at IWT terminal at Varanasi – July 2017), it is assessed to have open foundations for the sheds.in phase 1B, Godown 1 (Part-1) having storage size as 345 m x 35 m shall be provided.

In master plan Phase , Godown 1 (Part-2) having storage size as 280 m x 35 m and another Godown of size as 625m x 35 m adjacent to Godown 2 shall be provided.

Details are shown in the Drawing I-525/VTR/217 which is only indicative and may undergo changes based on the design.

## 9.6 Terminal Buildings

In phase 1B, the following terminal buildings are proposed for the Varanasi terminal:

### 9.6.1 Terminal Administration Building

It will be 2-storey building housing the following:

- Administration wing of the terminal including documentation
- Terminal operations wing

It is assessed that the terminal administration building will have a total floor area of 640 sqm (320 sqm per floor). Typical Layout and Elevations of Terminal Administration Building are shown in **Drawings I-525/VTR/211**.

### 9.6.2 Security Office

There shall be a single storey building for security office area of 09 sqm, and shall be provided near the terminal entrance. Details of security office is shown in **Drawing I-525/VTR/214**

### 9.6.3 Pump Room

There shall be a single storey building for pump room with area of 340 sqm, and shall be provided at the location shown in master plan terminal layout. Details of pump room are shown in **Drawing I-525/VTR/212**.

### 9.6.4 Underground reservoir

The underground reservoir is of RCC structure catering to the supply of water. The minimum capacity of the underground sumps should be 700 $m^3$.

The broad design parameters for water supply system are given below:

- Wastage and leakage in system: 15% of total theoretical demand
- Hydraulic design of the pipeline shall be using Hazen-Williams formula
- All pipelines shall be laid 1.2 m below ground

In Master Plan phase, the following terminal buildings are proposed for the Varanasi terminal:

### 9.6.5 Electrical Sub Station - 2

The electrical sub-station shall be a two storey building with a floor area of 800 sqm. The details of electrical sub-station are shown in **Drawing I-525/VTR/232**.

### 9.6.6 Banarasi Haat

There shall be a Banarasi haat with built up area of 120 sqm.

### 9.6.7 Shops/ Kiosks

There shall be a shops / Kiosks with built up area of 110 sqm.

### 9.6.8 Jal Yatri Niwas (Guest House)

The Jal Yatri Niwas (Guest House) shall be a two storey building with total floor area of 550 sqm (275 sqm per floor). Typical Layout and Elevations of Jal Yatri Niwas (Guest House) are shown in **Drawings I-525/VTR/229**.

### 9.6.9 Weighbridge control cabin

There shall be a single storey building for weighbridge control cabin with area of 09 sqm. Details of weighbridge control cabin is shown in **Drawing I-525/VTR/215**.

### 9.6.10 Canteen and Toilet Block

There shall be a single storey building for canteen and toilet block with area of 212 sqm, and shall be provided at the location shown in master plan terminal layout. Details of canteen and toilet block are shown in **Drawing I-525/VTR/216.**

### 9.6.11 Toilet Block

There shall be a single storey building for toilet block with area of 50 sqm, and shall be provided at the location shown in terminal layout. Details of toilet block are shown in **Drawing I-525/VTR/228**.

### 9.6.12 Gate house complex,

A Gate House complex shall be provided in the South-East boundary of the terminal, another Gate House shall be provided on alternative access on the other side of railway track as shown in the master plan layout. Typical details and dimensions of gate house complex are shown in **Drawing I-525/VTR/213**.

### 9.6.13 Design Criteria

All designs of RCC structures other than liquid retaining structures shall be carried out as per IS 456. The buildings shall be provided with adequate arrangements for plumbing, sanitary, electrical fittings, illumination, water distribution etc. The aspects considered for construction of buildings

- Floor to floor height of buildings is arrived considering the bylaws of National Building Code.
- Finished floor level of buildings is considered 500 mm above the finished ground level
- Grade Slab

All ground floors shall be of R.C.C. (M-20) with minimum thickness of 150 mm over 75mm thick P.C.C. (M-10) base. The sub base of 230 mm thick Stone/bolder soling over compacted earth is proposed. The floor finish of 40 mm thick including 13 mm thick metallic hardener topping is proposed for storage shed and substation building. For the remaining buildings i.e. administrative building, Workers amenity building (Toilet Block), Gate complex etc.,

vitrified floor finish is proposed. Floor top is proposed to be laid to slope minimum 1:100 towards floor drain for floor washing.

- A 750 mm wide plinth protection is proposed around each building.
- All external walls shall be of 230 mm thick, all partition walls shall be minimum 115 mm thick with 1:4 cement mortar
- Stair Case
  - Clear width : 1.2 m
  - Tread width : 250 mm
  - Riser : 180 mm
  - Continuous Hand rail is proposed.

### *9.6.13.1 Foundations*

Based on the review of geotechnical data (Reference: Geotechnical Investigation for Intermodal Terminal at Varanasi), it is assessed that open foundations will be proposed for buildings.

### *9.6.13.2 Loads*

9.6.13.2.1 Dead Load

The unit weight of all other materials shall satisfy the requirements of IS: 875.

9.6.13.2.2 Live Load

Live load shall be considered as given below and shall also satisfy the requirements of IS: 875.

| | |
|---|---|
| Flat Roof | 150 kg/$m^2$ + Dust load of 50 kg/$m^2$ hanging load for pipe shall be considered as 100 Kg/$m^2$ and 50 Kg/$m^2$ for electrical, ventilation & air conditioning (wherever applicable) |
| Non-accessible roof | 75 kg/$m^2$ + Dust load of 50 kg/$m^2$ |
| Inclined roof | Roof slope upto 10 Deg.: 75 Kg/$m^2$ +50 Kg/$m^2$<br>Roof slope above 10 Deg.: [(75-(θ-10) x2] + 50 Subjected to a minimum of (40+50) =90 Kg/ $m^2$<br>For sloping roofs with slope greater than 10°, members supporting the roof purlins, such as trusses, beams, girders etc. may be designed for two-thirds of live load stated above |
| MCC Floor | 300 kg/$m^2$ +1.2T/m of Panel |

9.6.13.2.3 Seismic Load

- Zone factor : Corresponding to seismic zone-III

- Importance factor : 1.50
- Response reduction factor : 5

9.6.13.2.4 Equipment Load

The Substation building is to be designed to accommodate anticipated static and dynamic loading from electrical equipment. Where the uniform floor live load adequately accounts for the equipment weight, the weight of such equipment as a dead load need not be considered.

9.6.13.2.5 Impact Factor

- For Manual monorail/Hoist design an impact factor of 1.20 shall be considered in design.
- For Electrical monorail/Hoist design an impact factor of 1.25 shall be considered in design.

### *9.6.13.3 Load Combinations*

The load combinations are in accordance with IS: 456, IS: 875 – Part 5, IS 1893 – Part 1 and IS: 800.

### *9.6.13.4 Minimum Cover*

Clear cover to main reinforcement shall be as mentioned hereunder but shall not be less than the diameter of such reinforcement.

| | |
|---|---|
| Pile (if any): | 75 mm |
| Top, bottom & side of footing: | 50 mm |
| Pedestal / column | |
| - Below ground | 50 mm |
| - Above ground | 40 mm |
| Beams | 25 mm |
| Slab | 20 mm |
| Face of walls & grade beam | 50 mm (in contact with soil) |
| Face of walls not exposed to soil | 25 mm (min.) or dia of main bar |
| At each end of reinforcing bar | 20 mm or twice the dia of bar whichever is greater |
| Columns of max. dimension 200mm or under and with longitudinal reinforcement diameter not exceeding 12mm | 25 mm |

### *9.6.13.5 Serviceability Checks*

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

### *9.6.13.6 Material Specification*

The specifications are as given in this volume.

<table>
<tr><td>Structural Concrete</td><td>Minimum M-30</td></tr>
<tr><td>Levelling Concrete</td><td>M-10 of 100 mm thick</td></tr>
<tr><td>Reinforcement</td><td>Reinforcement bars shall be low alloy steel reinforcement bars of grade Fe 500 D confirming to IS:1786.</td></tr>
<tr><td>Cement</td><td>For plain and reinforced concrete works cement shall be of any of the following types:<br>1. 43 Grade OPC Ordinary Portland cement conforming to IS 8112<br>2. Portland slage cement conforming to IS 455<br>3. Portland Pozzolana Cement (Fly ash based) conforming to IS 1489 (Part -1)<br>4. Portland Pozzolana Cement (Calcined based) conforming to IS 1489 (Part -2)<br>Chlorides in the concrete<br>Whenever there is chlorides in concrete there is an increased risk of corrosion of embedded metal. The higher the chloride content or if subsequently exposed to warm moist conditions, the greater the risk of corrosion. All constituents may contain chlorides and concrete may be contaminated by chlorides from the external environment. To minimise the chance of deterioration of concrete from harmful chemical salts, the levels of such harmful salts in concrete materials, that is, cement, aggregates, water and admixtures, as well as by diffusion from the environment should be limited. The total amount of chloride content (as Cl) in the concrete at the time of placing shall be as given below.<br>Limits of Chloride Content of Concrete
<table>
<tr><td>Sl. No</td><td>Type or Use of Concrete</td><td>Maximum Total Acid soluble Chloride Content Expressed as kg/m3 of Concrete</td></tr>
<tr><td>1</td><td>Concrete containing metal and steam cured at elevated</td><td>0.4</td></tr>
</table>
</td></tr>
</table>

| | | | |
|---|---|---|---|
| | | temperature and pre-stressed concrete | |
| | 2 | Reinforced concrete or plain concrete containing embedded metal | 0.6 |
| | 3 | Concrete not containing embedded metal or any material requiring protection form chloride | 3.0 |

The total acid soluble chloride content should be calculated from the mix proportions and the major chloride contents of each of the constituents. Whenever possible the total chloride content of the concrete should be determined as per the approval of the Engineer-in-Charge.

Sulphates in concrete:

Sulphates are present in most cements and in some aggregates; excessive amounts of water –soluble sulphate from these or other mix constituents can cause expansion and disruption of concrete. To prevent this, the total water-soluble sulphate content of the concrete mix, expressed as SO3, should not exceed 4 per cent by mass of the cement in the mix. The sulphate content should be calculated as the total from the various constituents of the mix as per the approval of the Engineer-in-Charge.

The 4 percent limit does not applied to concrete made with super sulphated cement complying with IS 6909 or as approved by the Engineer-in-Charge.

| | |
|---|---|
| Structural Steel | As per IS:2062 (Grade-A) with minimum thickness of 10 mm |
| Protective coating to structural steel | Minimum DFT of 240 micron after sand blasting to SA 2.5 grade. |

## 9.7 Boundary Wall / Fencing

It is proposed to provide boundary wall of 2.4 m height using brick masonry with barbed wire fencing of 1 m high. The boundary wall shall be provided along the periphery of the terminal area except the water-front side founded on strip footing. Layout of terminal boundary is shown in **Drawing I-525/VTR/207**.

## 9.8 Roads

Based on the traffic study, it is implicit that both the import and export cargoes will be carried to and from the hinterland through road only. Therefore, providing well-planned internal road network is essential for effective functioning of the terminal. Accordingly, the internal roads were provided with the capacity to cater the traffic of Phase-1B and Final phase.

The cross section for internal and external roads provided in Phase 1A, Phase 1B and Final Phase are shown in Drawing **I-525/VTR/204, 205 & 206 respectively**. The length and width of the internal and external roads are given below:

**Table 9-5: Details of roads within boundry Phase-1A**

| Width of Road | Length |
|---|---|
| 12m | 750 m |

**Table 9-6: Details of roads within boundry Phase-1B**

| Width of Road | Length |
|---|---|
| 12m | 310 m |

**Table 9-7: Details of roads within boundry Master Plan phase**

| Width of Road | Length |
|---|---|
| 14 m | 705 m |
| 12 m | 1190 m |
| 7.5m | 545 m |

**Table 9-8: Detail of roads outside boundry Master Plan phase**

| Width of Road | Length |
|---|---|
| 10.5 m | 235 m |
| 14 m | 510 m |

## 9.9 Water Supply

The water requirements for the terminal in different Phases are furnished in Table 9-9 below:

**Table 9-9: Water Demand in different phases for Terminal (Litre/per day)**

| S. No. | Facilities | Water Demand (Litre/per day) | |
|---|---|---|---|
| | | Phase 1A+1B | Master Plan Phase |
| 1. | Water for FFS and other requirement | | |
| | ◦ Greenery and Miscellaneous | 4000 | 4000 |
| | ◦ For fire fighting | 400000 | 600000 |
| | ◦ Water for Truck wash | 6000 | 9000 |
| | Total Water Requirement (Litre/per day) | 410,000 | 613,000 |
| 2. | Water for buildings and vessel | | |
| | ◦ Terminal Personnel, Canteen & Users | 15,000 | 20,000 |
| | ◦ Vessel Supply | 5,000 | 13,000 |
| | Total Water Requirement (Litre/per day) | 20,000 | 33,000 |

The scheme for providing raw water and potable water in Master plan phase development of terminal is described below.

The raw & potable water required for firefighting, truckwash, plantation, personnel and vessel supply shall be tapped from borewell. Water shall be tapped from that source and transferred to an underground reservoir of 700 cum capacity located within the project boundary. The raw water shall be pumped from underground sump to overhead tanks located above the buildings for personnel and to bunkering points. As can be seen from above Table , there is not much difference in the water requirement in the Phase 1 and Master Plan Phase, it is therefore proposed to provide Underground storage tank in Phase-1 itself, located near worker's amenity.

The schematic layouts of water supply system in two Phases are shown in Drawing **I-525/VRT/221 to I-525/VRT/222** respectively.

### 9.10 Sewerage System

The amount of sewage/waste water generated in the terminal are worked out in all the Phases and furnished in Table 9-10 below:

**Table 9-10: Details of Sewerage in different Phases of Terminal**

| S. No. | Phases of the Terminal | Sewerage/Waste water generation in L/day |
|---|---|---|
| 1. | Phase 1A+1B | 13,500 |
| 2. | Master Plan Phase | 18,000 |

Based on the number of persons working in the terminal and water requirement mentioned in the above section, the quantity of sewage that is expected to be generated from Varanasi will be around 90% of total water requirement i.e. 18 KLD. Accordingly, it is proposed to provide a sewage treatment plant of capacity 20 KLD which will suffice for the terminal. As can be seen from above Table , there is not much difference in the sewage generation in the Phase 1 and Master Plan Phase, it is therefore proposed to provide a small sewage treatment plant of 20 KLD capacity in Phase-1 itself, located near Container yard. It shall receive sewerage from the terminal buildings and Worker's Amenities Building. The treated sewage shall be used for greenery and in case of any surplus that will be discharged to the drainage network along the access road outside the terminal boundary. The sludge from the treatment plant will be processed and converted into Biomass used as manure. (Refer chapter 13 for STP details).

## 9.11 Storm Water Drainage

The drainage system for carrying the storm water run-off shall be designed for rainfall intensity of 55 mm/hr at project site location based on iso-pluvial maps of india.

The drainage network for the storage shed will comprise mainly of two longitudinal drains at front and rear end of shed and both sides of road. From the central part, shed pavements will slope at 1:1000 on either side to the drains. These longitudinal drains will discharge the water to the transverse drain/nalah, which disposes the water into the river. The storm water from the buildings will also be connected to the respective storm water drain through small drains and then discharged to the river.

The proposed drainage network in Phase-1 and Master Plan Phase are as shown in Drawing **I-525/VRT/225 to I-525/VRT/227** respectively.

## 9.12 Navigational Aids

Navigational aids are required to be provided to ensure safe and efficient navigation of vessels while transiting in the navigational channel as well as in the manoeuvring areas near the terminal. Marker buoys will be provided alongside the channel and manoeuvring areas to aid the navigation.

The navigation aids are detailed in below.

There will be a pair of marker buoys at the periphery of the manoeuvring area near terminal. Provision of 3 buoys is kept for marking manoeuvring area. The channel marker buoys will be procured as part of the navigation channel for the entire NW1.

The channel marker buoys will have the following characteristics:

| | |
|---|---|
| Material | Rotationally moulded in low density uv-stabilised virgin polyethylene |
| Body diameter | 1800 mm |
| Day Mark | PE Module (as per IALA) |
| Radar reflector | To be provided |
| Light Range | 3.5 – 4 nautical miles (T=0.74) |
| PLC Programmer all functions for monitoring of buoy and light | To be provided |
| Remote Monitoring Unit for buoy position and light | To be provided |
| Power | Solar plus backup battery for optimum autonomy |
| Mooring arrangement | 250 kg M.S. stockless anchor with 26 mm dia chain |

# 10 PRELIMINARY ENGINEERING - MATERIAL HANDLING SYSTEM/ EQUIPMENTS

As already discussed elseware in this document, cargo commodities are devided broadly into three catagories. i.e. 1. Bulk Cargo, 2. Containers and 3. Bagged cargo.

Dry bulk cargo (Construction Material, consumer goods) will be handled using MHC cranes (Grab operation), unloaded into truck loading hopper/Mobile hopper and transferred to storage area using dumper trucks/conveyor system. Dumper trucks will dump the cargo at storage area and high hipping will be done by front end loaders at storage yard. In final phase, Conveyor will stack the material in stock yard using rail mounted travelling stacker.

Bagged cargo will be handled using MHC cranes (Hook operation with Net), unloaded on flat bed trailers and transferred to warehouse for storage.

Containers will be handled using MHC cranes (Spreder operation), unloaded on flat bed trailers and transferred to container yard for storage. Unloading at container yard will be done by reach stackers.

## 10.1 Mechanical Equipment

Considering the cargo projections, the summary of mechanical equipment proposed for the terminal are given in Table 8.2.

## 10.2 Technical Requirements

The terminal parameters shall be adhered to in the bid. Berth layout, crane travel, Barge sizes and dimensions, clearances, water level details, etc., are given in this document against respective chapter. Those required but not given here shall be bidder responsibility to collect and implement.

## 10.3 Mobile Harbour Crane

MHC cranes shall have following specifications for technical requirement for the project.

MHC shall be equivalent or better than currently conceded in phase-1A LIEBHERR Model LHM180 (4 rope S-version)

OPERATING CONDITIONS
Mobile Harbour Crane shall be of rubber-tyre, self-contained construction and shall be equipped with a diesel engine as a prime mover for crane operation and travelling. The crane shall be of four-rope construction and shall be designed and equipped for multi-purpose operation like general cargo handling, bagged cargos, heavy lift operation as well as containers with semiautomatic Spreader and bulk handling with suitable four rope grab. Being a new terminal and to have edge in the industry market, equipment should have maximum efficiency to perform highest in its class.
Crane will cater to barge up to 2,000 DWT size with the dimension of 80 m x 11 m x 2.5 m.

Cargo handling capacity is provided in Annexure: A

### 10.3.1 Main Technical Requirements

The following minimum operating characteristics are required:

### 10.3.2 Load Capacities

The crane shall have a lifting minimum capacity under four rope grab, up to a radius of 20 m from crane centerline as given in data sheet table 10.1. Maximum Load carrying capacity of crane shall be 64 Ton.

### 10.3.3 Classification of Crane and Machinery

The crane and its machinery shall be classified according to the FEM 1.001 (Rules for the Design of Hoisting Appliances) and shall have the A7 classification for grab operation.

### 10.3.4 Operating Speeds

The following speeds shall be provided as a minimum:
Hoisting/ Lowering 0 - 90 m/min
Slewing 0 - 1.6 rpm
Luffing 0 - 83 m/min
Travelling 0 – 5.4 km/hr.

**Table 10-1: Data sheet for Mobile harbor crane.**

| | |
|---|---|
| Maximum Load carrying capacity | 64 ton |
| Lifting Capacity under four rope grab at 20m | 26 ton |
| Crane Classification Grab Operation | A7 for 35 ton |
| Minimum/Maximum out reach | 9 m / 35 m |
| Height of boom pivot above ground | 12.5 m |
| Height of eye level in tower cab | 17.6 m |
| Maximum hoisting height on hook above ground | 42 m |
| Minimum hoisting height on hook below ground | 12 m |

### 10.3.5 Main Dimensions

Main dimensions shall be suitable to handle 2000 DWT barge, with hook & slings for bagged and project cargo, four rope grab for bulk cargo and spreader for containers. Main dimensions shall be as per data sheet table 10.1 for MHC as above.

### 10.3.6 Quay Load Arrangements

Uniformly distributed load 1.36 $t/m^2$

Max. Load per tyre: 5.2 T

### 10.3.7 Environmental Conditions

The crane shall be designed to work safely and reliably under the following environmental conditions:

- Daily temperature range variation : ± 15$^0$ C
- Maximum operating wind speed : 24 m/s
- Maximum wind speed for travelling : 24 m/s
- Maximum wind speed out of operation with boom in steepest position: 46 m/s
- Maximum gradient for travelling…
    - In direction of travel : 6 %
    - Perpendicular to direction of travel : 2.5 %

### 10.3.8 Safety Devices

The crane shall provide the following safety equipment as a minimum:

- Safe load indicator
- Mechanical interlock of chassis and superstructure during travelling
- Stabilizer monitoring
- State-of-the-art electronic limit switching system
- Safety valves at hydraulic cylinders
- Anemometer
- Emergency stop buttons at various locations of the crane
- Video camera at the boom tip
- Appropriate lighting system for night-time operation
- Crane management system (optional)

### 10.3.9 Grab

4 rope cam shell grab suitable to handle various bulk materials having 8 m3 capacities shall be provided with MHC.

### 10.3.10 Spreader

Electro-Hydraulic Telescopic fully automatic Spreader with 35t SWL shall be required to handle 20ft & 40ft containers. Each spreader shall be fitted with hydraulically retractable twist lock housings mounted on the main centre section. It shall also have Telescopic design, CG adjustment, flipper guides and twist lock including all supporting accessories.
Figure shows typical details of spreader.

### 10.3.11 Typical Details of Mobile Harbour Crane


Figure shows Typical Details of Mobile Harbor Crane

## 10.4 Reach Stackers

Reach stackers shall be required to handle and stack containers in the yard to support import and export cargo movement with flexibility. It shall be used to load and unload 20ft and 40ft containers from flatbed trailers. Table shows the basic requirement of reach stacker specification.

**Table 10-2: Specifications of Reach stacker**

| SL. No. | Description | Data |
|---|---|---|
| 1 | Lifting Capacity at load center about 2m | 45000 Kg |
| 2 | Lifting Capacity at load center about 4m | 27000 Kg |
| 3 | Lifting Speed, unloaded – at 70% of rated load | 0.42 - 0.25 m/s |
| 4 | Lowering Speed, unloaded – at rated load | 0.36 m/s |
| 5 | Traveling Speed Forward, unloaded - at rated load | 21 - 25 Kmph |
| 6 | Traveling Speed Backward, unloaded - at rated load | 16 - 18 Kmph |
| 7 | Engine | Diesel |
| 8 | Transmission | Gearbox & clutch |
| 9 | Wheels | Pneumatic |

### 10.4.1 Typical Details of Reach Stacker


Figure shows the typical details of reach stacker

### 10.4.2 Truck Loading Hopper

Tyre mounted truck loading hopper to be loaded with natural aggregates having bulk density 1.6t/m3 using grab operation and further it will load the truck dumpers using hydraulically operated sector gates installed at hopper bottom openings. Following are the minimum technical requirements of the tyre mounted truck loading hopper.

**Table 10-3: Specifications of Tyre Mounted Truck Loading Hopper**

| **SPECIFICATION OF TYRE MOUNTED TRUCK LODING HOPPER** | |
|---|---|
| Type | Tyre mounted mobile hopper. |
| Capacity of Hopper | 100 tons of water minimum |
| Qty | As per equipment Table |
| Location | On Berth adjacent to Cranes |
| Material of Construction | Mild Steel (IS: 2062 Grade-B killed Steel), 10mm thick (min).,& Liners of 10thk. SS409 |
| Top opening | Approx. 8 m X 8 m Max. |
| Overall Height | 9.6 m max. |
| Handrail | Hand rail shall be provided at the top and intermediate platform and along the stairs.<br>It shall be 1m above the floor, a knee rail and a toe guard or by equivalent plain sheeting. There shall be min. clearance of 500mm between appliance and the hand rail.<br>The section of handrail shall be of galvanized pipe of 32mm nominal bore.<br>Grating shall be hot dip galvanised.<br>Hand rail shall be GI Coating with min 610 GSM; Grating shall be with min 910 GSM, painting as per APSEZL corrosion protection specification. |
| Wheels | 630mm Dia. -4 set (8 nos.) with swivelling arrangement & 4 nos. Jacking pads.<br>Wheel shall be of EN 19 Forged material with 300BHN hardness having moulded surface of tyre rubber. |
| Other ancillaries | 2nos Hydraulic operated sector gate and operator cabin. |

## 10.5 Mobile hopper with Feeder

Rail mounted mobile loading hopper to be loaded with natural aggregates having bulk density 1.6t/m3 using grab operation and further it will load the belt conveyor using suitable feeder arrangement. Hopper shall be provided with suitable dust suppression system using water spray nozzle at top hoper opening with piping, pump and water tank, hose reel etc. Following are the minimum technical requirements of the mobile conveyor loading hopper.

**Table 10-4: Specifications of rail Mounted mobile Hopper**

| **SPECIFICATION OF RAIL MOUNTED LODING HOPPER** | |
|---|---|
| Type | Rail mounted mobile hopper. |
| Capacity of Hopper | 75 tons of water minimum |
| Qty | As per equipment Table |
| Location | On Berth adjacent to Cranes |
| Material of Construction | Mild Steel (IS: 2062 Grade-B killed Steel), 10mm thick (min).,& Liners of 10thk. SS409 |
| Top opening | Approx. 8 m X 8 m Max. |
| Overall Height | 9.6 m max. |
| Handrail | Hand rail shall be provided at the top and intermediate platform and along the stairs.<br>It shall be 1m above the floor, a knee rail and a toe guard or by equivalent plain sheeting. There shall be min. clearance of 500mm between appliance and the hand rail.<br>The section of handrail shall be of galvanized pipe of 32mm nominal bore.<br>Grating shall be hot dip galvanised.<br>Hand rail shall be GI Coating with min 610 GSM; Grating shall be with min 910 GSM, painting as per APSEZL corrosion protection specification. |
| Wheels | 630mm Dia. With 4 nos. Jacking pads. |
| Other ancillaries | Belt feeder / vibrating feeder 600 TPH. |

## 10.6 Truck Dumpers

Multi axel, hydraulically operated 14CBM box body truck dumpers are to be used to transfer material from truck loading hopper to storage yard location. Truck dumpers will dump the

material near to storage yard stock piles and to be moved to jetty for further cargo transfer. Refer equipment table for quantity requirement.

### 10.7 Front End Loaders

Tyre mounted, hydraulically operated front end loader with 3CBM bucket are to be used to transfer material from dumped stack to stockpile. It can also be used for high hipping of material and maintain the stock piles.

### 10.8 Flat bed truck trailors

40 ft., 40 tonner flatbed truck trailers are to be used to transfer the bagged cargo from jetty to ware house. Crane will unload the bagged cargo using hook & net operation and further, it will be located on trailer bed. Truck trailers further transfer the cargo to the storage warehouse facility.

### 10.9 Weighbridge

The assembly shall be Static, pit less, surface mounted electronic load cell based weighbridge having 100 MT capacity and shall be installed with fully functional control cabins with data indication and weighment recording facility for inward and outward cargo.

The weigh bridge shall be of fabricated steel structure with ample safety margin suitably painted with anti-corrosion epoxy based paint.

The specifications for same are as given below:

**Table 10-5: Specifications of Road Weigh Bridge**

| S. No. | Description | Data |
|---|---|---|
| 1 | Type | Pit less, Static |
| 2 | Capacity | 100T |
| 3 | Accuracy | ± 0.05% of Full scale |
| 4 | Platform size | 15 m x 3 m |
| 5 | Trucks to be weighed | Heavy duty Trucks / dumpers |
| 6 | Operator interface | Menu driven |
| 7 | PC & Printer | Required |
| 8 | Auto zero & Auto Calibration | Required |

| | | |
|---|---|---|
| 9 | Anti-skid to plate | Required |
| 10 | Stamping by W&M Inspector | Required |

## 10.10 Belt Conveyor

### 10.10.1 Conveyor:

The conveyor shall have a sturdy, welded, structural steel frame and supports for mounting all the machinery. Frame shall be designed suitably for the belt tension, clearances etc. Frame shall be fabricated from steel conforming to IS: 2062. Antifriction bearings with double labyrinth dust seals and easily accessible pressure gun lubrication fittings shall be provided. It shall be possible to operate the telescopic movement of the spout, within the operating range while the machine is operating at its full capacity. All bearings shall be Spherical roller bearings with plummer blocks lubricated by grease. Belt Conveyors shall be complete in all respects and shall include but not limited to conveyor belting, idler rolls with supports, pulleys, drive units with base frames, head and tail frames, take-up units, skirt boards, scrapers, transfer chutes, stringer frames, short supports, deck plates, gates, etc. and all bolts including anchor bolts.

Belt Conveyor Parameter

| Conveyor No. | | J1C1 | J1C2 | J1C3 |
|---|---|---|---|---|
| Aprox. Length | m | 250 | 310 | 470 |
| Material to be handled | | Stone Chips | | |
| Bulk density | kg/m3 | 1600 | | |
| Rated Capacity | TPH | 900 | 900 | 900 |
| Design Capacity | TPH | 1000 | 1000 | 1000 |
| | | | | |
| Belt Width | mm | 1000 | 1000 | 1000 |
| Belt Speed | m/sec | 2.2 | 2.2 | 2.2 |
| Troughing Angle | Degree | 35 | 35 | 35 |
| | | | | |
| 3 PC Carrying Idlers | dia(mm) | 139.7 | 139.7 | 139.7 |
| Carrying Idler Pitch | m | 1.2 | 1.2 | 1.2 |
| | | | | |
| Flat Return Idler | dia (mm) | 139.7 | 139.7 | 139.7 |
| Return Idler Pitch | m | 3.6 | 3.6 | 3.6 |

### 10.10.2 Belting

The belting for conveyor shall be of suitable EP belt for heavy duty application and shall have adequate number of plies to withstand the tension and support load, adequately; top and bottom cover thickness shall not be less than 5 mm and 3 mm respectively. The ratio of breaking strength to rated allowable working tension shall be minimum nine (9). Belts

supplied shall not blister or separate in the plies or at seams or stretch more than two and half per cent of their original length within one year of installation and normal operation. Belt construction shall be such that in the case of edge damage, ply separation and ingress of moisture shall not take place.

(A) Belting shall conform to latest revision of IS: 1891 (Part I), IS: 11592-2000 and other relevant Indian Standards.

(B) Belts shall have hot vulcanized joints after erection

Nylon-Nylon belting shall be used for all conveyors. Belt ratings are selected in such a way that normal working tension in the belt will not exceed 80 % of the maximum allowable working tension. The belt cover for conveyors shall be of rubber and grade of cover shall be Fire Resistant (FR) grade conforming to Canadian Standard Association CAN / CSA / M-222-M87 Grade-C

### 10.10.3 Idlers

Carrying idlers shall be of fixed type and provided with three equal rolls with 35° troughing angle. Return idlers shall be of two equal rolls with 10° trough ('V' type). At loading zone impact idlers shall be provided.

Idlers shall be made from ERW steel tube. The rollers shall be mounted on EN 8 or equivalent material shaft by means of heavy-duty ball bearings. The bearings shall be adequately lubricated and sealed for life.

Idler rolls shall be water proof, dust proof and weather proof against a high velocity water jet. All idlers shall be provided with double labyrinth dust seal.

Deep groove ball bearings shall be used. The bearings shall be chosen for life L-10 equal to 50,000 hours minimum. The bearing seals shall have minimum resistance to rotation. Lubrication fittings for the labyrinth seals shall be provided in the case of idlers provided at loading points, for the purpose of occasional greasing to keep the dirt and dust out. Felt seals will not be accepted.

All idlers and assemblies shall conform to latest edition of IS: 8598 or equivalent.

Internal rolling friction resistance of idler rolls shall not exceed 0.015 while testing.

### 10.10.4 Pulleys :

Pulleys shall be made of welded steel and stress relieved in the furnace before machining. All pulleys shall have ring feeder or tapered lock be keyed to forged steel shafts of EN8 or equivalent material.

Pulley shall be straight faced. Drive and discharge pulleys shall be of same diameter provided with 16 mm thick diamond type grooved rubber lagging. The rubber hardness shall be IRHD 60. All pulleys shall be statically balanced. The balance weight shall not exceed 1% of the total weight of the pulley. The pulleys shall have minimum rim and disc thickness of 12 mm. The face width of pulleys shall be as per relevant IS Standards suitable for belt. The face run-out on diameter shall not be more than 0.5 mm. The run-out tolerance after lagging shall not be greater than 0.5 mm on diameter. Bearings for all pulleys shall be antifriction double row, self-aligning, spherical roller bearings mounted on adapter sleeves.

All Plummer blocks housings shall be of cast steel construction with double / triple labyrinth seals. All pulley bearings shall have life of 50,000 hours.

### 10.10.5 Belt Weighers

Belt weigher shall be provided in the system at appropriate locations for measurement of cargo handled. The belt scale shall be load cell type and shall be continuous operating. Accuracy shall be 0.25%. Provisions for local and remote measurement of instantaneous throughput and to falling shall be made. Signals for remote indication and overload alarm shall be provided. Local control panel including rate indicator and totalizer shall be provided. The load cells shall be completely sealed, water and dust proof, and maintenance free.

### 10.10.6 Belt Cleaners

External belt cleaners shall be double bladed, spring loaded modular segmented and replaceable polyurethane scrapper. The modular units shall be easily replaceable. The scraper assembly shall be easily maintainable from outside without any interference with the chute arrangement and assembly.

Internal belt cleaners shall be V plough type made of mild steel flats and hard rubber strips with automatic wear adjustment.

### 10.10.7 Safety & Control Devices

All conveyors, unless mentioned otherwise, to be equipped, but not limited to the following:

Pull chord type (manually reset type) emergency stop switches shall be located on both sides of belt conveyors along the walk ways for the entire length of conveyors for emergency stopping of conveyors.

Belt sway switches of resetting type shall be provided at periodic intervals on both sides of conveyor to limit belt sway to permissible extent. Zero speed switches shall be non-contact (proximity) type electronic switches and shall be mounted on tail / bend pulleys.

Chute blockage switch: All chutes shall be provided with plugging switches connected to the conveyor interlocking system.

### 10.10.8 Drive Unit

Drive shall be through reversible Geared Motor/Motor & shaft mounted Gear box, flexible couplings and brake etc. Gear type shall be Bevel Helical of reputed make.

### 10.10.9 Take-up Arrangement

The conveyors shall be provided with automatic take-up of gravity type. Gravity take up arrangement shall comprise of a structural steel frame sliding up and down on two vertical steel pipe guides, a take up pulley unit mounted on antifriction bearing pillow blocks bolted on to the steel frame and threaded counter weight rods secured to the lower edge of the steel frame each provided with two nuts and washer at their lower end for attaching counter weights.

The take up movement shall not be less than the values specified in Table 1 of IS 4776 (Part I).

Take-up weight shall consist of multi-blocks to facilitate adjustment in weight if required during operation. Weight of single heaviest piece shall be suitable for easy handling

### 10.10.10 Chute & Hood

Guided transfer chutes suitably designed with a minimum valley angle of 65 shall be provided at all transfer points for transfer of cargo from one conveyor to the next in the direction of belt travel.

Chutes shall be made of structural steel as per IS 2062 and shall have minimum thickness of 10mm.

Chutes shall be provided with replaceable type liner plates. Such liner plates shall be of abrasion resistant type or impact resistant type depending on whether the surface is subjected to friction or impact.

Hoods shall be provided over chutes having provision for fixing dust suppression system as per requirement.

### 10.10.11 Hoist / Chain pulley blocks

Monorail Hoists with pendant control shall be provided in towers, transfer towers, drive houses, and other areas, as required, where equipment parts heavier than 200 Kg are to be handled for maintenance or lifting height is more than 10m. Elsewhere, monorails shall be provided to facilitate manual chain pulley block operations for lighter parts.

### 10.10.12 Conveyor Galleries

Conveyor galleries shall be provided with walkways of adequate width on either side to facilitate inspection and maintenance work. Minimum walkway width of 1000mm on each side shall be provided.

Generally conveyor galleries shall be of open type with conveyor hood, however, at jetty hopper travel portion the gallery shall be open type.

Handrails of suitable size and construction shall be provided for safety reasons.

### 10.10.13 Transfer Towers

All transfer towers shall be provided with GI corrugated sheet cladding as necessary to have an enclosed structure for dust containment. Necessary louver arrangement shall be provided to have natural ventilation.

Sufficient headroom and a minimum space of 1500mm all-round the equipment installed shall be provided in all transfer towers for the purpose of maintenance and safe operation.

All transfer towers shall be provided with electric / manual hoists with monorails for maintenance purpose. The rails shall protrude out of the house by 1500mm or so for enabling lifting and lowering of heavy components / spares.

**Table 10-6: Data Sheet for Belt Conveyor System**

| | | |
|---|---|---|
| 1. | Belting | Nylon-Nylon |
| 2. | Cover Grade | Fire Resistant (FR) grade conforming to Canadian Standard Association CAN / CSA / M-222-M87 Grade-C |
| 3. | Motor | TEFC Squirrel cage Induction motors |
| 4. | Gear Box | Helical or bevel helical type without fans or cooling coils |
| 5. | High Speed Couplings | Scoop controlled / delayed chamber type |
| 6. | Low Speed Couplings | Geared type |
| 7. | Brakes (as applicable) | Thrustor type |
| 8. | Hold back units | Integral with gear box |
| 9. | Carrying idlers | Fixed type with three equal rolls with 35° troughing angle |
| 10. | Return idlers | Fixed type and provided with two equal rolls with 10° trough ('V' type) |
| 11. | Pulleys | Mild steel construction keyed to forged steel shafts with vulcanized natural rubber lagging |
| 12. | External belt cleaners | Double bladed, spring loaded modular segmented and replaceable polyurethane scrapper |
| 13. | Internal belt cleaners | V plough type made of mild steel flats and hard rubber strips |
| 14. | Take-up | Automatic take-up of gravity type |
| 15. | Belt Protection | Pull chord switches, Belt sway switches, Zero speed switches, Chute blockage switches, etc. |
| 16. | Chutes | Structural steel construction as per IS 2062, 10mm thick Mother Plate with replaceable type liner plates |
| 17. | Flap gates | Linear actuator operated |
| 18. | Belt scale | Load cell type |
| 19. | Magnetic separator | In-line D.C. operated, Electromagnetic suspended type |
| 20. | Metal detector | Electronic Solid State |
| 21. | Maintenance | Monorail Hoists/Cranes |

## 10.11 Rail mounted travelling Stacker

Stacker, as shown in Figure below, is a large machine mounted on a travelling gantry with a boom conveyor. Its function is to stack bulk materials in an orderly and geometric stockpile optimizing the area.

A stacker has three basic movements:

Luffing: This is vertical movement done by luffing (raising and lowering) of its boom by either a winch mechanism with a wire rope, or by hydraulic cylinders. This minimizes the dust generation by reducing the discharge height. The boom is luffed upwards as the height of the stockpile increases.

Travelling: The stacker moves on a rail track (gauge proportionate to the boom of the stacker), enabling it to stack the cargo along the length of the stockyard as required. For this purpose, traction motors powered with gear reducers and multi wheel bogies are provided. All controls are either in a control cabin located at the boom or in the Main Control Room. Stackers can also be controlled remotely.

Slewing: This allows the stacker to form stockpiles on either side of the conveyor by rotation of the stacker boom around its central axis to align where required. This works mostly by a slew pinion that rotates around a slew base with a sun and planet gear arrangement.

**Figure : Typical Arrangement of Stacker**

# 11 PRELIMINARY ENGINEERING - ELECTRICAL AND CONTROL SYSTEM

## 11.1 Electrical Power Requirement

The main power requirement for electrical load in the Construction of IWT Terminal at Varanasi on National Waterway-1 project shall be on account of illumination system, Conveyors, Transfer Towers, Godown, Overhead Water Pump, Sewage Treatment Plant, Weigh Bridge, Belt Scale, flap gates etc. for backup yard and other auxiliary services of Phase-1B and Final Phase. In case of operational power, all the installed loads shall not be required simultaneously. For instance, in case of FFS, Water pump, Dust extraction System etc., all the loads shall not be operating simultaneously. Similarly all the running conveyors shall also not draw maximum power at the same time.

All Electrical and controls equipment shall be designed for an ambient temperature of 45$^{o}$C.

Taking all such aspects and applying suitable diversity factors, the computation for estimated connected power and demand load are shown in the attached **Annexure-1,** summary of which is given below:

**Table 11-1 Summary of Load Calculations**

| Description | PHASE | Connected Load | Demand Load |
|---|---|---|---|
| Total LT Load | PHASE-1A & 1B | 493 kW | 365 kW |
| Total LT Load | FINAL PHASE | 1027 kW | 760 kW |

### 11.1.1 Source of Power Supply

Power at 11kV shall be made available up to Existing substation in Phase 1a.

### 11.1.2 System Description

Power at 11kV received at the incomer of HT Switchgear shall be fed at the same voltage to High Power Consuming Equipment (> 160kW) like Motors and other substations as required in future phases as also shown in attached **Power Single Line Diagram I-525/VTR/233**.

### 11.1.3 Utilization Voltages

The particulars of Power Supply shall be as follows:

| | |
|---|---|
| Voltage | 11kV ± 10% & 415V ± 10% |
| Phase | 11kV (3 Phase 3 Wires)<br>415V (3 Phase 4 Wires) |
| Frequency | 50 Hz ± 3% |
| Combined Voltage & Frequency Variation | 10% |
| Fault Level | 26.3kA for 3 second at 11kV |

| | |
|---|---|
| | 50kA for 1 second at 415V |
| System Earthing<br>415 V | Solidly Earthed |
| Control Circuits | |
| Circuit Breaker Protection & Tripping | 110 V DC, 2 Wire grounded |
| Control System | |
| UPS System, Field Hooters | 240 V ± 10%, AC, 50 HZ ± 3%, 1 Ph, 2 Wire |

### 11.1.4 Electrical Substation (ESS)

ESS-1 is already under construction for Phase 1A. Further One number substation ESS-2 is proposed to be located and constructed progressively as shown in the **Drawing I-525/VTR/232**. Switchgear room on the Ground Floor shall be housing Metering Panel of UPPCL, Transformers, Diesel Generator set, 11kV HT Switchgear Panel, 415V Power Control Center (PCC) and various distribution Boards etc.

Control room on the First Floor of ESS shall be housing Programming Station, Server Station, Operating Station, CCTV Control Station, PLC Panel, UPS & 64" LED Screen. First Floor shall also have facility of Store Room, Pantry, Conference Room and Toilet.

### 11.1.5 Power Factor Correction

415V capacitor banks with Automatic Power Correction Panels shall be provided at ESS1 & ESS2 as shown in the attached **Power Single Line Diagram I-525/VTR/233 & I-525/VTR/234** to achieve power factor of 0.95 lag on 415V bus respectively. One number capacitor bank for 415V shall be installed in Phase-1b at ESS1 and in final phase at ESS2.

### 11.1.6 Distribution Transformer

11kV voltage is further stepped down to 415V through two numbers of distribution transformers, which shall be installed in Phase-1A & Final phase each capable of handling 100% load at a time. Transformer of rating 11kV/433V, 500KVA, at EES1 and 11kV/433V, 1250KVA at ESS2. Transformer shall be indoor Dry type, having off circuit tapping of +/-10%, in steps of 2.5%, winding temperature detectors with scanner for temperature alarm and trip, door safety limit switch and accessories.

### 11.1.7 Motors

All Motors including and below 160 kW shall be 415V and all motors above 160 kW shall be 11 kV. Motors shall be energy efficient (IE3), squirrel cage induction type.

### 11.1.8 HT Power Distribution System

11kV HT Switchgear Panels are proposed at ESS1 & ESS2 as shown in the Single Line Diagram **Drawing I-525/VTR/233 & I-525/VTR/234 respectively**. All relays in these HT Switchgear Panels shall have intelligent type Multifunction relays (Numerical relays) and meters shall be of digital type with RS 485 communication port facility both for relays & meters. Lamps shall

be LED type. Busbars shall be high conductivity Aluminium alloy @ 1.0 Amps/mm$^2$ current density for HT Switchgear panels. One of each type of feeder, shall be provided as spare. The enclosure protection shall be IP54 minimum for indoor installation and IP55 minimum for outdoor installation.

11kV HT Switchgear Panel shall be provided with Vacuum Circuit Breaker (VCB) of suitable breaking capacities but not less than 26.3KA for 3 second.

### 11.1.9 LT Power Distribution System

One number of 415V Power Control Centre (PCC) is proposed at ESS1 & ESS2 as shown in the SLD **Drawing I-525/VTR/233 & I-525/VTR/234 respectively**. All relays in this LT Switchgear Panel shall have intelligent type Multifunction relays (Numerical relays) and meters shall be of digital type with RS 485 communication port facility both for relays & meters. Lamps shall be LED type. Busbars shall be high conductivity Aluminium alloy @ 1.0 Amps/mm$^2$ current density for PCC, ACDB & MLDB. Bus bar shall be of high conductivity electrolytic grade Copper @1.25 Amps/mm$^2$ current density for other distribution boards (like LDB, PDB, CDB etc.). PCC shall feed power at 415V to the various LT Loads such as motors, PDBs, MLDB/LDBs, Distribution Boards (DBs) etc. The enclosure protection shall be IP54 minimum for indoor installation and IP55 minimum for outdoor installation.

PCC shall be provided with Air Circuit Breaker (ACB) and moulded case circuit breaker (MCCB) of suitable breaking capacities but not less than 50KA for 1 second. The rupturing capacity of miniature circuit breaker (MCB) used in DB's/SB's/FP's for further distribution shall not be less than 10 KA.

Industrial power sockets 240V 15A, minimum 2 Nos. shall be installed at each floor of Electrical Substation, Control Room, Terminal Admin. Building, Worker's Amenity Building, Security Office, Weigh Bridge Building, Sewage Treatment Plant, Covered shed, Transfer towers etc. & at a distance of every 30m in case of Conveyors

Welding socket 415V TPN and earth 63A, minimum 2 Nos. shall be installed at each floor of Electrical Substation, Control Room, Terminal Admin. Building, Worker's Amenity Building, Security Office, Weigh Bridge Building, Sewage Treatment Plant, Covered shed, Transfer towers etc. & at a distance of every 30m in case of Conveyors

### 11.1.10 Standby Power Supply

Silent Diesel generator (DG) set has been envisaged for feeding 100% indoor lighting & 20% High Mast Load requirements. One number 160 KVA & one number 200 kVA DG set is proposed in Phase-1b at ESS1 and final phase at ESS2 respectively.

### 11.1.11 Illumination

The illumination level in various areas to be maintained at the working plane are mentioned below and for other areas not mentioned below it shall be based on National Electric Code.

| Location | Average lux level | Type of Luminaire |
|---|---|---|
| Stockpile and Jetty Area | 30 | 350W LED Flood Light, weather proof, Heavy duty High Mast(30 m) light in die cast Aluminium alloy housing |
| Electrical Substation, Transformer, DG Room, Worker's Amenity Building, Sewage Treatment Plant, Waste Collection Center, Weigh Bridge Building & Security Office | 200 | General Purpose Industrial compact batten suitable for 2x20 W LED Tube Light fitted with Aluminium heat sink |
| Terminal Admin. Building & Control Room | 300 | 34Watt LED Panel with ultramodern recess mounting luminaire suitable for armstrong/grid/POP ceiling complete with separate electronic driver & high brightness Surface Mounted Device (SMD) LEDs |
| Storage shed | 100 | Open type vertical Medium Bay LED luminaire with high power COB 70W LED as light source |
| Belt Conveyors walkways, Transfer Towers | 50 | Vertical/Horizontal surface mounting pressure die-cast aluminium well glass luminaires with high power 40W LED as light source |
| Electrical Substation, Control Room, Terminal Admin Building, Worker's Amenity Building, Security Office, Weigh Bridge, STP, Covered Shed, Transfer Towers, conveyor galleries, all exit / entry points etc. | 10 | Battery operated emergency lighting unit consist of aesthetically designed rechargeable 5 Watt LED lantern with dimming and SOS feature. Battery shall be rechargeable Li-ion type & 5V DC Li-ion charger with 1 hour battery backup |
| Road light | 20 | 70 Watt LED with single / double arm 9 meter hexagonal GI pole with FRP J.B and required accessories. |

Wherever required poles of suitable height with fittings shall also be installed for outdoor lighting of the buildings.

One number of MLDB is proposed. MLDB shall receive dual power from respective PCC and DG supply, which in turn shall feed various LDBs of Phase-1B & Final Phase as shown in attached **Power Single Line Diagram Drawing I-525/VTR/233 & I-525/VTR/234 respectively**. 1:1 Lighting trans-formers shall be placed at MLDB to maintain voltage drop within the permissible limits.

### 11.1.12 Cables

Power distribution at 11 kV shall be done through 11 kV (E), XLPE, stranded aluminium conductor, armoured, overall FRLS PVC sheathed cable laid on cable trays, ducts, directly buried in ground and in trenches, etc. as per site requirement.

LT power distribution to various LT motors and services such as illumination, firefighting, air conditioning, water supply etc. shall be done through 1.1 kV grade XLPE insulated, stranded aluminium conductor, armoured, overall FRLS PVC sheathed power cables. Laying of cables shall be done as per site requirement.

Internal wiring shall be done in recessed PVC conduit or on surface with GI conduit and single core PVC insulated FRLS copper wire.

### 11.1.13 Cable Trays & Accessories

FRP type cable trays & its accessories shall be considered for the project. Thickness of the various components shall be as per the calculations and these calculations shall be submitted by EPC Contractor for client approval before starting the manufacturing.

### 11.1.14 Earthing & Lightning Protection

An efficient earthing and lightning protection system shall be designed to ensure protection of men & material in worst of the weather conditions. Suitable Lightning protection system shall be installed as per the guide lines of the IS/IEC-62305:2010 (Superseding IS-2309: 1989).

All equipment of substation and various other services / equipment shall be earthed at two points. There shall be one earth grid formation using 75 x 8 mm GI strip and all equipment earthing shall be connected to this earth grid through Aluminium wire with PVC coating or GI strip as per the requirement. This grid shall be connected with number of pipe electrodes. However, the neutrals of transformers and DG sets shall be earthed separately. Each neutral shall be connected to 2 numbers separate pipe earth electrodes. Specialised Earthing shall be provided to the sensitive equipment by means of dedicated Cu. earthing pits, Cu. earthing conductor and Cu. earth bus bar mounted on the insulators. Earthing system shall be designed in principle as per IS: 3043, however for chemical earthing IEEE: 80-2000 shall also be followed.

For lightning protection separate earth pits shall be provided. Exact number of earth pits shall be worked out after earthing and lightning protection calculation has been carried out measuring the soil resistivity at site.

Earth (chemical) pits shall be based on High Conductivity Technology. In this technology of chemical earthing, a compound of high electrical conductivity shall be filled up in the space around the ground electrode, so that the earth resistance value would decrease appreciably. Minimum Electrode size shall be as per the latest amendments of IS: 3043.

The high Conductive Compound shall be able to perform in any weather and soil Conditions and shall have following properties;

1) It shall have high electrical conductivity, which should remain constant and unaffected by changes in temperature & moisture.

2) It shall permanently remain embedded and should neither dissolve in and swept away by water.

3) It shall have an ability to absorb large amount of water and retain the same over a long periods of time.

4) It shall decreases earth pit resistance with passage of time.

5) Solubility: Shall be partly miscible; so that it does not dissolve fully like common salt and thus increasing the Earth Pit Life.

6) The pH value shall be near neutral so that it does not pollute soil or water and also does not corrode earth electrode.

7) It shall be maintenance free Compound so that there shall be no need of extra water pouring at regular interval as in conventional earthing material, because it should retain the moisture.

8) Chemical Compound shall be thermally conductive, in order to maintain a constant Earth resistance in temperature range of -50 to +60 degree Celsius.

9) The Compound shall have relatively High conductivity so that it can create very low resistance even in rocky areas.

10) It shall have low earth resistance, carries high peak current repeatedly.

11) It shall have a Long and reliable life.

12) It shall be easily installed in any soil conditions.

### 11.1.15 Ventilation and Air Conditioning (AC) System

Electrical Substation at Ground Floor, metering room, Battery room, control Room, Worker's Amenity Building, STP (Pump room), all toilets & pantries shall be provided with exhaust fans for ventilation to maintain proper temperature inside the panel room and removal of additional heat produced due to various switchgears.

Split AC shall be used for Control Room, Security Office & Weigh Bridge building. The offices in the Terminal Admin. Building shall be Air-conditioned through centralized AC so as to maintain an inside temperature of $27^{o}$C.

Tentative layout of the various rooms is shown in the drawings mentioned below:

a) Typical Layout of Terminal Administration Building, **I-525/VTR/211**

b) Substation Equipment Layout, **I-525/VTR/232**

c) Typical Layout & Elevations of Security and Weigh Bridge control room and Canteen with toilet **I-525/VTR/214, I-525/VTR/215 & I-525/VTR/216**

d) Layout Plan (Phase-1A, Phase 1B & Phase-2) of Terminal Facilities, **I-525/VTR/204, I-525/VTR/205 & I-525/VTR/206 respectively.**

### 11.1.16 Battery and Battery Charger

One number dual Battery and Battery Charger with DC Distribution Board shall be provided for the control, protection, interlocks and indication of switchgear panels.

### 11.1.17 Closed Circuit TeleVision (CCTV) System

To ensure surveillance of required locations as well as create secured record for post event analysis, CCTV system is proposed. The system shall provide an online display of video images on LED monitors located in Control Room and PTZ (360O) cameras at various locations like Gate Complex, Terminal Administration building & at all berths etc. as per **Drawing I-525/VTR/235**. The core of the surveillance system shall be Network Video recorder (NVR) server. System shall also have operating systems, appropriate software, networking equipment and other essential components.

### 11.1.18 Control System

The Control system shall be installed to ensure safe and reliable operation of conveyors, dust extraction system and others facilities. PLC system shall read the inputs, perform all system logic, conduct online diagnostics, sequencing control and control the outputs. The processor based central control system is envisaged to control and monitor the material handling operations in the IWT Terminal so as to carry out the operation in an integrated mode from “Control Room”.

The Control Network shall be used for providing automation functions, interlocking, sequence starting, monitoring and supervisory functions with Belt Conveyors.

The Control Network shall also be used for providing monitoring and supervisory functions, interconnection with Equipment/Machines having its own Control Systems like Mobile Harbour Crane, Barge Loaders, Weigh Bridge, Gantry Type Grab Cranes etc.

The core of the system shall consist of an Operating station, Programming Station & Server station (all the computers shall be latest version of the Industrial PCs - IPC as on the date of bidding) with printer and along with centralized real –time redundant PLC system (One online and the other in hot standby excluding I/O modules), sharing a RAID 6 (redundant array of independent disk) data storage system and a data network, with shared high-capacity data backup and off-site data archiving.

The control system would incorporate all safety interlocks to ensure complete safety to operating personnel and to avoid any damage to equipment due to mal- functioning.

The control system shall generally be based on the following principles:

i) To start equipment in either of the two modes i.e. 'Local' or 'Remote'
ii) To trip off minimum equipment in the desired sequence during abnormal operating conditions, leaving all the other equipment running, which may safely be permitted to continue the operations
iii) To annunciate the fault which has tripped equipment along-with the cause for tripping
iv) To prevent restarting of the equipment until safe conditions have been restored
v) To retain maximum flexibility of operation consistent with safety
vi) To prevent mal-operation of equipment on interruptions
vii) To stop all the running equipment simultaneously by pressing Emergency Stop Push Button
viii) To stop running equipment in the reverse order with time lag during normal stop.

Processor would perform all operational and control functions. Processor would collect all the field related data from local field devices like local push button station, pull chord switch, belt sway switch, zero speed switch, local control panels etc. via junction boxes by means of data bus cable.

The control network shall be real-time network, requiring long time continuous operation. During normal operations, the system cannot be shut off and it shall be possible to replace the components without shutting off the power. It shall be feasible to program the system online.

Proper care shall be taken in data transfer so as to achieve quick response while transmitting control and management information. The response time should not be more than one millisecond. The network system shall have fault clearance functions, secure transmission of data through error checking routines on all data transmitted. The networks shall use open systems (universal protocol) technology, support multiple industrial standards, allow a combination of multiple communication agreements, and shall have the capability to join wider networks in future through the server.

The analogue module system shall have provision to accept signals from other subsystems generating 4-20mA analogue signals. Proper conversion to standard units shall be done by control software.

Redundancy (100% hot standby) is provided in the PLC's so that in case of failure of any of the processors, the hot stand by processor shall take over automatically. The changeover shall be smooth. Redundancy shall be provided for complete processor subsystem including CPU, memory, power supply.

Input/output units shall be capable of accepting discrete, analogue and digital input and output devices. If the number of slots for input and output modules in the controller rack is not sufficient, expansion units shall be connectable to the CPU by means of interface modules.

Each Input and Output module shall be electrically isolated from the controllers through opto-couplers or isolation transformers and shall withstand severe voltage transients without damage or adverse effect on the controller. Output modules shall incorporate self-contained damping networks and voltage limiting devices to prevent false triggering of outputs and to suppress line voltage spikes.

PLC power supply units must have self-test facilities for detecting under voltage and also must be able to give alarm and switch over to UPS mode in case the output voltage is + 20% above the normal value.

A SCADA system shall be provided to control and monitor operation of the proposed facility.

### 11.1.19 Safety Switches

Safety switches for conveyors shall mainly consist of the Zero Speed Switches (ZSS), Belt Sway Switches (BSS), Pull Chord Switches (PCS) and Belt Take-up Switches (BTS).

PCS shall be installed @ 30m on both sides of each pipe/belt conveyor to stop the conveyor instantly when an accident happens. BSS shall be installed @ 50m to stop drive unit for protecting belt from rubbing against the structural parts on both sides of each pipe/belt conveyor. One number ZSS shall be provided to stop the motor when the speed of the equipment drops below a specified value or if normal speed is not reached within a specified time, and to signal starting and stopping of preceding conveyor/ equipment.

PCS and BSS shall be microprocessor based addressable type and shall be connected to the Master Unit for monitoring, which in turn shall communicate with the PLC. This Master unit shall be placed in the Field / Remote I/O panel as shown in the attached Control Architecture.

BTS switches shall be provided and installed so as to be actuated by an extreme movement of the conveyor belt take ups, should the belt tension not be adequate for any reason.

### 11.1.20 Communication System

Telephone System

EPABX system of 50 lines is proposed for this project.

Public Address (PA) System

No PA system is proposed for this project.

# Annexure – 1

| LT LOAD CALCULATION – PHASE 1A & 1B | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.NO. | Equipment | Connected load (KW) | Utilization factor (%) | Maximum Demand (KW) | DG Rating (kVA) | TOTAL CAPACITANCE LOAD | |
| 1 | Power Supply to Godown 1 | 60 | 0.8 | 48 | 0 | 48 | |
| 2 | Power supply to Fuel station | 15 | 0.6 | 9 | 0 | 9 | |
| 3 | Power supply to Banarasi Haat | 15 | 0.6 | 9 | 0 | 9 | |
| 4 | Power supply to Shops & Kiosk | 15 | 0.6 | 9 | 0 | 9 | |
| 5 | Power supply to Jal Yatri Nivas | 20 | 0.6 | 12 | 0 | 12 | |
| 6 | Underground reservoir - Pump | 30 | 1 | 30 | 0 | 30 | |
| 7 | Sewage Treatment Plant | 7.5 | 1 | 8 | 0 | 8 | |
| 8 | Electric Hoist (5 X 5.9kW) | 29.5 | 0 | 0 | 0 | 0 | |
| 9 | Weigh Bridge (including control room) (2x3kW) | 6 | 0.8 | 5 | 0 | 5 | |
| 10 | MLDB Load Phase 1a | 130 | 1 | 130 | 100 | 130 | |
| 11 | MLDB Load Phase 1b | 100 | 1 | 100 | 50 | 100 | |
| 12 | PDB (For Welding Socket Load) | 60.0 | 0 | 0 | 0 | 0 | |
| 13 | Battery Charger | 5.0 | 1 | 5 | 5 | 5 | |
| | **LT Load in kW - PHASE-1** | 493.0 | | 364.3 | 155.0 | 364 | |
| | **Load in kW at 90% Diversity factor** | | | **327.9** | **139.5** | **Total Capacitance Load** | 364 |
| | **Load in kVA at .95 pf** | | | 345.1 | 174.4 | Multiplying Factor (0.75 to 0.95) | 0.553 |
| | **Load at 120% Overload** | | | 414.2 | 209.3 | Required Capacitance | 201 |
| | **TRANSFORMER & DG RATING SELECTED** | | | 500 kVA | 50 kVA, Phase 1a + 160 KVA Phase 1b | CAPACITOR BANK SELECTED | 25 KVAR Phase 1a+ 200 KVAR Phase 1b |

| LT LOAD CALCULATION - FINAL PHASE | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.NO. | Equipment | Connected load (KW) | Utilization factor (%) | Maximum Demand (KW) | DG Rating (kVA) | TOTAL CAPACITANCE LOAD | |
| 1 | Power Supply to Godown 2 | 60 | 0.8 | 48 | 24 | 48 | |
| 2 | Jetty Conv. 1 | 90 | 0.8 | 72 | 0 | 72 | |
| 3 | Conv. 2 | 90 | 0.8 | 72 | 0 | 72 | |
| 4 | Yard Conv. 3 | 150 | 0.8 | 120 | 0 | 120 | |
| 5 | Mobile Hopper 1 | 75 | 0.8 | 60 | 0 | 60 | |
| 6 | Mobile Hopper 2 | 75 | 0.8 | 60 | 0 | 60 | |
| 7 | Stacker 1 | 110 | 0.8 | 88 | 0 | 88 | |
| 8 | Conv. Accessories - Hoist, Drive coupling, transfer tower illumination etc. | 50 | 0.8 | 40 | 0 | 40 | |
| 9 | Road Weigh Bridge for MHS (2x3kW) | 6 | 1 | 6 | 0 | 6 | |
| 10 | Electric Hoist (5 X 5.9kW) | 29.5 | 0.8 | 24 | 0 | 24 | |
| 11 | Weigh Bridge (including control room) (2x3kW) | 6 | 1 | 6 | 6 | 6 | |
| 12 | MLDB Load Final Phase | 160 | 1 | 160 | 110 | 160 | |
| 13 | PDB (For Welding Socket Load) | 120.0 | 0 | 0 | 0 | 0 | |
| 14 | Battery Charger | 5.0 | 1 | 5 | 5 | 5 | |
| | **LT Load in kW - FINAL PHASE** | 1026.5 | | 760.6 | 145.0 | 761 | |
| | **Load in kW at 90% Diversity factor** | | | **684.5** | **130.5** | **Total Capacitance Load** | 761 |
| | **Load in kVA at .95 pf** | | | 720.6 | 163.1 | Multiplying Factor (0.75 to 0.95) | 0.553 |
| | **Load at 120% Overload** | | | 864.7 | 195.8 | Required Capacitance | 421 |
| | **TRANSFORMER & DG RATING SELECTED** | | | 1250 kVA | 200 kVA | CAPACITOR BANK SELECTED | 420 kVAR |

# 12 FIRE FIGHTING

## 12.1 Fire Fighting Facilities

The firefighting system should be Provided IWT Terminal, Varanasi. The system shall be designed in accordance with NFPA and TAC standards.

It is envisaged to use raw water for fire hydrant system.

## 12.2 Fire Water Tank & Pump House

**PHASE 1B**

The Fire water is stored in two compartments having capacity (8.5M X 7.1M X 4M H) 482 $M^3$ located near the fire water pump house. Two (2) nos. fire water storage tanks each of capacity sufficient to meet fire water requirements of phase 1B.

The 2 Nos. (1W+1S) pumps with capacity 171 $M^3$ located in fire pump house shall be operated in a semi-automatic mode. The capacity pump is sufficient to meet fire water requirements in phase 1B.

**Final Phase**

The Fire water is stored in two compartments having capacity 700 $M^3$ located near the fire water pump house. Two (2) nos. fire water storage tanks each of capacity sufficient to meet fire water requirements envisaged within the plant area.

The 2 Nos. (1W+1S) pumps with capacity 273 $M^3$ located in fire pump house shall be operated in a semi-automatic mode. I.e. starting of the pumps shall be automatic or manual and stopping shall be manual only. Main pump shall be electric motor driven and the standby pump shall be diesel driven. The jockey pump shall also be provided to keep the firewater main under required pressure.

Isolation valves (butterfly valves) shall be provided at suitable places in each of the ring mains / sub-loops to enable to take up part of any of the ring mains for maintenance.

## 12.3 Hydrant System

We have considered single headed Fire Hydrant System at Container yard, Bulk Cargo and jetty area only. Spacing of hydrants shall not be more than 45m. We have considered Water cum foam hydrant at Fuel station area.

We have considered internal hydrant at substation & Building.

Hydrant mains shall be G.I. heavy grade pipe with suitable type of fittings made of by same material. Underground pipes shall be treated for anti-corrosive material.

## 12.4 Fire Extinguisher

Fire extinguishers shall be installed in all the buildings within the plant boundary as per the requirement.

# 13 SEWAGE TREATMENT PLANT

## 13.1 General

The quantity of sewage that is expected to be generated from Varanasi MMT will be around 90% of total water requirement i.e. 18 KLD. The sewage treatment plant of 20 KLD (FAB technology) is proposed which should be compact, odour free and shall consume low power.

Plant shall be installed below ground level or at any desirable depth and shall generate minimum amount of excess sludge. Waste water after treatment below shall be suitable for A/C cooling towers irrigation and scrubber make-up.

Standards of the effluent discharge after treatment shall be as follows:

| Parameters | Value |
|---|---|
| pH | 6.0 - 8.8 |
| BOD | Less than 20 Mg/L. |
| Suspended solids | Less than 10 Mg/L. |
| COD | Less than 180 Mg/L. |
| Oil & Grease | Less than 10 Mg/L. |
| Coliform count | < 103 at the CCT outlet |

## 13.2 Special Notes

Cost of pump shall include provision of isolation valves at inlet and outlet, non-return valves at outlet, pressure gauge, and steel channel arrangement at base, power and control cable from and to electrical panel, level controllers and alarm system.

- Providing of air educator system shall be made for following through MS epoxy painted piping, fittings and valves
- Sludge recycle piping from clarifier
- Sludge waste piping from clarifier
- Skimmer return piping from clarifier
- Contractor to note that all submersible pipelines shall be in SS 304.

# 14 EXTERNAL CONNECTIVITY

## 14.1 External Road Connectivity

### 14.1.1 Existing Road Connectivity

During the site visit and as per topography survey, it is observed that there is no pucca road connectivity to the proposed site. There is an existing village road of about 700m which connects the site from NH 7.

### 14.1.2 Proposed road connectivity

To facilitate the movement of cargo from Varanasi Terminal to the hinterland, it is proposed to provide external road connectivity to the terminal from NH-7. A right of way of 23 m is acquired for the road connectivity. A canal and a nala exists along the alignment of the proposed road. The layout showing details of proposed road is shown in the Drawing I-525/VTR/242.

A two lane road of 650m length is proposed in Phase-1A, which is proposed to be widened to four lane road in Master Plan Phase. An additional four lane road is also proposed in Phase-2 on the other side of the Railway track to provide better accessibility to the terminal.

## 14.2 External Rail Connectivity

Rail connectivity plan for Varanasi Terminal was prepared considering the proposed jetty (under construction) level, Yard gradient for drainage, NH proposed alignment received from RITES. A RoB is proposed on NH-7 to accommodate rail alignment below proposed RoB. The railway level at the crossing of NH-7 is +77.00m and FRL of RoB is +87.50 m. The road traffic of Varanasi Terminal will be facilitated by U-Turn facility provided below the RoB and use of service road.

# 15 ENVIRONMENTAL IMPACT ASSESSEMENT (EIA) & ENVIRONMENT MANAGEMENT PLAN (EMP)

# 16 COST ESTIMATE

In this chapter, an estimate of the capital cost for both the phases viz. Phase-1 and Phase-2 has been prepared for the most optimal layout. The annual operation and maintenance cost of facilities that would be incurred annually for both the above mentioned phases is also provided.

## 16.1 Basis of Cost Estimates

The quantities for various project components has been arrived based on the preliminary engineering carried out by the consultant. Further, the cost estimate has been arrived on the basis mentioned below.

- The cost estimates for onshore civil works has been prepared on the basis of the rates provided in "Delhi Schedule of Rates – 2016"
- The cost estimates for the offshore civil works has been arrived based on the rates taken from current works of similar nature, updated rates of works of similar nature completed in the recent past and from Consultant's in-house data bank
- The cost estimate for equipment is based on Consultant's in-house data bank and budgetary quotations
- Taxes / Duties as applicable has been included

## 16.2 Capital Cost Estimates of Phase IA

**Table 16-1 Capital Cost Estimate for Varansi Terminal – Phase-1A**

| S. No. | Item | | Quantity | Unit | Rate (Rs.) | Capital Cost (Rs. in Cr.) |
|---|---|---|---|---|---|---|
| **1.** | **LAND & SITE DEVELOPMENT** | | | | | **17.15** |
| | 1.1 | Site clearance | | LS | | |
| | 1.2 | Earth Cutting & filling | 5,00,000 | cum | 343 | 17.15 |
| **2.** | **SHORE PROTECTION WORK** | | | | | **13.75** |
| | 2.1 | Shore protection | | LS | | 13.75 |
| **3.** | **JETTY** | | | | | **46.50** |
| | 3.1 | Berths | | LS | | 46.50 |
| **4.** | **STOCKYARD** | | | | | |
| | 4.1 | Stockyard development works (considered in Ph-1B) | 0 | Sqm | | - |
| **5.** | **BUILDINGS & SHED** | | | | | **1.22** |
| | 5.1 | Ware house (considered in Ph-1B) | 0 | sqm | - | - |
| | 5.2 | Sub station | 400 | sqm | 28,000 | 1.12 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 5.2 | Administrative building (considered in Ph-1B) | 0 | sqm | - | - |
| | 5.3 | Water tank and pump house (considered in Ph-1B) | 0 | sqm | - | - |
| | 5.4 | Banarasi hat (considered in Final Phase) | 0 | sqm | - | - |
| | 5.5 | Toilet block | 30 | sqm | 32,000 | 0.10 |
| | 5.6 | Shops and kiosk (considered in Final Phase) | 0 | sqm | - | - |
| | 5.7 | Jal Yatri Nivas (considered in Final Phase) | 0 | Sqm | - | - |
| | 5.8 | Weigh bridge cabin (considered in Ph-1B) | 0 | Sqm | - | - |
| | 5.9 | Security cabin (considered in Ph-1B) | 0 | sqm | - | - |
| | 5.10 | Fuel station/Storage area (considered in Final Phase) | 0 | sqm | - | - |
| | 5.11 | Gate Complex with Parking (considered in Final Phase) | 0 | LS | - | - |
| **6.** | **ROADS & PARKING AREA** | | | | | **6.91** |
| | 6.1 | Approach road (External) | - | LS | - | 1.81 |
| | 6.2 | Internal roads | - | LS | - | 5.10 |
| **7.** | **UTILITIES AND OTHERS** | | | | | **1.05** |
| | 7.1 | Water supply and distribution (considered in Ph-1B) | | LS | - | - |
| | 7.2 | Storm water drainage work | | LS | - | 1.05 |
| | 7.3 | Sewerage system (considered in Ph-1B) | | LS | - | - |
| | 7.4 | Electrical distribution system & IT | | LS | - | - |
| | 7.5 | Firefighting system (considered in Ph-1B) | | LS | - | - |
| | 7.6 | Boundary wall (considered in Ph-1B) | | LS | - | - |
| **8.** | **EQUIPMENTS** | | | | | **46.26** |
| | 8.1 | Mobile Harbour Crane | 2 | No. | 23,13,03,072 | 46.26 |
| | 8.2 | Semi-automatic spreader (considered in Ph-1B) | 0 | No. | - | - |
| | 8.3 | Grab 8 cum, 13Mt (considered in Ph-1B) | 0 | No. | - | - |
| | 8.4 | Road weigh bridge with Foundation | 0 | No. | - | - |
| | 8.5 | Dumper truck | 0 | No. | - | - |
| | 8.6 | Front end loader | 0 | No. | - | - |
| | 8.7 | Flat bed trailor | 0 | No. | - | - |
| | 8.8 | Truck Loading Hopper (considered in Ph-1B) | 0 | No. | - | - |
| | 8.9 | Reach stacker | 0 | No. | - | - |
| **9.** | **Pontoon and Gangway** | | | | | **10.95** |
| | 9.1 | Pontoon and Gangway and stairway | 1 | LS | - | 10.95 |
| **10.** | **Entry Gate** | | | | | **0.80** |
| | 10.1 | Entry Gate | 1 | LS | - | 0.80 |
| | | | | | | |

| | | |
|---|---|---|
| **A** | **TOTAL COST (1 TO 10)** | **144.59** |
| **B** | **CONTINGENCY (3%)** | **4.34** |
| **C** | **TOTAL PROJECT COST (A + B)** | **149.00** |
| **D** | **GST** | **31.45** |
| **E** | **GRAND TOTAL (C + D)** | **181.00** |

## 16.3 Capital Cost Estimates of Phase IB

The item-wise capital cost estimate of Phase-1B for the development of Varansi terminal is presented in below:

**Table 16-2 Capital Cost Estimate for Varansi Terminal – Phase-1B**

| S. No. | Item | | Quantity | Unit | Rate (Rs.) | Capital Cost (Rs. in Cr.) |
|---|---|---|---|---|---|---|
| **1.** | **LAND & SITE DEVELOPMENT** | | | | | **0.85** |
| | 1.1 | Site clearance | | LS | | - |
| | 1.2 | Earth Cutting & filling | 1,14,000 | cum | 75 | 0.85 |
| **2.** | **SHORE PROTECTION WORK** | | | | | **-** |
| | 2.1 | Shore protection | | LS | | - |
| **3.** | **JETTY** | | | | | **-** |
| | 3.1 | Berths | | LS | | - |
| **4.** | **STOCKYARD** | | | | | **11.54** |
| | 4.1 | Stockyard development works | 42,245 | Sqm | | 11.54 |
| **5.** | **BUILDINGS & SHED** | | | | | **17.11** |
| | 5.1 | Ware house | 12,075 | Sqm | 11,200 | 13.52 |
| | 5.2 | Adimnitrative building | 640 | Sqm | 45,000 | 2.88 |
| | 5.3 | Water tank and pump house | 300 | Sqm | 22,059 | 0.66 |
| | 5.4 | Banarasi hat | 0 | Sqm | 0 | - |
| | 5.5 | Toilet block | 0 | Sqm | 0 | - |
| | 5.6 | Shops and kiosk | 0 | Sqm | 0 | - |
| | 5.7 | Jal Yatri Nivas | 0 | Sqm | 0 | - |
| | 5.8 | Weigh bridge cabin | 9 | Sqm | 25,000 | 0.02 |
| | 5.9 | Security cabin | 9 | Sqm | 25,000 | 0.02 |
| | 6.0 | Fuel station/Storage area | 0 | Sqm | 0 | - |
| | 6.1 | Gate Complex with Parking | 1 | LS | | |
| **6.** | **ROADS & PARKING AREA** | | | | | **2.11** |
| | 6.1 | Approach road (External) | | LS | | |
| | 6.2 | Internal roads | | LS | | 2.11 |
| **7.** | **UTILITIES AND OTHERS** | | | | | **10.27** |
| | 7.1 | Water supply and distribution | | LS | | 0.95 |
| | 7.2 | Storm water drainage work | | LS | | 2.05 |
| | 7.3 | Sewerage system | | LS | | 0.28 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 7.4 | Electrical distribution system & IT communication | | LS | | 3.29 |
| | 7.5 | Fire fighting system | | LS | | 2.57 |
| | 7.6 | Boundary wall | | LS | | 1.14 |
| **8.** | **EQUIPMENTS** | | | | | **26.26** |
| | 8.1 | Mobile Harbour Crane | 1 | No. | 23,13,03,072 | 23.13 |
| | 8.2 | Semi-automatic spreader | 1 | No. | 52,50,000 | 0.53 |
| | 8.3 | Grab 8 cum, 13Mt | 1 | No. | 32,00,000 | 0.32 |
| | 8.4 | Road weigh bridge with Foundation | 1 | No. | 28,00,000 | 0.28 |
| | 8.5 | Dumper truck | 0 | No. | - | - |
| | 8.6 | Front end loader | 0 | No. | - | - |
| | 8.7 | Flatbed trailor | 0 | No. | - | - |
| | 8.8 | Truck Loading Hopper | 2 | No. | 1,00,00,000 | 2.00 |
| | 8.9 | Reach stacker | 0 | No. | - | - |
| **A** | **TOTAL COST (1 TO 8)** | | | | | **68.13** |
| **B** | **CONTINGENCY (3%)** | | | | | **2.04** |
| **C** | **TOTAL PROJECT COST (A + B)** | | | | | **71.00** |
| **D** | **GST** | | | | | **15.66** |
| **E** | **GRAND TOTAL (C + D)** | | | | | **87.00** |

The following items have not been included in the above cost estimate.

- Land acquisition cost
- Electricity and water connection cost from local electricity board and municipal corporation

## 16.4 Capital Cost Estimates of Master Plan

The item-wise capital cost estimate for Master Plan for the development of Varansi terminal is presented in below:

**Table 16-3 Cost Estimate of Varansi Master Plan**

| S. No. | Item | | Quantity | Unit | Rate (Rs.) | Capital Cost (Rs. in Cr.) |
|---|---|---|---|---|---|---|
| **1.** | **LAND & SITE DEVELOPMENT** | | | | | **24.42** |
| | 1.1 | Site clearance | | LS | | - |
| | 1.2 | Earth filling | 7,11,500 | cum | 343 | 24.42 |
| **2.** | **SHORE PROTECTION WORK** | | | | | **13.00** |
| | 2.1 | Shore protection | | LS | | 13.00 |
| **3.** | **JETTY** | | | | | **69.75** |
| | 3.1 | Berths | | LS | | 69.75 |
| **4.** | **STOCKYARD** | | | | | **11.42** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 4.1 | Stockyard development works | 58,920 | Sqm | | 11.42 |
| **5.** | **BUILDINGS & SHED** | | | | | **43.14** |
| | 5.1 | Ware house | 31,675 | sqm | 11,200 | 35.48 |
| | 5.2 | Sub station | 800 | sqm | 28,000 | 2.24 |
| | 5.3 | Banarasi Haat | 120 | sqm | 22,000 | 0.26 |
| | 5.4 | Toilet Block | 50 | sqm | 32,000 | 0.16 |
| | 5.5 | Shops/ Kiosks | 110 | sqm | 22,000 | 0.24 |
| | 5.6 | Jal Yatri Niwas (Guest House) | 550 | Sqm | 45,000 | 2.48 |
| | 5.7 | WeightBridge Cabin | 9 | Sqm | 25,000 | 0.02 |
| | 5.8 | Security Office (2 Nos) | 36 | sqm | 25,000 | 0.09 |
| | 5.9 | Fuel station/Storage area | - | - | - | 0.00 |
| | 5.10 | Gate Complex with Parking | | LS | | 1.37 |
| | 5.11 | Water tank and pump house (extension) | 120 | sqm | 22059 | 0.26 |
| | 5.12 | canteen and toilet block | 212 | sqm | 25000 | 0.53 |
| **6.** | **ROADS & PARKING AREA** | | | | | **9.75** |
| | 6.1 | Approach road (External) | | LS | | 2.99 |
| | 6.2 | Internal roads | | LS | | 6.76 |
| **7.** | **UTILITIES AND OTHERS** | | | | | **27.17** |
| | 7.1 | Water supply and distribution | | LS | | 0.20 |
| | 7.2 | Storm water drainage work | | LS | | 13.51 |
| | 7.3 | Sewerage system | | LS | | 0.49 |
| | 7.4 | Electrical distribution system & IT | | LS | | 9.45 |
| | 7.5 | Firefighting system | | LS | | 2.04 |
| | 7.6 | Boundary wall | | LS | | 1.49 |
| **8.** | **EQUIPMENT** | | | | | **125.99** |
| | 8.1 | Tyre mounted Mobile Harbour Crane | 4 | No. | 23,13,03,072 | 92.52 |
| | 8.2 | Grab 8 cum, 13Mt | 4 | No. | 32,00,000 | 1.28 |
| | 8.3 | Road weigh bridge with Foundation | 1 | No. | 28,00,000 | 0.28 |
| | 8.4 | Front end loader | 0 | No. | - | - |
| | 8.5 | Flat bed trailor | 0 | No. | - | - |
| | 8.6 | Mobile hopper | 2 | No. | 4,50,00,000 | 9.00 |
| | 8.7 | Conveyor system | 1,030 | Rmt | 71,538 | 7.37 |
| | 8.8 | Stacker reclamer | 1 | Nos | 15,54,21,335 | 15.54 |
| **A** | **TOTAL COST (1 TO 8)** | | | | | **324.64** |
| **B** | **CONTINGENCY (3%)** | | | | | **9.74** |
| **C** | **TOTAL PROJECT COST (A + B)** | | | | | **335.00** |
| **D** | **GST** | | | | | **70.55** |
| **E** | **GRAND TOTAL (C + D)** | | | | | **406.00** |

## 16.5 Operation and maintenance (O&M) costs

Operation and maintenance costs have been calculated as described below:

The following considerations have been taken to the repair and maintenance costs.

a) Civil works – 1 %

b) Mechanical works – 4 %

c) Electrical works – 4 %

d) Utilities – 4 %

The operation costs for manpower, electricity, water and fuel charges is calculated for Phase-1B as mentioned in the table below:

Based on the recent meeting held with IWAI on 5th October 2017, It is decided that entire O&M will be done by Operator and scope of authority will be limited to land lord. Therefore O&M cost for authority will be null as entire operation and maintenance of terminal will be done by operator.

**Table 16-4 Annual O&M Cost**

| S. No. | Item | Annual Costs (Rs. in Cr.) |
|---|---|---|
| **A.** | **REPAIR AND MAINTENANCE COSTS** | **Nil for IWAI as it is outsourced** |
| **B.** | **OPERATION COSTS** | |
| **C.** | **TOTAL - (A) + (B)** | |
| **D.** | Admin, Insurance and Miscellaneous expenses | |
| **E.** | **TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS - (C) + (D)** | |

# 17 PROJECT IMPLEMENTATION SCHEDULE

## 17.1 General

The implementation schedule for the development of Phase-1B for the development of Varansi MMT and its associated facilities are presented in this chapter. The probable time schedule for various activities from onset to completion of the project and commencement of operation are also discussed in this chapter.

Phase IA of the project is likely to be operationalized in year 2018.

## 17.2 Basic consideration for Implementation

For timely completion of the project, identification of major project components and sequential planning of various modules is very important for any project. The major components of Varansi MMT include both the construction of offshore and onshore facilities, apart from installation of mechanical and electrical equipment.

The offshore facilities like berths are being developed as part of Phase IA. Whereas development of onshore facilities includes site development, stockyard development, construction of buildings, storage shed, development of internal roads, and providing utilities like water supply system, sewerage system, storm water drainage system and firefighting facility.

### 17.2.1 Development of Phase-1B

The following are the major activities involved for effective completion of Phase-1B, which involves engineering, procurement, construction and commencement of operational activities.

- Detailed Engineering
- Site development including site clearance, and earth filling
- Development of stockyard
- Construction of covered storage shed for handling fertilizer
- Incremental addition of building, internal road, water supply system, storm water drainage system, electrical, firefighting system and other utilities
- Supply, installation and commission of equipment

Implementation schedule indicating timelines for Phase-1A & Phase IB is presented in figure below:

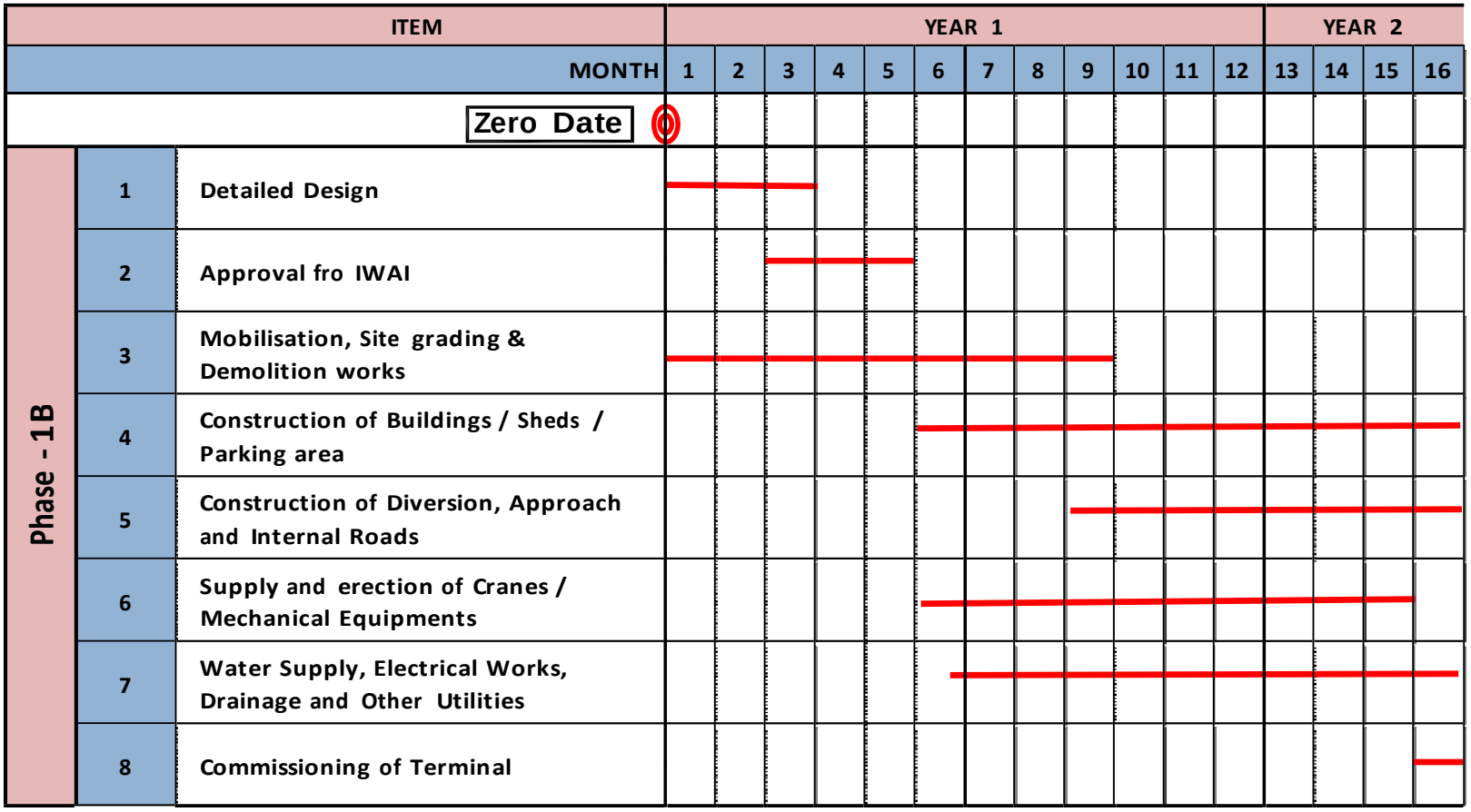
## IMPLEMENTATION SCHEDULE - VARANSI TERMINAL PHASE IA

| | | ITEM | YEAR 1 | | | | | | | | | | | | YEAR 2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MONTH | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| | | Zero Date | 0 | | | | | | | | | | | | | | | | | | | | | | | |
| Phase - 1 | 1 | Detailed Design | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Approval from IWAI | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | Mobilisation, Site grading & Demolition works | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3 | Shore Protection | | | | | | | | | | | | | | | | | | | | | | | | |
| | 4 | Jetty & Approach construction | | | | | | | | | | | | | | | | | | | | | | | | |
| | 5 | Site development | | | | | | | | | | | | | | | | | | | | | | | | |
| | 6 | Construction of Buildings / Sheds / Parking area | | | | | | | | | | | | | | | | | | | | | | | | |
| | 7 | Construction of Approach and Internal Roads | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Pontoon , Gangway and Stairway | | | | | | | | | | | | | | | | | | | | | | | | |
| | 8 | Supply and erection of Cranes / Mechanical Equipments | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Water Supply, Electrical Works, Drainage and Other Utilities | | | | | | | | | | | | | | | | | | | | | | | | |
| | 10 | Commissioning of Terminal | | | | | | | | | | | | | | | | | | | | | | | | |

**Figure 17-1 Project Implementation Schedule – Phase-1A**

**Figure 17-2 Project Implementation Schedule – Phase-1B**

## IMPLEMENTATION SCHEDULE - VARANSI TERMINAL - PHASE 1B



# 18 FINANCIAL AND ECONOMIC ANALYSIS

## 18.1 Introduction

Financial feasibility is a key determinant in a business oriented investment decision. For the projects of public/national interest like development of Varanasi Multi-modal Terminal, the viability of the project depends on the economic feasibility which acts as the deciding factor. In this note, economic and financial viability for the development of Varanasi Multimodal terminal has been carried out and presented.

## 18.2 General Assumptions

Following are the key assumptions considered for carrying out the Financial and Economic Analysis for Capacity Augmentation of National Waterways-1.

The inputs are taken from the technical studies carried out by M/s HOWE Engineering Projects (India) Pvt. Ltd and traffic study carried out by M/s HPC Consultant.

The inflation rate of 5% per annum is considered based on CPI index and as per Indian government's targeted inflation rate.

The cost of diesel is considered as Rs. 70/ litre (based on advice from IWAI) and same has been escalated for the forthcoming years.

As per World bank data, the purchasing power parity (PPP) of India is 0.3, whereas the PPP of France is 1.1 (Source: data.worldbank.org)

The analysis has been carried out for Phase-I development, Phase II Development and master Plan

Even though the inland waterways has various socio-economic benefits, this study is restricted to the economic factors mentioned in the below section.

## 18.3 Construction Period and Project Life

Phase IA of the terminal has been under construction and likely to be started by year 2018 and project life is considered as 30 years. Terminal-wise implementation schedule considered in the economic model is presented below.

## 18.4 Means of Finance

The financial analysis is carried out presuming that the entire capital expenditure for Phase 1A+ Phase 1B will be invested in the form of fund and therefore no debt component is considered. In case of master phase, the entire capital expenditure will be made by the selected concessionaire. Therefore it is assumed that the concessionaire will raise 70% debt and 30% equity for the development of master phase.

## 18.5 Income Tax Calculations

IWAI is registered with the Income Tax Department, Ghaziabad under section 12 A (a) and has got exemption of income tax under section 10(23) (c) (iv) of Income Tax Act. Therefore, income tax is not considered in the Financial Analysis.

## 18.6 Tariff Analysis

### 18.6.1 Prevailing IWAI charges

Inland Waterways Authority of India (IWAI) has published new Tariff for Patna/ Ghaighat and Haldia Terminal in September 2018 and they have suggested to consider same tariff for Varanasi Terminal. In case of the proposed Varansi MMT, the cargo handling will be carried out through various mechanised/semi-mechanised systems. Summary of the same considered in analysis are shown below:

**Table 18-1 Storage Charges as per new Gazette**

| Storage Charges | Unit | GR Jetty |
|---|---|---|
| First 3 days | INR/Ton/day | 0 |
| From 4th - 15th day | INR/Ton/day | 15 |
| From 16th - 30th day | INR/Ton/day | 27 |
| From 31st day onwards | INR/Ton/day | 54 |

**Table 18-2 Cargo Handling Charges**

| Type of Cargo | Unit | Handling Charges |
|---|---|---|
| Construction Materials (Bulk) | Rs/MT | 170 |
| Construction Materials ( Bagged) | Rs/MT | 210 |
| Consumer good | Rs/MT | 170 |
| Containers | Rs/TEU | 4500 |
| Food and Food Stuff | Rs/MT | 170 |
| Project Cargo | Rs/MT | 170 |

**Table 18-3: Tariff Considered for Augumented NW-1**

| Vessel related charges | | |
|---|---|---|
| Berthing Charges | Rs/ 24hrs | 1000 |
| Pilotage | Rs/ 24hrs | 750 |

## 18.7 Capital Costs

**Table 18-4: Capital Cost considered in Varansi MMT analysis**

| S. No. | Item | Capital Cost (Rs. in Cr.) |
|---|---|---|
| **1** | **Phase IA** | **184.92** |
| **2** | Phase IB | **20** |
| **3** | Master Plan | **334** |

As per discussion with IWAI, authority will only incur expenditure towards development of warehouse and ancillary infrastructure therefore cost of same (20 Cr) has been considered in the evaluation.

## 18.8 Operation and Maintenance Costs

As per the industry norms, the repair and maintenance cost have been calculated under various heads, as described below.

1% of capital cost for Civil Works

3 % of capital cost for Utilities

3 % of capital cost for Mechanical and Electrical Works

In addition, operating expenses would be incurred on day to day basis which includes administrative expenses, salaries, expenses towards electricity, fuel, hiring of equipments, labour deployment, payment of insurance premium etc. Escalation of 5% for manpower and 3% for fuel has been considered on YoY basis for evaluation.

## 18.9 Key Results - Financial Analysis

Based on the capital cost and operating expenditure, the financial analysis has been carried out considering 30 years of operation. The financial IRR is worked out to be positive –

12.24% for overall development including Phase IA, Phase IB and Master Plan.



**Table 18-5 Snapshot of Financial Analysis**

| Year | | | | 1 | 6 | 11 | 16 | 21 | 26 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2017 | 2018 | 2019 | 2024 | 2029 | 2034 | 2039 | 2044 | 2048 |
| **Project Cost** | Million INR | | | | | | | | | |
| **Cargo in Million Tonnes** | Million Tonnes | | | 0.78 | 1.301 | 2.576 | 3.852 | 3.852 | 3.852 | 3.852 |
| | | | | | | | | | | |
| **Revenues** | | | | | | | | | | |
| Cargo Handling Revenue | Million INR | | | 147.80 | 274.34 | 654.17 | 980.82 | 1082.90 | 1195.61 | 1294.16 |
| Storage Revenue | Million INR | | | 66.78 | 122.88 | 330.78 | 508.82 | 561.78 | 620.25 | 671.38 |
| Vessel Related Revenue | Million INR | | | 0.68 | 1.30 | 3.20 | 5.01 | 5.81 | 6.73 | 7.58 |
| **Total Income** | Million INR | | | **215.26** | **398.53** | **988.15** | **1494.65** | **1650.49** | **1822.59** | **1973.12** |
| | | | | | | | | | | |
| **Expenses** | | | | | | | | | | |
| Operating Expense | Million INR | | | | | | | | | |
| Electricity Cost | Million INR | | | 5.79 | 6.72 | 24.48 | 28.37 | 32.89 | 38.13 | 42.92 |
| Fuel Cost | Million INR | | | 3.62 | 6.98 | 16.50 | 25.61 | 29.68 | 34.41 | 38.73 |
| Other Labour Cost | Million INR | | | 11.96 | 37.02 | 102.87 | 200.20 | 255.51 | 326.11 | 396.38 |
| Manpower Cost | Million INR | | | 16.44 | 20.98 | 39.39 | 50.27 | 64.16 | 81.88 | 99.53 |
| Equipment Hiring Cost | Million INR | | | 24.50 | 28.41 | 65.86 | 76.35 | 88.51 | 102.61 | 115.49 |
| Insurance @ 0.75% of Project cost | Million INR | | | 1.39 | 1.54 | 4.61 | 4.61 | 4.61 | 4.61 | 4.61 |
| Maintenance Cost | Million INR | | | 28.54 | 30.54 | 110.46 | 110.46 | 110.46 | 110.46 | 110.46 |
| **Total Expense** | Million INR | | | **92.24** | **132.18** | **364.17** | **495.87** | **585.83** | **698.22** | **808.12** |
| **EBITDA** | Million INR | | | **123.02** | **266.35** | **623.98** | **998.77** | **1064.65** | **1124.37** | **1165.00** |
| **Cash Flow before Tax** | Million INR | (885) | (885) | **123** | **266** | **624** | **999** | **1065** | **1124** | **1165** |
| **IRR ( PRE – TAX)** | | | 12.24% | | | | | | | |
| **NPV** | Million INR | | +58.39 | | | | | | | |

## 18.10 Economic Analysis

In this section, economic analysis has been carried out for 'Capacity Augmentation of National Waterway – 1 (Jal Marg Vikas)' based on various socio-economic factors as mentioned below.

### 18.10.1 Approach and Methodology

The economic analysis of the project has been evaluated based on the following scenarios.

'With Project' Scenario and

'Without Project' Scenario

Both 'with project' and 'without project' scenarios have been quantified over the full life of the project. Also the 'incremental situation' or 'Benefit from the project' have been arrived by comparing the 'with project' scenario and 'without project' scenario wherein in the former case, the cargoes will be transported through barges and in later case, cargoes will be transported through road & rail.

### 18.10.2 Economic Factors considered

Following are the factors that are considered to carry out the economic analysis for this project.

- Energy Consumption
- Air Pollution
- Emission of CO2
- Noise Pollution
- Soil and Water Pollution
- Accidents
- Surface Occupation
- Benefit from exporting flyash
- Energy Consumption

Transport infrastructure plays a key role in the economic development of a country and an efficient transport sector, particularly for transportation of bulk goods is vital for development of any country. As per the World Bank study, Indian logistics cost is one of the highest in the world. As per this study, the logistics cost is 6% to 8% of the total value of goods in developing countries, 10% of the total values of goods in China whereas the cost of logistics in India is 14% of the total value of goods. By using the energy efficient mode of transportation, the logistics cost can be drastically reduced which in turn will boost the economy of the country.

In this section, a comparative study on the energy performance of inland shipping versus that of other land transportation modes has been carried out.

The energy consumption pattern of waterways, roadways and railways is illustrated in the below table, which is based on the 'Eleventh Working Group Report on Shipping and IWT' and 'Working Group Report on Railways'.

**Table 18-6: Energy Consumption - Waterways, Road and Rail**

| Energy Consumption | Waterways | | Road | | Rail | |
|---|---|---|---|---|---|---|
| | Mj/t km | litre/Tkm | Mj/t km | litre/Tkm | Mj/t km | litre/Tkm |
| 11th Working Group Report on shipping and IWT (Based on EU: Progress Report on short sea shipping 1999) | | 0.0048 | | 0.0313 | | 0.0089 |
| Report of Working Group on Railways-2012 | | | 1.3550 | 0.0350 | 0.2550 | 0.0066 |
| 'Energy Consumption' considered for the Study | | 0.0048 | | 0.0313 | | 0.0089 |

For the present study, the energy consumption pattern published by `11th Working Group Report on shipping and IWT' has been considered for further analysis.

### 18.10.3 External Costs

Transport contributes significantly to economic growth. Unfortunately, most forms of transport do not only affect society in a positive way but also give rise to side effects. In contrast to the benefits, the cost of these effects of transport are generally not borne by the transport users and hence not taken into account when they make a transport decision. Therefore these effects are generally labelled as external effects. The various cost associated with the external effects are described below.

#### *18.10.3.1 Air Pollution*

Transport related air pollution causes damages to humans, biosphere, soil, water, buildings and materials. The most important pollutants are the following:

- Particulate matters
- Nitrogen oxides
- Sulphur oxide
- Ozone
- Volatile organic compounds

Several studies have been carried out to estimate the level of impact caused due to the air pollution triggered by road, rail and inland shipping. Subsequently, the cost factor was arrived for the air pollution by critically valuating various cost elements like valuation of human life, market prices for crops, valuation of building damages, and valuation of long term risks in biosphere. The external cost of air pollution arrived by various studies are listed below:

**Table 18-7: External Costs of Air Pollution - Waterways, Roadways and Railways**

| Inland Water Transportation | Unit | Cost | Cost (in Rs/tkm) |
|---|---|---|---|
| Total Transportation System Study - Planning Commission Report | Rs / t km | 0.0300 | 0.0300 |
| Union Internationale des Chemins de fer (PIANC) | €/Tkm | 0.0040 | 0.0011 |
| le Groupe d'Economie des Transports de l'ULB (PIANC) | €/ Tkm | | |
| Bundesamt fur Umweltschutz (PIANC) | €/Tkm | 0.0014 | 0.0004 |
| Cost considered for the study | | | 0.0300 |
| Roadway | Unit | Cost | Cost (in Rs/tkm) |
| Total Transportation System Study - Planning Commission Report | Rs / t km | 0.2020 | 0.2020 |
| Union Internationale des Chemins de fer (PIANC) | €/Tkm | 0.0122 | 0.0033 |
| le Groupe d'Economie des Transports de l'ULB (PIANC) | €/ Tkm | 0.0329 | 0.0090 |
| Bundesamt fur Umweltschutz (PIANC) | €/Tkm | 0.0096 | 0.0026 |
| Cost considered for the study | | | 0.2020 |
| Railway | Unit | Cost | Cost (in Rs/tkm) |
| Total Transportation System Study - Planning Commission Report | Rs / t km | 0.0366 | 0.0366 |
| Union Internationale des Chemins de fer (PIANC) | €/Tkm | 0.0122 | 0.0033 |
| le Groupe d'Economie des Transports de l'ULB (PIANC) | €/ Tkm | 0.0329 | 0.0090 |
| Bundesamt fur Umweltschutz (PIANC) | €/Tkm | 0.0096 | 0.0026 |
| Cost considered for the Study | | | 0.0366 |

#### *18.10.3.2 Noise Pollution*

Noise costs consist of costs for annoyance and health. The external cost of noise pollution arrived by various studies are listed in the below table. The cost factors for noise pollution

are available only based on European conditions and are mentioned in Euros. Same has been converted to Rupees based on the purchasing power parity as mentioned in the Key Assumptions.

**Table 18-8: External Cost of Noise Pollution**

| Inland Water | Unit | Cost | Cost (in Rs/tkm) |
|---|---|---|---|
| Union Internationale des Chemins de fer (PIANC) | €/Tkm | Nil | Nil |
| le Groupe d'Economie des Transports de l'ULB (PIANC) | €/ Tkm | Nil | Nil |
| Bundesamt fur Umweltschutz (PIANC) | €/Tkm | Nil | Nil |
| Cost considered for the study | | | |
| Roadways | Unit | Cost | Cost (in Rs/tkm) |
| Union Internationale des Chemins de fer (PIANC) | €/Tkm | 0.0119 | 0.0032 |
| le Groupe d'Economie des Transports de l'ULB (PIANC) | €/ Tkm | - | - |
| Bundesamt fur Umweltschutz (PIANC) | €/Tkm | 0.0018 | 0.0005 |
| Cost considered for the Study | | | 0.0012 |
| Railways | Unit | Cost | Cost (in Rs/tkm) |
| Union Internationale des Chemins de fer (PIANC) | €/Tkm | 0.0044 | 0.0012 |
| le Groupe d'Economie des Transports de l'ULB (PIANC) | €/ Tkm | 0.0010 | 0.0003 |
| Bundesamt fur Umweltschutz (PIANC) | €/Tkm | 0.0035 | 0.0009 |
| Cost considered for the study | | | 0.0008 |

### *18.10.3.3 Soil and Water Pollution*

The external cost of soil & water pollution arrived by various studies and it is observed that only roadways tends to produce soil & water pollution as mentioned.

**Table 18-9: External Cost of Soil and Water Pollution**

| Roadways | Unit Rs/t km | Cost | Cost in Rs. |
|---|---|---|---|
| Union Internationale des Chemins de fer (PIANC) | €/Tkm | - | - |
| le Groupe d'Economie des Transports de l'ULB (PIANC) | €/ Tkm | - | - |
| Bundesamt fur Umweltschutz (PIANC) | €/Tkm | 0.0020 | 0.0005 |
| Cost considered for the Study | | | 0.0005 |

### *18.10.3.4 Reduction in Accidents*

The external cost for accident considered for three modes of transportation is mentioned below.

**Table 18-10: Accident Cost - Waterways, Roadways and Railways**

| Accident Cost | | Unit | Cost | Cost (in Rs/tkm) |
|---|---|---|---|---|
| Waterways | Total Transportation System - Planning commission | Rs./Tkm | Nil | Nil |
| | Union Internationale des Chemins de fer (PIANC) | €/Tkm | Nil | Nil |
| | le Groupe d'Economie des Transports de l'ULB (PIANC) | €/Tkm | Nil | Nil |
| | Bundesamt fur Umweltschutz (PIANC) | €/Tkm | Nil | Nil |
| | Cost considered for the Study | | Nil | Nil |
| Roadways | Total Transportation System - Planning commission | Rs./Tkm | 0.0620 | 0.0620 |
| | Union Internationale des Chemins de fer (PIANC) | €/Tkm | 0.0208 | 0.0057 |
| | le Groupe d'Economie des Transports de l'ULB (PIANC) | €/Tkm | 0.0353 | 0.0096 |
| | Bundesamt fur Umweltschutz (PIANC) | €/Tkm | 0.0091 | 0.0025 |
| | Cost considered for the Study | | | 0.0620 |
| Railways | Total Transportation System - Planning commission | Rs./Tkm | 0.0010 | 0.0010 |
| | Union Internationale des Chemins de fer (PIANC) | €/Tkm | 0.0008 | 0.0002 |
| | le Groupe d'Economie des Transports de l'ULB (PIANC) | €/Tkm | 0.0005 | 0.0001 |
| | Bundesamt fur Umweltschutz (PIANC) | €/Tkm | 0.0006 | 0.0002 |
| | Cost considered for the study | | | 0.0010 |

### 18.10.4 Observation on Key Results – Economic Analysis

Taking in the consideration of the economic benefits from the projects as worked out above, the economic IRR has been worked out to be 41 % for Phase-1A, Phase 1B and Master Plan development which indicates that the project is economically viable.

**Table 18-11 Detailed Economic Cost Estimation**

| **Year** | | 2019 | 2024 | 2029 | 2034 | 2039 | 2044 | 2048 |
|---|---|---|---|---|---|---|---|---|
| **Energy Consumption** | | | | | | | | |
| **Without Project Scenario** | | | | | | | | |
| Road Transportation | 92% | | | | | | | |
| Road - Energy Consumption | Rs/ Tkm | 2.20000 | 2.55040 | 2.95662 | 3.42753 | 3.97344 | 4.60631 | 5.18444 |
| Road- Total Energy Consumption | in Rs. Mn | 894 | 1727 | 4468 | 7085 | 8214 | 9522 | 10717 |
| Rail Transportation | | | | | | | | |
| Rail Transportation | 8% | | | | | | | |
| Rail - Energy Consumption | Rs/ Tkm | 0.90000 | 1.04335 | 1.20952 | 1.40217 | 1.62550 | 1.88440 | 2.12091 |
| Rail- Total Energy Consumption | in Rs. | 31.79865085 | 61.43891921 | 158.9392586 | 252.0444232 | 292.1885654 | 338.7266287 | 381.2398048 |
| Total | in Rs. Mn | 926 | 1789 | 4627 | 7337 | 8506 | 9861 | 11098 |
| **With Project Scenario** | | | | | | | | |
| Waterways Transportation | | | | | | | | |
| Waterways - Energy Consumption Cost | Rs/ Tkm | 0.30000 | 0.34778 | 0.40317 | 0.46739 | 0.54183 | 0.62813 | 0.70697 |
| Waterways- Total Energy Consumption Cost | in Rs. Mn | 235 | 455 | 1204 | 1918 | 2224 | 2578 | 2902 |
| **Incremental Benefit from the project** | **in Rs. Mn** | **690** | **1334** | **3423** | **5419** | **6282** | **7283** | **8197** |
| | | | | | | | | |
| **Air Pollution** | | | | | | | | |
| Without Project' Scenario | | | | | | | | |
| Road Transportation | 92% | | | | | | | |
| Unit Cost | Rs/ Tkm | 0.20200 | 0.23417 | 0.27147 | 0.31471 | 0.36483 | 0.42294 | 0.47603 |
| Total cost | in Rs. Mn | 82.07585102 | 158.580677 | 410.2398864 | 650.5546613 | 754.1711528 | 874.291065 | 984.0222962 |

| Year | | 2019 | 2024 | 2029 | 2034 | 2039 | 2044 | 2048 |
|---|---|---|---|---|---|---|---|---|
| Rail Transportation | 8% | | | | | | | |
| Unit Cost | Rs/ Tkm | 0.03660 | 0.04243 | 0.04919 | 0.05702 | 0.06610 | 0.07663 | 0.08625 |
| Total cost | in Rs. Mn | 1.293145134 | 2.498516048 | 6.46352985 | 10.24980655 | 11.88233499 | 13.7748829 | 15.50375206 |
| Without Project' Scenario - Total cost | **in Rs. Mn** | 83.36899616 | 161.0791931 | 416.7034162 | 660.8044679 | 766.0534878 | 888.0659479 | 999.5260482 |
| With' Project Scenario | | | | | | | | |
| Waterways Transportation | | | | | | | | |
| Unit Cost | Rs/ Tkm | 0.03000 | 0.03478 | 0.04032 | 0.04674 | 0.05418 | 0.06281 | 0.07070 |
| **Total cost** | **in Rs. Mn** | 23.52834116 | 45.45965987 | 120.3708988 | 191.8421161 | 222.3975916 | 257.8197621 | 290.1784136 |
| Increamental Benefit from the project | **in Rs. Mn** | 59.84065499 | 115.6195332 | 296.3325174 | 468.9623517 | 543.6558962 | 630.2461858 | 709.3476346 |
| | | | | | | | | |
| **Noise Pollution** | | | | | | | | |
| Without Project' Scenario | | | | | | | | |
| Road Transportation | 92% | | | | | | | |
| Unit Cost | Rs/ Tkm | 0.00124 | 0.00144 | 0.00167 | 0.00194 | 0.00225 | 0.00261 | 0.00293 |
| Total cost | in Rs. Mn | 0.505678848 | 0.977033964 | 2.527535574 | 4.008142805 | 4.64653604 | 5.386608767 | 6.062675623 |
| Rail Transportation | 8% | | | | | | | |
| Unit Cost | Rs/ Tkm | 0.000808182 | 0.000936904 | 0.001086129 | 0.001259121 | 0.001459666 | 0.001692153 | 0.001904533 |
| Total cost | in Rs. Mn | 0.028554546 | 0.055170908 | 0.142724243 | 0.2263308 | 0.262379429 | 0.30416967 | 0.342345643 |
| Without Project' Scenario - Total cost | **in Rs. Mn** | 0.534233394 | 1.032204872 | 2.670259817 | 4.234473606 | 4.908915469 | 5.690778436 | 6.405021266 |
| With' Project Scenario | | | | | | | | |
| Waterways Transportation | | | | | | | | |
| Unit Cost | Rs/ Tkm | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| Total cost | **in Rs. Mn** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Increamental Benefit from the project | **in Rs. Mn** | 0.534233394 | 1.032204872 | 2.670259817 | 4.234473606 | 4.908915469 | 5.690778436 | 6.405021266 |
| | | | | | | | | |
| **Soil and Water Pollution** | | | | | | | | |
| Without Project' Scenario | | | | | | | | |
| Road Transportation | 92% | | | | | | | |

| Year | | 2019 | 2024 | 2029 | 2034 | 2039 | 2044 | 2048 |
|---|---|---|---|---|---|---|---|---|
| Unit Cost | Rs/ Tkm | 0.00055 | 0.00063 | 0.00073 | 0.00085 | 0.00099 | 0.00114 | 0.00129 |
| Total cost | in Rs. Mn | 0.22162696 | 0.428210649 | 1.107758469 | 1.756673253 | 2.036465759 | 2.360821958 | 2.657125912 |
| Rail Transportation | 8% | | | | | | | |
| Unit Cost | Rs/ Tkm | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total cost | in Rs. Mn | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Without Project' Scenario - Total cost | **in Rs. Mn** | 0.22162696 | 0.428210649 | 1.107758469 | 1.756673253 | 2.036465759 | 2.360821958 | 2.657125912 |
| With' Project Scenario | | | | | | | | |
| Waterways Transportation | | | | | | | | |
| Unit Cost | Rs/ Tkm | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total cost | **in Rs. Mn** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Increamental Benefit from the project | **in Rs. Mn** | 0.22162696 | 0.428210649 | 1.107758469 | 1.756673253 | 2.036465759 | 2.360821958 | 2.657125912 |
| | | | | | | | | |
| **Accidents** | | | | | | | | |
| Without Project' Scenario | | | | | | | | |
| Road Transportation | 92% | | | | | | | |
| Unit Cost | Rs/ Tkm | 0.062 | 0.071874993 | 0.083322816 | 0.09659398 | 0.111978897 | 0.129814232 | 0.146107061 |
| Total cost | in Rs. Mn | 25.19159784 | 48.67327711 | 125.9152126 | 199.6751931 | 231.4782746 | 268.3467625 | 302.0266454 |
| Rail Transportation | 8% | | | | | | | |
| Unit Cost | Rs/ Tkm | 0.001 | 0.001159274 | 0.001343916 | 0.001557967 | 0.001806111 | 0.002093778 | 0.002356566 |
| Total cost | in Rs. Mn | 0.035331834 | 0.068265466 | 0.176599176 | 0.280049359 | 0.324653962 | 0.376362921 | 0.423599783 |
| Without Project' Scenario - Total cost | **in Rs. Mn** | 25.22692967 | 48.74154257 | 126.0918118 | 199.9552424 | 231.8029286 | 268.7231254 | 302.4502451 |
| With' Project Scenario | | | | | | | | |
| Waterways Transportation | | | | | | | | |
| Unit Cost | Rs/ Tkm | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total cost | **in Rs. Mn** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Increamental Benefit from the project | **in Rs. Mn** | 25.22692967 | 48.74154257 | 126.0918118 | 199.9552424 | 231.8029286 | 268.7231254 | 302.4502451 |
| | | | | | | | | |
| **Surface occupation** | | | | | | | | |

| Year | | 2019 | 2024 | 2029 | 2034 | 2039 | 2044 | 2048 |
|---|---|---|---|---|---|---|---|---|
| Without Project' Scenario | | | | | | | | |
| Road Transportation | 92% | 0.000166364 | 0.000192861 | 0.000223579 | 0.000259189 | 0.000300471 | 0.000348329 | 0.000392047 |
| Unit Cost | Rs/ Tkm | 0.067596223 | 0.130604248 | 0.337866333 | 0.535785342 | 0.621122057 | 0.720050697 | 0.810423403 |
| Total cost | in Rs. Mn | | | | | | | |
| Rail Transportation | 8% | | | | | | | |
| Unit Cost | Rs/ Tkm | 5.45455E-05 | 6.32331E-05 | 7.33045E-05 | 8.498E-05 | 9.85152E-05 | 0.000114206 | 0.00012854 |
| Total cost | in Rs. Mn | 0.001927191 | 0.003723571 | 0.009632682 | 0.01527542 | 0.017708398 | 0.020528887 | 0.023105443 |
| Without Project' Scenario - Total cost | **in Rs. Mn** | 0.069523414 | 0.134327819 | 0.347499015 | 0.551060762 | 0.638830454 | 0.740579584 | 0.833528846 |
| With' Project Scenario | | | | | | | | |
| Waterways Transportation | | | | | | | | |
| Unit Cost | Rs/ Tkm | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total cost | **in Rs. Mn** | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Increamental Benefit from the project | **in Rs. Mn** | 0.069523414 | 0.134327819 | 0.347499015 | 0.551060762 | 0.638830454 | 0.740579584 | 0.833528846 |
| | | | | | | | | |

| Economics User Cost of Commodities | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Railways | Rs/MT | 593.1 | 687.5 | 797.0 | 924.0 | 1071.1 | 1241.8 | 1397.6 |
| Road | Rs/MT | 358.0 | 415.0 | 481.1 | 557.7 | 646.5 | 749.5 | 843.5 |
| Coastal Shipping | Rs/MT | 754.9 | 875.2 | 1014.6 | 1176.2 | 1363.5 | 1580.7 | 1779.0 |
| | | | | | | | | |
| Railways | **in Rs. Mn** | 37.0 | 71.5 | 180.5 | 284.7 | 330.1 | 382.7 | 430.7 |
| Road | **in Rs. Mn** | 257.0 | 496.5 | 1253.1 | 1976.3 | 2291.1 | 2656.0 | 2989.4 |
| Without Project' Scenario - Total cost | **in Rs. Mn** | 294.0 | 568.0 | 1433.6 | 2261.1 | 2621.2 | 3038.7 | 3420.1 |
| | | | | | | | | |
| Coastal Shipping | | | | | | | | |
| Total cost | **in Rs. Mn** | 589.1 | 1138.2 | 2872.6 | 4530.6 | 5252.2 | 6088.7 | 6852.9 |
| Incremental Benefit from the project | **in Rs. Mn** | -295.1 | -570.1 | -1439.0 | -2269.5 | -2631.0 | -3050.0 | -3432.8 |

| Year | | 2019 | 2024 | 2029 | 2034 | 2039 | 2044 | 2048 |
|---|---|---|---|---|---|---|---|---|
| **Total Economic Benefits** | **in Rs. Mn** | 481 | 930 | 2411 | 3825 | 4434 | 5140 | 5785 |

**Table 18-12 Snapshot of Economic Analysis**

| | Year | Unit | 2017 | 2018 | 2019 | 2024 | 2029 | 2034 | 2039 | 2044 | 2048 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **A** | **Traffic** | **Million Tonnes** | | | **0.7803** | **1.3005** | **2.8314** | **3.852** | **3.852** | **3.852** | **3.852** |
| B | Benefit from the project | Rs Million | | | | | | | | | |
| 1 | Revenue | Rs Million | | | 215.257 | 398.5286 | 988.1526 | 1494.645 | 1650.486 | 1822.59 | 1973.12 |
| 2 | Economic Benefit from the project | Rs Million | | | 481 | 930 | 2411 | 3825 | 4434 | 5140 | 5785 |
| **3** | **Total Benefit from the project** | **Rs Million** | | | **696** | **1328** | **3399** | **5319** | **6085** | **6963** | **7759** |
| | | | | | | | | | | | |
| **C** | **Operation Expenses** | | | | **92.2405** | **132.1813** | **364.1713** | **495.8735** | **585.8320** | **698.2155** | **808.1230** |
| | | | | | | | | | | | |
| **D** | **EBIDTA** | | | | **604** | **1196** | **3035** | **4824** | **5499** | **6265** | **6950** |
| | | | | | | | | | | | |
| E | CAPEX | Rs Million | -885.071 | -885.071 | | | | | | | |
| | | | | | | | | | | | |
| F | Cash Flow (Before Tax) | Rs Million | -885.071 | -885.071 | 604.2361 | 1196.123 | 3034.731 | 4823.611 | 5498.691 | 6264.639 | 6950.41 |
| | | | | | | | | | | | |
| G | **Economic IRR** | | **41%** | | | | | | | | |

# Annexure - A : Cargo handling capacity with 2 Cranes

| S. No. | Description | Unit | Construction Materials | Construction Materials | Consumer good | Containers | Food and Food Stuff | Project Cargo | Total Cargo |
|---|---|---|---|---|---|---|---|---|---|
| | | | Bulk | Bagged | | | | | |
| 1 | Cargo Volume | Million T | 0.31 | 0.31 | 0.14 | 0.06 | 0.36 | 0.084 | 1.26 |
| 2 | Average Parcel Size | T/TEU | 1,000 | 1,000 | 1000 | 75 | 1,000 | 500 | |
| 3 | Number of Vessels | Nos. | 306 | 306 | 140 | 66 | 364 | 168 | |
| 4 | Effective Working Hours | Hours | 20 | 20 | 20 | 20 | 20 | 20 | |
| 5 | Average Cargo Handling Rate | T per hr | 300 | 150 | 150 | 17 | 150 | 75 | |
| 6 | Service Time per Vessel | Hours | 3.3 | 6.7 | 6.7 | 4.4 | 6.7 | 6.7 | |
| 7 | Addl. Time for Peripheral activities | Hours | 1 | 1 | 1 | 1 | 1 | 1 | |
| 8 | Total Time per Vessel | Hours | 4.3 | 7.7 | 7.7 | 5.4 | 7.7 | 7.7 | |
| | | | 0.22 | 0.38 | 0.38 | 0.27 | 0.38 | 0.38 | |
| 9 | Total Berthdays Reqd. | Days | 66.4 | 117.4 | 53.7 | 17.9 | 139.5 | 64.4 | |
| | No. of Working days | | 330.0 | | | | | | |
| 10 | Number of Berths | Nos. | 2 | | | | | | |
| 11 | Total Berth Days Available | Days | 660 | | | | | | |
| 12 | Berth Occupancy | % | 69.6 | | | | | | |
| | | | 4615 | 2609 | 2609 | 277 | 2609 | 1304 | |