Assam Inland Water Transport Project

Preparation of Detailed Project Report (DPR), Front End Engineering Design (FEED) and Tender Documents for Development of Ferry Services in Assam

DETAILED PROJECT REPORT FOR GUWAHATI GATEWAY GHAT – FINAL
P.013223
VOLUME 1

Dept of IWT, Govt of Assam, Guwahati
Assam | INDIA

RESTRICTED

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REPORT

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DETAILED PROJECT REPORT FOR GUWAHATI GATEWAY GHAT – FINAL

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Client: **Assam Inland Water Transport Development Society (AIWTDS)**

Project: **Preparation of Detailed Project Report (DPR), Front End Engineering Design (FEED) and Tender Documents for Development of Ferry Services in Assam**

Subject: **Detailed Project Report for Guwahati Gateway Ghat – FINAL**

Comments:

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Detailed Project Report for Guwahati Gateway Ghat – FINAL VOLUME – 1

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ABBREVIATIONS

Abbreviations	Description
AIWTDS	Assam Inland Water Transport Development Society
BIS	Bureau of Indian Standard
BM	Bench Mark
BOQ	Bill of Quantity
BRFD	Brahmaputra River Front Development Project
CWC	Central Water Commission
CWPRS	Central Water and Power Research Station
D/S	Downstream
DGPS	Differential Global Positioning System
DPR	Detailed Project Report
DWT	Dead Weight Tonnage
EIRR	Economic Internal Rate of Return
EGL	Existing Ground Level
EPC	Engineering Procurement & Construction
FEED	Front End Engineering Design
FIRR	Financial Internal Rate of Return
GOI	Govt. of India
HFL	Highest Flood Level
ISDP	Integrated Strategic Development Plan
IWAI	Inland Waterways Authority of India
IWT	Inland Water Transport
LWL	Low Water Level

MOM	Minutes of Meeting
MWL	Maximum Water Level
NH	National Highway
NW	National Waterway
PMC	Project Management Consultancy
PWC	Price Waterhouse Coopers
RL	Reduced Level
STAAD	Structural Analysis And Design
TBL	Top Bank Level
TEPL	Tractebel Engineering Pvt. Ltd.
TOR	Terms of Reference
TSSC	Technical Services and Supervision Consultant
U/S	Upstream
WRD	Water Resource Department

EXECUTIVE SUMMARY

Introduction

Tractebel Engineering Pvt. Ltd. (TEPL) and Tractebel Engineering S.A (TESA) signed an agreement with Assam Inland WaterTransport Development Society (AIWTDS), a part of Assam Transport Department, on 22nd October 2018. As per the contract, AIWTDS has engaged TEPL & TESA to prepare the detailed project report for the project "PREPARATION OF DETAILED PROJECT REPORT (DPR) ALONG WITH FRONT END ENGINEERING DESIGN, DRAWINGS, TENDER DOCUMENTS AND MODULARIZATION OF DESIGN ELEMENTS FOR DEVELOPMENT OF FERRY SERVICES IN ASSAM", Front End Engineering Design (FEED) and tender document for each of the validated feasible locations identified by the ISDP Consultant.

Project Background

In order to leverage the benefits of inland water transport, the Government of Assam wishes to transform the quality of inland water transport services and integrate high quality passenger and vehicle ferry services, and inland water freight transport into Assam's wider transport network system. The framework to realize this objective will be established through 2 studies – Institutional Strengthening & Business Planning (ISBP) and Integrated Strategic Development Plan (ISDP). ISBP study will provide the roadmap for creating a more supportive institutional framework to facilitate policy implementation and fulfil capacity building requirements for the new institutional setup. ISDP study intends to review, assess the overall transport sector in Assam and prepare transport strategy to help the Government of Assam to use it for comprehensive and integrated transport solution in the State as well as guide the sustainable development of the inland water transport sector in Assam till 2035. As an outcome of these two studies, large scale engineering infrastructure will be identified and executed in order transform inland water transport in Assam.

Project Location

The proposed project is located in the Indian state of Assam at the location of Guwahati.

Review of previous reports

As per the Terms of Reference, the TEPL shall review/assess the outputs provided by ISDP Consultant on feasible IWT investments under Assam IWT Project as they are made available, for development works amounting to approx. US $100 million. Outputs from ISDP are expected as follows:

i. An early feasibility assessment of locations for passenger (including cargo) ferry terminals from a list of 10 pre-selected existing ghats /terminals as stated.
ii. Complete feasibility report on strategic IWT investments under the project.

The following documents/reports have been collected by TEPL and have been studied

Sr. No.	Document Title	Document Owner
1	Report Module 1: Assam Transport Strategy 2018 - 2035	ISDP Consultant
2	Report Module 2: Investment Strategy for Assam IWT Sector	ISDP Consultant
3	Report Module 3: Feasibility Assessment for Assam IWT Project	ISDP Consultant
4	Report Module 4: Feasibility Assessment for Pre-identified IWT Infrastructure	ISDP Consultant
5	DPR for Brahmaputra River Front Development	Guwahati Smart City Limited
6	Thalweg Survey Data	AIWTDS

7	Bathymetric Data of Pandu Area	Tractebel internal data from secondary sources
8	Soil Investigations Report	Guwahati Smart City Limited
9	Water Levels at Silchar Area	Tractebel internal data from secondary sources

Overview of Detailed Project Report

Land Records

The total land required for the terminal construction at Gateway Guwahati is 341.58 sq. m. Land to be acquired along with ownership details are mentioned in section 4.9.2.

Study of hydrology and morphology

The data collected from various sources were studied in detail for variation in sediment transport (size and quantity), sources of sediments, locate degrading, aggrading, and stable reaches and correlate these results with historical data and / or previous study reports to qualitatively analyse the effects of anticipated project features.

Surveys and investigations

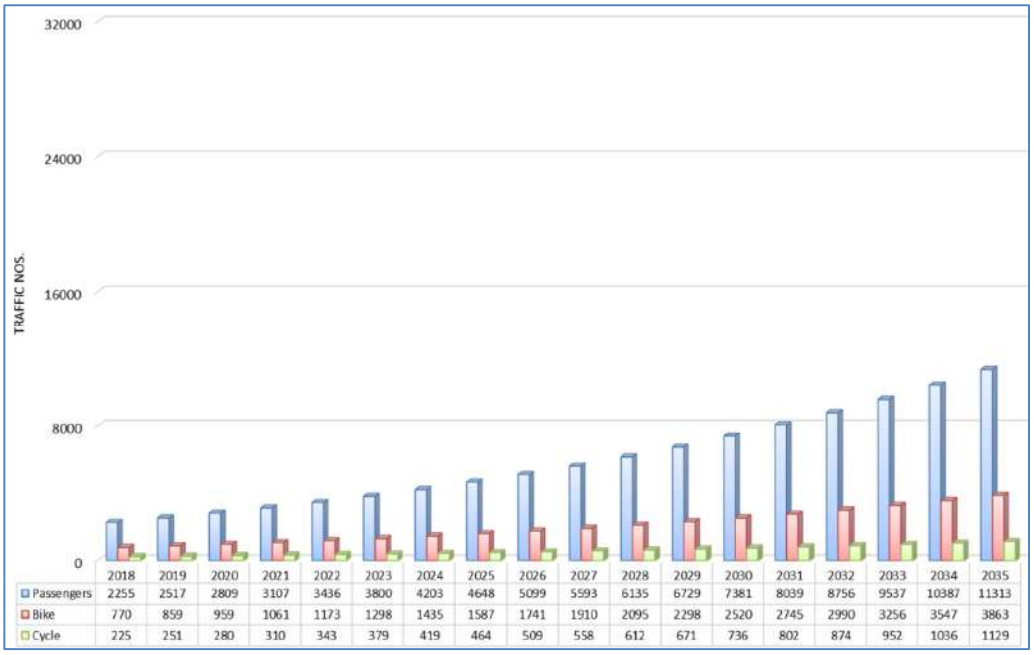
Detailed Topographical / Hydrographical survey and Geo-technical/Geological investigation at proposed ferry locations and analyse the data for the purpose of design of proposed structures as per standard/prevailing guidelines have been conducted. The hydrographical survey data collection will include identification and detailing of all such features which may affect river navigation including but not limited to survey and data collection / data acquisition of tidal , topographic, bathymetric, flow and discharge conditions, water level variations, soil (suspended sediment, bed and bank) conditions, geological, geomorphologic and all other conditions. In compliance with the Work Schedule agreed to in the Contract, the designated team for carrying out Bathymetric and Topographic Survey, collection of field data and interaction with the project authorities was deputed on the award of work. The teams mobilized and reached at Guwahati by 10th January 2019, started the fieldwork on 11th on site by 11th January 2019 and completed the field work in all respect on 24th January 2019. Hydrographic and Topographic has been carried out as per TOR.

Geotechnical investigations have been carried out to realize the subsurface geological and geotechnical conditions required for the proper planning and foundation design of the proposed structure. One borehole (RBH-1) at the pontoon location has been drilled to obtain the subsurface soil information.

Traffic analysis

The passenger growth rate of Assam is calculated on the basis of various economic factors. The past performance of the economic indicators for the Project influence area (PIA) are collected for the same time period, with the objective of establishing the elasticity of travel demand with respect to different economic indicators. The economic indicators considered for the analysis include the following parameters.

- Ø Net State Domestic Product (NSDP) of PIA states
- Ø GDP of India
- Ø Per Capita Income (PCI) of PIA states
- Ø Population of PIA states



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Passengers	2255	2517	2809	3107	3436	3800	4203	4648	5099	5593	6135	6729	7381	8039	8756	9537	10387	11313
Bike	770	859	959	1061	1173	1298	1435	1587	1741	1910	2095	2298	2520	2745	2990	3256	3547	3863
Cycle	225	251	280	310	343	379	419	464	509	558	612	671	736	802	874	952	1036	1129

Traffic Forecast Guwahati Gateway Terminal

Planning and design of terminal

The proposed ferry terminal at Guwahati gateway ghat caters to the passenger and two-wheeler traffic traveling to and from North Guwahati ghat and other nearby terminal locations. The riverine and landside infrastructure proposed for the ferry terminal are robust structures and provide floating but permanent boarding/deboarding locations for passenger and vehicles. This also ensures a greater sense of safety among the passengers especially during high flood season when the currents are extreme. The boarding/deboarding location is accessible for all passengers and ample waiting areas are also provided for convenience of passengers. The terminal utilities and services are provided for ease of operation and maintenance during any water levels.

The riverine infrastructure comprises of the following components:

1. Berthing pontoons
2. Dolphins for berthing pontoons
3. Steel linkspans
4. Intermediate pontoons
5. Dolphins for intermediate pontoons
6. Bankseat

The landside infrastructure comprises of the following components:

1. Terminal building
2 Utilities and services

Design basis

The various bases of design, which have been discussed in the report are:

- Water Levels
- Currents

- Wind
- Seismic
- Soil Conditions
- Material grades etc.
- Design basis for utilities and services

The details of the aforesaid design bases have been elaborated in the respective sections of the report.

EIA and EMP

As per the ToR, full integration of Environment Management Plan including proposed mitigation and enhancement measures (to be prepared under the parallel EA consultancy) into the designs and cost estimates.

The environmental impact assessment has been carried out in line with World Bank Operational Policies, IFC EHS Guidelines for Ports, Harbours, and Terminals, IFC General Guidelines for EHS, MoEF &CC EIA Guidelines for Ports and Harbours. Based on the outcomes of the EIA study, an Environment Management Plan has been prepared for the project.

As part of the EIA study, baseline environmental status around 10 km radius of the proposed terminals has been considered. Relevant primary and secondary data with respect to various environmental components have been collected and analysed to establish the baseline environmental status. In addition, consultations have been carried out with all key stakeholders including the community, the local business associations and NGOs active in the project area.

Implementation Schedule

The development works detailed in this Detailed Project Report is elaborated in the subsequent sections. The time schedule for the construction activities of the project is considered as 18 months after award of the procurement and construction contract.

1. INTRODUCTION

1.1 Project Background

The Brahmaputra and the Barak Rivers are two of the most important rivers in the state of Assam. The Brahmaputra River traverses between Sadiya in Assam and Bangladesh border for a distance of about 891km. This stretch of the Brahmaputra River was declared National Waterway no. 2 by the Government of India in 1988, the development of its navigation infrastructure thereafter being the responsibility of the Inland Waterways Authority of India (IWAI). IWAI is currently aiming to maintain a navigable depth of 2.5m from Bangladesh Border to Neamati (629 km), 2.0 m from Neamati – Dibrugarh (139 km) and 1.5m from Dibrugarh – Sadiya. However, while IWAI is responsible for the navigation 'fairway' it does not own the water resources or have responsibility for operating water transport services. Landside activities such as riparian land-use development are regulated by State or local governments.

The Brahmaputra, running through the heart of the state of Assam, provides a vital link for both urban and rural ferry services which are the single most important transport mode for many sections of the population, especially rural households in Assam. These ferry services are provided by the Directorate of Inland Waterway Transport Assam, and by country boat operators – typically small independent and informal private businesses.

In addition to the 102 ferry service routes designated by the Directorate of IWT, there are numerous routes licensed by the local (village) and district councils. Other users of the river include the Central Inland Water Corporation Limited (a Government of India Undertaking transporting cargo and operating some terminals on the rivers in the Eastern India & North-Eastern India and on the Indo-Bangladesh protocol routes), border security forces, tourist organizations and private operators. Navigation on the Barak River (152 km) is minimal at present, but the river is designated as National Waterway 16 under the National Waterways Bill (2015).

The ferry industry as a whole is characterized by an aging and poorly equipped fleet. Most demand is now met by the informal sector operating traditional country boats without supporting infrastructure. Terminal facilities and navigational aids are insufficient. Most ferry terminals consist of no more than improvised moorings on the bank of the river, which require relocation with changing river conditions, often over substantial distances. In the absence of bank protection, the main ferry terminals in or close to the urban centers (provided with floating, movable steel pontoons and temporary access roads) also typically require frequent relocation as river conditions change across seasons. The cargo sector is small partly because of market circumstances, partly because of connectivity problems and partly because the navigation standards provided do not permit reliable year round use by large modern vessels that can deliver competitive advantage over other transport modes. The Government of Assam wishes to transform the quality of inland water transport services and integrate high quality passenger and vehicle ferry services, and inland water freight transport into Assam's wider transport network system.

Better utilization of Assam Waterways for mobility-centered economic development is a necessity today. Development of models for integrated urban transport planning and an infrastructural solution that provides mobility for commuters and goods are required to define and address contextually-sensitive economic growth and urban planning for many cities along Assam Waterways. Development of ferry services at various urban locations viz. Guwahati and Dibrugarh as well as locations in rural areas which are vital to enhance connectivity to the riparian communities dependent on IWT in the state of Assam may largely contribute towards the holistic development of the region.

Benefits offered by such systems to cities that have historically relied on the Assam Inland Waterways include considerable traffic decongestion, better intermodal connectivity, and economic revitalization of the urban core. Transit-oriented development and optimal use of this river requires coordination with various stakeholders, state governments, municipalities, and private players that will benefit from and contribute to capital improvements that link river-based infrastructure to transportation and logistics systems in the region.

It is necessary to devise planning and design of ferry terminals integrated with governance and licensing frameworks that define opportunities to partner public and private initiatives in commercial transport operations and ancillary commercial development pertaining to transit-oriented usage of the river. Accordingly, AIWTDS plans to engage consultants to investigate the strategic planning and design, as well as the technical, economic and financial feasibility of ferry service infrastructure development and operations in the state of Assam. The Work shall include selection of best locations within the specific regulatory, planning, and investment framework of transit points in the state, design development, preparation of DPR and procurement strategy.

1.2 Objective of the Study

The objective of the study is to develop ferry services;

- at various urban locations viz. Guwahati and Dibrugarh as well as locations in rural areas which are vital to enhance connectivity to the riparian communities dependent on IWT in the state of Assam.
- that offers benefits in terms of traffic decongestion, better intermodal connectivity, and economic revitalization of the urban core.
- to transform the quality of inland water transport services.
- to integrate high quality passenger and vehicle ferry services, and inland water freight transport into Assam's wider transport network system.
- to create sustainable transport facilities considering social, economic and environmental aspects

The objective of the assignment is divided into two (2) modules as shown below:

Module A

Review/Assess the outputs provided by ISDP Consultant on feasible IWT investments under Assam IWT Project as they are made available, for development works amounting to approx. US $100 million. Outputs from ISDP are expected as follows:

i. An early feasibility assessment of locations for passenger (including cargo) ferry terminals from a list of 10 pre-selected existing ghats/terminals as stated.
ii. Complete feasibility report on strategic IWT investments under the project

Based on the output of the ISDP reports, the Consultant will prepare a DPR, FEED and tender documents for each of the validated feasible locations identified by the ISDP Consultant (i) and (ii) above for developing modern IWT infrastructure - primarily the passenger (including those with cargo facilities) ferry terminals with all associated facilities including user access.

Module B

Modularization of design elements for passenger (and cargo) ferry terminals for both high traffic and low traffic locations & development of customizable design models for future interventions, based on the potential traffic and the number of vessels that needs to be berthed at the terminal.

1.3 Review of previous reports

1.3.1 Documents reviewed

The following data/information have been collected by the Consultant since the award of the contract and have been studied:

Sr. No.	Document Title	Document Owner
1	Report Module 1: Assam Transport Strategy 2018 - 2035	ISDP Consultant
2	Report Module 2: Investment Strategy for Assam IWT Sector	ISDP Consultant
3	Report Module 3: Feasibility Assessment for Assam IWT Project	ISDP Consultant

4	Report Module 4: Feasibility Assessment for Pre-identified IWT Infrastructure	ISDP Consultant
5	DPR for Brahmaputra River Front Development	Guwahati Smart City Limited
6	Thalweg Survey Data	AIWTDS
7	Bathymetric Data of Pandu Area	Tractebel internal data from secondary sources
8	Soil Investigations Report	Guwahati Smart City Limited
9	Water Levels at Silchar Area	Tractebel internal data from secondary sources

1.3.2 Review of Site conditions for finalized sites

The following sections discuss the Consultant's observations, comments and recommendations subsequent to review of hydrological, hydraulic, morphological characteristics of the river reaches of interest.

1.3.2.1. WATER LEVELS

Table 1-1 Water level in Guwahati corridor sites

Report/Data	LWL (m) amsl	HFL(m), amsl	Remarks
ISDP, Module 4	41.40 (Pandu in 2002)	51.46 (21/7/2004) (CWC,FF website) at D C court	http://www.india-water.gov.in/eSWIS-MapViewer/
BRFD , Chapter IV, Hydraulic Study and Modelling	Average Min LWL 40.50m (2012-2017 daily data at D C court)	51.46 (21/7/2004) (CWC,FF website) at D C court	
TEPL	40.19 m at Pandu (21/2/2017)	51.46 (21/7/2004) (CWC,FF website) at D C court	
TEPL Recommendation for design	**40.19**	**51.46**	

Table 1-2 Water level in Dibrugarh corridor sites

Report/Data	LWL (m) amsl	HFL(m), amsl	Remarks
ISDP, Module 4	79.9 25/4/2004) at Neamati	87.37 (11/7/1991) (CWC,FF website) at Neamati	http://www.india-water.gov.in/eSWIS-MapViewer/
TEPL	79.9 (21/2/2017) m at Neamati, from daily data 2007-2018 (Oct)	87.37 (21/7/2004) (CWC,FF website) at Neamati	http://www.india-water.gov.in/eSWIS-MapViewer/

TEPL Recommendation for design	**79.9**	**87.37**	

Table 1-3 Water level in Silchar corridor sites

Report/Data	LWL (m) amsl	HFL(m), amsl	Remarks
ISDP, Module 4	8.41 at Annapurna Ghat	21.37 at Annapurna ghat	DPR –Lakhipur Bhanga Stretch
TEPL	8.48 (1995) m at AP Ghat, from annual minimum data, 1975-2010	21.37 (11/7/1991) (CWC,FF website) at AP Ghat	http://www.india-water.gov.in/eSWIS-MapViewer/
TEPL Recommendation for design	**8.41**	**21.37**	

1.3.2.2. VELOCITY

Table 1-4 Current/Speed in Guwahati corridor sites

Report/Data	Current/Speed m/s in Flood season	Remarks
ISDP, Module 4	2.5	The current velocity mentioned in ISDP report is based on the interview with ferry operational staff
BRFD , Chapter IV, Hydraulic Study and Modelling	3.5-4	Based on 100 year flood routing
TEPL Recommendation for design	**3.5-4**	For design of terminal infrastructure extreme current speed based on flood routing is recommended to be used

Table 1-5 Current/Speed in Dibrugarh corridor sites

Report/Data	Current/Speed m/s in Flood season	Remarks
ISDP, Module 4	2.5 (Neamati site) 3.0 – 4.0 (Aphalamukh site)	The current velocity mentioned in ISDP report is based on the interview with ferry operational staff
TEPL Recommendation for design		TEPL will make detailed assessment and derive the design velocity for terminal infrastructure

Table 1-6 Current/Speed in Silchar corridor sites

Report/Data	Current/Speed m/s in Flood season	Remarks
ISDP, Module 4	2.0	The current velocity mentioned in ISDP report is based on the interview with ferry operational staff
TEPL Recommendation for design		TEPL will make detailed assessment and derive the design velocity for terminal infrastructure

1.3.2.3. DISCHARGE

Table 1-7 Discharge for Guwahati corridor sites

Report/Data	Discharge (m^3/s)	Remarks
ISDP, Module 4	-	-
BRFD , Chapter IV, Hydraulic Study and Modelling	74958 m^3/s , 100 year return period	
TEPL Recommendation for design		TEPL will make detailed assessment and derive the design discharge for terminal infrastructure

Table 1-8 Discharge for Dibrugarh corridor sites

Report/Data	Discharge (m^3/s)	Remarks
ISDP, Module 4	-	-
TEPL Recommendation for design		TEPL will make detailed assessment and derive the design discharge for terminal infrastructure

Table 1-9 Discharge for Silchar corridor sites

Report/Data	Discharge (m^3/s)	Remarks
ISDP, Module 4	-	-
TEPL Recommendation for design		TEPL will make detailed assessment and derive the design discharge for terminal infrastructure

1.3.2.4. MORPHOLOGY

Table 1-10 Locations in Guwahati corridor sites

Location	ISDP Proposed	TEPL Suggestion	Remarks
Guwahati Gateway	Existing Lachit Ghat (26.182661° N 91.736847° E	Existing Lachit Ghat	Location proposed in ISDP report is on a stable bank. However, the exact coordinates will be finalized by the designers.
North Guwahati	Majegaon (Existing ghat) 26.185786°, 91.722100° E	Around 120-140 m upstream close to rocky nose (near temple)	Existing/ISDP suggested location needs reconsideration as the location falls in the sedimentation zone, needs regular dredging and shifting of landing points. The site suggested by TEPL seems in a morphologically stable reach.
	Rajaduar (Existing ghat) 26.205258° N 91.745131° E	Around 350-400 m upstream close to rocky nose	The lat-long shown for ISDP 4 site seems incorrect in comparison to the recommendation for the site. However, TEPL confirms that the recommendation site is on a stable bank reach but the proposed navigation channel to the site poses high probability of sedimentation and difficult to maintain. Thus, as of now Rajaduar site poses challenges to maintain the navigational channel which will be confirmed after bathymetric survey.

Table 1-11 Locations in Dibrugarh corridor sites

Location	ISDP Proposed	TEPL Suggestion	Remarks
Neamati	Existing Neamati Ghat 26.861200° N 94.241970° E	Existing Neamati Ghat	The proposed site is on the protected bank. The strength of the existing bank protection will be assessed and adequate measures will be suggested to protect the proposed permanent terminal infrastructure.
Aphalamukh	Aphalamukh (Existing ghat) 26.915870° N 94.299390° E	Existing Ghat	Although the bank does not seems stable the proposed site is close to Thalweg line and provides a potential subject to bank protection works to be done in future. However, the proposed site is very far from the Kamalabari town and therefore poses additional travel for the locals.

Kamalabari	-		Presently the ferry operates from 2 different locations during summer (flood) and winter (lean) seasons. The winter season site is approximately 2.2km in the river whereas the summer location is very close to Kamalabari town. The summer location has shallow water depth owing to higher river bed levels and dredging required at this site will be substantially very high and in the braided river, this is not a sustainable solution. Thus, a limited investment at Kamalabari is worth owing to the existing traffic eventhough the operation period is 4-6 months in a year and for rest of the year, the locals can use Aphalamukh terminal and then travel to Kamalabari town. ISDP consultant has not recommended any site near Kamalabari town.

Table 1-12 Locations in Silchar corridor sites

Location	ISDP Proposed	TEPL Suggestion	Remarks
Annapurna		TEPL will make detailed assessment after the site visit and will suggest proposed concepts at these sites.	The concept layouts proposed by the ISDP Consultant for Annapurna and Dudhpatil ghats are not feasible as there is virtually no space between the two terminals to allow the navigation of vessels upstream and downstream of the proposed terminals. (The terminals occupy fully the river width). However, we have noted that the ISDP Consultant has not provided any concept and technical feasibility at sites such as Berenga, Gangapur, Kanakpur etc. It may be noted that these sites are in the acute meandering reach. Thus, these sites will pose challenges owing to sedimentation.
Dudhpatil, 1, 2, 3, 4			
Barenga-Gangapur			

1.3.3 Review of Geotechnical Investigations

For assessment of Geotechnical considerations made by ISDP consultant, Section 2.2 of Module 4 was referred and important observations are presented below.

1.3.3.1. GUWAHATI CORRIDOR

a. Guwahati Gateway Terminal:
ISDP consultant has considered 18 boreholes conducted by the consultant appointed for Guwahati smart city project.

b. North Guwahati Terminal:
ISDP consultant has not carried out any borehole investigation and neither adopted any past data/reports to consider geotechnical conditions at proposed site.

c. Rajaduar Terminal:
ISDP consultant has not carried out any borehole investigation and neither adopted any past data/reports to consider geotechnical conditions at proposed site.

d. Umananda Terminal:
ISDP consultant has not carried out any borehole investigation and neither adopted any past data/reports to consider geotechnical conditions at proposed site.

1.3.3.2. DIBRUGARH CORRIDOR

In Dibrugarh corridor 3 boreholes, one each at Neamati, Kamalabari and Aphalamukh were conducted fresh by ISDP consultant. In Silchar corridor 2 boreholes at Annapurna and Gangapur have been conducted. The depth of each of the bore holes is 30 m. Soil strata at the location of investigation comprises of Sand, Silty Sand and Clay layer. Disturbed sample are collected from sand layer, but collection of Undisturbed samples has not been done adequately. Test for determination for shear properties are not conducted all along the boreholes. Therefore the input properties of soil upto the termination of borehole are not available for design. Triaxial test on UDS samples are not conducted. The Particle size distribution curve, which is essential for determination of D10, Uniformity coefficient and Coefficient of curvature are not appended with the report. Foundation recommendation and capacities for Deep and Shallow foundation has been provided and is unclear as to how have the parameters been determined. Our critical observations have been reported below for each site separately.

a. Neamati Ghat
- Borehole Coordinate (x, y) is missing & ground elevation at the borehole is not provided. Thus, it is difficult to know where exactly the borehole is carried out.
- Borehole depth = 30m.
- According to the Borehole log, initially a 7.5m clay layer was present at the top of the borehole then upto the termination level a Sand layer is present.
- No UDS sample was collected for clay strata.
- Direct shear test was conducted in samples of sandy soil collected upto depth 15m only, layers at greater depth are not investigated.
- No Shear test for clay strata had been conducted.
- Particle size distribution curve were not provided with the report.

b. Kamalabari Ghat
- Borehole Coordinate (x, y) is missing & ground elevation at the borehole is not provided. Thus, it is difficult to know where exactly the borehole is carried out.
- Borehole depth = 30m
- According to the Borehole log, initially a 4.5m Silty Sand layer was present at the top of the borehole then upto the termination level Sand layer is present.
- Direct shear test was conducted in samples of sandy soil collected upto depth 20m only, layers at greater depth were not tested.
- Particle size distribution curve were not provided with the report.

c. Aphalamukh Ghat
- Borehole Coordinate (x, y) is missing & ground elevation at the borehole is not provided. Thus, it is difficult to know where exactly the borehole is carried out.
- Borehole depth = 30m.
- According to the Borehole log, initially a 15m clay layer was present at the top of the borehole then upto the termination level Sand layer is present.
- No UDS sample was collected for clay strata.
- Direct shear test was conducted in samples of sandy soil collected upto depth 20m only, layers at greater depth were not tested.
- Particle size distribution curve were not provided with the report.

1.3.3.3. SILCHAR CORRIDOR

In Silchar corridor 2 boreholes at Annapurna and Gangapur had been conducted. The depth of each of the bore hole is 30m. Soil strata at the location of investigation comprises of Sand, Silty Sand and Clay layer. Disturbed sample are collected from sand layer, but collection of undisturbed samples has not been done adequately. Test for determination for shear properties are not conducted all along the boreholes. Therefore, the input properties of soil upto the termination of borehole is not available for design. Triaxial test on UDS samples are not conducted. The Particle size distribution curve, which is essential for determination of D10, Uniformity coefficient and Coefficient of curvature are not appended with the report. Foundation recommendation and capacities for Deep and Shallow foundation has been provided and is unclear as to how have the parameters been determined.

a. Annapurna Ghat
   - Borehole Coordinate (x, y) is missing & ground elevation at the borehole is not provided. Thus, it is difficult to know where exactly the borehole is carried out.
   - Borehole depth = 30m.
   - According to the Borehole log, intermittent layer of clay and Silty sand was available in borehole. It should be noted that an 8.5m thick clay layer was observed from depth 22.5m to borehole termination level.
   - Direct shear test was conducted in samples of sandy soil collected upto depth 16m only, layers at greater depth were not tested.
   - Triaxial test were not conducted on UDS sample.
   - SBC of soil for shallow foundation had not been provided.
   - Particle size distribution curve were not provided with the report.

b. Gangapur Ghat
   - Borehole Coordinate (x, y) is missing & ground elevation at the borehole is not provided. Thus, it is difficult to know where exactly the borehole is carried out.
   - Borehole depth 30m.
   - According to the Borehole log, all along the borehole sand layer was available along with 1.5m thick clay seam at 19m depth from borehole top.
   - No UDS sample was collected for clay strata.
   - Only two direct shear tests were conducted in this borehole.
   - SBC of soil for shallow foundation had not been provided.
   - Particle size distribution curve were not provided with the report.

1.3.4 Traffic Volumes, Terminal Sizing, Proposed Concepts and Development Plans

1.3.4.1. OBSERVATIONS AND COMMENTS ON ISDP REPORT – MODULE 2

The Module 2 of the ISDP Report describes the existing conditions of the vessels, terminals and operations along with details of vessels that need to be considered for the proposed terminals/ghats. Based on our review, we have following key observations and comments. Some of the below observations affect the planning and designing of the terminals. Thus, it's essential that such observations are clarified by AIWTDS to TEPL to proceed further.

<u>Guwahati Corridor:</u>

a) There are no calculations presented in the report justifying the berth occupancy and handling capacity of each floating pontoon terminal. Thus, it is not possible to verify if the number of proposed pontoons comply with the traffic requirements.

b) A phased layout is observed in drawings, but the report does not provides any basis for the same.

c) The floating type of infrastructure is recommended by the ISDP consultant at Guwahati. The proposed concept will also necessitate pontoons to be shifted to a new location as per the requirements if excess sedimentation occurs at site. But it should be noted that pontoons will have to be connected through guide piles and these guide piles will be redundant if the site has to be shifted. Thus, it's essential to drive new guide piles at new site before pontoons are brought at new location. Moreover, this concept may not work properly if sedimentation happens only at selected locations and in such circumstances, dredging will be required to make the pontoon move freely in vertical axis.

d) It is to be noted that no engineering drawings are provided to understand the technical working of the proposed concept under different water levels. Thus, it is difficult to comment in detail.

e) It is noted that no cargo demand has been reported for river crossing. Thus, it is assumed there is no requirement for cargo terminal and jetty to handle goods.

Dibrugarh Corridor:

a) The floating type of infrastructure is recommended by the ISDP consultant at Dibrugarh. The proposed concept will also necessitate pontoons to be shifted to a new location as per the requirements if excess sedimentation occurs at site. But it should be noted that pontoons will have to be connected through guide piles and these guide piles will be redundant if the site has to be shifted. Thus, it's essential to drive new guide piles at new site before pontoons are brought at new location. Moreover, this concept may not work properly if sedimentation happens only at selected locations and in such circumstances, dredging will be required to make the pontoon move freely in vertical axis

b) It is reported that 76,328 (no unit given, presumably kg) goods/cargo was handled at the Neamati – Kamalabari locations (although there is no record of the type of cargo, their packing arrangement, loading and unloading methods etc.). It is noted that no traffic demand survey has been done to establish the total volume of cargo over the next 10-20 years. Thus, in absence of such data, it is not possible to plan the jetty and terminal infrastructure needed for cargo handling.

c) AIWTDS to confirm the total volume of cargo to be considered and in what form (pallets/containers/ cardboard boxes etc.)

d) It is noted that ISDP has ruled out any development at Kamalabari site whereas there is greater demand for cars, passengers, bikes and bicycles.

e) At present Aphalamukh, Neamati and Kamalabari ghats are seen to be catering to cars along with passengers, bikes and bicycles but no defined cargo mentioned for each of the ghats. Thus, it is assumed that the cargo/goods mentioned in above refers to passengers carrying their own boxes of domestic produce and thereby not necessitating the need for any separate cargo terminal. AIWTDS to confirm.

f) It is to be noted that no engineering drawings are provided to understand the technical working of the proposed concept under different water levels. Thus, it is difficult to comment in detail.

Silchar Corridor:

a) The floating type of infrastructure is recommended by the ISDP consultant at Silchar. The proposed concept will also necessitate pontoons to be shifted to a new location as per the requirements if excess sedimentation occurs at site. But it should be noted that pontoons will have to be connected through guide piles and these guide piles will be redundant if the site has to be shifted. Thus, it's essential to drive new guide piles at new site before pontoons are brought at new location. Moreover, this concept may not work properly if sedimentation happens only at selected locations and in such circumstances, dredging will be required to make the pontoon move freely in vertical axis

b) In Silchar Corridor (Gandhighat – Dudhpatil) apart from passengers, bicycles and motorcycles, another category of "Light Vehicles" are also provided. It is not clear whether light vehicles mean small cars or any other type of vehicles. However, we will consider our site observations and ensure that there are no LCV's.

c) In Sonabari – Neargram ghats, the ISDP consultant has observed loading/unloading of cars. Hence these locations (if listed) need also be considered for small vehicles. We will consider this based on our site observations for terminals in module B.

d) It is to be noted that no engineering drawings are provided to understand the technical working of the proposed concept under different water levels. Thus, it is difficult to comment in detail.

It is noted that no cargo demand has been reported for river crossing. Thus, it is assumed there is no requirement for cargo terminal and jetty to handle goods.

1.3.4.2. OBSERVATIONS AND COMMENTS ON ISDP REPORT – MODULE 4

The Module 4 of the ISDP Report assesses the existing site conditions along with detailed description of the concepts of terminal facilities for different corridors. The traffic forecast and projection are also discussed in addition to the magnitude of investment expected for the development of the ferry terminals. Based on our review, we have following key observations and comments. Some of the below observations affect the planning and designing of the terminals. Thus, it's essential that such observations are clarified by AIWTDS to TEPL to proceed further

General comment: The names of many selected ghats are misspelled at different places and lead to confusion and difficulty in identification of actual name.

Guwahati Corridor:

a) As per Cl. 2.4, a detailed assessment of the existing conditions along with review of historical data has been made by the ISDP Consultant, however the historical data have not been presented in report to verify the findings.

b) Table 4.1 – This table states that there is no traffic between Kachari Ghat and Umananda Island. However, Annex 1 (Fact finding missions) of Module 2 states that a minimum of about 500-600 passengers travel between these ghats every day. Similarly, the ferry line from Nagarbara to Majorchar/Alopatty is shown as not present in the table whereas the Annex 1 of Module 2 shows the existing services. Hence there is ambiguity between Module 2 and Module 3 of the ISDP Reports. We understand that there is no services on these sites anymore and thus there is no need for terminal in immediate future under module A & B. AIWTDS to convey to TEPL if they disagree with views of TEPL.

c) The total present demand for passenger, cars and bikes and projected growth numbers will be adopted for planning and design of terminals. AIWTDS to convey any alternate views on the total demand presented in ISDP report before TEPL starts planning of the terminals.

d) Clause 5.5.2 – It is mentioned that there is almost negligible movement of cargo/goods between the selected ghats. Thus, TEPL will not consider the planning and design of cargo terminals and associated infrastructure and equipment separately.

Dibrugarh Corridor:

a) As per Cl. 2.4, a detailed assessment of the existing conditions along with review of historical data has been made by the ISDP Consultant, however the historical data have not been presented in report to verify the findings.
b) The total present demand for passenger, cars and bikes and projected growth numbers will be adopted for planning and design of terminals. AIWTDS to convey any alternate views on the total demand presented in ISDP report before TEPL starts planning of the terminals.

c) Clause 5.5.2 – It is mentioned that there is almost negligible movement of cargo/goods between the selected ghats. Thus, TEPL will not consider the planning and design of cargo terminals and associated infrastructure and equipment separately.

Silchar Corridor:

a) Clause 8.14.2 – The concept layouts proposed by the ISDP Consultant for Annapurna and Dudhpatil ghats are not feasible as there is virtually no space between the two terminals to allow the movement of the vessels in the navigational channel.

b) As per Cl. 2.4, a detailed assessment of the existing conditions along with review of historical data has been made by the ISDP Consultant, however the historical data have not been presented in report to verify the findings.

c) The total present demand for passenger and bikes and projected growth numbers will be adopted for planning and design of terminals. AIWTDS to convey any alternate views on the total demand presented in ISDP report before TEPL starts planning of the terminals.

d) Clause 5.5.2 – It is mentioned that there is almost negligible movement of cargo/goods between the selected ghats. Thus, TEPL will not consider the planning and design of cargo terminals and associated infrastructure and equipment separately.

1.4 Project Location

The proposed terminal in Guwahati Gateway is on the left bank of Brahmaputra River. The river width is about 1.5 km. IWAI terminal at Pandu is about 5.8 km downstream of the proposed terminal. The upcoming new road bridge across the river is about 300 m on the right bank side (26^{0}11'4.59" N & 91^{0}43'7.97" E) and about 1000 m on the left bank side (26^{0}10'30.46" N & 91^{0}43'49.18" E) downstream of the terminal locations.

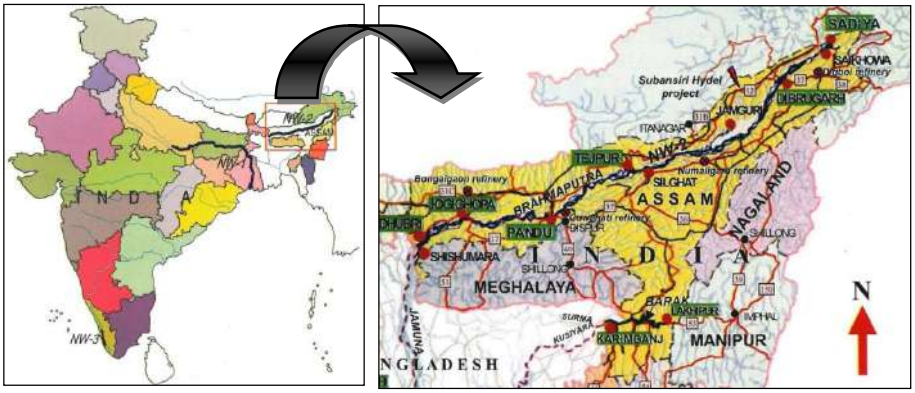


Figure 1-1: Location map

Figure 1-2: Proposed project location at Guwahati Gateway Ghat (Source: Google Earth)

The closer view of Guwahati gateway location on the south bank of Brahmaputra River is shown in Figure 1-3. The existing terminal (operating location) during lean flow period (low water level) is very close to a big sand bar which is between the operating location and the south riverbank near Fancy Bazar.

Figure 1-3: Existing terminal operation locations

2. HYDROLOGY AND MORPHOLOGY

2.1 Hydrology

2.1.1 Discharge data

Annual maximum discharge measured at Pandu which is about 5.5 Km downstream of Majegaon-Guwahati Gateway is shown in Figure 2-1. Annual maximum discharge in Brahmaputra at Pandu from 1955 to 1983 was obtained from a PhD thesis (*Hasan Ahmed, 1986, On the erosion aspects of the Brahmaputra River around Maijan and Mathola, Dibrugarh district, Assam- A Geological Study*) and data from 1984 to 1998 was collected from WRD Assam.

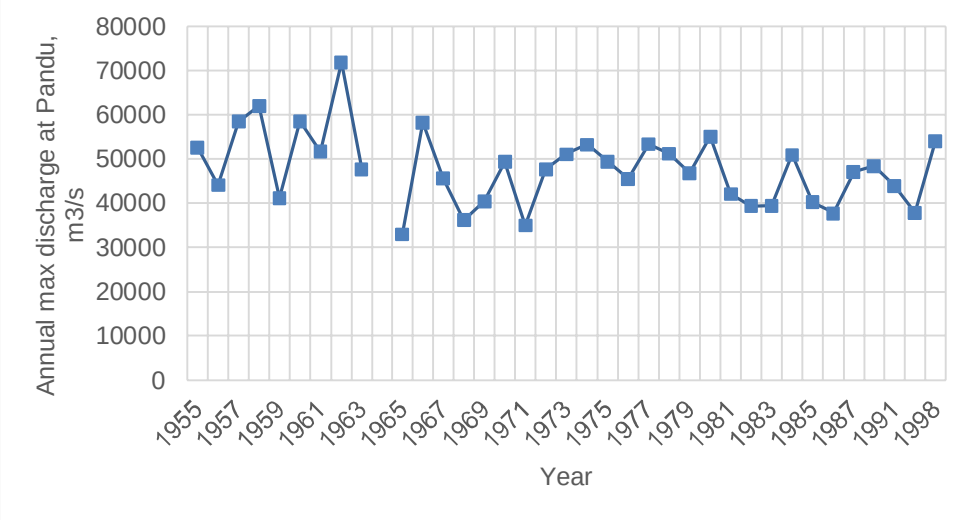


Figure 2-1: Annual maximum discharge observed at Pandu (Guwahati)

2.1.2 Flood Frequency Analysis and Design Flood

The 36 years annual maximum discharge was used for flood frequency analysis to estimate floods of different return period which is presented in Table 2-1 ***(detailed calculations are presented in Annexure 2.1).***

Table 2-1: Return flood estimated at Pandu (Guwahati)

Return Period (years)	Log Pearson Type III	Gumbel Type 1
25	64681	64861
50	68715	69437
100	72642	73980

2.2 Hydraulics

The nearest water level measurement stations upstream and downstream of Guwahati gateway and Majegaon terminal locations are at D C Court and Pandu in Guwahati respectively. The nearest High flood level (HFL) observed is at D C Court (CWC Flood forecasting station) in Guwahati about 2.5 km upstream side. However, Lowest Flood Level (LWL) data at D C Court was not available. To determine LWL at terminal locations, water surface slope during non-monsoon between Jogighopa and Pandu has been extrapolated up to Majegaon-Guwahati Gateway locations.

2.2.1 HFL and LWL

Estimation of HFL at Guwahati Gateway

- HFL observed at D C Court Guwahati, CWC Flood Forecasting Station (21/7/2004) = 51.46 m
- HFL considered for the new bridge= 52.00 m
- HFL considered for river front development = 51.46 m

Estimation of LWL at Guwahati Gateway

- The maximum difference of water levels measured at Pandu and Jogighopa in Non-monsoon was (Jan 2012) = 10.99 m,
- The flow distance between Pandu and Jogighopa during lean period is about 110 km (along thalweg)
- The water surface slope worked out 10.99/110 = 0.0999 m/Km or 1 in 10000
- The flow distance between Pandu and Guwahati Gateway-Majegaon = 4.6 Km
- Lowest water level at Guwahati Gateway-Majegaon will be higher than Pandu LWL by = 0.0999*4.6 = 0.46 m
- The LWL measured at Pandu = 40.19 m
- *Therefore, LWL at Guwahati Gateway-Majegaon = 40.10 +0.46 = 40.56 m*

Therefore, recommended design HFL and LWL at Guwahati gateway are 51.46 m and 40.56 m respectively.

2.2.2 Velocity

Based on local enquiry, the ISDP module 4 report suggested about 2.5 m/s current speed in Brahmaputra River at Guwahati. 2D mathematical modelling study was carried out for the Brahmaputra River Front Development (BRFD) project shows current speed of 1 m/s close to riverbank to 4 m/s in the main channel corresponding to 100-year return flood. In the present assignment, HEC RAS 2D hydrodynamic simulation was carried out on 12 M DEM (Alaska Satellite Facility data portal) corresponding to 74000 m^3/s in Brahmaputra near in Guwahati reach which gives velocity distribution as shown in figure below. The results shows that velocity distribution near Guwahati gateway is in the range of 1.0 m/s near the south bank and current speed at about 200 m away from the bank is about 2.5 m/s.

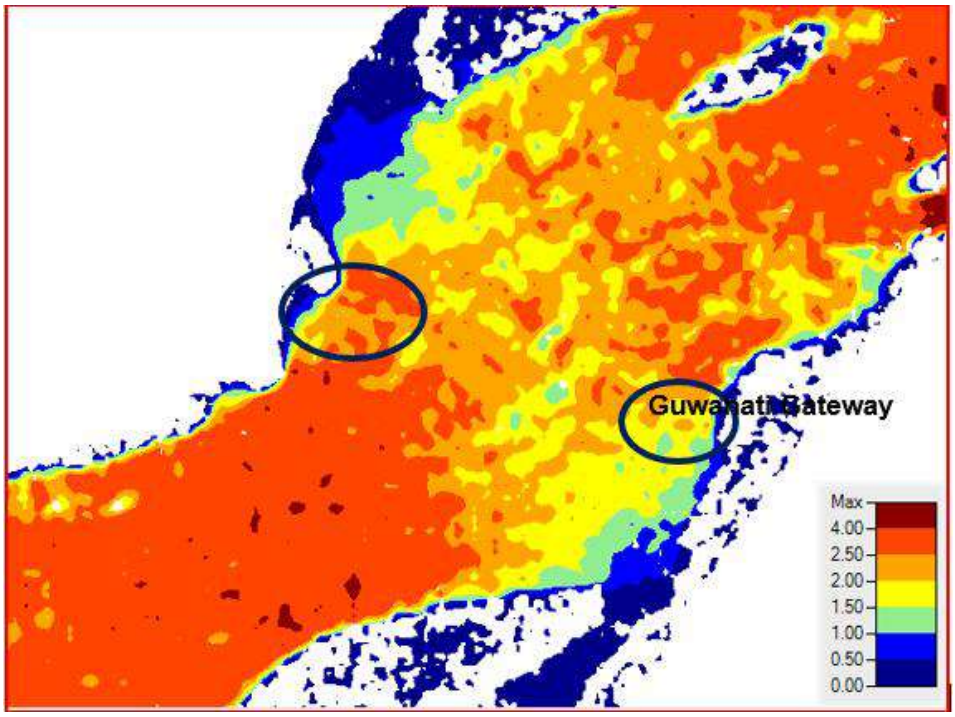


Figure 2-2: 2D velocity distribution in Brahmaputra River in Guwahati Reach (Based on satellite DEM/Bathymetry)

Further, HEC RAS 2D hydrodynamic simulation was also carried out on DEM prepared from bathymetry survey conducted by IWAI in Jan 2018. Corresponding to flood of 74,000 m^3/s in Brahmaputra River, the simulated current speed distribution near in Guwahati reach is shown in Figure 2-3.

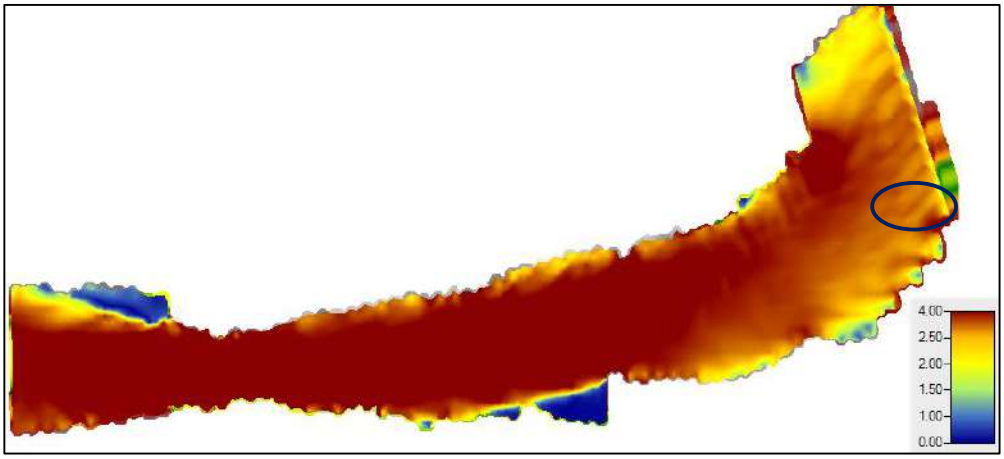


Figure 2-3: 2D velocity distribution in Brahmaputra River in Guwahati Reach (Based on IWAI Bathymetry survey in Jan 2018)

The above figure also shows that the simulated current speed is in the range of 3 m/s about 200 m away from the left bank.

Therefore, the design velocity at Guwahati Gateway terminal location is 3 m/s.

2.3 Morphological Changes

2.3.1 Historical erosion and deposition trend

The IWT location on the south bank near Guwahati Gateway /Fancy Bazar is also in concave side of a big curvature and is prone to sedimentation. Water level in Brahmaputra is found at lowest level in the month of February when the river features like sand bars are maximum exposed and visible. To understand the position and sizes of sand bars near Guwahati Gateway terminal location near Fancy Bazar, a number of RS images captured in the month of lean season months Nov-March in different years are presented in the following Figure 2-4 through Figure 2-8.

Figure 2-4 RS image- South Bank of Brahmaputra River near Guwahati Gateway in Feb 2004 (Source: Google Earth)

Figure 2-5 RS image- South Bank of Brahmaputra River near Guwahati Gateway in Feb 2005 (Source: Google Earth)

Figure 2-6 RS image- South Bank of Brahmaputra River near Guwahati Gateway in Nov 2011 (Source: Google Earth)

Figure 2-7 RS image- South Bank of Brahmaputra River near Guwahati Gateway in Nov 2015 (Source: Google Earth)

Figure 2-8 RS image- South Bank of Brahmaputra River near Guwahati Gateway in Mar 2019 (Source: Google Earth)

All the above figures show presence of sand bar very close to the terminal location. Another big sand bar also exists downstream of the terminal location near Lachit Statue. Overall, the terminal zone is sedimentation zone and existing ferry services keep changing their operation locations depending upon available water depth during lean months.

2.3.2 Bathymetry

TEPL has conducted bathymetry survey at the proposed terminal location at Guwahati Gateway which is shown in Figure 2-9. The bathymetry data and RS image (Feb 2019) show a big sand bar close to the proposed terminal location and riverbank. This sand bar may increase and move towards downstream with time. However, due to adequate water depth is available, dredging is not envisaged at the terminal location.

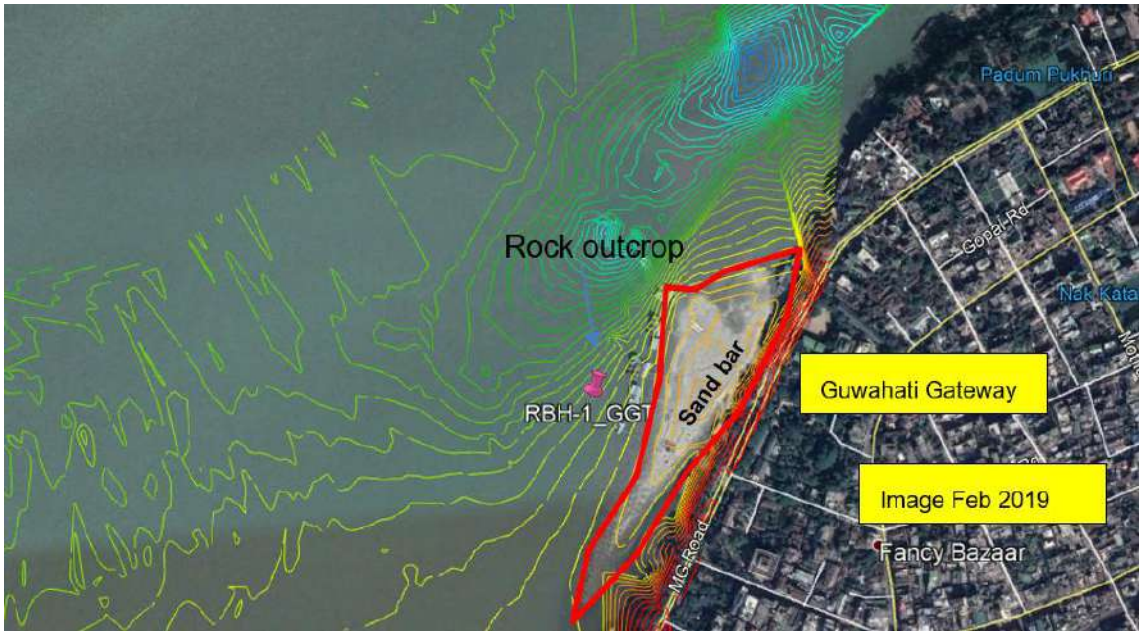


Figure 2-9: Bathymetry near Guwahati Gateway Terminal on South bank of Brahmaputra in Guwahati

2.3.3 Scour depth.

The scour depth has been estimated as below:

Design discharge adopted Q = 73,000 m^3/s

Particle size, D_{50}= 0.3 mm

Silt factor, f= 1.76 * Sqrt (D_{50}) = 0.964

Lacey's regime scour depth = 0.473 * $(Q/f)^{(1/3)}$ = 20.01 m

Scour depth from HFL= 2*20.01= 40.02 m

HFL= 51.46 m (amsl)

Scour Level from Lacey Regime depth formula= 51.46 -40.02 = 11.44 m

Existing bed level close the location = 38 m

Scour level calculated from Lacey's regime depth formula = 11.44 m is adopted.

The design scour level = 11.44 m

2.4 Bank Protection

The Brahmaputra River Front Development (BRFD) project covers south bank of Brahmaputra River from Raj Bhawan to Kamakhya Temple of about 6.3 km. Guwahati Gateway IWT terminal falls in the BRFD stretch near Fancy Bazar. The south bank of Brahmaputra River in this stretch is already protected (MG Road) and it will further be strengthened with BRFD.

Therefore, pertaining to the IWT terminal development separate bank protection measures are not envisaged and due to adequate water depth is available, dredging is also not envisaged at the terminal location.

3. SITE SURVEYS AND INVESTIGATIONS

In compliance with the Work Schedule agreed to in the Contract, the designated team for carrying out Bathymetric and Topographic Survey, collection of field data and interaction with the project authorities was deputed on the award of work. The teams mobilized and reached at Guwahati by 10th January 2019, started the fieldwork on 11th on site by 11th January 2019 and completed the field work in all respect on 24th January 2019. Hydrographic and Topographic has been carried out as per TOR.

3.1 Bathymetric and Topographic Survey

The water-covered area in the river was surveyed using modern hydrographic survey techniques. The most modern hydrographic surveys are conducted using electronic Echo Sounder and DGPS. The speed of the acoustic sound wave is mainly affected by water temperature and salinity.

Depth is derived from time measurements of the return trip of the acoustic pulse from the water surface to the river bottom and return.

The principle of the method is to send an acoustic signal and measure the travel time to derive a depth. This depth conversion process is done by first measuring the velocity of sound in water at different depths. This calibration was done twice a day to ensure a good accuracy.

IHO (International Hydrographic Organization) Standards for hydrographic surveys, special publication No.44 have been adopted, which also incorporates the procedure for elimination of doubtful data, and thus maintaining a high level of accuracy.

HYPACK-2018 software was used for Acquisition, data processing and map preparations. HYPACK is capable of generating spot levels and Contours, which are then transferred to AutoCAD for annotations and plotting charts and contour plan.

The depths derived using hydrographic surveys were converted into reduced level with respect to the water level of that particular day. The water level readings are taken with respect to Mean Sea Level (MSL). Observed water levels during survey period are given in tables below:

Table 3-1: Details of Water Level during Survey Period at Existing/ Proposed Terminal Locations

Corridor	Proposed / Existing Terminal Location	Observed water level (m)	Survey Date
Guwahati	Lachit Ghat / Guwahati Gateway Ghat	41.34	12/01/2019
	North Guwahati	41.295	13/01/2019
	Kurwa	41.657	14/01/2019
	Umananda	41.352	15/01/2019
	Uzan Bazar	41.49	15/01/2019

Inferences of observed water levels:

The observed water levels have been compared with historic water level data available from the desktop studies carried out for all the corridors. The following inferences can be drawn from the comparison of the observed water level and historic data.

The highest observed water level at the Guwahati corridor is 41.657m. The HFL at Guwahati corridor is 51.46m and LWL is 40.2m. The following graph gives the historic water level data for Guwahati corridor along with the observed water level marked. It can be inferred from the below graph that the observed water level matches well with the historic data.

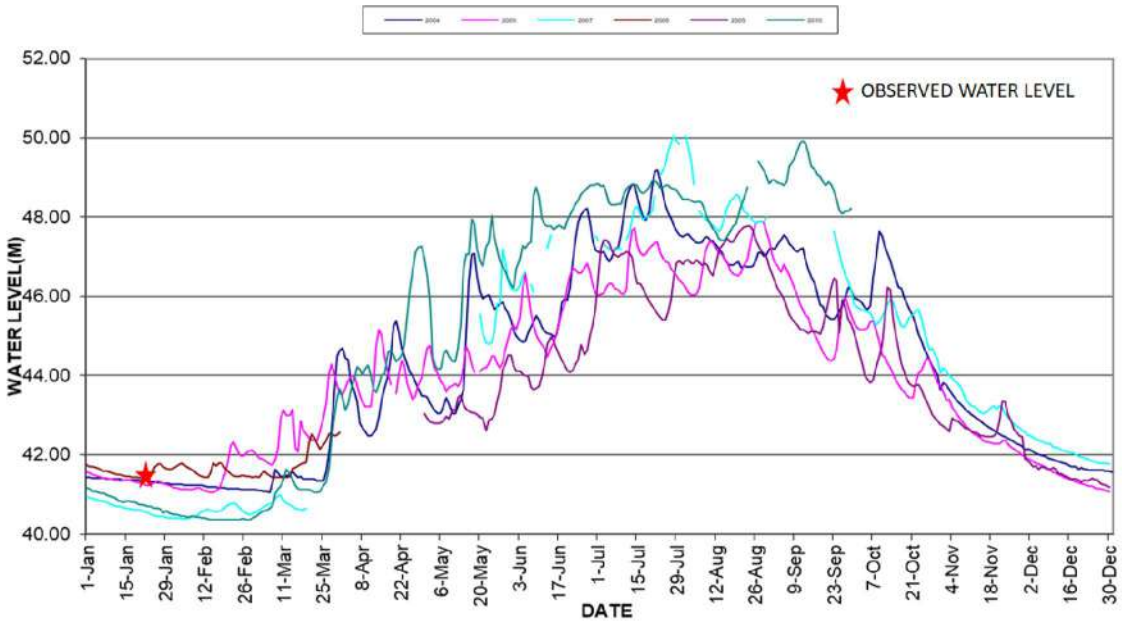


Figure 3-1: Water level variation in a year at Guwahati corridor

3.1.1 Survey Equipment

Bathymetric survey was carried out in the area by using Echo sounder, Flow meter, DGPS and Auto Level. Bathymetry has been carried out in each terminal location area to get an accurate picture of the river topography coupled with DGPS wherever necessary. Photographs of Equipment's used during survey period given in Figure-4-1 and details of equipment's given in Table-4.2.

Equipment's used for Bathymetric survey:	
 **C-Nav1010M- GPS Receiver**	 **L-Band Antenna**
 **Bathy-500 DF**	 **Transducer**

Equipment's used for Topographic Survey:

GRX1 Base Station

GRX1 Rover

GRX1 Controller

Auto level

Figure 3-2: Photographs of Equipment's used during survey

Table 3-2: Details of Equipment's used for Survey

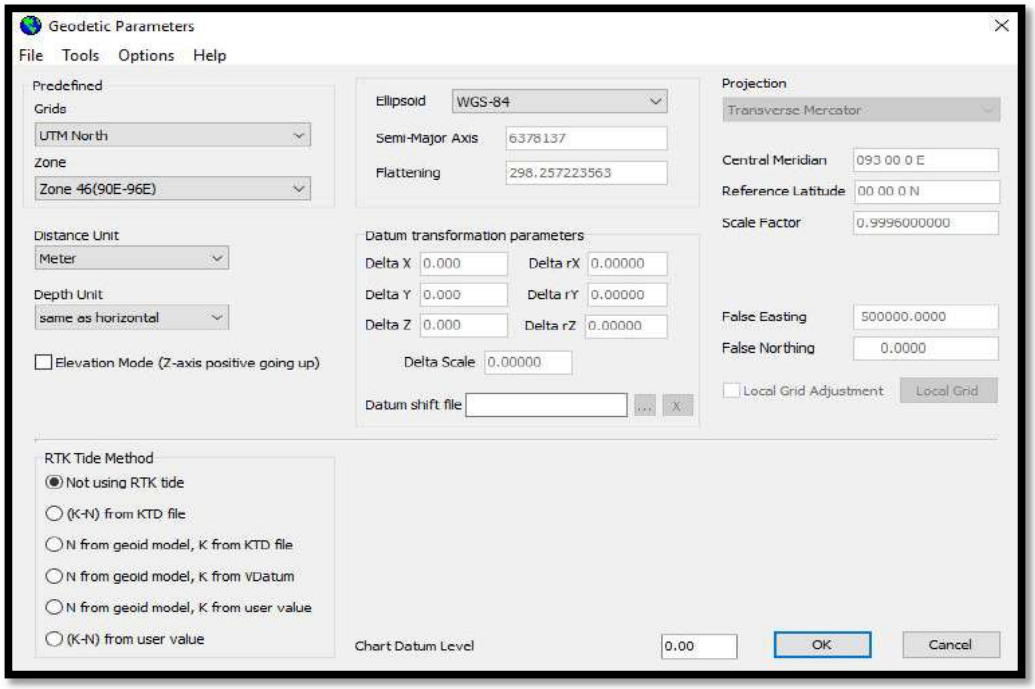
Equipment	Make	Model
DGPS Sets for Topographic Survey	Sokia/Topcon	GRX-1
GPS for Bathymetric Survey	C-Nav Technologies	1010M
Auto Level	Sokia	D4
Echo Sounder	Syquest	Bathy 500 DF
Software	HYPACK	2018
Software	Auto CAD 2016	-
Software	Microsoft Office	2017
Survey Boat	Survey boat provided by IWT, Guwahati on hire basis	

3.1.2 Control of Survey work

Geodetic parameters:

Surveys carried out in WGS 84 spheroid, Indian Datum, Grid co-ordinates in terms of Universal Transverse Mercator (UTM) Projection. Details of Spheroid and Grid systems are as follows:

Table 3-3: Geodetic parameters was used for survey



Horizontal Control:

To provide positioning data as input to the HYPACK hydrographic data logging system, C-Nav 1010M GPS system was used during Bathymetric survey. The system was configured to receive C-Nav service, throughout the duration of survey operations. The C-Nav service provides centimetric positional accuracies. C-Nav corrections are modelled on a worldwide network of reference sites using carrier phase measurement to maximize accuracy. The system operates in real-time without the need for local base stations or telemetry links.

The positioning data received will have high reliability and integrity with a horizontal positioning accuracy of decimetre. The system will be calibrated at a known location within the survey area.

Sokkia GRX1, DGPS sets were used in baseline mode for extension and establishment of geodetic control in the survey area. The GTS/ CWC Benchmark station at each corridor premises was correctly recovered and WGS 84 co-ordinates of the station were accepted by processing the Static dual frequency GPS observations using online processing service. Extension of the geodetic control was achieved by setting up Local Marks throughout the proposed/ existing terminals area. Co-ordinates of such marks were established by simultaneous dual frequency GPS Static observations between established and spot level picked by stop-go method. The data was processed using Spectrum Survey office v.8 Processing software.

Vertical Control:

The vertical control at each proposed/ existing terminal location for bathymetry & Topographic surveys are based on the datum levels established by GTS/ CWC benchmarks. The extension of horizontal and vertical control was carried out by the baseline processing with the nearest reference station in the corridor.

Equipment setup during survey as shown in Figure-4.1 and site photographs enclosed in Annexures

Figure 3-3: Equipment setup during survey

3.1.3 Preparation of Charts

Data collected from field in the form of raw files which contain XYZ. Processed the data format with single beam editor and applying Water level correction and erase unwanted data, so the final form of data also comes as XYZ and generate the contours and plotted in CAD platform.

3.2 Topographic Survey

The topographic survey was conducted at proposed/existing Terminals at Dibrugarh Corridor, to gather the topographic information for design and field engineering activities. The survey includes joint site inspection of the boundary limits identified by Client's Engineer-in-Charge (EIC) to generate information on the topography of the site, transferring of benchmark to the Site, details of features on the site, generating co-ordinates for various areas and spots, preparation of survey and Contour drawings.

Carrying out and setting up of Benchmark

The procedure to carry out benchmark by levelling from the nearest benchmark (CWC Gauge/GTS) available. The benchmark to be established at a convenient location at existing/ proposed terminal location of all three corridors as per the instructions, all subsequent transfer of levels were carried out with respect to this benchmark. Details of Reference Benchmarks and Established TBM at survey area as given in Table 3-4 and Table 3-5 respectively.

Topographic survey has been carried out in accordance with the guidance from the BIS code 5497:1983 “Guide for topographical surveys for river valley projects”. Methods of topographical survey vary depending on the degree of accuracy to be attained, extent of the project and topography of the project area.

The reference point used for Hydrographic Surveys has also been used for Topographical Survey in the same coordinate system. The Topographical Survey was conducted using the latest instruments i.e. SOKKIA DGPS GRX1 with one Base and one Rover. The base is operated at a single known point while the Rover (counterpart of Base) is used for land survey of various locations.

The GRX1 receiver is a multi-frequency, GPS+ receiver built to be the most advanced and compact receiver for the surveying market. The receiver is a multi-function, multi-purpose receiver intended for precision markets. Precision markets means markets for equipment, subsystems, components and software for surveying, construction, commercial mapping, civil engineering, precision agriculture and land-based construction hydrographic and any use reasonably related to the foregoing.

The GRX1 can receive and processes multiple signal types (including the latest GPS L1, L2, C/A, L2C GLONASS L1, L2, C/A signals) improving the accuracy and reliability of the survey points and positions, especially under difficult jobsite conditions. The multifrequency and GPS+ features of the receiver combine to provide a positioning system accurate for any survey. Several other features, including multipath mitigation, provide under-canopy and low signal strength reception. The receiver provides the functionality, accuracy, availability, and integrity needed for fast and easy data collection.

Table 3-4: Details of Reference Benchmark

Corridor	Reference Benchmark location and Elevation	Photographs
Guwahati	GTS Benchmark available Near Commissioner of Police office and adjacent CWC Gauge site office, Guwahati. Elevation: 50.755m above MSL	

Table 3-5: Details of Established TBM (Benchmarks) at survey area

Corridor	Code	Location	Grid Northing (m) Grid Easting (m)	Latitude (N) Longitude (E)	Elevation (m)
Guwahati	TBM	Near CWC Gauge Guwahati	2897359.831N 374566.377E	26°11' 24.9065"N 91°44' 40.8118"E	42.450
	TBM-1	Lachit Ghat / Guwahati Gateway Ghat	2896847.563N 374023.553E	26°11' 8.0876"N 91°44' 21.4376"E	51.710
	TBM-2	North Guwahati	2896984.59N 372345.654E	26°11' 12.0077"N 91°43' 20.9512"E	50.363
	TBM-3	Umananda	2898008.481N 374618.088E	26°11' 46.0032"N 91°44' 42.4486"E	46.923

	TBM-4	Kurwa Ghat	2902207.319N 382474.182E	26°14' 4.8556"N 91°49' 24.0845"E	48.226
	TBM-5	Ujanbazar	2897658.375N 375272.638E	26°11' 34.8304"N 91°45' 6.149"E	49.706
	TBM-6	Nehrupark	2897224.577N 374814.696E	26°11' 20.589"N 91°44' 49.8036"E	55.239

Contouring

Survey has carried out spot level for contouring the terminal area. Levels were also taken on all traverse stations and on salient points located at random over the area. Contours are generated at 1.0m intervals after the points are plotted. The contours were not just interpolated but properly surveyed on the ground so that features falling between the two successive levels are also picked up. Sufficient points properly distributed over the entire area shall be located and levels taken so that accurate contouring can be done. At places of sharp curvature or abrupt change in direction and elevation, points selected shall be close to each other. Salient points on river bank lines were also measured.

Levelling operation was always considered from existing structure at terminal, whose levels are based on the benchmark established in the survey area.

The survey maps of the site indicating grid lines and contour lines have been placed appropriately duly demarcating all permanent features like roads, waterways, buildings, natural streams. Riverbed level variation showing for Different terminal location as given in figure below.

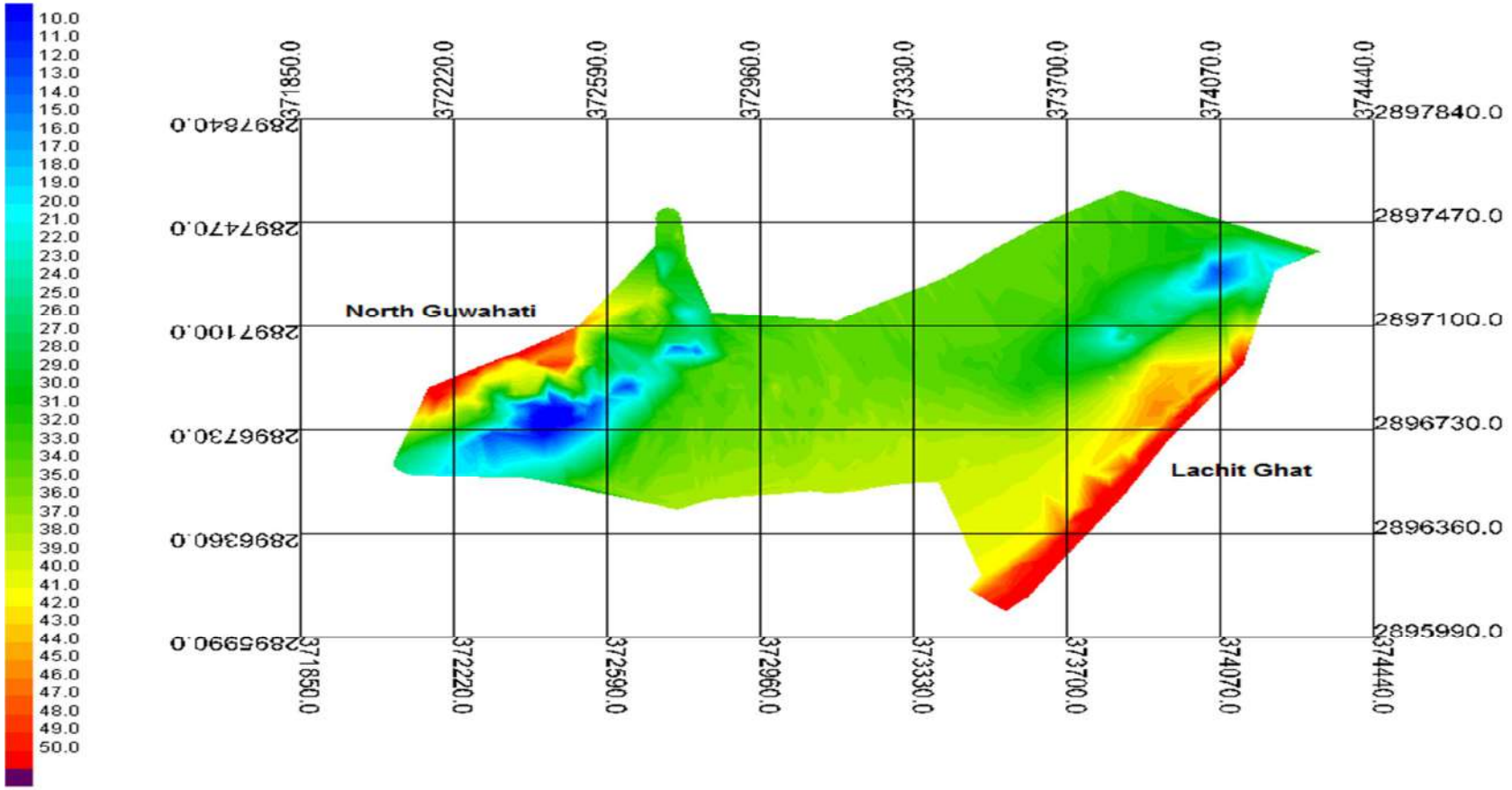


Figure 3-4: River bed level variation at Guwahati Gateway Ghat

3.3 Geotechnical Investigations and Interpretation

3.3.1 General

Floating Pontoons, Approach Trestle and Terminal building has been planned at the Guwahati Gateway Ghat to facilitate the ferry services to North Guwahati Ghat, Umananda Ghat, Kurua Ghat. Geotechnical investigations have been carried out to realize the subsurface geological and geotechnical conditions required for the proper planning and foundation design of the proposed structure.

3.3.2 Sub-surface Investigations

One borehole (RBH-1) into the river has been drilled to obtain the subsurface soil information. The borehole has been drilled vertically down to the depth of 45.39m from EL. +37.255 m to EL. -8.135. Predominantly silty sand soil strata has been encountered in the borehole. The details of the borehole and the soil stratification obtained in the borehole has been described in **Table 3-6** and **Table 3-7** respectively.

Location map, Borehole log, Soil profile are in appended in Annexure 3.1.

Table 3-6: Borehole Details

Sr. No.	Borehole Mark	Location	Co-Ordinates	Riverbed Level (m)	Termination Level (m)	Drill Depth (m)	Water Depth (m)
1	RBH-1	Pontoon area	N - 2896822.00 m E - 373749.00 m	+37.255	-8.135	45.39	3.95 above RBL

Table 3-7: Soil Stratification

Sr. No.	Depth from RBL		Thickness (m)	Description of Strata
	From (m)	To (m)		
1.	0.0	1.0	1.0	Loose grey silty sand with fine mica flakes.
2.	1.0	17.0	16.0	Medium dense grey silty sand with fine mica flakes.
3.	17.0	24.0	7.0	Dense greyish brown sandy silt with fine mica flakes and silt lamination.
4.	24.0	45.39	21.39	Very dense greyish brown to dark grey silty sand with fine mica flakes and nodule pieces.

Along with drilling of borehole various in-situ tests such as Standard Penetration Test (SPT) and determination of bulk density has been conducted at the site. SPT samples were also collected from the borehole. Various laboratory test has been conducted on these soil samples for determination of index properties and shear parameters of the sub-soil.

The N-value, bulk density obtained from in-situ tests and shear parameters obtained laboratory test are presented in Table 3-8. For further details regarding all the tests conducted and the result obtained from the tests refer Annexure 3.1.

Table 3-8: Summary of Test Results

Sr. No.	Depth from RBL		Description of Strata	SPT N-Value	In-situ Bulk Density (kN/m^3)	Cohesion (kPa)	Angle of Internal friction (degrees)
	From (m)	To (m)					
1.	0.0	1.0	Loose grey silty sand with fine mica flakes.	5	16.1		
2.	1.0	17.0	Medium dense grey silty sand with fine mica flakes.	12 - 29	17.0 - 18.5	0.22 - 0.82	32 - 35
3.	17.0	24.0	Dense greyish brown sandy silt with fine mica flakes and silt lamination.	28 - 42	18.2 - 21.6	0.25 - 0.80	36
4.	24.0	45.39	Very dense greyish brown to dark grey silty sand with fine mica flakes and nodule pieces.	48 - 114	19.3 - 21.0	0.14 - 0.65	37 - 41

4. PLANNING AND DESIGN OF TERMINALS

4.1 Proof Checking

Consultant has obtained approvals from Proof Checking Agency (IIT-R) for the concept, structural elements, design basis and drawings for Guwahati Gateway Ghat and enclosed as an attachment to this report at Annexure 1.2.

4.2 Traffic Analysis

4.2.1 Overview

The main objective of this exercise is to analyse the total no. of ferry users at present at pre-identified locations/ Ghats their purpose and how often they are using ferry services. This data will be used to forecast the usage of ferry services for year 2035 which will enable us to finalise the capacity of terminal in terms of area requirement for Passenger waiting areas, parking, ticketing booth, Admin Staff and other physical Infrastructure. The horizon year is fixed as per the Integrated Strategic Development Plan (ISDP) which has been prepared to provide comprehensive and integrated transport solution in the State as well as guide the sustainable development of the inland water transport sector in Assam till 2035.

The analysis is done on the basis of economic growth factors as mentioned in methodology below -

4.2.1.1. METHODOLOGY FOR TRAFFIC GROWTH RATE ANALYSIS

The passenger growth rate of Assam is calculated on the basis of various economic factors. The past performance of the economic indicators for the Project influence area (PIA) are collected for the same time period, with the objective of establishing the elasticity of travel demand with respect to different economic indicators. The economic indicators considered for the analysis include the following parameters.

- Ø Net State Domestic Product (NSDP) of PIA states
- Ø GDP of India
- Ø Per Capita Income (PCI) of PIA states
- Ø Population of PIA states

Table 4-1 : Economic Data Assam (Source - https://des.assam.gov.in/)

Year	NSDP (in Rs. Crores)	% age Growth	PCI (in Rupees)	% age Growth	GDP (in Rs. Crores)	% age Growth	Population (IN CRORES)	% age Growth
2011-2012	12935412	-	45538	-	14317491	-	314410	-
2012-2013	13251760	2.45%	46264	1.59%	14734238	2.91%	318480	1.29%
2013-2014	13872476	4.68%	47900	3.54%	15452540	4.88%	322600	1.29%
2014-2015	14642539	5.55%	50558	5.55%	16521230	6.92%	326780	1.30%
2015-2016	16042557	9.56%	54056	6.92%	17892964	8.30%	331010	1.29%
Average		**5.56%**		**4.40%**		**5.75%**		**1.29%**

4.2.2 Elasticity of Passenger traffic with economic growth

Elasticity method will be used project the passenger traffic growth rate in Assam.

4.2.2.1. DESCRIPTION ON REGRESSION ANALYSIS

The Regression analysis tool performs linear regression analysis by using the "least squares" method to fit a line through a set of observations. We can analyse how a single dependent variable is affected by the values of one or more independent variables. In the present case registered vehicles by type are dependent variables whereas the economic parameters are independent variables. Once the relation is established by regression there are the following measures to accept or reject the relation as explained below.

4.2.2.2. T-STATISTIC

The t-statistic is a measure of how strongly a particular independent variable explains variations in the dependent variable. The larger the t-statistic the better the independent variable's explanatory power. Next to each t-stat is a P-value. The P-value is used to interpret the t-stat. In short, the P-value is the probability that the independent variable in question has nothing to do with the dependent variable. Generally, we look for a P-value of less than .05, which means there is a 5% chance that the dependent variable is unrelated to the dependent variable. If the P-value is higher 0.1, a strong argument can be made for eliminating this particular independent variable from a model because it "isn't statistically significant."

4.2.2.3. R SQUARE

R Square is another measure of the explanatory power of the model. In theory, R square compares the amount of the error explained by the model as compared to the amount of error explained by averages. The higher the R-Square the better is the regression. Regression analysis is carried out by creating econometric models using past vehicle registration data of states and economic indicators, like, Population and PCI for passenger vehicles and NSDP. The results of regression value are given below –

Table 4-2 : Result of regression values

Modes	Variables	R Square	Coefficient
Car	PCI	0.788	2.366
2-W	PCI	0.965	2.600
Buses	PCI	0.907	0.851
Buses	Population	0.944	2.995
LCV Pass	PCI	0.000	0.000
LCV Pass	Population	0.000	0.000
LCV	GDP	0.731	4.608
Trucks	GDP	0.147	-0.203
MAV	GDP	0.788	2.165
Tractor	GDP	0.764	5.806
Others	GDP	0.724	-3.446
LCV	NSDP	0.694	4.698
Trucks	NSDP	0.116	-0.189
MAV	NSDP	0.736	2.190
Tractor	NSDP	0.786	6.167
Others	NSDP	0.678	-3.491

4.2.2.4. RECOMMENDED ELASTICITY VALUES

Considering the PIA and the economic indicators of Assam, the projected elasticity values for various vehicle types are presented below, which are used to estimate the passenger growth rates of Assam. The transport demand elasticity by vehicle type, over a period, tends to decline and approach unity or even less. As the economy and its various sectors grow, every region tends to become self-sufficient. Moreover, much of the past growth has been associated with the country's transition from a largely rural, subsistence economy to cash based urban economy, dominated by regional and national linkages. As the transition proceeds, its impact on transport pattern can be expected to become less dominant. Therefore, the demand for different type of vehicles falls, over time, despite greater economic development. The same is also clear from the relationships of the economy and transport demand elasticity over time nationally and internationally.

Table 4-3 : Elasticity estimation

Mode	Upto 2016	Up to 2020	2021-2025	2026-2030	2031-2035	2036-2040	Beyond 2040
Car	2.37	2.13	1.92	1.72	1.55	1.40	1.26
2-W	2.60	2.34	2.11	1.90	1.71	1.54	1.38
Buses	0.85	0.77	0.69	0.62	0.56	0.50	0.45
LCV Passenger	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCV	4.61	4.15	3.73	3.36	3.02	2.72	2.45
2-Axle/ 3-Axle	-0.20	-0.18	-0.16	-0.15	-0.13	-0.12	-0.11
MAV	2.17	1.95	1.75	1.58	1.42	1.28	1.15
Tractor	5.81	5.23	4.70	4.23	3.81	3.43	3.09
Others	-3.45	-3.10	-2.79	-2.51	-2.26	-2.03	-1.83
LCV	4.70	4.23	3.81	3.43	3.08	2.77	2.50
2-Axle/ 3-Axle	-0.19	-0.17	-0.15	-0.14	-0.12	-0.11	-0.10
MAV	2.19	1.97	1.77	1.60	1.44	1.29	1.16
Tractor	6.17	5.55	5.00	4.50	4.05	3.64	3.28
Others	-3.49	-3.14	-2.83	-2.54	-2.29	-2.06	-1.86

4.2.3 Passenger Growth rate Assam

Based upon Assam GSDP, National GDP and ferry data available for three years Elasticity of passenger traffic in relation to economic growth have seen below –

Table 4-4 : Passenger growth rate for ferry Ghats

Various Transport Mode	Up to 2020	2021-2025	2026-2030	2031-2035	2036-2040	Beyond 2040
Car	9.89	8.90	8.01	7.21	6.49	5.84
2-W	10.89	9.80	8.82	7.94	7.14	6.43
Buses	5.00	5.00	5.00	5.00	5.00	5.00
LCV Passenger	5.00	5.00	5.00	5.00	5.00	5.00
LCV Goods	13.65	12.29	11.06	9.95	8.96	8.06
2-Axle	6.21	5.59	5.03	5.00	5.00	5.00
3-Axle	8.87	7.98	7.19	6.47	5.82	5.24
MAV	12.67	11.41	10.27	9.24	8.31	7.48
Tractor	38.91	35.01	31.51	28.36	25.53	22.97
Others	5.00	5.00	5.00	5.00	5.00	5.00
Average Growth	**11.61**	**10.60**	**9.69**	**8.92**	**8.23**	**7.60**

4.2.4 Traffic Volumes at priority Ghats

This is on the basis of data provided for recent years by Assam Inland waterways transport development society for feasibility report.

Table 4-5 : Traffic records of Priority Ghats (Source- Feasibility report)

Heads	No. of passenger			No. of Motorcycles			No. of Bi cycles		
	2016	2017	2018	2016	2017	2018	2016	2017	2018
Guwahati - North Guwahati	946652	876301	823002	315319	282496	281196	33974	29383	82052
Guwahati - Rajaduar Ferry Services	697112	687219	730000	100471	153579	164542	6740	6190	47450
Kachari Ghat / Uzan Bazar Ghat - Umand Island			560640						
Neamati- Kamalabari	667800	195483	500780	118086	25711	116654	2196	889	8614
Aphalamukh - Neamati	125880	135734	347772	16395	7012	108040	2187	1538	1752
Annapurna ferry service	219916	179154	514212	30838	47435	31828	42457	47435	75336
Berranga (Khanakur)- Gangapur Services	396532	284475	513190	87114	77262	120888	86319	77262	40150

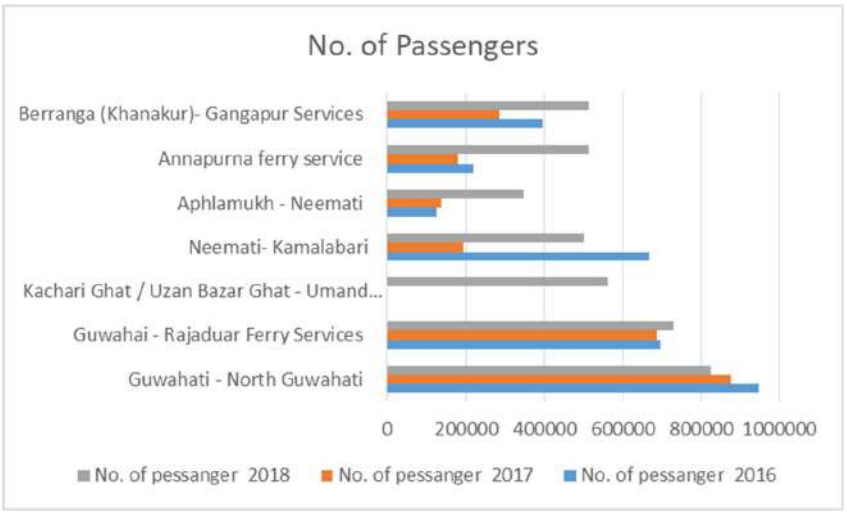


Figure 4-1: Number of passengers at priority ghats

The data clearly shows that that the highest no. of passenger movement is from South Guwahati i.e., Lachit ghat followed by Guwahati – Rajaduar and passenger movement at Aphalamukh is the lowest.

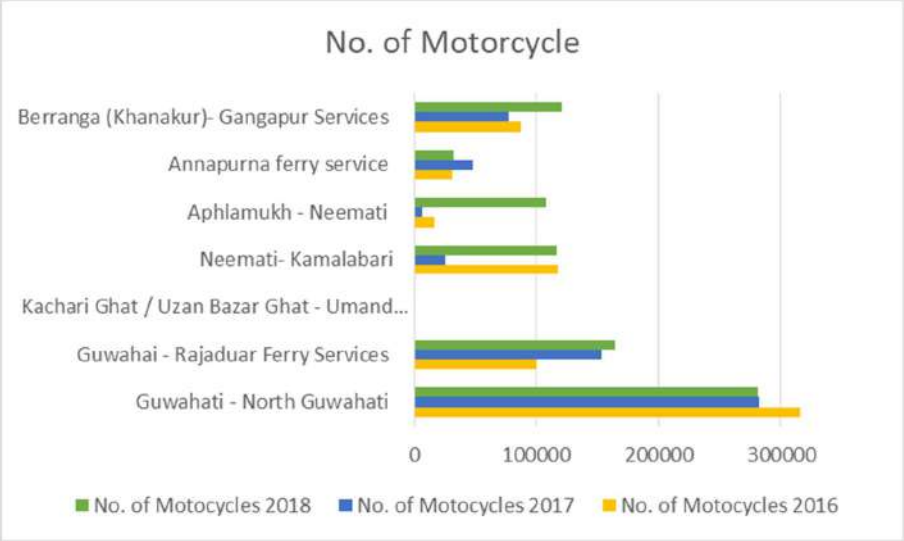


Figure 4-2: Number of motor vehicles at priority ghats

The no. of bikers are highest at South Guwahati, followed by Guwahati – Rajaduar and Bikers movement at Annapurna is the lowest in year 2018 however there are lot of fluctuation in bikers data for Aphalamukh Site.

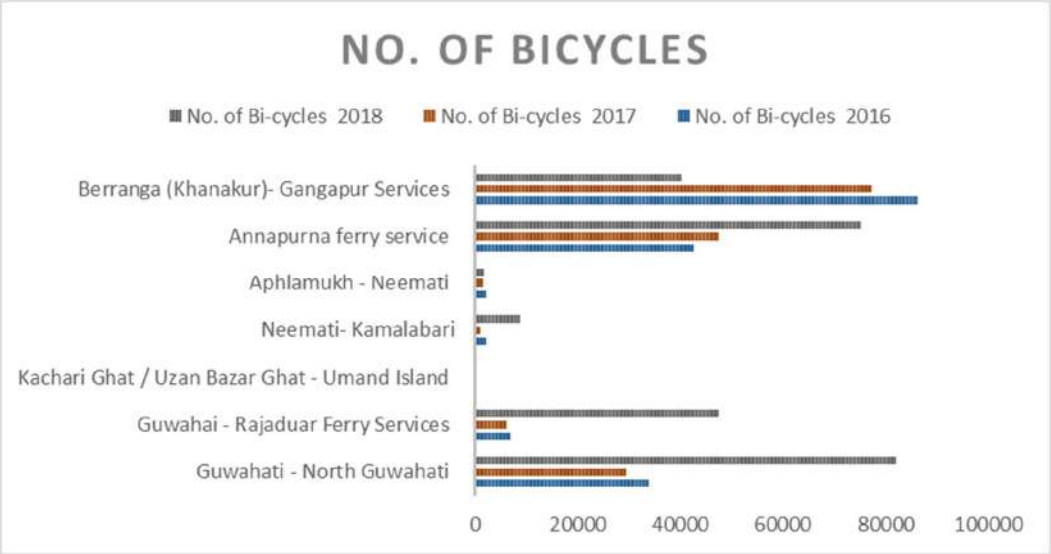


Figure 4-3: Number of bicycles at priority ghats

As per the available data the highest no. of bicyclist seen at South Guwahati, followed by Annapurna, and lowest for Kachari ghat and Aphalamukh in 2018.

However, there are lot of variation found in year wise data, therefore it is suggested to rely upon primary data collected in July 2018 (For Feasibility report) and all calculation, trend analysis and forecast of the traffic data shall be taken from feasibility report.

4.2.5 Finding based upon Traffic Survey

Following are the observations based on the conducted O/D Survey from Guwahati Gateway to North Guwahati and vice versa:

- These terminals will serve heavy traffic movements.
- There will be varied traffic in the terminal which includes, Passengers, Two wheelers, Cycles Etc.

- Majority of passengers are on work, Tourism and education related trip. Cargo Traffic is negligible in this area.

A seasonal correction factor of 1.2 has been added, as mentioned in feasibility report. However details of the assumption is not given, Anticipated traffic details after adding this factors are given below –

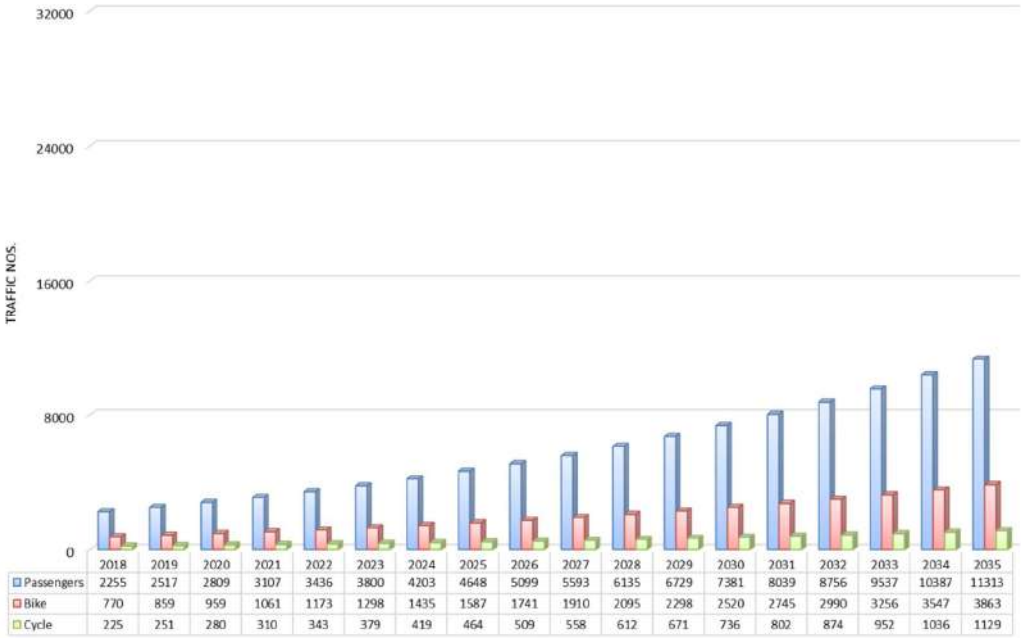
Table 4-6 : Anticipated Annual average daily traffic (AADT) based on assumption

Modes	AADT	Correction @1.2
Passengers	1879	2255
Bikes	642	770
Cycle	187	225
Vendors	21	25

4.2.6 Traffic Forecast for Guwahati Gateway Terminal

Traffic forecast for Guwahati Gateway terminal is given below –

Table 4-7 : Traffic Forecast Guwahati Gateway Terminal



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Passengers	2255	2517	2809	3107	3436	3800	4203	4648	5099	5593	6135	6729	7381	8039	8756	9537	10387	11313
Bike	770	859	959	1061	1173	1298	1435	1587	1741	1910	2095	2298	2520	2745	2990	3256	3547	3863
Cycle	225	251	280	310	343	379	419	464	509	558	612	671	736	802	874	952	1036	1129

It is clear from the above data that highest no. of passenger movement happens from South Guwahati to North Guwahati.

Peak Hour data will be used for Designing of terminal Building.

4.2.6.1. PEAK HOUR TRAFFIC

As per the Average Daily traffic anticipated in Guwahati Gateway the peak hour daily traffic is calculated which will be the basis of finalisation of function requirement of the terminal building.

AADT converted into PEAK Hour Traffic					
From	TO	Passengers	Bike	Cycle	Vendors
07:00	08:00	2.50%	3.20%	3.60%	21.70%
08:00	09:00	11.10%	13.70%	15.60%	28.30%
09:00	10:00	6.00%	6.40%	5.60%	0.00%
10:00	11:00	13.80%	15.70%	8.90%	13.30%
11:00	12:00	5.00%	4.10%	3.80%	0.00%
12:00	13:00	6.80%	6.00%	8.90%	0.00%
13:00	14:00	6.80%	4.80%	5.30%	0.00%
14:00	15:00	9.50%	8.00%	11.80%	0.00%
15:00	16:00	4.70%	3.90%	4.75%	0.00%
16:00	17:00	7.60%	6.80%	4.75%	0.00%
17:00	18:00	13.10%	14.50%	17.40%	0.00%
18:00	19:00	11.80%	12.20%	8.30%	25.00%
19:00	20:00	1.30%	0.70%	1.30%	11.70%
Total		100.00%	100.00%	100.00%	100.00%

Based upon the data following observation has been made –

1. Peak hour passengers and Bikers movement are observed at 10:00 to 11:00 am in the morning and 17:00 to 18:00 in the evening.
2. The movement of Vendors are observed highest at 08:00 to 09:00 in the morning and 18:00 to 19:00 in the evening.
3. It is understood that Peak Hour traffic will be 25 % more than in terms of Guwahati Gateway Traffic.

This data will be used to project the peak hour demand for horizon year till 2035.

Table 4-1: Peak hour demand projection till 2035

From	TO	2019	2020	2021	2024	2025	2026	2029	2030	2031	2034	2035
07:00	08:00	81	70	78	105	116	127	168	185	201	260	283
08:00	09:00	345	312	345	467	516	566	747	819	892	1153	1256
09:00	10:00	161	169	186	252	279	306	404	443	482	623	679
10:00	11:00	395	388	429	580	641	704	929	1019	1109	1433	1561
11:00	12:00	103	140	155	210	232	255	336	369	402	519	566
12:00	13:00	151	191	211	286	316	347	458	502	547	706	769
13:00	14:00	121	191	211	286	316	347	458	502	547	706	769
14:00	15:00	201	267	295	399	442	484	639	701	764	987	1075
15:00	16:00	98	132	146	198	218	240	316	347	378	488	532
16:00	17:00	171	213	236	319	353	388	511	561	611	789	860
17:00	18:00	365	368	407	551	609	668	881	967	1053	1361	1482
18:00	19:00	307	331	367	496	549	602	794	871	949	1226	1335

19:00	20:00	18	37	40	55	60	66	87	96	105	135	147
Total		2517	2809	3107	4203	4648	5099	6729	7381	8039	10387	11313

The traffic observed for various years have been bifurcated in to four main milestone years i.e. year 2020, 2025, 2030 and 2035. The space requirement for passengers waiting area will be govern from peak hour traffic in these years.

4.2.6.2. PASSENGER WAITING AREA CAPACITY

Traffic of Guwahati Gateway has been considered and calculations are based upon assumption of vessels type as provided in below mentioned table.

Due to high frequency of ferry services, it is assumed that all passengers shown in peak hour need not wait at terminal/ Pontoon. Passenger / bikers waiting area will be purely dependent upon the frequency of the ferry services as assumed in below mentioned table.

Table 4-8 : Passenger Handling capacity

Year	Vessel-1	Vessel-2	Vessel-3	Vessel-4	Vessel-5	Vessel-6	Total
2020	50	50	50	50	50	50	**300**
2025	100	50	50	50	50	50	**350**
2030	100	100	50	50	50	50	**400**
2035	100	100	100	100	100	100	**600**

There will be 3 Pontoons which can handle 6 Vessels at a time and based upon passenger peak hour handling capacity the requirement of infrastructure is determined.

Table 4-9 : Traffic Handling capacity and passengers waiting area provided at Guwahati Gateway Terminal

Year	Passenger Peak Hour	Passenger Handling Capacity per Hour	Passenger waiting per hour	Passenger Waiting Area Provided			
				At Terminal	At Pontoon	Total	Percentage
2020	388	300	88	94	400	494	127%
2025	641	350	291	94	400	494	77%
2030	1019	400	619	94	400	494	48%
2035	1561	600	961	188	624	812	52%

In year 2020 it is anticipated that peak hour passengers would be 349 Nos. and the passengers handling capacity per hour of the terminal would be 400 nos. the waiting area provided at the terminal is for 150 No. and 200 Nos. passengers can handled at Pontoons . The total waiting area provided w.r.t passengers peak hour is 127% in year 2020 and 77% in year 2025.

In year 2030 it is anticipated that peak hour passengers would be 1019 Nos. and the passengers handling capacity per hour of the terminal would be increased up to 800 nos. by construction of phase-2 Building the waiting area provided at the terminal is for 300 No. and 400 Nos. passengers can handled at Pontoons. The total waiting area provided w.r.t passengers peak hour is 48% in year 2030 and 52% in year 2035.

4.2.6.3. PEAK HOUR BIKERS HANDING CAPACITY

Bikers handling capacity is also worked out in terms of expected peak hour load of bikers and the frequency / type of vessels provided by AIWT. The capacity / frequency of vessels are given below –

Table 4-10 : Bikers Handling capacity by the vessels

Year	Vessel-1	Vessel-2	Vessel-3	Vessel-4	Vessel-5	Vessel-6	Total
2020	25	25	25	25	25	25	**100**
2025	50	25	25	25	25	25	**125**
2030	50	50	25	25	25	25	**150**
2035	50	50	50	50	50	50	**200**

Based upon the Peak hour bike projection till year 2035, the waiting area details are given below.

Table 4-11 : Traffic Handling capacity and bikers waiting space provided at Guwahati Gateway Terminal

Year	Bikes Peak Hour	Bike Handling Capacity per Hour	Bike waiting per hour	Bikers Waiting Area Provided			
				At Terminal	At Pontoon	Total	Percentage
2020	151	150	1	32	160	192	127%
2025	249	175	74	32	160	192	77%
2030	396	200	196	32	160	192	49%
2035	607	300	307	64	260	324	53%

•In year 2020 it is anticipated that peak hour bikers would be 151 Nos. and the bikers handling capacity per hour of the terminal would be 200 nos. the waiting area provided at the terminal is for 50 Nos. and 100 Nos. bikers can handled at Pontoons. The total waiting area provided w.r.t bike peak hour is 127 % in year 2020 and 77% in year 2025.

•In year 2030 it is anticipated that peak hour bikers would be 396 Nos. and the Bikers handling capacity per hour of the terminal would be increased up to 400 nos. by construction of phase-2 Building the waiting area provided at the terminal is for 100 No. and 200 Nos. passengers can handled at Pontoons . The total waiting area provided w.r.t Bikers peak hour is 49% in year 2030 and 53% in year 2035.

4.3 Functional Requirements for Ferry Terminal

The proposed ferry terminal at Guwahati Gateway ghat caters to the passenger and vehicular traffic traveling to and from North Guwahati ghat and other terminals. The riverine and landside infrastructure proposed for the ferry terminal are robust structures and provide floating but permanent boarding/deboarding locations for passenger and vehicles. This also ensures a greater sense of safety among the passengers especially during high flood season when the currents are extreme. The boarding/deboarding location is accessible for all passengers and ample waiting areas are also provided for convenience of passengers. The terminal utilities and services are provided for ease of operation and maintenance during any water levels.

The following figure shows an overall site plan of the proposed terminal location.

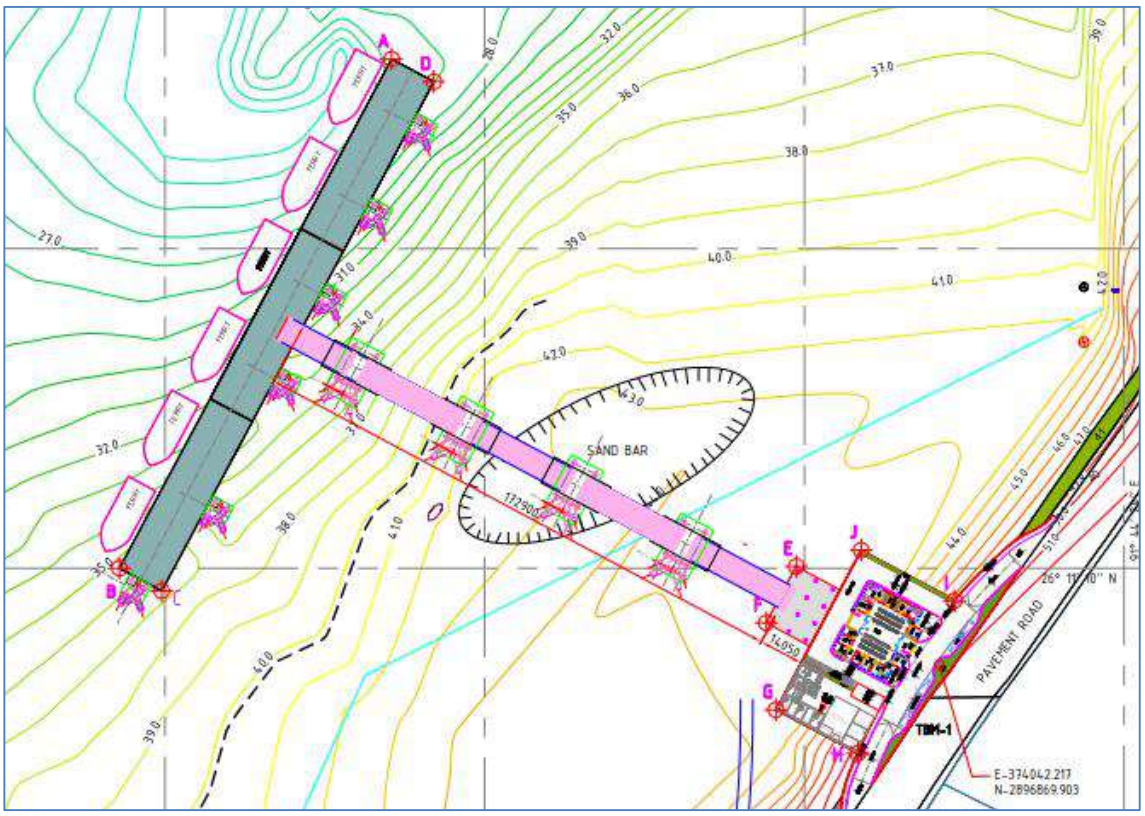


Figure 4-4: Overall site plan of proposed terminal.

The following sections describe the basis of planning and design of terminal infrastructure (both riverine and landside).

4.4 Riverine Terminal Infrastructure

The riverine infrastructure comprises of the following components:

1.2 Berthing pontoons – 60x15m (3 nos.)

2. Dolphins for berthing pontoons – 7.5x7.5m (6 nos.)

3. Steel linkspans – (approx.) 32m span x 8m wide (4 nos.)

4. Steel linkspan – (approx.) 20m span x 8m wide (1 no.)

4. Intermediate pontoons – 20x9m (4 nos.)

5. Dolphins for intermediate pontoons – 19.5x11.5m (4 nos.)

6. Bankseat (15m wide and 20m long)

The layout and general arrangement of the components of riverine infrastructure listed above are shown in drawing no. P.013223-P-20301-201.

The dimensions of the above-mentioned structures are based on many factors like pile spacing, rake angle which are governed by forces and proposed stiffness to resist the forces.

The pile layout plan including number of piles, spacing, diameter and thicknesses for riverine infrastructures are shown in the drawing no.s from P.13223-P-20305-201 to P.13223-P-20305-212. It is proposed that the load test on tubular steel piles is to be conducted, which shall be included in the EPC tender.

4.4.1 Planning of riverine infrastructure

The usage of the ferry terminal is greatly enhanced if the proposed location is at the same location or very near to the existing ferry terminal location. Hence the proposed ferry terminal is located at the same location where the current ferry services are under operation. However, it has been observed that the location of the current ferry services changes periodically depending on the available water levels. Since the proposed ferry terminal is at a fixed location, the riverine infrastructure is provided at a depth where a minimum water depth is available round the year. The low water level evaluated at Guwahati gateway ghat based on the water levels recorded is found to be 40.56m RL. Considering a minimum draft of pontoon of 1.0m, keel clearance of 1.0m, a conservative allowance for sedimentation at riverbed and the required length of the linkspans to cater to the difference in water levels, the proposed berthing pontoons are situated at 35.0m RL.

4.4.2 Berthing pontoons and supporting dolphins

The berthing pontoons are steel floating structures that provide safe boarding/deboarding for passengers and vehicles at any water level and possess fenders and bollards for berthing and mooring of ferries. The size of the berthing pontoons are considered based on the suggestions in the feasibility report and also based on the proposed ferry sizes that are going to operate at the terminal. Considering the above criteria, 60m (long) and 15m (wide) berthing pontoons are provided. The ferry terminal is proposed with two (3) numbers of berthing pontoons. The following figure shows general arrangement of berthing pontoons.

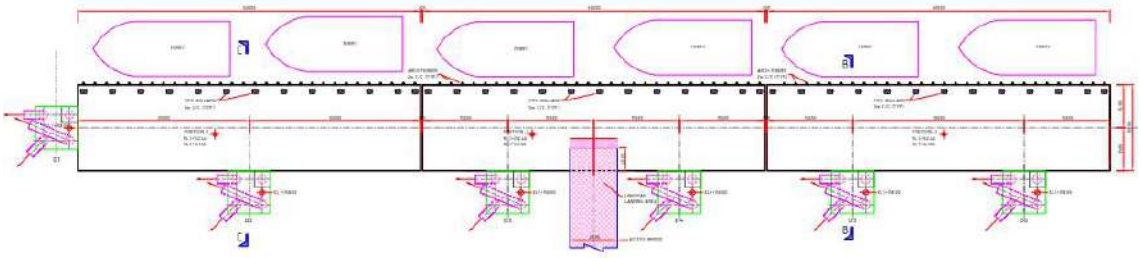


Figure 4-5: General arrangement of berthing pontoons

BERTH OCCUPANCY AND BERTHING PONTOON REQUIREMENTS:

The number of berthing pontoons to be provided is evaluated based on the berth occupancy of the vessels and traffic requirements. The berth occupancy of the vessels and traffic are considered with respect to the vessel turnaround times and traffic requirements respectively as described below:

Vessel Turnaround Time:

The vessel turnaround times are calculated based on the following inputs provided in the feasibility report (Table 11-21, Module 2, Investment Strategy for Assam IWT Sector, Integrated Strategic Development Plan):

Distance between North Guwahati and Guwahati Gateway ghats	= 1.5 km
Time at each ghat for boarding and deboarding	= 04 min
Travel time on each direction (at 8 knots)	= 06 min

Considering the above parameters, the following tentative schedule is derived;

Table 4-2: Tentative vessel schedule showing turnaround times

Service from	Vessel No.	Boarding at GGG			Ride from GGG to NGG			Deboarding at NGG			Boarding at NGG			Ride from NGG to GGG			Deboarding at GGG		
		Start	Duration (min)	End	Start	Duration (min)	End	Start	Duration (min)	End	Start	Duration (min)	End	Start	Duration (min)	End	Start	Duration (min)	End
GGG	1	07:00	00:04	07:04	07:04	00:06	07:10	07:10	00:04	07:14	07:14	00:04	07:18	07:18	00:06	07:24	07:24	00:04	07:28
	2	07:04	00:04	07:08	07:08	00:06	07:14	07:14	00:04	07:18	07:18	00:04	07:22	07:22	00:06	07:28	07:28	00:04	07:32
	3	07:08	00:04	07:12	07:12	00:06	07:18	07:18	00:04	07:22	07:22	00:04	07:26	07:26	00:06	07:32	07:32	00:04	07:36
	4	07:12	00:04	07:16	07:16	00:06	07:22	07:22	00:04	07:26	07:26	00:04	07:30	07:30	00:06	07:36	07:36	00:04	07:40
	5	07:16	00:04	07:20	07:20	00:06	07:26	07:26	00:04	07:30	07:30	00:04	07:34	07:34	00:06	07:40	07:40	00:04	07:44
	6	07:20	00:04	07:24	07:24	00:06	07:30	07:30	00:04	07:34	07:34	00:04	07:38	07:38	00:06	07:44	07:44	00:04	07:48
NGG	1										07:00	00:04	07:04	07:04	00:06	07:10	07:10	00:04	07:14
	2										07:04	00:04	07:08	07:08	00:06	07:14	07:14	00:04	07:18
	3										07:08	00:04	07:12	07:12	00:06	07:18	07:18	00:04	07:22
	4										07:12	00:04	07:16	07:16	00:06	07:22	07:22	00:04	07:26

The vessel turnaround time as per the above schedule is found to be 28 minutes only. It can be seen that all the six (6) vessels can board and depart from Guwahati Gateway Ghat in 20 minutes. Thereby allowing vessels inbound from North Guwahati ghat to arrive and start boarding.

Traffic Requirements:

The following table describes the peak passenger traffic (per hour) and corresponding passengers catered by the vessels and the terminal waiting areas.

Table 4-3: Vessel requirements based on traffic numbers

Year	Peak passengers per hour	Max. no. of vessels	Max. no. of passengers catered by vessels	No. of passengers waiting	No. of passengers that can be accomodated in the proposed waiting rooms (areas)			Check
					Building	Pontoon	TOTAL	
2020	293	6	600	0	72	96	168	Okay
2025	484	6	600	0	72	96	168	Okay
2030	769	6	600	169	72	152	224	Okay
2035	1,178	6	600	578	72	224	296	Okay

It can be seen that a total of six (6) vessels would cater to more than 100% of the projected traffic until 2025. Also, more than 50% of the passengers waiting can be easily accommodated in the waiting areas on the pontoon or on the terminal building. Hence berthing requirements for 6 vessels shall be provided in terms of three (3) berthing pontoons. Addition of another pontoon will lead to increase in the overall cost owing to provision of additional approach trestle, linkspan and dolphins.

The lateral restraint to the berthing pontoons are provided by means of dolphins. The dolphins are pile supported deck structures with both vertical and raker (1:3) steel tubular piles. The vertical piles act as guide piles for the berthing pontoons. Each berthing pontoon is provided with two (2) numbers of dolphins. This will also allow in distribution of lateral loads from berthing pontoons on two guide piles. The typical layout of a dolphin for berthing pontoon is shown below.

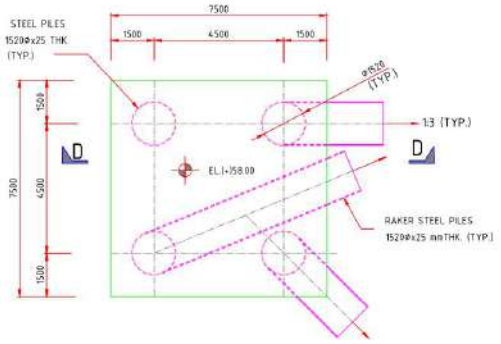


Figure 4-6: Typical layout of dolphins for berthing pontoons

The berthing pontoons are covered structures and are provided with waiting areas for passengers along with required utilities for operation of ferries at any water level. The typical details of the berthing pontoons with general arrangement are shown in drawing number P.013223-P-20305-206.

The sliding mechanism of pontoons along the vertical circular pile surface showing details like gap, tolerance, size etc., are shown in the drawing number P.013223-P-20305-201.

4.4.3 Linkspans

The linkspans bridge the gap between the approach trestle/bank seat and the berthing pontoons. The linkspans are steel truss elements formed with box sections and enclosed built-up sections. The terminal is provided with five (5) linkspans for access to the berthing pontoons. The linkspans are hinged at one end and are provided with roller supports the other end. The roller supports allow the slope of linkspan to vary with the fluctuation of water level. Hence when the water level is at HFL (51.46m RL), the linkspans are near horizontal and when the water level is at LWL (40.56m RL), the linkspans are sloped to a maximum of 1 in 12 as shown in the figures below.

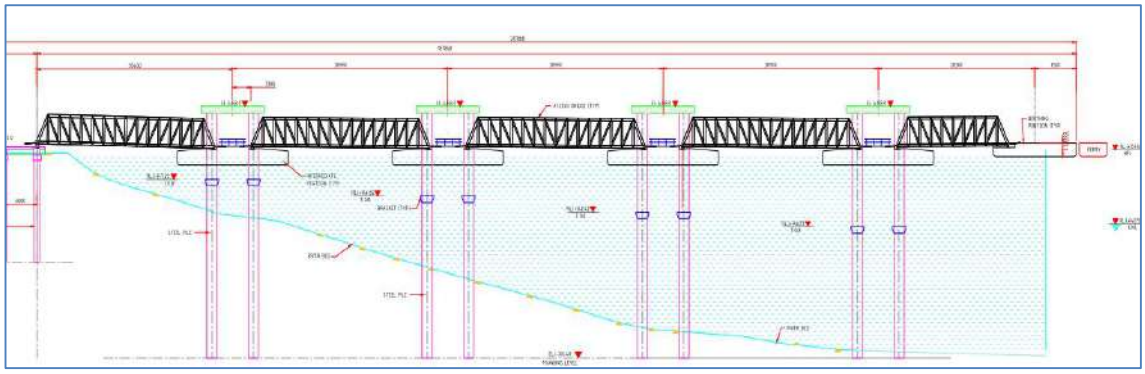


Figure 4-7: Linkspans at high flood level

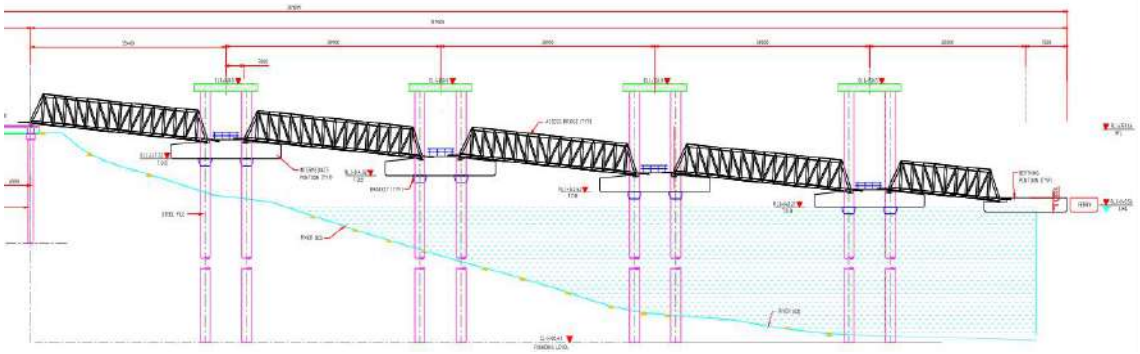


Figure 4-8: Linkspans at low water level

Top level of dolphins has been kept based on maximum high flood level when all linkspans are horizontal and necessary head room is available for passengers and bikers to pass on linkspan through dolphins. The dolphin piles should be connected at a suitable height that provides a head room of minimum 2.1-3.0 m.

Considering the total vertical variation of the water level and the required slope of 1 in 12, the total length of a single linkspan works out to be more than 130m. Considering the buoyancy effect on heavier linkspans, it is divided into smaller linkspans of four spans of 32m (approx.) length each and one span of 20m (approx.) length. This would substantially reduce the weight of the linkspan and would economize the sections considered. The intermediate supports for linkspans are provided on the intermediate pontoons. The general arrangement and typical details of the linkspans are shown in drawing number P.013223-P-20305-211.

For successful functioning of the linkspans to adjust the river water levels, end-bearings (rollers and rockers) shall be provided as shown in the drawing number P.013223-P-20305-203.

4.4.4 Intermediate pontoons and supporting dolphins

The intermediate pontoons provide support to the linkspans and act as intermediate landings for passengers between the approach trestle and the berthing pontoons. The ferry terminal is provided with four (4) numbers of intermediate pontoons. The intermediate pontoons also allow the linkspans to slope to a maximum of 1 in 12 with the variation of water level. The intermediate pontoons are steel structures of 20 x 9m plan dimensions and 2.75m deep. One end of the intermediate pontoons allow for roller support from the linkspan whereas the other end allows for hinged support.

The following figure shows a typical arrangement of the intermediate pontoon with the guiding dolphin.

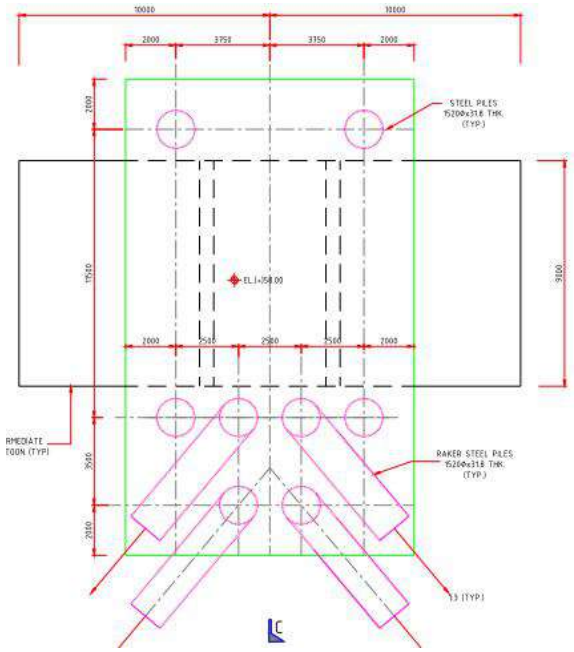


Figure 4-9: Typical arrangement of intermediate pontoon with dolphin

The lateral restraint to the intermediate pontoons are provided by means of dolphins as shown in the figure above. The dolphins are pile supported deck structure with both vertical and raker (1:3) piles. The four (4) number of vertical piles in the dolphin act as guide piles for the intermediate pontoons. The vertical piles are also provided with brackets at different levels as shown in Figure 4-8 to restrict the vertical movement of the intermediate pontoons when the water level goes below the required level. Hence this allows a maximum slope of 1 in 12 to enable passengers to walk freely on the linkspans. The lateral loads acting on the intermediate pontoons from wind and current at extreme conditions are also transferred to the dolphins.

The dolphins also cover the intermediate pontoons hence a separate roof need not be provided for the pontoons. The utilities and services like lighting and firefighting can be provided on the dolphins. The typical details of the intermediate pontoons and the dolphins along with the general arrangement are shown in drawing number P.013223-P-20305-306.

4.4.5 Bankseat

The bankseat is a pile supported deck structure that supports the steel linkspan at the hinged end. The proposed bankseat structure is 15m wide and 20m long. The following figure shows typical arrangement of the bankseat structure.

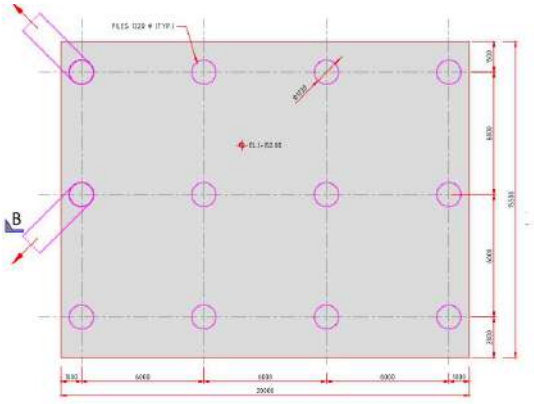


Figure 4-10: General arrangement of Bankseat

The pile forces and the proposed stiffnesses to resist the forces are the key factors for pile spacing and rake angle. Based on these factors the dimensions of deck structures of dolphins and Bankseat has been finalized.

All the steel piles provided for Dolphins and Bankseat are of open ends with shoe plate at bottom as shown in the drawing number P.013223-P-20305-210.

4.5 Landside Terminal Infrastructure

Based on the traffic analysis and forecast in previous chapter, terminal building areas and infrastructure requirement will be finalised.

Typical elements/ Activities in terminal building are given below -

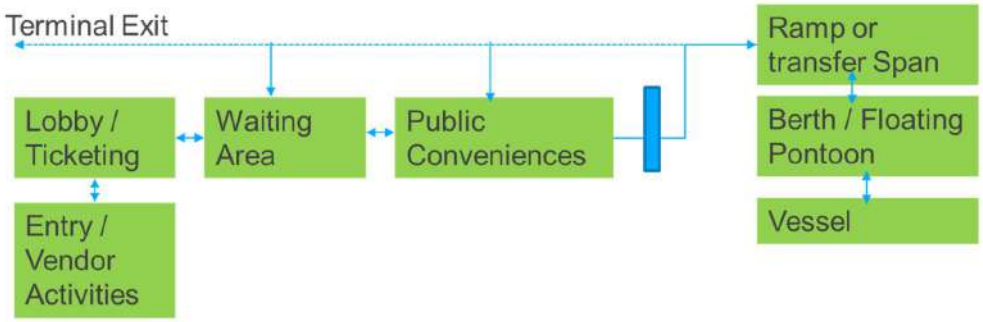


Figure 4-11: Typical element for terminal building

The broad component of terminal building are as under –

- Waiting areas for passengers
- Emergency service facilities
- Toilets facilities
- Security check areas
- Ticketing booths
- Parking areas
- Office and Meal Room
- Shops
- Open area

- § Entry exit routes
- § Access to ferry services by disabled persons
- § Space for utilities / infrastructure requirements
- § Control room for ferry services
- § Storage Areas

4.5.1 Guwahati Gateway terminal building area requirement

The area required for Guwahati Gateway terminal is based upon peak hour passenger traffic mentioned in feasibility report. Space required terminal building area is as under.

Table 4-12 : Area requirement for terminal Building

TERMINAL BUILDING					
EXTERNAL DEVELOPMENT		NOS.	SIZE		**AREA (SQM)**
1	VISITOR'S CAR PARKING	5	2.5 X5		62.5
2	TWO-WHEELER PARKING	32	2X0.8		51.2
3	GREEN / POTTED PLANTING AREA				275
4	PATHWAY				148.5
5	ROADS/FIRE TENDER MOVEMENT/RAMPS				1248.8
				TOTAL	**1784**
UTILITIES					
5	TRANFORMER & OIL COLLECTION PIT	2,1			44.3
6	DG SET	1	4.64x5.39		24.38
7	CONTROL AND SWITCH GEAR ROOM	1			87.4
8	BATTERY ROOM	1	4.3x2.65		11.4
9	FIRE WATER TANK& FILTER ROOM	1			181.4
10	CIRCULATION				121.37
				TOTAL	**470.25**
BUILDING		NOS.	LENGTH	BREADTH	AREA
			(M)	(M)	(SQ.M)
1	TICKET COUNTER 1		3.5	3.95	13.82
2	TICKET COUNTER 2		3.17	4.47	14.17
3	SHOP		3.615	4.065	14.69
4	OFFICE		3.94	5.65	22.26
5	MEAL ROOM		4.055	3.84	15.57
6	ELECTRICAL ROOM		3	4.065	12.19
7	SECURITY POST		2.5	4.47	11.17
8	FEMALE TOILET		5.125	3.75	19.21
9	MALE TOILET		3.625	7.415	26.87
10	HANDICAP TOILET		2.7	1.75	4.73
11	BABY CARE ROOM		3.625	2.135	7.74
12	JANITOR / STORE		3.5	2.865	10.13

13	DRINKING WATER		1.93	1.2	2.32
14	FIRST AID ROOM		3.625	2.7	9.79
15	WAITING	94	@1.2 sqm		112.8
16	CIRCULATION & WAITING(STANDING)				216.54
				TOTAL	**514**
				GRAND TOTAL	**2770**

Area Requirement for Pontoon Side Given Below –

Table 4-13 : Area requirement Pontoon Side

PONTOON SIDE					
Components of Pontoon Area		NOS.	SIZE (m^2)		**AREA (SQM)**
1	WAITING	400	1.2		480
2	TWO-WHEELER WAITING	160	2X0.8		256
3	TOILET	3	1.8X1.2		6.48

4.6 Planning for Terminal Building

4.6.1 Vision

"Rivers are a spatial system woven into the geographic fabric of the city" Cities have evolved in proximate of water bodies.

Water based transport most reliable means of Communication and transport for goods and passengers.

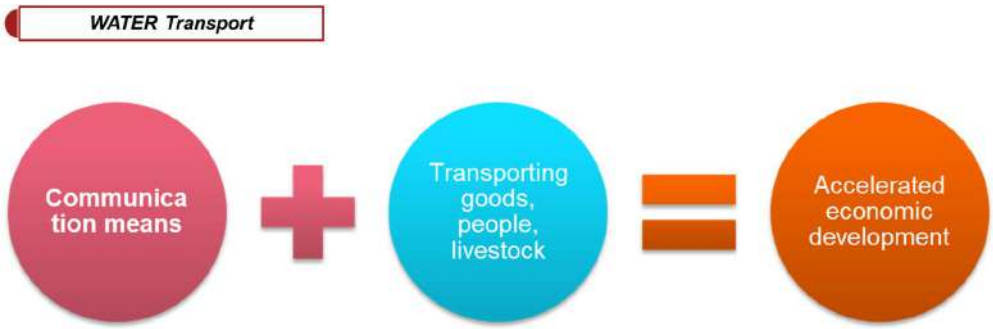


Figure 4-12: Water transport importance

and Ferry terminal is a building used for marine transportation of goods and People . Therefore Vision for designing the terminal building is –

"To develop a self-sustainable building focused upon positive customer experience from embarking till last mile Connectivity"

4.6.2 Objective

to develop any ferry terminal building, following points should be taken care off

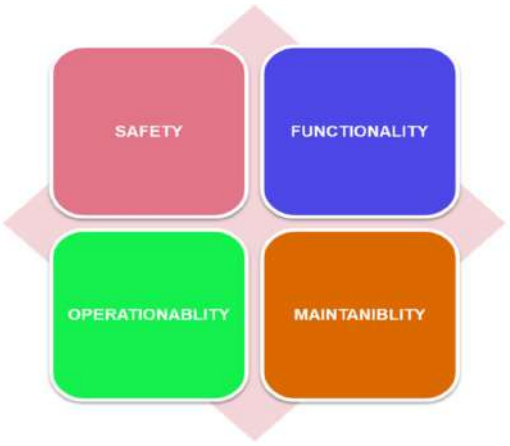
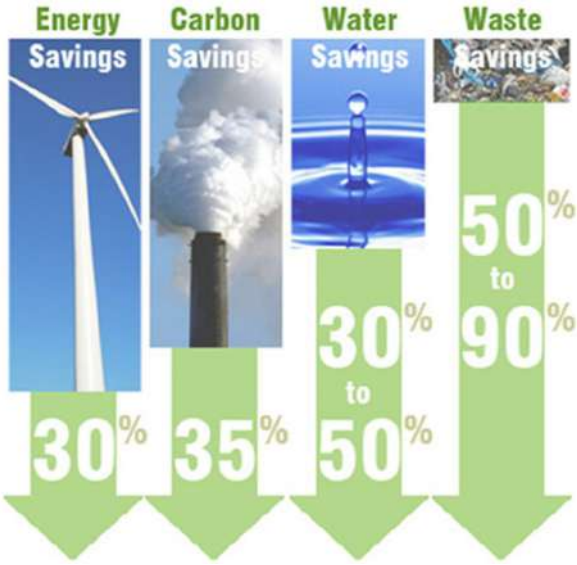


Figure 4-13: Design criteria for terminal building

4.6.3 Safety of users and Environment

Safety of the users and the environment is the main objective of designing of any building. Safety of the intended users means provision of proper functional spaces, avoiding hidden / dark spots, provision of CCTV surveillance, signages. Avoid conflict between passengers and vehicles / vessels. Accessibility of the building by all age group of people. provision of safety alarm systems and emergency services.

The building should be designed as environment friendly design with minimum disturbance with the natural features available at the site, therefore the building should be design on green building concept which leads to –



1. Planet
   - Reduced Environment Impact
   - Optimal Performance
2. Profit
   - Lower Operational Cost

- Increased Asset Value

3. People

   - Improved Productivity
   - Increased Occupant Satisfaction

GRIHA RATING – (Green Rating for Integrated Habitat Assessment)

There are 31 components for GRIHA rating related to Site planning, Sustainable building materials, Energy, water, occupant comfort and wellbeing, Solid waster management, construction management etc. On the basis of these component rating to the building will get finalised on the scale of 1 to 5.

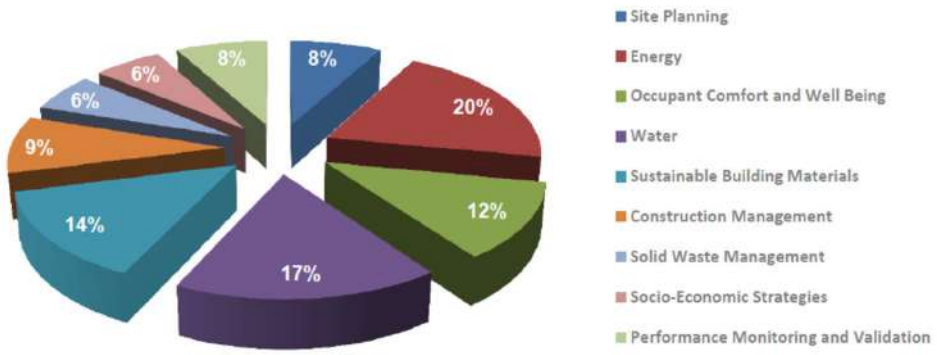


Figure 4-14: Green Building Point weightage by GRIHA

4.6.4 Functionality of the building

Ferry terminals are transport focused facilities. The main role of a terminal is the movement of people to and from ferries. Functionality means design should be responsive to –

1. Easy and Convenient embarkment and disembarkment
2. Positive customer response from entry to the building till the last mile connectivity
3. Appropriate waiting areas and entrance lobby
4. Hassel free ticket purchase
5. Segregation of departure and arrival points and split between pedestrian movement and vehicular movement
6. Adequate Basic amenities such as well-lit toilets, snacks shop,
7. Provision of first aid Services
8. Emergency responsive building
9. Public Address System
10. Adequate space available for Infrastructure services

The AIWTD Society has already approved SOP and guidelines provision will be made for displaying the same in a prominent place.

4.6.5 Operationability

The operation of a ferry terminal is a complex process, influenced by many factors, each with a varying degree of predictability. The design of a successful and efficient facility will result in an optimal balance between capital investments and operational costs. One of the parameters used in measuring a terminal's ability to operate efficiently is the dwell time. Dwell time can be described as the time during which the vessel is positioned at the ferry dock. A typical sequence of events occurring during the dwell time can be summarized as follows:

• Vessel landing is made.

• Vessel is secured (2 minutes is provided for this).

• Traffic arm is raised.

• Passengers are directed to disembark to shore side passenger exit way

• Bicycles are directed to disembark with separation.

• Motorcycles are directed to disembark with separation.

• At completion of offload the traffic gate is lowered and vessel crews conduct security sweeps of all decks and spaces.

• At completion of security sweep the vessel crew mans stations in preparation for loading.

• Vessel crew communicates to terminal staff to begin loading.

• Passengers are directed to embark onto the vessel via the vehicle deck

• Bicycles are directed to board with separation.

• Motorcycles are directed to board with separation.

While the dwell time is governed by the vessel size and capacity, the design of the terminal can have a significant impact on this parameter. Lack of vehicle holding space, remote or distant holding of ferry traffic, single lane load/unload, toll booth configuration, and transit connections are all factors that can increase the dwell time.

4.6.6 Maintainability

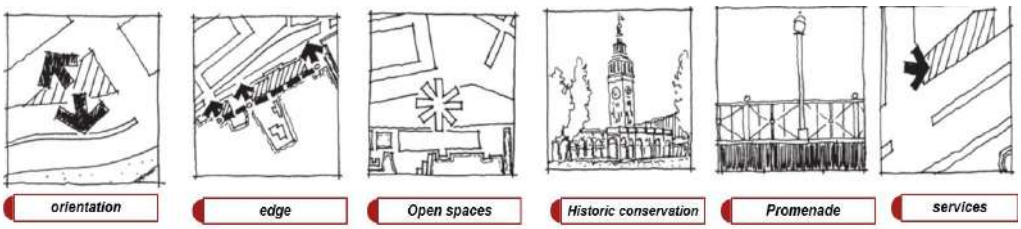
The material used for construction of terminal building should be easy to maintain and repairable locally. Therefore Maintainability is considered, inherent to the building system design, ensuring the ease, accuracy, safety, and economy of maintenance tasks within that system. The purpose of maintainability is to improve effectiveness and efficiency of maintenance. One of the major products desired of such an activity is the optimization of building life—cycle costs. Design for Maintainability (DfM) is the first step of an effective maintenance program, linking maintenance goals to the design process.

Figure 4-15: Broad component of terminal Building

4.6.7 Design consideration

Following parameters need to be kept in mind while designing of terminal building.

1. Orientation of the building
2. Efficiently manage the river edge
3. Best Usage of Open Spaces
4. Preservance of any Structure with heritage value
5. Development of Promenade or Viewing area of passengers
6. Utility services to sustain the operations



4.7 Site analysis for Guwahati Gateway Terminal Building

The terminal building is conceptualised in accordance to the traffic result analysis and recommendation given in feasibility report for Guwahati Gateway Ghat.

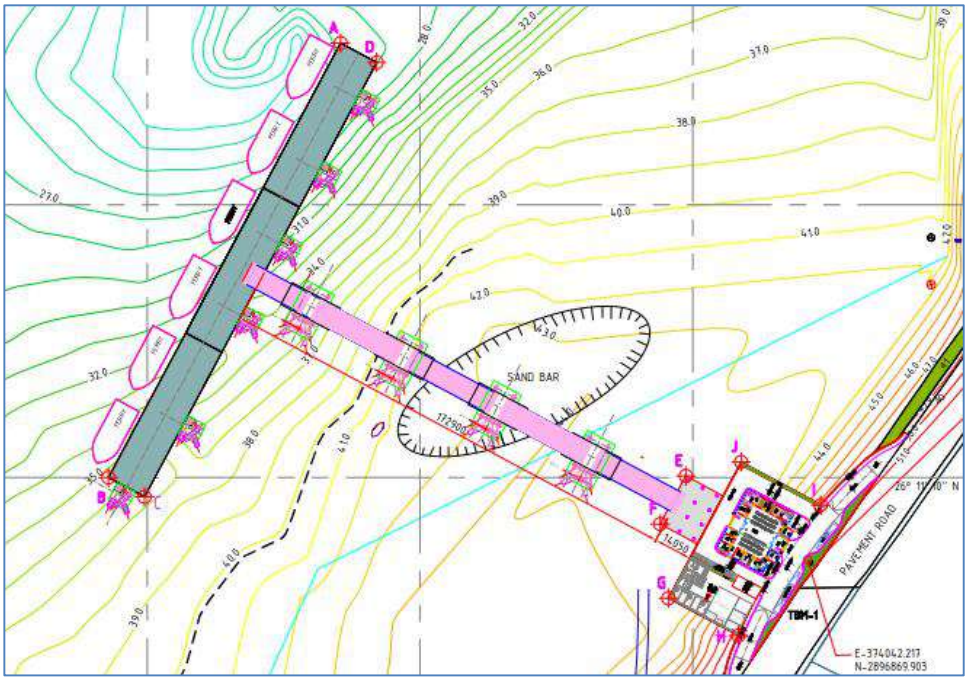


Figure 4-16: Guwahati Gateway Ghat Location

The terminal design parameters include the requirements related to

a) water side operations and

b) the interfaces between berthing facilities and land mode transport.

Therefore, in Guwahati gateway terminal function requirement of terminal building is sub divided in to two parts i.e. Land Side terminal and facilities at pontoon. Following facilities shall be given in land side terminal.

1. Parking areas for Bikers and 4- Wheelers
2. Ticketing booth
3. Public Amenities
4. Infrastructure services
5. Security areas
6. Control room
7. Staff room
8. Passenger Waiting areas

On the other side following facilities is given at pontoon Side –

1. Passenger waiting areas
2. Bio Toilet
3. Bikers Waiting areas

For last mile connectivity The Land Side terminal building will be connected to the existing road by means of ramps for convenient entry and exit of passengers and vehicles.

4.8 Architecture Design of terminal Building

4.8.1 Concept development

Terminal design is driven by the following factors.

4.8.1.1. FUNCTIONALITY

The concept is an outcome of design philosophy, “Form follows function”. Landside development broadly comprises of the circulation space, parking lots, utility/substation zone and the main building with administration and waiting areas.

Spatial arrangement of various zones revolves around the main building mass which comprises of the basic amenities for all the users, pedestrians and passengers on vehicles. Customers coming by bikes and cars can park in the designated spaces and avail the public amenities in the waiting time, if they wish to. The beauty of the concept is its absence of complication combined with its clarity of functional and richness of cultural experience.

Functional zoning of the terminal building is explained below: -

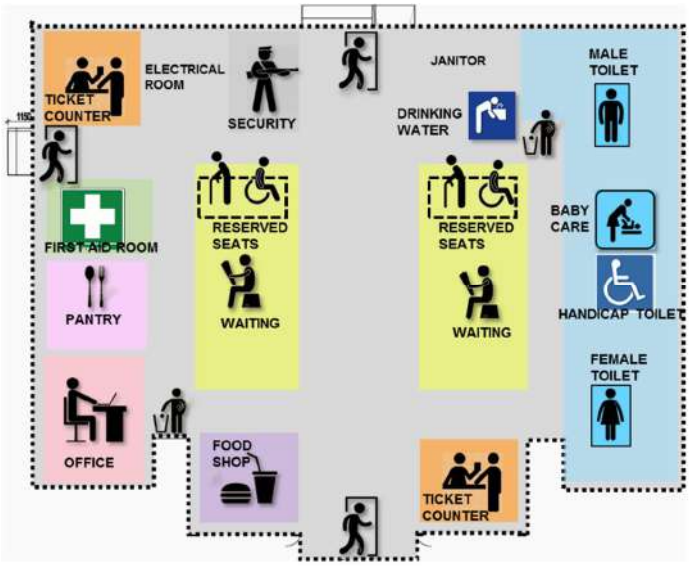


Figure 4-17: Terminal building:- zoning plan

The form of terminal building is a modern interpretation of the vernacular architecture of the site. It is an amalgamation of state of the art and local materials.

Reference Drawings of detail layout of Terminal have been displayed in the Annexure.

4.8.1.2. SEGREGATION OF TRAFFIC MOVEMENT

Terminal design aims at creating separate routes for the vehicular and pedestrian movement to have least to no conflict in the two types of user movements.

4.8.1.3. SUSTAINABLE BUILDING

Parameters for sustainability adopted in terminal design are:

1. Minimum disturbance with natural scape
2. Use of local material
3. Proper shading
4. Proposal for roof top solar panels- Renewable energy
5. **Waste treatment –** Provision of STP to treat waste water and use the treated water for irrigation.
6. Use of Water saving equipment.

A single story structure is proposed that respects and reflects the natural landscape of the site and does not stand out as an eye sore.

Sloping roofs on terminal building have been proposed as a climate responsive design and following the local architecture.

Use of local material for tiling of roads and sloped roofs has been adopted.

Proper shaded pathways and parking lots have been given by proving line of shade giving native trees and shrubs along the parking bays. It reduces heat island effect and provides a positive experience for the end users.

To provide for 10% of energy being consumed as renewable energy, roof top solar panels are proposed above the link spans.

4.8.2 Particulars of Guwahati Gateway Ghat

4.8.2.1. TERMINAL & INFRASTRUCTURE

The following main components are considered to form the basic infrastructure required at Guwahati gateway ghat:

- Ticketing Office
- Administration & Security
- Passenger waiting area
- Public Amenities: Toilet Facilities, Drinking water fountain, Vending area
- Vehicle parking area
- Roads / Turning Areas
- Utilities
- Green cover

4.8.2.1.1. Ticket (Service) Counter

Since segregation of pedestrian and vehicular movement is the main design criteria, two ticket counters are considered within the terminal building. The times for tickets could be reduced by providing automatic ticket machines, increasing the numbers of counters, arranging ticket selling services within the city (for example in supermarkets, bakery, etc.). The recommended area for one counter considers two to three cash desk per counter. Ticket counters will also have lockers for the customers as required in any terminal.

• Area considered for one ticket counter is approximately 3.5 x 3.95 m = 13.82 m²

4.8.2.1.2. Administration and security

One office room of size 3.94 m x 5.65 m (22.26 m²) has been considered for administration and security departments. The office shall at least be equipped with workstation, cupboard and visitor sitting place. This room will also suffice any small office meeting for the working staff. External walls of the staff room are glazing to maximize usable floor area.

One meal room cum staff room of size 4.055m x 3.84 m (15.57 m²), has been proposed with kitchenette to enable the office staff to take their breaks or to have some small meals.

For storage of office consumables and cleaning tools a small room 3.5 m x 2.865 m has been given.

At exit point of building security post of size 4.47m x 2.5 m is given that overlooks complete waiting area as well. One small security hut at the entrance of the terminal from outside is also proposed to check any terrorist threat 50mts before approaching the building. These posts should provide enough space for more than one Guard, similar to security posts at the access ways to airports. These posts are generating a feeling of security and protecting the staff at the ticket counter.

For incident control purpose, first aid room of size 3.625m x 2.7 m, has been given along the waiting area, to immediately attend to any mishappening, before the Ambulance arrives.

Other than the above basic facilities, one electrical room within the building is given (3m x4.065m).

4.8.2.1.3. Passenger waiting area

As explained in Traffic Handling capacity and passengers waiting area provided at Guwahati gateway Terminal, certain waiting areas are provided at the pontoon and some at Terminal building. Spacing between seating arrangements and other structures is taken into account with 2.0 m to allow comfortable passing of two passengers with luggage. Total waiting of 94 nos. is proposed at the terminal building. Waiting area will have the necessary amenities, such as toilets, baby care room, food kiosk, dustbins, drinking water. It is equipped with led signage boards and announcement systems.

Terminal building has interior spaces, such as plain walls, columns, which can be used for display of local art in terms of mural work and paintings.

For details refer Area requirement Guwahati gateway terminal Building Land Side

4.8.2.1.4. Public Amenities

For a compact and feasible structure the administrative functions and public amenities have been arranged around the waiting area. Public amenities include

- Male: 4 toilets, 5 urinal, 3 washing basin:- 26.87 sqm
- Female: 6 toilets, 3 washing basin:- 19.21sqm
- 1 toilet for handicap people:-4.73sqm
- 1 baby care room:-7.74sqm

4.8.2.1.5. Vehicle parking area

As explained in Peak hour Bikers handing capacity Scenario-1, parking requirements for bikes have been met partly on Pontoon and partly on landside. Parking bay of size 2.5 m x5m is considered for cars and 2.0m x 0.8m is considered for two wheelers. Car parking 3 nos. is given for delivery vehicles/autos/taxis and one reserved for Bus stop. Minimal car parking space is given due to non-availability of land and complexity of deck structure.

- Two wheeler parking on landside: 32 nos.:- 51.2 sqm
- Car parking: 3 nos.:- 37.5 sqm
- One Bus stop

4.8.2.1.6. Roads / Turning Areas

All access roads are minimum 6 m wide that will also suffice for exigency vehicle routes, along parking, at drop off and approach in and out of concrete platform. Total area for vehicular circulation on landside development is 1248.8 sqm.

4.8.2.1.7. Utilities

This will be explained in detail in Section 9.

4.8.2.1.8. Green cover

Shrubs and trees planting at the boundary of terminal and green islands, for creating positive experience for users. Presence of plants helps create shaded walkways, shaded parking spaces, sense of enclosure and security.

Trees suitable for planting over slab such as Plumeria alba(Champa), Ficus Benjamina shall be planted.

For ornamental effect, Christmas tree, Ravenala palm and rose variety are proposed.

Hardy shrubs including Allamanda, Tecoma, Bougainvillea, Togor and Mussaenda as row planting along parking has been given.

For layered planting effect ground covers plants like Duranta, Ixora, Acalypha wilkesiana are proposed.

Linear brick planters are proposed along the boundary on the pile cap. Landscaping would include preparation of planting bed and subbase layers for proper drainage. Sub base comprises of Geofabric, HDPE drain board laid to sleep over screed and water proofing membrane. Drainage of planters will be through weep holes in the deck slab. A depth of 600 mm is considered for small trees to grow.

4.9 Land Details

Apart from all the technical requirement for operation of ferry services, Land Availability is considered the main criteria for finalisation of terminal building.

4.9.1 Land Availability

Land is a highly valuable asset so that it should be very judiciously used by the implementing agencies for development. Land Availability for the ferry terminal is ascertained by various site visits, reconnaissance Surveys, Meeting with Govt. Officials, Data collected from various govt. departments such as –

1. Director of Land Records and Surveys, Assam
2. Data collected from website of Integrated land records management system

Following factors have been considered while finalisation of land for ferry terminal.

1. Land Should be encumbrance free to enable AIWTDS to start the development works on priority.
2. Any Land owned by the AIWTDS / DIWTA will be the first priority to develop any land side facilities, as in this case we can save our time and efforts towards land Acquisition process.
3. Second priority will be given to any vacant government land in vicinity, for which necessary procedure for land transfer from govt. to AIWTDS will be initiated.
4. Land should be free from any encroachment and in case of any existing utility is there, it should be properly assessed.
5. In case of any settlement is found there that should be properly addressed in Social Management Plan.

4.9.2 Land to be acquired

Location of ferry terminal at Guwahati Gateway is proposed after due analysis of geotechnical data , surveys and the land availability details collected from the revenue department.

The land ownership details collected from the department are superimposed on the terminal building layout and it is observed that the land mentioned in below table belongs to government and AIWTDS has initiated the process for allotment of the same with the revenue department, GoA.

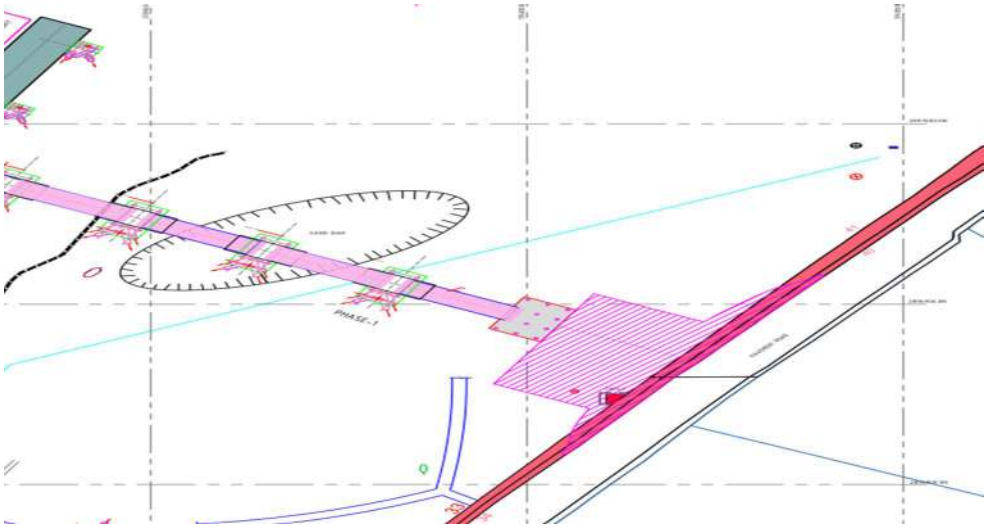


Figure 4-18: Land ownership details at proposed terminal location.

The details of land to be acquired for terminal building at this location is given below

Table 4-14 : Land to be Acquired /transferred for Guwahati Gateway terminal

DAG No.	Total Area (m^2)	Area to be acquired (m^2)
33	633.48	124.93
41	956.18	216.65

4.10 Connectivity

The connectivity to the proposed terminal location is through main road called MG Road. The area on South East side of the road is densely populated with commercial and residential establishments.

4.11 No Objection Certificates (NOC)

NOC from	Status	Remarks
IWAI	NOC obtained from IWAI	
GMDA	NOC from GMDA is attached in the Volume II DPR in relevant sections.	
Land revenue department	Land acquisition request has been applied to Land revenue department regarding DAG no. 33 and 41 as explained in the above clauses.	
PWD	NOC from PWD has been received.	

The relevant documents obtained are attached in Annexure 4.2

5. DESIGN BASIS – RIVERINE AND LANDSIDE INFRASTRUCTURE – CIVIL

5.1 Basic Design Criteria

5.1.1 Units

The international system of units (S.I.) shall be used for the design of all items unless specified otherwise.

5.1.2 Design Life

The design life of all the components of the riverine structures are described in Table 5-1 along with relevant maintenance criteria.

TABLE 5-1: DESIGN LIFE AND MAINTENANCE INTERVALS

Structural Component	Design Life
Reinforced concrete structures	50 years
Steel Piles	50 years
Steel for link spans and walkways	25 years
Intermediate and berthing pontoons	25 years
Fenders and bollards	8-10 years
Buildings	50 years

5.1.3 Ferry Dimensions

Dimensions of the largest ferry considered in the planning and design of the infrastructure are given below:

- Length : 30 m
- Beam : 12 m
- Laden Draft : 0.75 m

5.1.4 Water levels

Estimation of HFL at Guwahati Gateway

- HFL observed at D C Court Guwahati, CWC Flood Forecasting Station (21/7/2004) = 51.46 m
- HFL considered for the new bridge= 52.00 m
- HFL considered for river front development = 51.46 m

Estimation of LWL at Guwahati Gateway

- The maximum difference of water levels measured at Pandu and Jogighopa in Non-monsoon was (Jan 2012) = 10.99 m,
- The flow distance between Pandu and Jogighopa during lean period is about 110 Km (along thalweg)
- The water surface slope worked out 10.99/110 = 0.0999 m/Km or 1 in 10000
- The flow distance between Pandu and Guwahati Gateway-Majegaon = 4.6 Km
- Lowest water level at Guwahati Gateway-Majegaon will be higher than Pandu LWL by= 0.0999*4.6= 0.46 m
- The LWL measured at Pandu = 40.19 m
- *Therefore, LWL at Guwahati Gateway-Majegaon=40.10 +0.46= 40.56 m*

Therefore, recommended design HFL and LWL at Guwahati gateway are 51.46 m and 40.56 m respectively.

5.1.5 Structural levels

Levels for structures to be used in design are as follows:

Top of deck of concrete approach trestle	+52.00 m RL
Top of deck of dolphins	+58.00 m RL
Link Span caters for differential flood levels in a slope of	1 in 12
Building levels	Refer drawings

5.1.6 Current Speed

Based on local enquiry, the ISDP module 4 report suggested about 2.5 m/s current speed in Brahmaputra River at Guwahati. 2D mathematical modelling study was carried out for the Brahmaputra River Front Development (BRFD) project shows current speed of 1 m/s close to river bank to 4 m/s in the main channel corresponding to 100 year return flood. In the present assignment, HEC RAS 2D hydrodynamic simulation was carried out on 12 M DEM (Alaska Satellite Facility data portal) corresponding to 74000 m^3/s in Brahmaputra near in Guwahati reach which gives velocity distribution as shown in figure below. The results shows that velocity distribution near Guwahati gateway is in the range of 1.0 m/s near the south bank and current speed at about 200 m away from the bank is about 2.5 m/s. Therefore, the design velocity at Guwahati Gateway terminal location is 3 m/s.

5.1.7 Topography

Topographic survey has been carried out in the location of the proposed terminal. Average existing ground level in the terminal area varies from +50m RL (approx.) to +40mRL (approx.). Refer Section 3 for detailed description on topographic survey.

5.1.8 Bathymetry

The bathymetric survey in the terminal location depicts that the riverbed level varies from +50 m RL (approx.) at landfall point to +25 m RL (approx.) at berthing pontoon location. Please refer Section 3 for detailed description on bathymetric survey.

5.1.9 Scour

The scour depth has been estimated as below:

Design discharge adopted Q = 73,000 m^3/s

Particle size, D_{50}= 0.3 mm

Silt factor, f= 1.76 * Sqrt (D_{50}) = 0.964

Lacey's regime scour depth = 0.473 * $(Q/f)^{(1/3)}$ = 20.01 m

Scour depth from HFL= 2*20.01= 40.02 m

HFL= 51.46 m (amsl)

Scour Level from Lacey Regime depth formula= 51.46 -40.02 = 11.44 m

Existing bed level close the location = 38 m

Scour level calculated from Lacey's regime depth formula = 11.44 m is adopted.

The design scour level = 11.44 m

5.2 Materials of Construction

5.2.1 Concrete

The reinforced concrete member sizes considered for all the components of the riverine and landside infrastructure works shall comply to minimum dimensions prescribed in Fig. 1 of IS 456-2000 for a fire resistance of 4 hours. The following grades of concrete shall be used for construction of precast / cast-in-situ concrete components:

Sr. No	Members / Components	Proposed Grade of concrete
1	Piles	M40
2	Beams & Deck slab for superstructure of approach bridge and dolphins	M35
3	Buildings	M35

Partial Safety Factor γ_m for Material Strength

- Concrete $\gamma_m = 1.50$
- Reinforcement $\gamma_m = 1.15$

5.2.2 Reinforcement

Main reinforcement steel shall conform to [Fe 500 (IS 1786)] TMT, 500 S with low alloy steel grade. Strength parameters shall be as follows:

- Minimum yield stress (Main steel) : 500 N/mm²
- Elongation (min): 18 %
- Secondary steel shall be HYSD : 500 N/mm² (confirming to IS 1786)

Cover to Reinforcement

The nominal cover to reinforcement for all reinforced concrete members complies with Fig. 16A of IS 456-2000 for a fire resistance of 4 hours. Nominal cover to be followed are as shown below:

Riverine Structures:

Piles and Pile caps	75mm
Deck slab	50mm
Beams	50mm

Landside Structures:

Superstructure	45mm
Substructure	50mm

5.2.3 Structural steel

The grade of structural steel considered for pontoons, linkspans and other superstructures shall conform to Grade 250 as per IS;2062 with a minimum yield strength of 250 N/mm^2. However, the structural steel shall conform to Grade E275BR as per IS: 2062 with minimum yield Strength of 275 N/mm^2 for steel tubular piles.

5.2.4 Material Specifications

The detailed material and workmanship specifications are provided in Annexure 5.1 and also as part of the tender documentation. However, the material specifications for major items are provided below for reference.

1.1.1 General

The Contractor shall be responsible for furnishing all materials required for execution of the Works. The Contractor shall submit the source and method of execution for the Employer's review before any execution. All materials used in the construction of permanent works required under this Contract shall be of 1st class quality as specified herein and comply with the latest IS Codes or equivalent. The material shall be tested before bringing it to the site.

This specification establishes and defines the requirements of various materials to be used in Civil and Structural works.

Whenever any reference to IS Codes is made, the same shall be taken as the latest revision (with all amendments issued thereto) as on the date of submission of the Tender.

Apart from the IS Codes mentioned in particular in various clauses of this specification, all other relevant codes related to specific job under consideration regarding quality, tests, testing and/or inspection procedures shall be applicable. Reference to some of the codes in various clauses of this specification does not limit or restrict the scope of applicability of other referred or relevant codes.

In case of any variation/contradiction between the provision of IS Codes and this specification, the provision given in this specification shall be followed, unless the Employer agrees/consents to follow IS codes or other proposal of the Contractor as provided in the Contract.

All materials shall be of standard quality and shall be procured from renowned sources/manufacturers approved by the Employer. It shall be the responsibility of the Contractor, to get all materials/manufacturers approved by the Employer prior to procurement and placement of order.

Wherever brand is not mentioned, Contractor can choose a brand complying with the tender specifications however mentioning the brand considered in the Bid submission for the approval of the Employer if required.

Whenever called for by the Employer, all tests of the materials as specified by the relevant IS Codes shall be carried out by the Contractor in an approved laboratory and test reports duly authenticated by the laboratory, shall be submitted to the Employer for his approval. If so desired by the Employer, tests shall be conducted in the presence of the Employer or his authorised nominee.

Quality and acceptability of materials not covered under this specification shall be governed by the relevant IS Codes. In case IS code is not available for the particular material, other codes e.g. B.S. or DIN or API/ASTM etc. shall be considered. The decision of Employer in this regard shall be final and binding on the Contractor.

Whenever asked for, the Contractor shall submit representative samples of materials to the Employer for his inspection and approval. Approval of any samples does not necessarily exempt the Contractor from submitting necessary test reports for the approved material, as per the specification/relevant IS Codes.

The Contractor shall submit manufacturer's test reports on quality and suitability of any material procured from them and their recommendation on storage, application, workmanship etc. for the intended use. Submission of manufacturer's test reports does not restrict the Employer from asking fresh test results from an approved laboratory of the actual material supplied from an approved manufacturer/source at any stage of execution of work.

All costs relating to or arising out of the tests and submission of test reports and or samples to the Employer for his approval till the date of issuance of Performance Certificate shall be borne by the Contractor.

Materials for approval shall be separately stored and marked, as directed by the Employer and shall not be used in the Works till these are approved. All rejected materials shall be immediately removed from the site by the Contractor at his own cost.

1.1.2 Water

Water used in construction for all civil & structural works shall be clean and free from injurious amount of oil, acids, alkalies, organic matters or other harmful substances, which may be deleterious to concrete, masonry or steel. The ph value of water sample shall be not less than 6. Potable water shall be considered satisfactory.

Tests on water samples shall be carried out in accordance with IS: 3025 and they shall fulfil all the guidelines and requirements given in IS: 456.

The Employer may require the Contractor to prove, that the concrete prepared with water, proposed to be used, shall not have average 28 days compressive strength lower than 90% of the strength of concrete prepared with distilled water.

The Employer may require the Contractor to get the water tested from an approved laboratory before starting the construction work and in case the water contains any oil/organic matter or an excess of acid, alkalies or any injurious amount of salts etc., beyond the permissible maximum limits given in IS: 456, the Employer may refuse to permit its use. In case there is any change in source of water, water samples shall be tested again to meet the specified requirements.

Water shall be stored in tin barrels, steel tanks or water tight reservoirs made with bricks/stone or reinforced concrete. Brick/stone masonry reservoirs shall have RCC base slab and shall be plastered inside, with 1 part of cement and 4 parts of sand and finished with neat cement punning. These reservoirs shall be of sufficient capacity to meet the water requirements, at any stage of construction.

Water for curing shall be of the same quality as used for concreting and masonry works. Sea water shall not be used for preparation of cement mortar, concrete as well as for curing of plain/reinforced concrete and masonry works. Sea water shall not be used for hydro-testing and checking the leakage of liquid retaining structures also.

1.1.3 Aggregates

1.1.3.1 General

Coarse and fine aggregates for civil and structural Works shall conform in all respects to IS: 383 (Specification for coarse and fine aggregates from natural sources for concrete). Aggregates shall be obtained from an approved source known to produce the same satisfactorily. Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel and sand or a combination thereof. These shall be chemically inert, hard, strong, dense durable, clean and free from veins, adherent coatings, injurious amount of alkalies, vegetable matter and other deleterious substances such as iron pyrites, coal, lignite, mica, shale, sea shells etc.

Source and type of aggregates shall be got approved by the Employer prior to procurement. Change in source and type of aggregates, at later stage, shall not be generally permitted; but under specific circumstances, the Employer subject to the Contract may accept the proposal to change. Contractor shall produce necessary test certificates from approved laboratories regarding the quality and suitability of the proposed aggregates and submit fresh mix design for approval of the Employer. Aggregates, which may chemically act with alkalies of cement or might cause corrosion of the reinforcement, shall not be used. If so desired by the Employer, the Contractor shall carry out alkali reactivity tests and submit the results to him for approval.

The maximum quantities of deleterious materials in the aggregates as determined in accordance with IS: 2386 – Part II (Methods of Test for aggregates for concrete), shall not exceed the limits defined in IS:383. No special test is required to prove the absence of such deleterious matters if the aggregates are from a known source with satisfactory prior data on the properties of concrete made with them. In case of newly developed quarry sites, the Contractor shall submit necessary test results as per IS:383 and IS:2386 to the Employer prior to his acceptance and approval. The method of Sampling shall be in accordance with the requirements given in IS:2430.

Coarse and fine aggregates shall be batched separately. All-in-aggregates shall be used only where specifically permitted by the Employer.

Separate sieve analysis and grading curves shall be prepared by the Contractor for any/all batches of coarse and fine aggregates, and submitted to the Employer, whenever asked for, to ensure conformity with those submitted along with the mix design.

Whenever required by the Employer, the aggregates (coarse/fine) shall be washed and/or sieved by the Contractor before use in the works to obtain clean and graded aggregate at no extra cost to the Employer.

Aggregates not in conformity with the specifications shall be rejected and the Contractor shall immediately remove them from the site of work.

1.1.3.2 Coarse Aggregates

Coarse aggregates are the aggregates, which are retained on 4.75 mm IS Sieve. It shall have a specific gravity not less than 2.6 (saturated surface dry basis).

These may be obtained from crushed or uncrushed gravel or stone as per Clause 1.1.3.1 and may be supplied as single sized or graded. The grading of the aggregates shall be as per IS:383 or as required by the mix design, to obtain densest possible concrete. For this purpose, the Contractor shall submit to the Employer at least three sets of mix design and test results, each with different grading of coarse aggregates, proposed to be used. The Employer may allow “All-in-aggregates” to be used provided they satisfy the requirements of IS:383.

1.1.3.3 Fine Aggregates

Fine aggregates are the aggregates which pass through 4.75 mm IS sieve but not more than ten percent (10%) pass through 150 micron IS sieve. These shall comply with the requirements of grading zones I, II, III and IV of IS:383. Fine aggregates conforming to grade zone IV shall not be used for reinforced concrete works.

Fine aggregates shall consist of material resulting from natural disintegration of rock and which has been deposited by streams or glacial agencies, or crushed stone sand or gravel sand. Sand from sea shores, creeks or river banks affected by tides, dredged sand shall not be used for filling or concrete works.

1.1.3.4 Sampling and Testing

Storage of all types of aggregates at site of work shall be at Contractor’s expense and risk and shall be stored as specified in IS:4082. Aggregates shall in no case be stored near to the excavated earth or directly over ground surface.

Each type and grade of aggregate shall be stored separately on hard, firm surface having adequate slope for drainage of water.

Aggregates delivered at site in wet condition or becoming wet due to rain or any other means, shall not be used for at least 24 hours. The Contractor shall obtain prior approval of the Employer for the use of such aggregates and shall adjust the water content in accordance with IS:2386 to achieve the desired mix. In the absence of test results, and to allow variation in mass of aggregates and water content on account of moisture content, the Contractor can make suitable adjustment in the masses as per IS:456, for preparation of nominal mix concrete only.

1.1.4 Sand

1.1.4.1 Sand for Masonry Mortars

The sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. The sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than specified in IS: 2116.

The crusher sand / manufactured sand with grading limits satisfying requirements of IS 383 shall be considered.

The sand shall not contain any harmful impurities such as iron pyrites, alkalies, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shells in such form or in such quantities as to affect adversely the hardening, strength or durability of the concrete.

Unless found satisfactory as a result of further tests as may be specified by the Employer, or unless evidence of such performance is offered which is satisfactory to him, the maximum quantities of clay, fine silt, fine dust and organic impurities in the sand, when tested in accordance with IS: 2386, shall not be more than 5% by mass in natural sand, or crushed gravel sand or crushed stone sand. For organic impurities, when determined in accordance with IS: 2386, colour of the liquid shall be lighter than that indicated by the standard solution specified in IS: 2386.

1.1.4.2 Grading of Sand

The particle size grading of sand shall be within the limits as specified below:

IS Sieve Designation	Percentage Passing by Mass	Method
IS:460 (Part I)		
4.75 mm	100	IS: 2386 (Part I)
2.36 mm	90 – 100	
1.18 mm	70 – 100	
600 micron	40 – 100	
300 micron	5 to 70	
150 micron	0 to 15	

1.1.4.3 Sampling and Testing

The method of sampling shall be in accordance with IS: 2430. The amount of material required for each test shall be as specified in relevant parts of IS: 2386. Any test which the Employer may require in connection with this shall be carried out in accordance with the relevant parts of IS: 2386.

If further confirmation as to the satisfactory nature of the material is required, compressive test on cement mortar cubes (1:6) may be made in accordance with IS:2250 using the supplied material in place of standard sand and the strength value so obtained shall be compared with that of another mortar made with a sand of acceptable and comparable quality.

1.1.4.4 Sand for Filling

Sand for filling shall meet the requirements of IS: 383 and shall be natural sand, hard, strong, free from any organic and deleterious materials. Any sand proposed for filling, shall be used only after it is approved by the Employer. Sand obtained from sea shores, creeks or river banks affected by tides shall not be used for filling. Fine aggregates suitable for concreting works shall be suitable for filling also. No sand below grading zone-III as per IS-383 shall be allowed for filling.

1.1.5 Cement

For plain and reinforced concrete works cement shall be of any of the following types:

- 43 Grade OPC Ordinary Portland cement conforming to IS 8112
- Portland slage cement conforming to IS 455
- Portland Pozzolana Cement (Fly ash based) conforming to IS 1489 (Part -1)
- Portland Pozzolana Cement (Calcined based) conforming to IS 1489 (Part -2)

For riverine structures , the above mention types of cement shall also confirm to IS 4651 Part 4.

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 acid soluble chloride content should be calculated from the mix proportions and the major chloride contents of each of the constituents. Chloride content in concrete shall be within limits specified in relevant IS Code.

1.1.5.1 Storage at Site

The storage of cement at the site of work shall be at Contractor's expense and risk and shall meet the requirements of IS:4082. The cement shall be stored above ground in a suitable weather tight building or godown and in such a manner as to permit easy access for proper inspection and also to prevent determination due to moisture.

All approved cement shall be arranged in batches with type, brand and date of receipt flagged on them. A maximum of eight bags shall be stacked one over the other. Cement bags shall be used in the same order as received from the manufacturer. The Contractor shall maintain a register, on day to day basis, giving the details of the receipt/consumption, source of supply and type of cement etc. The register shall always be accessible to the Employer for verification.

1.1.5.2 Tests after Delivery

Each consignment of cement procured by the Contractor, shall, after delivery at Site and at the discretion of the Employer, be subjected to any or all of the tests and analyses, required by the relevant Indian Standard Codes.

1.1.5.3 Rejection

The Employer may reject at his discretion any cement, notwithstanding the manufacturer's certificate or failing to meet the requirements of relevant IS Codes for testing of cement. He may similarly reject any cement which has deteriorated owing to inadequate protection from moisture or due to intrusion of foreign matter or any other cause. Any cement which is considered defective shall not be used and shall be promptly removed from the site by the Contractor.

1.1.6 Steel

1.1.6.1 General

All steel bars, sections, plates and other miscellaneous steel materials, etc. shall be free from loose mill scales, rust as well as oil, mud, paint or other coatings. The materials construction specifications such as dimensions, shape, weight, tolerances, testing, etc. for all materials covered under this section, shall conform to respective IS Standards.

1.1.6.2 Reinforcement Bars

Reinforcement bars to be used for civil and structural works shall be low alloy steel of grade Fe 500 S confirming to IS: 1786.

Reinforcement steel shall be purchased only from primary suppliers and that purchased from secondary suppliers shall not be accepted.

The list of primary suppliers is given below:

Primary suppliers

- Steel Authority of India Ltd (SAIL)
- TATA Steel
- Rashtriya Ispat Nigam Ltd (RINL)

- JSW Steel Ltd
- Jindal Steel and Power Limited (JSPL)

1.1.6.3 Structural Steel

Structural steel to be used for general structural purposes shall be of grade A conforming to IS:2062.

Structural steel sections shall conform to following IS specifications.

Steel tubes for structural purposes

IS:1161

Mild Steel Tubes, tubulars and other wrought steel fittings

IS:1239

Hollow steel sections for structural use

IS:4923

1.1.6.4 Miscellaneous Steel Materials

Miscellaneous steel materials shall be conforming to the following IS specifications.

Expanded Metal Steel Sheets for General purposes IS:412

Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (grade I) (for mild steel bars of anchor bolts, rungs, metal inserts, grating etc.) IS:432

Hexagonal head bolts, screws & nets of product grade C IS:1363

Cold formed light gauge structural steel sections IS:811

Technical supply conditions for threaded steel fasteners IS:1367

Plain washers IS:2016

Steel wire ropes for general engineering purposes IS:2266

Thimbles for wire ropes IS:2315

Bulldog grips IS:2361

Mild Steel Tubes, tubulars and other wrought steel fillings. IS:1239

Drop forged sockets for wire ropes for general engineering purposes IS:2485

Steel chequered plates IS:3502

Hexagonal bolts and nuts (M42 to M150) IS:3138

1.1.6.5 Storage

The storage of all materials at site of work shall be at the Contractor's expense and risk and shall be done as per the requirements given in IS: 4082. The Contractor shall maintain the proper records of receipt/consumption. The records shall always be accessible to the Employer for verification.

The reinforcement bars, structural steel sections and other miscellaneous steel materials etc., shall be stored in such a way as to avoid and prevent deterioration, corrosion, bending, twisting and wrapping.

1.1.6.6 Tests after Delivery

Materials procured by the Contractor, shall, after delivery at site and at the discretion of Employer, be subjected to any or all of the tests, required by the relevant IS Codes. The Contractor shall carry out and bear the cost of such tests. The Contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense.

1.1.6.7 Rejection

The Employer may reject at his direction any material, notwithstanding the manufacturer's certificate, failing to meet the requirements of relevant IS Codes for testing of materials. He may similarly reject any material, which has deteriorated or corroded etc., due to improper storage, handling or transport. Defective materials shall not be used and has to be removed from the site by the Contractor at his own expense.

1.2 Plain and Reinforced Concrete Works

1.2.1 General

The section of the specifications includes requirements for furnishing and placing all plain and reinforced cement concrete including form work, reinforcement and incidental works required for the completion of this Contract and herein specified.

This specification establishes the materials, mixing, placing, curing, etc. of all types of cast- in-situ and precast concrete used in jetty, approach trestle, retaining walls, underground structures, floors, buildings, etc. Any special requirements as shown shall supersede over the provisions of this specifications.

Apart from this specification, construction of concrete works shall be in accordance with the Indian Standard Code of Practice for "Plain and Reinforced Concrete" IS:456 and other relevant codes mentioned therein.

In case of conflict between the clauses mentioned in this specification and those in the Indian Standards, this specification shall govern.

1.2.2 Materials

Materials for concrete viz cement, sand, coarse aggregate, water, etc. shall be as described in under specification of 'Materials'.

Materials for all reinforcements, embedment, inserts, water bars, etc. shall conform to specification of 'Materials'.

1.2.3 Grades of Concrete

Unless otherwise noted, the grades of concrete shall generally be as per Table 1.

Table 1 – Grades of Concrete

Grade Designation	Characteristic Compressive Strength of 15 cm cube at 28 days (N/mm2)
M 15	15
M20	20
M25	25
M30	30

M35	35
M40	40

The characteristic strength is defined as the strength of material, below which not more than five (5) percent of the test results are expected to fall.

1.2.4 Type of Concrete Mix

Unless otherwise noted all lean and reinforced concrete shall be nominal mix and design mix types respectively.

1.2.4.1 Nominal Mix Concrete

The Nominal Mix Concrete shall not be used. Only Design Mix concrete shall be used. Hand mixing of cement/sand mortar for use in plastering shall not be allowed. All such mixing shall be done through mechanical mixer only.

1.2.4.2 Design Mix Concrete

The mix shall be designed to produce the grade of concrete having the required workability and characteristic strength not less than appropriate values given in Table 1 above.

As long as the quality of materials does not change, a mix design done earlier shall be considered adequate for later work. However, in case the quality of materials changes, the Employer may ask for a new design mix.

While designing the mix, the durability requirements as given in IS: 456 shall also be taken into account.

1.2.5 Concrete Mix Proportioning

Proportioning, as used in this specification, shall mean the process of determining the proportions of the various ingredients to be used to produce concrete of the required strength, workability, durability and other properties.

The Employer shall verify the strength of the concrete mix, before giving his sanction of its use. However, this does not absolve the Contractor of his responsibility as regards achieving the prescribed strength of the mix. If during the execution of the work, cube tests show lower strengths than required, the Employer shall order fresh trial mixes to be made by the Contractor. Any variation in cement consumption shall be taken into consideration for material reconciliation. Preliminary mix designs shall be established well ahead of start of work. The design mix shall conform to the guidelines of IS: 10262.

1.2.5.1 Maximum Density

Suitable proportions of sand and the different sizes of coarse aggregates for grade of concrete shall be selected to give as nearly as practicable the maximum density. This shall be determined by mathematical means, laboratory tests, field trials and suitable changes in aggregate gradation. The Contractor shall submit to the Employer at least three sets of mix design and corresponding test results after varying the mix proportions and / or grading of aggregate so as to establish the maximum density of any particular grade of concrete.

1.2.5.2 Water-Cement Ratio

Once a mix, including its water-cement ratio, has been determined and approved for use by the Employer, that water-cement ratio shall be maintained. The Contractor shall determine the water content of the aggregates frequently as the work progresses, and the amount of mixing water shall be adjusted so as to maintain the approved water-cement ratio. Maximum water-cement ratio shall never exceed the values given in IS: 456 and IS: 4651 for various exposures and sulphate attack conditions from durability considerations.

1.2.5.3 Consistency

The concrete shall have a consistency such that it shall be workable in the required position and when properly vibrated it flows around reinforcing steel, all embedded fixtures, etc.

1.2.5.4 Workability

The concrete mix proportion shall be such that the concrete is of adequate workability for the placing condition and can be properly compacted with the means available. Use of plasticiser / super-plasticiser of approved make shall be taken recourse to where required for attaining proper workability as specified in Table 2 below. However, prior written approval of the Employer shall be obtained for any such use of plasticiser / super- plasticiser before submitting the proposed design-mix for approval. Where adequate workability is difficult to obtain at maximum permissible water-cement ratio, increased cement content shall also be alternatively considered while designing the mix proportions.

The suggested ranges of values of workability of concrete measured in accordance with IS:1199 are indicated in Table 2 below. However, the actual values to be followed shall be established depending on aggregate sizing, mix proportions, placing conditions, etc. and shall be got approved by the Employer.

Table 2 - Values of Workability

Placing conditions

Degree of workability

Values of workability

Concreting of shallow sections with vibration

Very low

20-10 seconds vee-bee time or

0.75-0.80 compacting factor

Concreting of lightly reinforced sections with vibration

Low

10-5 seconds vee-bee time or 0.80-

0.85 compacting factor

Heavily reinforced sections with vibration

Medium

5-2 seconds vee-bee time or 0.89-

0.92 compacting factor or 25-75mm slump for 20mm aggregate

1.2.5.5 Durability

For achieving sufficiently durable concrete, strong, dense aggregates, low water-cement ratio and adequate cement content shall always be used. Workability of concrete shall be such that concrete can be completely compacted with the means available. Leak-proof formwork shall be used so as to ensure no loss of cement-slurry during pouring and compaction. Cover to reinforcement shall be uniform and as per standard codes. Concrete mix design shall always take into account the type of cement, minimum cement content irrespective of the type of cement and maximum water-cement ratio conforming to the exposure conditions as given in table below.

Exposure	Type of Cement	Plain Concrete		Reinforced Concrete	
		Minimum Cement Content ($Kg./m^3$)	Maximum Water-Cement Ratio	Minimum Cement Content ($Kg./m^3$)	Maximum Water-Cement Ratio
Moderate	OPC* PPC* PSC'	250	0.6	350	0.50
Severe	SSC* PSC* SRC'	310	0.45	400	0.45

Note:

1. Severe exposure shall include structures exposed to sea or saline water (e.g. tidal rivers, brackish water, estuaries etc.), alternate wetting and drying, freezing whilst wet and subject to heavy condensation or corrosive environment. This shall also include structures exposed to sulphate and/or chloride attack due to presence of these chemicals in Soil and ground water. Total SO3 content of 0.2% and above in Soil and 300 ppm in ground water shall be considered to constitute severe exposure. Similarly, chloride (as CI) content exceeding 1500 ppm in ground water or soil shall be considered as severe exposure condition.

2. Structures subjected to aggressive environment below the minimum limits expressed in Note-1 above and/or those in industrial/chemical plants atmosphere shall be considered under moderate exposure. Also, any concrete structure in contact with water or retaining water or any other liquid not usually harmful to concrete shall be considered under moderate exposure.

3. All other environmental conditions not covered under Notes-1&2 shall be categorised under Normal exposure.

* OPC - Ordinary low heat Portland Cement

* PPC - Portland Pozzolana Cement

* PSC - Portland Slag Cement

* SRC - Sulphate Resistant Cement

* SSC - Super Sulphated Cement

1.2.6 Batching

In proportioning concrete, the quantity of both cement and aggregate shall be determined by mass. Where the mass of cement is determined on the basis of mass of cement per bag, a reasonable number of bags shall be weighed periodically to check the net mass. Where the cement is weighed at site and not in bags, it shall be weighed separately from the aggregates. Water shall be either measured by volume in calibrated tanks or weighed. Any solid admixtures that are to be added shall be measured by mass; liquid and paste admixtures shall be measured by volume or mass. Batching plant, where used, shall conform to IS: 4925. All measuring equipment shall be maintained in a clean serviceable condition, and their accuracy periodically checked.

Except where it can be shown to the satisfaction of the Employer that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, different sizes being stacked in separate stock piles. The grading of coarse and fine aggregates shall be checked frequently, the frequency for a given job being determined by the Employer to ensure that the approved grading is maintained.

The amount of added water shall be adjusted to compensate for any observed variations in the moisture contents in both fine and coarse aggregates. For the determination of moisture content in the aggregates, IS: 2386 (Part-111) may be referred to. To allow for the variation in mass of aggregates due to variation in their moisture content, suitable adjustments in the mass of aggregate shall also be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in Table below.

Surface Water Carried by Aggregate

Aggregate	**Approximate Quantity of Surface**	
	Percent by mass	**Litre / m^3**
Very wet sand	7.5	120
Moderately wet sand	5.0	80
Moist sand	2.5	40
Moist Gravel or Crushed Rock	1.25-2.5	20-40

No substitutions in materials used on the work or alterations in the established proportions, except as permitted shall be made without additional tests to show that the quality and strength of concrete are satisfactory. In case the Contractor proposes any change in the already approved mix design, fresh mix design with supportive laboratory tests shall be submitted to the Employer and his approval has to be obtained prior to using the revised mix proportion in the works. However, such proposals for revision shall only be entertained in case of successive failure of test cubes to achieve the required strength.

1.2.7 Concrete Mixing

The mixing of concrete shall be strictly carried out in an approved type of Concrete Batching Plant of required capacity. The mixing shall be continued until there is a uniform distribution of the material and the mass is uniform in colour and consistency. If there is segregation, after unloading from the mixer, the concrete shall be rejected.

1.2.7.1 Mixer

Mixers shall comply with IS: 1791 and shall be maintained in satisfactory operating condition. Mixer drum shall be kept free of hardened concrete and blades shall be replaced when worn down more than ten percent (10%) of their depth. Should any mixer at any time produce unsatisfactory results, leak mortar or cause waste of materials, its use shall be promptly discontinued until it is repaired.

1.2.7.2 Mixing Time

Mixing time shall be as indicated in the following table. Excessive mixing requiring additions of water shall not be permitted. Time shall start when all solid materials are poured in the revolving mixer drum, provided that all of the mixing water shall be introduced before one-fourth of the mixing time has elapsed. The Employer may, however, direct a change in the mixing time, if he considers such a change necessary.

Capacity of mixer	**Minimum Mixing time**
2 m^3 or less	1½ minutes
3m^3	2½ minutes
5m^3	3 minutes

All records and charts for the batching and mixing operations shall be prepared and maintained by the Contractor as per the instructions of the Employer.

1.2.7.3 Deleted

1.2.7.4 Admixtures

Admixtures in concrete shall be used only with the prior approval of the Employer. Any admixture used for obtaining proper workability or leak-proof-ness of concrete or repair/rendering works of concrete due to non-conformance to the specifications, shall not be measured and paid for.

1.2.8 Transportation, Placing and Compaction

The entire concrete placing programme including transportation arrangements, deployment of equipment, lay out, proposed procedures and methods, shall be submitted to the Employer 24 hours prior to concreting, for approval. No concreting shall be placed until his approval has been received. Approval of the Employer for pouring concrete shall be taken as 'conveyed', when the concrete pour card is signed by him.

1.2.8.1 Placing of Concrete

Placing of concrete shall be carried out by use of pump, placer boom, conveyor or crane and bucket etc. subject to approval of Engineer-in-Charge.

1.2.8.2 Vibrators

Concrete shall be compacted with mechanical vibrating equipment supplemented, if necessary to obtain consolidation, by hand spreading, rodding and tamping. The vibrators shall be of immersion type with operational frequency ranging between 8,000 and 12,000 vibrations per minute. All vibrators shall comply with IS: 2505. Screed board concrete vibrators or concreting vibrating tables or form vibrators conforming to IS: 2506, 2514 and 4656, respectively, shall be used where specifically required and directed by Employer.

Immersion type vibrators shall be inserted in a vertical position at intervals of about 600mm, depending upon the mix, the equipment used, and experience on work. The vibrators shall be withdrawn slowly. The spacing shall provide some overlapping of the area vibrated at each insertion. In no case shall vibrators be used to transport concrete inside the forms. Over vibration or under vibration shall not be permitted as both are harmful. Hand tamping in some cases may be allowed subject to the approval of the Employer.

In placing concrete in layers which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, bonding and moulding of the concrete between the succeeding batches.

The vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

Care shall be taken to prevent contact of vibrators against all embedded reinforcing steel or inserts. Vibrators shall not be allowed to come in contact with forms.

The use of form vibrators shall not be permitted for compaction of in-situ concrete without specific authorization of the Employer.

The use of surface vibrators of screed board type shall not be permitted for consolidation of concrete under ordinary conditions. However for thin slabs (of thickness less than 200mm) surface vibration by such vibrators may be permitted, upon approval of the Employer.

Whenever vibration has to be applied externally, the design of formwork and the disposition of vibrators shall be carefully planned to ensure efficient compaction and to avoid surface blemishes.

1.2.8.3 Transportation

All concrete shall be conveyed from the mixer to the place of final deposit as rapidly as possible in suitable buckets with crane, dumpers, boom placers, pumps or conveyors, which shall be mortar leak tight. Care shall be taken to prevent the segregation or loss of the ingredients and maintaining the required workability.

During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted. All equipment used for transporting and placing of concrete shall be maintained in clean condition. All buckets, hoppers, chutes, dumpers and other equipment shall be thoroughly cleaned after each use.

1.2.8.4 Placing and Compaction

Before placing concrete, all surfaces upon which or against which concrete is to be placed shall be well compacted and free from standing water, mud or debris. The surface of absorptive soil (against which concrete is to be placed) shall be moistened thoroughly so that moisture is not drawn from the freshly placed concrete.

Concrete shall not be placed until the formwork, the placement of reinforcing steel, embedded parts, pockets etc. have been inspected and approved by the Employer. Any accumulated water on the surface of the bedding layer shall be removed by suitable means before start of placement. No concrete shall be placed on a water-covered surface.

Concrete shall be discharged by vertical drop only and the drop height shall not normally exceed 1.5m throughout all stages of delivery until the concrete comes to rest in forms. For continuous concreting operation windows of suitable size shall be kept in the formwork or chutes shall be used to avoid segregation of concrete.

Concrete shall be deposited as near as practicable in its final position to avoid rehandling. Concrete shall be placed in successive horizontal layers. The bucket loads, or other units of deposit, shall be placed progressively along the face of the layer with such over-lap as will facilitate spreading the layer of uniform depth and texture with a minimum of hand shoveling. Any tendency to segregation shall be corrected by shoveling coarse aggregates into mortar rather than mortar on the coarse aggregates. Such a tendency for segregation shall be corrected by redesign of mix, change in process or other means, as directed by the Employer.

All struts, stays and braces (serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations) shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These shall not be buried in the concrete. Concrete shall be thoroughly compacted with vibrators and fully worked around the reinforcement, embedded fixtures and into corners of formwork before setting commences and shall not be subsequently disturbed. Methods of placing shall be such as to preclude segregation. The formation of stone-pockets or mortar bondage in corners and against face forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for thorough bonding as directed by the Employer. Care shall be taken to avoid displacement of reinforcement and embedded inserts or movement of formwork.

Unless otherwise approved, concrete shall be placed in single operation to the full thickness of foundation rafts, slabs, beams and similar members. Concrete shall be placed continuously until completion of the part of the work between approved construction joints or as directed by the Employer.

The method of placing and compaction employed in any particular section of the work shall be as per direction of the Employer.

During hot weather (atmospheric temperature above 40 degree Celsius) or cold weather (atmospheric temperature below 5 degree Celsius), the concreting shall be done as per the procedure set out in IS:7861. Concrete that has set standing and becomes stiffened shall not be used in the work.

Formation of cold joints shall be avoided.

1.2.8.5 Items Embedded In Concrete

Concreting shall not be started unless the electrical conduits, pipes, fixtures etc., wherever required, are laid by the concerned agency. The Contractor shall afford all the facilities and maintain co-ordination of work with other agencies engaged in electrical and such other works as directed by the Employer.

Before concreting, the Contractor shall provide, fabricate and lay in proper position all metal inserts, anchor bolts, pipes etc. (which are required to be embedded in concrete members) as per relevant drawings and directions of Employer.

All embedment, inserts etc. shall be fully held and secured in their respective positions by the concerned agencies to the approval of Employer so as to avoid any dislocation or displacement during the concreting operations. The Contractor shall take all possible care during concreting to maintain these embedment/inserts in their exact locations.

1.2.9 Construction Joints

Construction joints shall be provided in position as described in the drawings or as directed by the Employer. Such joints shall be kept to the minimum. These shall be straight and at right angles to the direction of main reinforcement.

When the work has to be resumed on a surface, which has hardened, such surface shall be cleared of any foreign materials and roughened to expose the tips of the coarse aggregate. It shall then be swept clean and thoroughly washed and wetted before any new concrete is poured. Any set mortar or concrete sticking to the exposed reinforcing rods in and around such joints shall be thoroughly removed. The reinforcements shall be wire brushed and washed just before pouring any cement slurry or mortar. For vertical joints neat cement slurry shall be applied on the surface before it is dry. For horizontal joints the surface shall be covered with a layer of mortar about 10 to 15mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing new concrete.

Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgment of particles of aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface, layer of concrete not exceeding 150mm in thickness shall first be placed and shall be well rammed against old work, particular attention being paid to corners and close spots; work thereafter shall proceed in normal way.

1.2.10 Separation Joints

Separation joint shall be obtained by using an approved alkathene sheet stuck on the surface against which concrete shall be placed. Adequate care shall be taken to cause no damage to the sheet.

1.2.11 Expansion Joints/Isolation Joint

Expansion/Isolation joints in structures shall be formed in the positions and to the required shapes. Isolation joints shall be provided around all equipment foundations, columns, pedestals, trenches, etc. on grade.

1.2.12 Water Stops

PVC water stops as per specifications under ‘Materials’ shall be accurately cut, fitted and integrally joined as per manufacturer's specifications to provide a continuous, watertight diaphragm at all points.

The water stops shall be located and embedded at expansion/contraction/ construction joints.

Adequate provision shall be made for the support and protection of water stops during the progress of the work. Damaged water stops shall be replaced and/or repaired as directed.

1.2.13 Protection of Freshly Laid Concrete

Newly placed concrete shall be protected, by approved means, from rain, sun and wind as per direction of the Employer.

1.2.14 Curing

Concrete shall be cured by keeping it continuously moist wet for the specified period of time to ensure complete hydration of cement and its hardening. Curing shall be started after 8 hours of placement of concrete, and in hot weather after 4 hours. The water used for curing shall be of the same quality as that used for making of concrete.

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances such as hose, sprinklers etc. A layer of sacking, canvas, hessian, or other approved material, which will hold moisture for long periods and prevent loss of moisture from the concrete, shall be used as covering. Type of covering which would stain, disfigure, or damage the concrete, during and after the curing period, shall not be used. Only approved covering shall be used for curing.

Exposed surfaces of concrete shall be maintained continuously in a damp or wet condition for at least the first 7 days after placing of concrete, except that high early strength concrete shall be so maintained for at least the first 3 days, thereafter as per direction of the Employer.

The Contractor shall have all equipment and materials required for curing on band and ready to use before concrete is placed.

For curing the concrete in pavements, the ponding method of curing is preferred after the expiry of first 24 hours during which (i.e. first 24 hours) the concrete shall be cured by use of wet sacking, canvas, hessian etc. The minimum water depth of 25mm for ponding shall be maintained. The method of containing the ponded water shall be approved by the Employer. The ponded areas shall be kept continuously filled with water, and leaks, if any, shall be promptly repaired. Areas cured by ponding method shall be cleared of all debris and foreign materials after curing is over.

Alternatively, membrane curing may be used in lieu of moist curing with the permission of the Employer. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing as soon as possible after the concrete has set. Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer. This film of curing compound shall be fully removed from the concrete surface after the curing period specified earlier. Employer may not allow curing by curing compounds for those surfaces where use of curing compound may be detrimental to future finishes.

1.2.15 Steel tubular piles

The tubular steel marine piles include vertical driven and raking driven piles. The technical requirements of this specification are the absolute minimum acceptable. Where not specifically referenced herein, materials and workmanship shall comply with the latest edition and amendment of the applicable Indian Standard or approved International Standard like API/ASTM/BS/DIN.

Materials and workmanship shall comply with the parts and sections of IS 2911. Code of practice for the Design and Construction of pile Foundations, set out below, except where modified and/or extended by this Specification:

IS 2911 Part 4 – Load Tests on Piles.

The Contractor shall:

- Undertake new geotechnical investigations and submit detail investigation report to the owner for approval.
- Note the variability of strata likely to be encountered in the various sections of the Works.
- Critically assess plant requirements and pile installation techniques on the basis of the above information in order to achieve pile capacities consistent with the design.
- Undertake any additional foundation investigations and testing as considered necessary to make his assessment of the nature of the sub-surface conditions at the Site to allow the piling to be carried out in accordance with the Contract.
- As a minimum requirement, carry out the additional geotechnical investigations and testing, before any piling work is started.

At least four weeks before any piling is due to start, the Contractor shall submit to the Owner for approval full details of the pile driving plant and hammers proposed, together with detailed method statements for the supply/fabrication/casting, handling, splicing, driving and testing of piles. The details shall include the proposed sequence of working.

The Contractor shall select his pile driving pant and hammers to ensure that the piles can be driven to obtain the required ultimate resistances covered above. Unless otherwise approved by the Owner, the minimum rated energy/blow for the pile hammers shall be as follows:

Pile Type	**Energy/Blow (kJ)**
Marine Vertical Steel Tubular Pile	130

Steel piles shall be spliced on Site by the Contractor to lengths, to the approval of the Owner, before pile pitching, in order to minimise the number of piles to be spliced in-situ during driving.

Piles shall be supplied true to shape and size, without distortion, and with all necessary provisions for handling and Site splicing. Sections damaged by hammer marks of otherwise marked, or defaced, shall be rejected.

The tolerance on straightness of a completed spliced pile length shall not exceed 15mm for lengths over 15m.

The minimum distance between splices shall be 900mm. There shall be no more than two splices in any 3m interval of pile. No splice shall be located closer than 1m from a joint with another structural number, unless otherwise approved by the Owner.

During splicing, the Owner shall have free access to the works at all reasonable times for the purpose of carrying out inspections and shall be afforded all necessary facilities for the carrying out of such inspections. Pile lengths shall be laid out for splicing, as necessary, so that all parts are accessible for inspection.

Inspections by the Owner shall not prevent the ultimate rejection of any work or materials in which defects have been found.

Piles shall be set out to the alignment and centres as shown on the Drawings and with the piles axes in correct rake and orientation.

Each pile shall be driven continuously, subject to stopping for in-situ splices, until the approved set and/or depth has been reached, except that the suspension of driving may be permitted when it is apparent that the rate of penetration, prior to the cessation of driving, will be substantially re-established on its resumption or, if suspension of driving is unavoidable. A follower (long dolly) shall not be used unless approved in which case the set shall be revised to take into account the reduction in effectiveness of the hammer blow.

Unexpected changes in driving characteristics shall be reported to the Owner.

At the start of work or at a new section or area of the work and for everyone in 10 piles, sets shall be taken at 0.5 metre intervals over the full driven depth to establish the behaviour of piles.

The final set of each pile shall be recorded as the number of millimetres penetration per blow averaged over the last five blows. When a final set is being measured the following requirements shall be met:

- The exposed part of the pile shall be in good condition, without damage or distortion.
- The dolly and packing if any shall be in sound condition.
- The hammer blow shall be in line with the piles axis and the impact surfaces shall be flat and square to the pile and hammer axis.
- The hammer shall be in good condition and be operating correctly.
- The temporary compression of the pile shall be recorded.

Set shall be monitored during driving by recording the number of blows required to achieve a 25mm penetration. Detailed records of sets shall be taken by the Contractor over the last 0.5m of penetration before the final set and when sets reduce significantly. Final sets shall be witnessed by the Owner.

Piles shall be driven in a sequence to minimize detrimental effects of heave and lateral displacement. Measurements to determine the movement of the ground or of any pile during the driving process shall be made and recorded.

Proposed details for correcting the movement to adjacent piles together with proposed methods to prevent recurrence in subsequent work shall be submitted to the Owner for review and approval.

Temporary bracing details shall be submitted to the Owner for review and approval prior to installation.

5.3 Method of design

All structural steel members shall be designed in accordance with IS 800 or as applicable.

Reinforced concrete members of riverine structures shall be designed using limit state design method as per IS 4651.

The suspended deck structures shall be analyzed by preparing a three-dimensional (3D) model in STAAD-Pro or similar software package. The 3D model shall be applied with all relevant load cases and load combinations complying Indian standards.

Based on the soil profile at the respective location, approximate fixity levels of piles can be calculated and the same shall be used in the analysis of structures.

5.4 Geotechnical Design Criteria

The foundation/substructure for all riverine structures consists of driven steel piles.

Pile safety factor for axial pile capacity (tension and compression) shall be as per API guideline:

- 2.0 in axial compression and
- 1.5 in axial tension

The lateral load capacity, end bearing and skin friction capacity shall be checked and the pile spacing shall be decided accordingly.

Allowable bearing pressure for shallow foundation shall be based on permissible settlement provided in Table 1, IS1904 for dead plus live load conditions.

For Transient loading (wind / seismic forces), allowable bearing pressure of soils shall be increased as per the recommendation provided in Table 1, IS1893 (Part 1)

While designing foundations at various levels, the bearing capacity at that particular level and also the effect of uplift /sub soil water table shall also be considered.

5.5 Design Loads

5.5.1 Dead Loads

The specified dead load for a structural members consists of the weight of the member, the weight of all materials of construction incorporated in the structure to be supported permanently by that member and the weight of permanent equipment.

In assessing dead loads for the purpose of design, the following material unit weight shall be used:

Reinforced Concrete	25 kN/m^3
Plain Concrete	24 kN/m^3
Structural Steel	78.5 kN/m^3
Backfill Soil	18 kN/m^3
Water	10 kN/m^3
Water proofing	4 kN/m^2

The unit weights of other materials shall be considered as defined in IS 875 – Part 1.

5.5.2 Live Loads

A uniform live load of 5 kN/m^2 shall be considered for the design of approach trestle, link spans, dolphins and intermediate pontoons. The live loads on the buildings shall be considered in accordance with IS 875 – Part 2.

Hand railing and kerb on approach roadway shall be designed in accordance with IRC-6 2014.

5.5.3 Wind Loads

An operational wind speed of 30 m/s and an extreme wind speed of 50 m/s shall be considered as per provisions of IS 875-2015. Suitable risk, terrain, height and topography factors (k1, k2 and k3) shall be considered as per site conditions. The following factors shall be considered for wind load analysis:

K1 = 1.00

K2 = 1.05

K3 =1.00

5.5.4 Current Loads

The current loads have been evaluated based on the current velocity described in Section 5.1.6. The current loads are considered at different directions with respect to the river flow. The predominant current load will be in the direction of the river flow. However, the current loads on the structures are also considered at 45° (maximum) from the direction of the river flow as shown in the figure below:

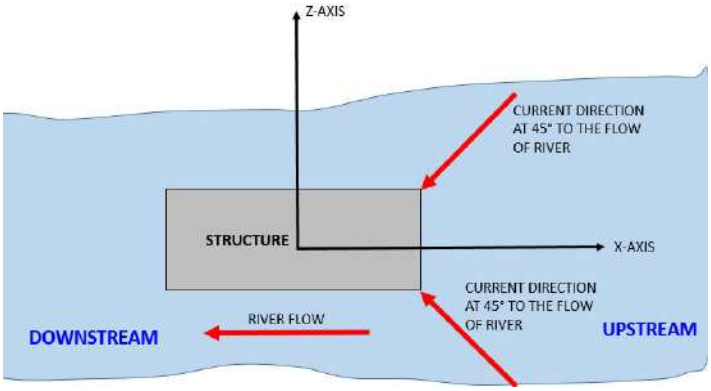


Figure 5-1: Direction of currents considered on the structure

The current loads are resolved with respect to the X & Z axis of the structure as shown in the table below:

Degrees	X Component	Z Component

10	0.990	0.180
22.5	0.930	0.390
30	0.870	0.500
45	0.710	0.710

These factors are considered with the current loads in X & Z direction in the STAAD-Pro analysis of the structure.

5.5.5 Seismic Loads

Earthquake forces as applicable for the site shall be evaluated and computed with reference to IS 1893 – 2002. Design horizontal seismic coefficient shall be evaluated as per procedure detailed in IS 1893-2002.

The parameters to be considered for seismic analysis are as follows:

- Seismic zone : V
- Design horizontal seismic coefficient, Ah : ZI (Sa/g)/ (2R)
- Zone Factor Z: 0.36
- Importance Factor I : 1.5
- Response Reduction Factor R: 4.00
- Damping : 5% for Reinforced concrete

Time period of specified structures shall be evaluated by STAAD analysis considering Dead load + Super imposed dead load + 50% Live load.

Provisions of IS 13920 shall be considered for ductility detailing of reinforcement in reinforced concrete members.

5.5.6 Berthing Loads

The berthing loads shall be computed in accordance with IS 4651 part III, considering following parameters.

- Berthing and site conditions: Sheltered and difficult
- Approach angle: 10 degrees
- Approach velocity: 0.5 m/s
- Maximum displacement of ferry vessel (100 seater + 50 bikes) : 95 Tons
- Maximum displacement of ferry vessel (50 seater + 25 bikes): 40 Tons

Arch fender AN 400 shall be chosen corresponding to rated reaction of 230.5 kN as shown in drawing number P.013223-P-20305-201.

The friction force shall be considered 0.30 times the reaction of the fender in the longitudinal direction.

5.5.7 Surcharge Load

Surcharge load will be taken as minimum 10 kN/m^2 for design of boundary wall, drain and other underground structure.

5.5.8 Load Combinations

The factors for load combinations shall be arrived with reference to Table 1 of IS 4651 (Part 4): 2014 for both limit state of collapse and limit state of serviceability for the riverine and landside structures.

5.5.9 Increase in permissible stress

Increase in permissible stresses for members designed as per working stress design method will be as per Cl. 7 of IS 4651 (Part 4) – 2014.

The partial load factor for all the load cases shall be considered as 1.0 for use in working stress design. However, the permissible stress may exceed up to the limit as mentioned in Table 2 of IS 4651 (Part 4) – 2014.

5.6 Miscellaneous Components and Details

5.6.1 Handrails

All handrails shall be hot dip galvanized.

Horizontals of handrails shall be of at least 40 mm diameter

Toe plate of mild steel conforming to IS: 2062. Height of handrail shall be 1100 mm from deck.

5.6.2 Corrosion Protection

All structural steel surfaces exposed to the atmospheric zone shall be provided with sacrificial corrosion thickness and painted in accordance with the painting specifications. All concrete surfaces in contact with the soil shall be coated with 2 coats of Bituminous Paint in line with Manufacturer specification.

5.7 Serviceability Criteria

5.7.1 Deflection

The deflection criteria shall be so limited that it shall not produce difficulties in serviceability conditions nor shall it cause damage to the structures and its components.

Horizontal deflection of piles shall be limited to H/250 (H – unsupported length of pile).

Vertical deflection of link span members shall not exceed span/325.

The link span shall be designed to accommodate transverse and longitudinal differential movements between the intermediate pontoons and hinged support. One end of the structure shall be designed as a hinge support and the other end as a sliding/rolling support. The sliding support shall provide guide restrains in the vertical/lateral directions.

150% of the total calculated translation shall be allowed for in the end conditions and bridge design. The hinge connection shall be designed to withstand 150% of the expected axial/horizontal thrust.

5.7.2 Crack Control

The structural concrete elements shall be checked for crack width for operating load combinations in accordance with provisions of IS: 456-2000. The crack width shall be limited to the values as defined in the table below:

Table 5-2: Crackwidth limitations

Sr. No.	Item	Sustained Load Cases (mm)	Transient Load Cases (mm)
1	Above water zone	0.2	0.3
2	Splash zone	0.1	0.2
3	Submerged zone	0.2	0.3
4	Buried Zone	0.3	0.3

NOTE:

Sustained Load: Dead load, Live load and earth pressure load

Transient Load: Berthing, Mooring and Crane Loads (whatever applicable)

6. DESIGN BASIS - WATER SUPPLY, SEWERAGE AND DRAINAGE

6.1 Design Standards & Codes

- CPHEEO:1999 - Manual on Water supply and Treatment
- CPHEEO:2013 - Manual on Sewerage and sewage treatment
- SP35:1987 - Handbook on Water Supply and Drainage
- NBC:2016 - National Building Code
- SP 42:1994 - Guidelines on Road Drainage
- CPCB/ SPCB/ MoUD Guidelines
- Relevant Indian Standards

6.2 Design Criteria

Provision of safe, adequate water is a basic necessity for the healthy living. Water demand is estimated based on the unit demand norms along with the Average Number of Passenger projected per day for design phases of development up to year 2035. The water requirement for vendor and staff at ferry terminal is also considered. Potable water required for the terminal amenities is computed as per NBC 2016 norms. In absence to water demand requirement for ferry terminal, the per capita water demand for Interstate bus terminal/Metro stations is considered. As per CPHEEO norms, the sewage generation is taken as 80% of the water demand.

The water demand estimation and sewerage generation is calculation and given in the flowing table.

Table 1: Demand Estimation

SOUTH GUWAHATI @ Year 2035					
S. No	**Type of Building**	**Annual Average Daily Numbers**	**Unit Demand in LPCD**	**Total Demand in LPCD**	
1	Average Number of Passenger	7381	15	110,715.00	
2	Vendor	82	15	1,230.00	
3	Staff	25	15	375.00	
			Total	**112,320.00**	**LPCD**
			Water Demand	**112.32**	**KLD**
			Raw Water requirement after Loss @ 5%	**118.23**	
			Say	**120.00**	
			Sewage Generation @ 80% of water demand	**96**	**KLD**
			Say	**100.00**	**KLD**

7. DESIGN BASIS – ELECTRICAL

Design Life

The installation and equipment (including auxiliaries) covered by this specification shall be designed and constructed for a minimum service life of 20 years.

Ambient Condition

Item No.	Item Description	Value
	Outdoor Ambient Temperature Design Range (^{0}C)	From 5 to 50
	Relative Humidity: Average Range (%)	25 – 90
	Basic Wind Speed	200 km/hr
	Monthly Rainfall in typical year (mm)	308
	Equipment design temperature (°C)	50

POWER SUPPLY PHILOSOPHY

General

In order to meet the total power demand for river Terminal, power supply shall be provided by ASEB at 11 kV level. The power tap-off location shall be in vicinity of Terminal building with a suitable breaker. The main electrical substation location shall be near the Terminal Building only. Cabling from power tap-off point to the substation shall be considered in present scope of work. Further onward power transmission to the Terminal building area (through 415V LT Power cable) and all downstream distribution to Pontoons, pathways and associated facilities shall also be considered in present scope of work and shall be through 415V Switchgear.

Upon receiving the power at 11 kV level from ASEB tap-off point, power shall be taken up to main sub-station area through 11 kV cable and it will be stepped down to 415V level by means of 11/.415 kV step down transformer. It shall be connected with 415 V Switchgear for downstream LV power supply. Other necessary voltages below 415V shall be derived from thereon.

The 415V Switchgear consists of two bus sections i.e. normal and emergency, which are coupled by bus coupler & electrical interlock and shall be serving as normal-cum-emergency Switchgear. Emergency power required by emergency loads shall be made available by Emergency Diesel Generator (EDG) located in a separate room adjacent to the Electrical Room. EDG will be directly connected to emergency bus section of Switchgear and all emergency loads shall be fed from this bus section. Incomer breaker of EDG shall be Normally Open (NO). EDG shall start automatically after failure of normal power supply, however shut down of EDG shall be manual.

Under emergency condition normal load (fed from on normal bus section) from Switchgear shall be shed off due to under voltage and Emergency load shall be connected. Emergency load shall also be in operational condition even during availability of normal power supply.

The lighting load is fed from emergency bus of LT Switchgear through lighting transformer. The output of Lighting Transformer is fed to Main Lighting Distribution Board. A bus coupler is provided in bus section of MLDB and one more incomer is also provided to feed power from solar plant for lighting loads. When EDG incomer is closed, the bus coupler breaker of MLDB is tripped and thus power is restricted to emergency bus of MLDB and power is supplied to emergency lighting bus.

For basic conceptualization of power distribution within battery limit of project, please refer SINGLE LINE DIAGRAM FOR OVERALL POWER DISTRIBUTION.

SYSTEM DESIGN PHILOSOPHY

General

The electrical system shall be designed to provide;

- Safety to personnel and equipment both during operation and maintenance.
- Reliability of Service
- Minimal fire risk

- Ease of maintenance and convenience of operation

- Automatic protection of all electrical equipment through selective relaying system.

- Electrical supply to equipment and machinery within the design operating limits.

- Adequate provision for future extension and modification.

- Suitability for applicable environmental factors.

- Maximum interchangeability of equipment.

- Expandability provision for future.

The IP protection shall generally follow as per below:

Sl. No.	Item Description	IP Class
	LT Switchgear	IP-54 (for indoor)
	DBs/Panels/Local control station	IP-54 (for indoor) IP-65 (for outdoor)
	Motor & MOV (indoor & outdoor use)	IP-55 (Outdoor motor shall be provided with FRP canopy)
	Lighting fixtures	IP-54 (for indoor) IP-65 (for outdoor)
	Welding receptacles/small receptacles	IP-41 (for indoor) IP-65 (for outdoor)

SYSTEM STUDIES

System studies for the Electrical Power Distribution System shall be carried out and shall include following:

Load Flow Studies.

b) Short Circuit Studies (Phase and earth fault)

Short circuit studies shall be carried out in accordance with IEC 60909. The software to be used shall be ETAP or approved equivalent.

CAPACITY OF ELECTRICAL SYSTEM

All the components of the electrical system shall be sized to suit, the maximum load, working under the most severe operating conditions along with the future expansion of facilities on the Pontoon as well as in the land area. Accordingly, the maximum simultaneous consumption of power, required by continuously operating loads shall be considered and an additional margin shall be taken into account for intermittent service loads, if any. System design shall permit direct-on-line starting of all motors unless specified otherwise. No motor shall be directly switched-on from the substation.

The switchgear shall have provision for addition of cubicles for future expansion and accordingly sufficient spare space shall be provided in substation/electrical room.

SYSTEM VOLTAGE

Item No.	Item Description	Value
	Primary distribution	415 V, 3 Phase, 50 HZ
	Secondary distribution	415 V, 3 Phase, 50 HZ
	0.18≤Motor kW≤200	415 V, 3 Phase, 50 HZ
	0.18<Motor kW	415 V, 3 Phase, 50 HZ
	Motor kW>200 kW	11 kV,3 Phase, 50 HZ
	Welding receptacles	415 V, 3 Phase, 50 HZ
	Switchgear/PMCC Control Power	240 V, 1 Phase, 50 HZ (UPS fed)
	Normal & emergency lighting system, small power receptacle system	240 V, 1 Phase, 50 HZ
	Critical lighting system	240 V, 1 Phase, 50 HZ(UPS fed)

VOLTAGE DROP

The maximum voltage drops in various sections of the electrical system under steady state conditions at full load shall be within the limits stated in the following table;

Sr. No.	System Element	Maximum allowable Voltage Drop
b)	Cable between LT Switchgear and motor	4%
d)	Circuit between lighting panels and lighting	3%

The maximum voltage drop at various buses start-up of motor shall be within the limits stated below:

Sl. No.	System Element	Operating Condition	Max. Permissible Voltage Drop
a)	At the bus bars of the LT Switchgear	Start-up of largest LV motor with other loads on the bus,	10%
b)	Cables between LT Switchgear	Motor start-up or reacceleration	15%

Notes:

a) The voltage available at the motor terminals during start-up must be sufficient to ensure positive, starting or reacceleration of the motor (even with the motor fully loaded, if required), without causing any damage to the motor.

b) For low voltage motors, the voltage available at the motor terminals must not be less than 75% of the rated value during start-up or reacceleration. For medium voltage motors, the voltage available at the motor terminals must not be less than 80% of the rated value during start-up or reacceleration

LOAD ASSESMENT & ELECTRICITY CONSUMPTION

The load summary shall be prepared for recording and calculating the electrical loads for the impacted switchboards. The Load Summary shall include continuous, intermittent, stand-by columns.

The maximum running plant load for transformer shall be determined as follows:

Rating (Peak Load) = 100 % continuous load + 15% intermittent load or single largest load whichever is higher + 10% standby load or largest standby load whichever is higher.

Transformer to be loaded 80% at full/peak load condition.

Transformer shall be capable to re-start of largest motor without exceeding permissible voltage drop.

This following shall be used to verify the rating of Emergency Diesel Generator,

Rating (Peak Load) = 100 % continuous load + 15% intermittent load or single largest load whichever is higher + 10% standby load or largest standby load whichever is higher + 10% future margin.

Generator shall be capable to re-start of largest motor without exceeding permissible voltage drop.

Emergency Loads

Following loads shall be fed from emergency supply during outage of normal AC:

- AC inputs to AC UPS and Battery chargers.

- Emergency lighting distribution board.

- Any other critical load required by process required emergency backup supply.

SYSTEM EARTHING

System earthing for different voltage level shall be as per below:

Item No.	Item Description	Value
	415 V Solidly earthed	3 Phase, 4 wire
	240 V UPS Unearthed	1 Phase, 2 wire

SHORT CIRCUIT CAPACITIES

Each short circuit interrupting device shall be designed to have rated service-breaking capacity (Ics) equal to or higher than the maximum value of short circuit current calculated, at its location. The related switchgear shall withstand the above maximum available fault current for a minimum period of one second.

INSULATION SYSTEM

The insulation of electrical facilities shall be designed considering the system voltage, the system neutral earthing and the over voltages resulting due to system fault, switching or lighting surges. The insulation coordination between the electrical equipment and the protective devices shall be done in line with IS: 3716.

Lightning arresters and surge absorbers shall be provided where necessary.

PROTECTION AND METERING SCHEMES

The protective system shall be selected and coordinated to ensure the following:

Protection of equipment against damage, which can occur due to internal or external short circuit or atmospheric discharges.

Uninterrupted operation of those parts of the system, which are not affected by the fault.

Personnel and plant safety.

In general, quick acting relays (with time delays, if necessary) shall be used. In addition to above any other protective relay & auxiliary relays if required shall be provided to fulfill functional requirements.

In general, quick acting relays (with time delays, if necessary) shall be used. In addition to above any other protective relay & auxiliary relays if required shall be provided to fulfill functional requirements.

Protective relays shall be of numerical type with latest version with non-volatile memory. Special protections for any feeder such as directional power relay etc., shall be provided wherever necessary.

Protective relays shall be of numerical type with latest version with non-volatile memory. Special protections for any feeder such as directional power relay etc., shall be provided wherever necessary.

415V Switchgear (LV) shall have two (2) incomers & one (1) bus coupler and both the incoming supply shall be electrically interlocked. During normal operation, incomer supplied from LV transformer shall remain ‘CLOSE’, and bus coupler between normal & emergency bus section ‘CLOSE’. However the second incomer, fed from EDG shall be taken into service only during failure of the LV transformer. The loads required to run during emergency shall be connected with emergency bus section.

Emergency load like critical drive, emergency lighting shall be fed from EDG of suitable capacity. At both locations, in case of complete shutdown of normal AC supply, all non-emergency loads shall be tripped using shunt trip after suitable time delay. Upon restoration of normal AC supply, the EDG shall be manually shut down.

All instruments shall be flush mounted back-connected type. The minimum metering requirements for the various switchboards shall be as per Electrical design data. The metering requirements of UPS shall be as per the respective equipment specification.

Wherever possible metering function of numerical relay shall be utilised.

AC UPS SYSTEM

Uninterrupted power supply system shall be provided for meeting critical loads that cannot withstand a momentary interruption in voltage as well as critical lighting. Following loads shall be connected to the UPS system.

- Control supply (for LT Switchgear for breakers)
- Critical lighting
- Critical instrumentation

- Critical communication equipment
- Critical security equipment
- Annunciation Panel
- Telephone System
- Fire Alarm System
- Communication System
- Telecom (if applicable)

PROTECTION SYSTEM MATRIX

Protection devices for power distribution system shall be as indicated below:

RELAY DESCRIPTION	**RELAY NUMBER**	**CONTACTOR MOTOR STARTER**	**LV ACB MOTOR FEEDER**	**INCOMER**	**OUTGOING BREAKER FEEDER**	**BUS COUPLER**
				415V	**415V**	**415 V**
IDMTL over-current relay	51	-	-	√	√	√
IDMTL earth-fault relay	51N	-	-	-	√	√
51G backup earth-fault relay	51G	-	-	√	√	-
Motor protection relay with (50, 50N,46, 49, 50L/R,86,95)	99	√(6)	√(6)	-	-	-
Instantaneous over-current relay	50	-	√	-	-	-
Instantaneous earth-fault relay	50N	-	√	-	-	-
Hand reset lock out relay	86	-	√ (1)	√ (1)	√ (1)	√ (1)
Trip circuit supervision relay (7)	95	-	√ (1)	√ (1)	√ (1)	√ (1)
Under-voltage relay with timer	27/2	-	√ (3)	√(4)	√ (4)	√ (4)
Check synchronization relay	25	-	-	√ (2)	-	√(2)
Differential Protection	87	-	-	-	-	-

Minimum protection relays for emergency generator shall be as follows:

RELAY DESCRIPTION		
Synchronous check		
Under voltage with timer		

Reverse power		
Low power flow		
Loss of excitation		
Negative sequence		
Over current		
Earth Fault back up		
Over voltage with timer		
VT failure		
Rotor Earth fault		
Under frequency/df/dt		
Tripping relay		
Trip circuit supervision		
Dead bus charging relay		
Over fluxing		
Alarm Relay		

√ () indicates as applicable (Figure inside bracket refers to note below)

Notes:

Tripping relays (86) & Trip Circuit supervision relay (95) shall be part of numerical relay. 2Nos of 86 relays shall be considered for LV and MV breaker fed motors, for ease of differentiating between Process and Electrical trips.

Synchronization shall be applicable for 415V Switchgear considering momentary paralleling between normal incomer (from transformer) & emergency incomer (from EDG).

Numerical relays where ever provided for motor feeders shall use in built under voltage relay and timer for delayed tripping on bus under voltage.

All numerical relays shall be comprehensive units including all protection, metering and control unless otherwise specified. Under voltage and over voltage along with associated timer shall be part of the numerical relays.

DG set shall be provided with protection but not limited to 51V, 51G, 40, 46,86,95,80, 64R (for rated above 500 kVA) etc. for generator.

Earth fault protection shall be provided through CBCT and earth fault relay. Relay 50 shall not be provided for contactor controlled feeders.

Differential protection is applicable for critical/long feeders and plant feeders connected to main power generation and distribution bus. A plant feeder implies outgoing feeders from one switchboard to another switchboard of same voltage level.

GENERAL

All electrical equipment's shall be brand new and of make & type as per approved vendor list. The equipment shall be of proven design, complying with the latest versions of codes & standard mentioned in this document and considering the requirement as minimum stated under this section.

The type test certificates for all electrical equipment's shall not be more than 5 years old at the time of contract award. In case this criterion is not met, then the type test shall be conducted before delivery of equipment without any additional cost & schedule impact to the Owner. Vendor shall specify in his offer addition cost for any special tests/type tests, which are envisaged to be conducted for various electrical equipment in MR.

All electrical panels shall have potential-free contact for remote monitoring and all numerical relays shall be communicable through MODBUS protocol.

LT TRANSFORMER

11/.415 kV, 400 KVA LT Transformers shall be oil filled, natural air and natural oil cooled (ONAN) suitable for outdoor installation. Transformer will be capable of operating under natural cooled condition up to the corresponding rated MVA specified. Detail of transformer shall be provided in respective specifications & datasheets.

The transformers will be installed in hot, humid, tropical outdoor atmosphere and suitable for IP-55. All equipment, accessories and wiring will be provided with tropical finish to prevent fungus growth.

The coils will be manufactured from electrolytic copper conductor of suitable grade and fully insulated for rated voltage. Insulation will be of Class A. Coil will be so insulated that impulse, switching and power frequency voltage stresses are minimum. Insulation levels conform to relevant standards.

The winding material will be copper. The windings and connections of all transformers will be braced to withstand shocks which may occur during transport or due to short circuits, repeated peak loads and other transient conditions during service.

All insulation shall be of proven design. All insulating materials used will be compatible with transformer oil, under all service conditions. Clamping bolts for current carrying parts inside the transformer will be compatible with oil under all service conditions.

Transformers will be suitable for over loading as per IS: 6600. Transformer shall be provided with Off-circuit tap switch.

Tank will be made from high quality low carbon steel and will be of oil tight welded construction. The base of each tank shall be so designed that it shall be possible to move the complete unit by skidding in all direction without injury using rail.

Transformers installed adjacent to sub-station/building shall be provided with oil containing pits. The oil containing pit may be shaped as per OISD standard 173. The pit shall extend all around the transformer for a width of 20% of the transformer height, with a minimum width of about 800 mm.

The transformer shall be placed inside fence surrounding the transformer. The under carriage of the transformer shall be provided with detachable steel flanged wheels as specified in Design Criteria. Flanged wheels shall be spaced to allow specified rail gauge.

LIGHTING TRANSFORMER

0.433 KV / 0.433 kV, 200 kVA Lighting Transformers shall be dry type natural air cooled (AN) suitable for indoor installation. Detail of transformer shall be provided in respective specifications & datasheets.

Transformer shall be housed in freestanding enclosure of welded sheet steel frames with expanded metal screens of suitable size or louvers backed by wire mesh.

The transformer shall be double wound core type with cold rolled grain oriented silicon steel insulated laminations and clamped to minimise vibrations and noise. Core fastening bolts shall be insulated to reduce losses and to avoid hot spots. All the parts of the magnetic circuit shall be effectively connected to the earth system.

The winding shall be of copper and shall be designed for full load current and to withstand the thermal and electromagnetic stress arising due to the through fault current. The current carrying winding joints shall be electrically brazed.

Transformer shall be of energy efficient level 2 as per IS 1180.

Insulation shall be of cast resin type having class of insulation as H.

Transformer shall have degree of protection as IP-42 for indoor Installation; however Marshalling box and cable termination box shall have degree of protection not less than IP-55.

The percentage impedance of transformer shall generally be as per Indian Standards. However, the specified impedance rating while carrying out the electrical system study shall be informed later in the technical specification of the said equipment.

NEUTRAL GROUNDING RESISTOR

Neutral-grounding resistor is intended for neutral earthing of power transformer.

NGR will be sheet steel enclosed, base channel mounted, outdoor / Indoor type as specified in the design criteria. The material of NGR will be Fecral Stainless Steel.

The resistance grids will be supported on porcelain insulators of adequate mechanical strength and having minimum total creepage distance related to atmospheric condition mentioned in relevant standard.

All conductor terminations will be bolted, welded or brazed. Low melting alloys should not be used for connections. Air insulated cable boxes or bushings will be provided for incoming and outgoing terminals as specified.

LT SWITCHGEAR

The 415V Switchgear shall be designed to ensure maximum safety during operation, inspection, connection of cables and maintenance with Switchgear energised. The switchgear shall be totally dust and vermin proof. The details of LT Switchgear and feeder ratings are given in Single Line diagram.

Each unit of the switchgear shall have necessary internal sheet metal barrier to form separate compartments for buses instruments/ relays/ cable connections etc. Compartment for cable connection shall allow cable pulling, termination and connection work with switchgear energised. Suitable arc propagation barriers shall also be provided. Independent pressure release flaps shall preferably be provided for each different compartment of the Switchgear.

The drawout carriage on the switchgear shall have three positions viz., 'Service', 'Test' and 'drawn out'. It shall not be possible to operate the circuit-breaker unless it is fully in service or Test or isolated position. The similar rating of breaker compartment shall be interchangeable. Automatic safety shutters shall be provided to ensure the inaccessibility of all live parts after the breaker is drawn out.

Busbars and supports shall withstand specified short circuit level without permanent deformation. Busbars shall be preferably sleeved and joints shall be taped/ shrouded. Minimum clearances between live parts, between live parts to Earth and Neutral shall conform to IS 4237.

Starting of motors from substation shall not be allowed and switch boards shall not have close push button at switchgear for motor starting.

Emergency diesel generator incomer shall be rated at least equal to 110% of the continuous rating of generator and transformer incomer shall be rated at least 110% of transformer rating as applicable. In no case shall the tie breaker rating be less than the bus-bar current rating.

Circuit breakers/contactors controlling motor feeders shall have a rating of at least 125% of the maximum continuous rating of the connected motors.

All circuit breakers of LT Switchgear and MLDB shall be of the drawout type housed in individual metal enclosed compartments. The air circuit breakers shall be three pole electrically operated with motor driven stored energy operating mechanism. The continuous rating shall be as per Single Line Diagram. The motor for operating the spring loading device shall be for 240V AC supply. The closing and tripping coils shall be suitable for 110 V DC. The closing mechanism shall be trip free and wired so that pumping is not possible. Manual charging and operation of the breakers shall be possible. The provision for remote indication and operation shall be made.

All MCCBs of LT Switchgear and MLDB shall be drawout type housed in individual metal enclosed compartments. Each MCCB shall be mounted on a carriage assembly with wheels running on tracks secured to the inside of the compartment. A mechanical interlock shall prevent moving of the MCCB from the connected position while the breaker is closed and also prevent the access door being opened unless the breaker is in withdrawn position.

All relays shall be numerical type providing comprehensive protection as required for each feeder. Relays shall be provided with communication interface. It should be possible to program the relays from the work station as well as relay face.

All distribution boards (MLDB/DB) not directly fed from generator and transformers shall have rating at least equal to the maximum demand under any circuit configuration plus a provision for 10% future load growth. Incomers of these DBs shall be designed to cater to the complete load including 10% margin for future load growth. The feeder ratings of MLDB is given in Single Line Diagram. The MLDB/DB shall be designed for 35KA.

The LT Switchgear and MLDB/DB components viz. Circuit breakers, main horizontal and vertical bus-bars, bus-bar joints, bus-bar supports etc. shall be designed to withstand the maximum expected short circuit level for a minimum time of 1 sec.

The Earth fault protection shall be provided to motor feeders using CBCT and Earth fault relay.

MCCB for contactor motor starter shall have only magnetic coil for short circuit protection.

BATTERIES

Batteries shall be of adequate capacity to meet the back-up requirements as envisaged on the duty cycle as well as to take care of future load growth of 10%.

While sizing the battery, temperature correction factor and ageing factor shall be considered in addition to the maintenance factor. Batteries shall be complete with battery racks and accessories.

The batteries shall be 110V 200 AH lead acid type having positive Tubular plates complete with electrolyte, supporting racks and accessories along with float cum boost charger and 110V DC Distribution Board. The short circuit current rating of DCDB shall be 20KA. DCDB shall be provided with 20% spare feeders to cater to future loads.

The number of cells for 110V batteries shall be chosen to suit the following conditions:

The nominal floating voltage of batteries shall be 110V.

The manufacturer shall ensure that the terminal voltage at 110V terminal of batteries shall not fall below 90% of rated voltage after meeting required load for satisfactory operation. Further the voltage across continuous load shall not exceed 110% of the corresponding rated values under charging conditions.

The charger shall be connected to 110V load and will operate parallel with the battery. The charger shall be capable of supplying boost charging as well as trickle charging current.

The battery charger shall be static rectifier type, fully automatic and solid state type, regulated for input voltage 415V, 50Hz, three phase. These shall be without fans or moving parts. The rectifiers shall be full wave bridge type using silicon thyristors.

The battery charging unit shall be suitable for both buffer mode and standby power operation. In both cases charging follows the IU curve as defined in DIN41773. When mains power is available, the battery charger shall accept the respective load current and charge the battery with the float charge current so that the battery maintains its full charge. The charging unit compensates for short term discharge of current from the battery. In the event of main power supply failure, the battery is required to take over uninterrupted supply of the load. At the same time, the battery voltage may fall at least to its open circuit voltage. Therefore when main power is restored, the charging unit shall immediately supply the load current and charge the battery in parallel with the available residual current. On reaching present value of charging value, the battery accepts only the float charge current. The value of short circuit rating for chargers shall be suitable for the batteries offered.

The battery shall be vented lead acid type with tubular positive plate and pasted negative plate. The self-discharging shall be not more than 0.1% per day. The number of cells in series shall be 55. The electrolyte shall be of dilute sulphuric acid with a rated density of 1.22 Kg/litre at 20 degree C. The battery service life shall be guaranteed to be not less than12-15 years provided the requirements imposed on storage batteries are followed up.

The charger shall be suitable for 40A rated direct current with charging voltage of 2.4V/cell +/- 1% and float charge voltage of 2.23V/cell +/- !%.

If battery voltage falls below an adjustable threshold, a deep discharge protection shall be provided for disconnecting the load from the battery to prevent possible deep discharge which would damage the battery.

Dry type transformers and static type rectifiers shall be used throughout.

UNINTERRUPTED POWER SUPPLY SYSTEM

The panels for UPS system shall be of floor mounted, free standing, metal enclosed and vermin proof type having hinged door for front access and suitable for indoor use.

UPS shall consist of PWM inverter utilizing IGBT as switching device, electronic static bypass switch, manual maintenance bypass breaker, microprocessor based data monitoring system.

The UPS continuously supplies stable conditioned AC power to the critical load. The 110V DC supply is used as inverter input.

UPS system shall be sized to take care of the crest factor of the load current. The UPS shall be provided with fault diagnostic unit.

The continuity of power to critical load can further be maintained through static bypass in case the inverter fails/trips. The transfer from inverter to bypass takes place without any interruptions if the inverter is within synchronization band. Manual/auto retransfer operation from bypass to inverter is possible only in synchronized condition.

The manual bypass operation gives the maintenance facility for Inverter by transferring the load on static bypass and then on manual bypass manually with MAKE-BEFORE-BREAK operation.

The UPS thus comprise of Inverter 10 KVA, parallel kit, by-pass isolation transformer 10KVA, Main ACDB with all accessories. The UPS ACDB shall be provided with 20% spare outgoing feeders to cater to future loads.

MOTOR

In general, three phase squirrel cage induction motors designed for direct on line starting shall be used. Motors shall be totally enclosed, fan cooled type and enable for continuous use.

All motors shall be continuous maximum rated which may be rated for the envisaged duty cycle

Generally Motors up to and including 200 kW shall be rated for low voltage i.e. 415 V.

The vertical motors shall have thrust bearings suitable for the load imposed by the driven machinery, unless otherwise specified.

Winding insulation shall be class F and temperature rise limited to that specified in the applicable IS for class B insulation. Motors with anti-condensation heaters shall have a separate terminal box provided for the same. Space heaters shall be provided for the motors rated10kW and above.

The motors shall be suitable for starting under specified load conditions with 75% of the rated voltage at the terminals.

For high starting torque motors where minimum 150% of the rated torque shall be provided and starting time shall be limited to ensure adequate protection by motor protection relays that are breaker fed.

The motor hot withstand time at 100% voltage shall be 2sec. (Min) more than the starting time of the motor at 80% voltage.

Motor ratings and torque characteristics shall be adequate to accelerate the load from zero to rated speed under starting requirements as stipulated by process operating conditions.

MOTOR CONTROL

The normal method of control from the field shall be with momentary ‘start’ contact and maintained “stop” contact.

The local control station shall consist of below:

Start/stop push button (Pad lockable facility at “stop” shall be provided.)

Auto/Manual selector switch

Ammeter (for motor above 30kW)

No push button shall be provided directly on LT Switchgear.

Motor field local control station (LCS) shall be directly wired to motor control unit in order to start or stop the associated motor, auto/manual select switches (if any) shall be wired to central control station via MCC using common cable for start stop selector switch.

Local control station shall be installed adjacent to and within reach, of the associated controlled motor.

EMERGENCY DIESEL GENERATOR

The emergency generator set shall be procured as a complete package and shall be designed to start automatically on power failure and feed the selected loads. It shall be capable of taking care of the load variations (e.g. starting of the largest rated motor). The unit shall be complete with necessary starting equipment, associated automatic mains failure control panel (AMF panel) and shall be suitable for auto/manual remote starting (in case of failure of AMF panel). AMF panel shall have facility to local manual starting of DG set.

The emergency generator set shall comprise of silent type Diesel Generating set having prime mover rating of 250KVA, 415 Volts at 1500RPM, 0.8 lagging power factor at 415V suitable for 50 Hz, 3 phase system consisting of following Diesel Engine. The Diesel Engine 4 stroke water cooled electric start of suitable BHP at 1500 RPM suitable for above output of alternator and conforming to BS 5514, BS 649, IS 10000.

The engine shall be fitted complete with all the required accessories including the following accessories:

Flywheel to suit flexible coupling,

Flexible coupling,

Exhaust gas turbo charger,

Automatic safety control in case of high water temperature,

Automatic safety control in case of low lubrication oil pressure,

Automatic over speed trip protection,

Lubrication oil pump,

Lubrication oil filter,

Lubrication oil pan,

Lube oil by pass filter,

Fuel pump,

Fuel filter,

Hoses for fuel tank,

Air intake manifold,

Air cleaner dry type,

Electronic governor,

Self-starter,

Alternator for battery charging,

Flexible pipe for silencer,

Engine mounted instrument panel having digital display for different parameters.

Synchronous alternator shall be rated at 250KVA, 415 volts at 1500 RPM, 3 phase, 50 Hz, AC supply with 0.8 lagging power factor at site condition. The alternator shall have SPDP enclosure, brushless, continuous duty, self-excited and self-regulated through AVR conforming to IS: 4722 / BS 2613 suitable for tropical condition and with class F/H insulation.

Both the engine and alternator shall be mounted on suitable base frame made of MS channel with necessary reinforcement which shall be installed on suitable cement concrete foundation and vibration isolation arrangement as per recommendation of manufacturer.

Daily service fuel tank of 990 litres capacity fabricated out of 3 mm thick MS sheet shall be provided complete with all standard accessories and fuel piping between fuel tank and diesel engine with MS class C pipes of suitable diameter complete with valves, level indications and accessories as required.

The regulation of generator voltage shall be automatic and necessary instruments for metering viz., ammeter, voltmeter, frequency meter, kwh meter, power factor, hour run counter etc. shall be included in control panel. Warning of abnormal conditions shall be incorporated prior to automatic trip to prevent unnecessary shutdown.

Emergency generator shall be rated for hours of prolonged operation. The generator shall have at least 10% spare capacity for meeting future requirements. D.G set will be suitable for operation at 10% overload for one hour in every 12 hours.

Emergency D.G. set shall have auto-starting arrangement but only with manual switching off features. “Fail to start” annunciation shall be provided, in case the engine fails to start.

The DG set shall be equipped with auto on mains failure scheme (AMF). The Auto-Mains failure scheme shall be PLC based.

The load shall be switched on to the generator only after the requisite voltage build-up. The generator set shall be provided with complete protection against overloads, short-circuits, ground faults, excitation failure, prime mover failure and shall include other connected instrumentation interlocks.

POWER CABLES AND WIRES

MV power cable shall be stranded Aluminium construction, multi-core/ single core, XLPE insulated, extruded black FRLS PVC inner sheathed and overall FRLS extruded black PVC sheathed armoured cables.

LV power cables shall be with stranded Aluminium conductor, multi-core/ single core, XLPE insulated, PVC inner sheathed & FRLS PVC outer sheath armoured cables.

The control cables shall be with stranded Copper conductor, XLPE insulated, PVC inner sheathed & FRLS PVC outer sheath. Twisted pair or shielded control cables shall be used where electromagnetic / electrostatic interference is expected.

All power and control cables shall have extruded inner and outer sheaths.

The cables shall be sized based on the maximum continuous load current, the voltage drop, system voltage, system earthing and short circuit withstand criteria. The derating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other, thermal resistivity of soil, etc. shall be taken into account.

All incoming cables to switchgear / MCC/ DBs and other equipment shall be sized for actual rated capacity of the equipment.

Multicore / multi pair control cables shall have minimum 20% spare cores.

All power and control cables shall be in continuous lengths (except for long feeders) without any splices or intermediate joints. The cables used for lighting and wires in conduits shall have appropriate junction boxes with adequately sized terminals.

CONTROL STATION

Each motor shall be provided with a local control station in the field unless otherwise a specific requirement from any package vendor.

The control station enclosure shall have suitable protection for site conditions (such as weather proof, dust proof, corrosion resistant etc.). Canopy shall be provided to protect outdoor control stations against direct rain.

The control station shall include the following minimum equipment as per individual requirement;

- Start/stop push button pad lockable in stop position motors

- Ammeter for all motors 5.5kW and above

- Auto/Manual or Local / Remote selector switch

- Cable glands

Stop push button shall generally have stay put feature.

All control stations shall be provided IP 65 protection.

Motors installed at elevated platforms shall be provided with a stop push button at ground level in addition to the one near the motor.

Weatherproof emergency pushbutton station near distribution transformer room shall be to trip transformer feeder in case of emergency. The switch shall be with pad lock feature.

Stop push button shall generally have stay put feature except in some special cases as per requirement.

WELDING AND CONVENIENCE RECEPTACLE

Adequate number of welding receptacles shall be provided at suitable locations to ensure accessibility with a 30-meter length of trailing cable to any point in the process area. These shall be rated for 63A, 5 pin suitable for 415V, 3 phase system with a scraping earth. Outdoor receptacles shall be provided with FRP canopy.

The enclosure shall have suitable protection for site conditions specified (weatherproof, dust proof, corrosion resistant) etc. These shall have the necessary mechanical interlocks and earthing facilities.

Adequate number of sockets for lamps and portable tools shall be provided at suitable locations to ensure accessibility with a 15-meter length of cable to all process equipment's & other important areas. These shall be rated for 6A, 5 pin with earth connection. Automatic protection employing earth leakage detection scheme (e.g. using ELCB with current sensitivity of 30 mA) shall be provided to disconnect supply on occurrence of an earth fault.

Sufficient dual 16/6A, convenience outlets shall be provided in areas requiring man access.

Motor Operated Valve (MOV)

The MOVs shall be provided with integral starters and shall conform to Instrumentations specifications for MOV. MOVs shall be provided with remote ON/OFF facility.

Necessary contacts and other interfacing devices for integration with control room shall be provided as per process requirement.

Electrical will provide single point 415V, 50Hz power supply to valve DB placed at suitable location for power distribution of MOV's. Field MOV panel shall be considered if long route length and large number of MOV's.

The earth fault protection shall be considered for MOV feeders.

All MOVs shall be with Limit switch, Torque operated switch and Phase reversal prevention switch

Large Screen Display

The large screen shall be connected to both network switches through CPU and capable to display the same graphics as displayed by the screen on any location. On screen commands shall be possible with the click of the mouse located on respective system. It shall have following features:

Diagonal size:	Minimum 50''
Resolution:	Full HD (1920x1080)
Screen Brightness:	450
Contrast Ratio:	1600:1
Pixel Shape:	Square
Lifetime:	60000 hours
Screen Type:	Ag screen, 3 layer
Screen to screen gap:	<0.7Mm
Brightness uniformity:	>95%
Colours:	16.7 Million
Operating Temperature:	0-50 degree C
Serviceability:	Full Rear Access
Power Supply:	2240V AC 50 Hz
Noise:	40-50 db
Control:	IR Remote, RS-232/Rj45 Ethernet TCP/IP
Screen Dimension:	Minimum 43.6''(W) X 31.3''(H)

The above screen shall be suitable for continuous operation for display of arrival / departure. It shall operate jointly with PC or connected to server to receive information of each arrival /departure for display on the screen.

Surveillance System

Surveillance system shall comprise of control console, monitor, switching unit, line unit, coupling unit, TV cameras with remote control of pan and tilt video recorder.

The CCTV is intended for remote monitoring of different operations. The TV image can also be recorded on the video recorder. The visual surveillance facility with control console and video recorder will be located in the Electrical room. TV cameras shall be located as shown in layout drawings. There are 6 nos dome cameras and 10 nos PTZ outdoor cameras with bracket.

The CCTV shall be able:

To monitor and supervise in colour the objects, outdoor and indoor areas,

To control TV cameras and pan and tilt units remotely from Electrical Room,

To over view simultaneously images on one monitor from several TV cameras (up to 4),

To operate in the automatic mode according to the programme specified by the operator,

To transmit video signal and supply power to TV camera over a signal cable,

To operate jointly with PC,

To tag current time, date, TV cameras for recording on video recorder,

The CCTV system shall comprise control console, monitor, switching unit, line unit, coupling unit and TV cameras.

Control Console: The Control Console is intended for control of multi camera installation using the 2 wire communication line. The control console shall ensure:

Remote switching on and switching off of the TV cameras,

Control of TV camera switching and

Control of pan and tilt units.

Monitor: The monitor will ensure:

Display of any four input images at the operator's command,

Automatic over view of input images.

Switching unit: The switching unit shall perform the following functions:

Processing of control signals for pan and tilt units,

Switching of video signal for output,

Switching of video signal and its transmission over coaxial cable.

Line Unit: The Line Unit shall provide:

Power supply to control console,

Conversion of input and output control signal levels,

Correction of video signal distortion transmitted by coaxial cable.

Coupling Devices: The coupling device is intended for multi camera TV installation. The coupling unit shall perform the following functions:

Power Supply to TV cameras,

Transmission and receiving of control signals over two wire communication line,

Transmission of video signal over coaxial cable.

TV Cameras:

Colour TV cameras integrated with pan and tilt units for indoor use,

Colour TV cameras integrated with pan and tilt units housed in protective enclosure and intended for outdoor use.

Video Recorder:

The video recorder shall have 24 hour time laps in different modes of slow down and on line recording with sound and different modes of playback,

The surveillance of 16 cameras for monitoring from any camera location.

Communication System

The Communication system shall comprise of the following:

General Telephone System,

Intercommunication System,

Loud speaking and staff locating system.

Automatic Telephone Communication shall have Digital automatic exchange, telephone sets of desk and wall type. It shall have following devices/components:

Intercommunication System: Operator's switchboard (master control multifunctional station), recording and playback facility (recorder).

Staff Location (Paging) and Public Address System: The amplifier stations, speakers of 2 W, speakers of 6 W, cone speakers of at least 10 W and subscribers' speakers,

Cable Work: Telephone box, junction boxes, multi pair telephone cables, single pair telephone drop wires.

The automatic telephone services as per above features shall be provided by digital programmable automatic) exchange of EPABX type of 6 P&T ports, 30 extension ports (upgradeable up to 140 extensions) to be installed in Electrical Room with facilities for:

Connection of subscribers' lines,

Connection of digital subscribers' lines,

The lines with automatic exchange,

The subscribers' telephone terminals shall include:

Analog push button telephone sets permitting operation in the tone and pulse mode,

Digital multifunctional telephone set to be installed in different areas.

The communication system shall include the facility (recorders) for automatic recording of the conversation and its playback which are to be connected to the multifunctional telephone sets. The recorder can be coupled to the line both automatically and by hand.

The automatic telephone exchange shall provide the following services:

Subscriber shall have facility using one telephone set to organize several independent talks with possibility of mutual inter connection, joint conversations and listen in functions,

a new call while holding up the conversation in progress,

Diversion of calls,

Conference coupling,

Circulating conference.

The system shall include the PA and staff locating (paging) system. For this purpose provision shall be made for amplifier station of 500W to be installed in the communication centre located in Electrical Room. The amplifier station shall permit paging of the personnel and passing of important messages to all areas over different feeders as well as to distribute music or speech programs. The feeders shall be programme controlled remotely from the operator's switchboard. The programme shall provide both selective and collective control of the feeders and distribute music or speech programs.

Wired Broadcasting station: the wired broadcasting equipment shall comprise:

Audio power amplifier of 500W output power,

Switching equipment for radio feeders,

Equipment monitoring system,

Receiver,

Professional audio recorder.

Audio Power Amplifier: The audio power amplifier is intended to page personnel, pass important messages and distribute music or speech programmes. The amplifier shall be designed for continuous operation and protected against overload and short circuit. The amplifier shall have priority in one of the microphone outlet.

Mixer Unit: The Mixer unit is intended to compensate for noise and suppress feedback.

Control Unit: The control unit permits transmission of information both over separate radio feeders and through all radio feeders and through all radio feeders simultaneously.

Telephone Set: The offices and other areas shall be furnished with push button telephone sets of desk/wall mounting type and modern design. The telephone set shall have syllable intelligibility of at least 80% at noise level of 60db. The calling signal volume shall be adjustable and shall be at least 70 db. There are 9 no desktop telephone sets and 11 no wall mounted telephone sets. Out of 9 no desk top handsets 5 no are digital phones whereas the remaining are analog handsets. The wall mounted telephone sets are all analog type only.

Master Control Station Multifunctional Telephone: The intercom master station to be connected to the digital automatic exchange which shall provide high quality control due to combination of the intercom analog master control station functions and capabilities of the digital automatic exchange. The intercom master control station shall have a wide range of different functions and convenient user's interface. The master control station shall have a keyboard with assigned keys for programmable access to any subscribers', external or connection lines.

Multi Pair Telephone Cables: The multi pair telephone cables shall be suitable for communication lines to be laid inside wall of buildings and outdoor areas. Telephone communication system shall be carried with cables to be laid on the racks, trays along the walls or underground. Power and telecommunication cables shall not be laid down together on the cable racks and trays. In case of joint running of telephone and power cables, the minimum distance between them shall be in the manner specified by the Codes of practice. When the cables are laid down on the wall surface, they shall be run through PVC conduits. When cables are laid underground a sand cushion shall be arranged on the trench bottom and covered by bricks. All cables shall carry a tag with indication of its type, no as shown in the cable logbook.

Solar Power

The Solar Power Plant shall generate 20 kW from the solar power panels installed on top of the linkspan bridges.

The system shall include array junction boxes, main junction boxes, installation kit and earthing kit etc. The power conditioning unit shall be PCU – 96V DC – 5 KVA – 230V AC, 50Hz and connected to solar array for DC to AC output.

The battery bank shall be tubular type of 96V, 400AH. The interconnection between devices shall be with stranded Cu cables only.

LAYOUT PHILOSOPHY

The sub-stations shall be located in a safe area close to the load centre. Control room, UPS room, battery charger / battery room shall be provided with at least 25% space for future expansion.

A separate entry with rolling shutter shall be provided for drawing in all equipment for erection. The main entry for operating personnel shall be preferably provided with double door system. The sub-station shall also have an emergency door opening outwards.

Battery banks shall be located in a separate adequately ventilated room adjacent to the Electrical Room along with the necessary exhaust system and water connection with sink. The floor & wall tiles (up to 1.5 mtr. height of room), light fittings in this room shall be chemical resistant type. One set of accessories consisting of cell testing voltmeter, spanner, face shield, PVC apron, rubber gloves etc. shall be provided in battery room.

A Switchgear room shall be provided in the sub-station for locating LT Switchgear, electrical panels, battery charger, UPS panel, Fire Fighting Panel etc.

Sub-station shall have firefighting equipment, first aid boxes and other safety equipment as per statutory requirements. Mats of required voltage rating shall be provided in front of switchboards.

The Electrical Rooms shall be sized to take care of present and future needs and to maintain adequate clearances between equipment for ease of maintenance.

The following minimum clearances around various equipment shall be maintained;

Front clearance for all other switchboards /2000 mm Panels

Rear clearance for panels having Less than 200mm maintenance access from front only

Rear clearance for panels requiring 1500 mm (MV Swbds) & 1000 mm (LV Swbds) for maintenance

d) Side clearance between two switchboards 1000 mm

Vertical clearance above the top of the highest equipment shall be minimum 1500 mm measured from bottom of roof slab and minimum 500 mm measured from the bottom of the lowest roof beam. However, for the areas with false ceiling, minimum clearance of 750mm shall be provided between false ceiling and top of any equipment.

EDG set foundation shall be structurally delinked from the slab/floor of the rest of the sub-station building. Exhaust of diesel engine shall be kept away from the process handling areas and diesel day tanks shall be located outside the EDG shed. Suitable ventilation system shall be provided to avoid heat accumulation in the EDG shed.

INSTALLATION PHILOSOPHY

GENERAL

The installation work for the equipment, cabling system, earthing system and lighting system shall generally conform IE rule and Indian standards.

Cabling System

Cabling system for various areas shall be generally as under, unless otherwise specified in job design data.

- Above ground galvanized cable trays on pipe racks and partly through approach trestle

- Lighting, fire alarm, communication and other cables shall be laid on overhead cable trays.

- Direct buried (from ASEB power supply point to proposed Substation)

Cable trays & racks shall be sized to allow for 25% future cables. Routing shall be decided to avoid interference with pipes or places subject to undue fire risk. Cable installations shall provide minimum cable bending radii as recommended by cable manufacturer. Separate trays shall be provided for MV/LV power, control and plant communication cables. However, in case of some limitation LV power and control cable can be placed in same tray with suitable barrier. Separate cables shall be provided for AC and DC signal/control circuits.

For tray system design, in addition to self-load and wind forces, following guidelines for design shall be considered as minimum:

a) Support span : 3000 mm

b) Cable load : 75 kg/linear meter

In addition to this, 75 kg concentrated load at center span shall be considered. All structural steel design shall be as per Indian Standards.

Bends, tees, reducers, crosses, droppers etc. shall have the required bending radii as required for various cable sizes with a minimum of 300 mm.

Instrumentation cables shall not be laid in the LV/control electrical cable trays. The overall cable layouts shall be designed for 300 mm minimum interference between signal and power cables.

The armour and semiconductor screen of single core cables shall be earthed at one end. The continuity of armour and semiconductor screen shall be broken at each joint. The unearthed end of armour and screen shall be insulated.

Where cables are laid direct in the ground the bottom of such areas shall be cleared of all rocks, stones and sharp objects and covered with a 75 mm lightly compacted layer of sifted soil or clean sand. After laying, the cables shall be covered with a further layer of lightly compacted sifted soil or sand to a depth of 75 mm. While crossing the roadways, underground cables shall be protected by hume pipe and shall be laid at a depth of minimum 1000 mm such that cables shall not be damaged. Hume pipes shall be preferred to GI pipes from the point of view of corrosion.

The straight through joints shall be avoided to the maximum extent possible.

All cables shall carry the cable tag numbers for easy identification at both ends as well as every 3mtr throughout its run.

Earthing & Lightning Protection System

Earthing & Lightning system in general shall cover the following;

- Equipment earthing for personnel safety

- System neutral earthing

- Static and lighting protection

The size of main earth grid around the substation and Terminal Building shall be as per earthing calculation.

All utility / process pipelines shall be earthed on entering or leaving the hazardous areas. In addition, steel pipe racks shall be earthed at every 25 meters. Earth continuity shall be ensured across all the flanges in process units and other hazardous areas. Equipment located remote from main earth network, may be earthed by means of individual earth conductors and earth electrodes.The numbers of connection points shall be as given below:

Sr. No	Particulars	No. of Earthing Points
1	Equipment such as tanks, vessels & Heat exchangers etc.	2
2	EDG SET	2
3	LT Switchgear/MLDB	2
4	500 KVA Transformer	2 (for neutral) 2 (for body)
5	Lighting Transformer	2 (for neutral) 2 (for body)
6	UPSDB/Lighting and power panels/PDB/Battery charger	2
7	Control panels	2
8	Low Voltage Motors	2
8.1	Motor up to 7.5kW	2
8.2	9.3Kw to 37kW	2
8.3	Above 37Kw to 90kW	2
8.4	Above 90kW	2
9	Local Control Station	2
10	Lighting Pole	2

The resistance value of an earthing system to general mass of the earth should not exceed.

4 Ohms for electrical systems and metallic structures

7 Ohms for storage tanks

1 Ohm for main earth grid, and bonding connections between joints in pipelines and associated facilities.

2 Ohms for each electrode to the general mass of the earth.

The main earth network shall be used for earthing of equipment to protect against static electricity.

In general, the resistance value of an earthing system to the general mass of earth shall be as follows;

For the electrical system and equipment, a value that ensures the operation of the protective device in the electrical circuit but not in excess of 5 ohms. However, for substation this value shall not be more than 1 ohm.

For lightning protection, the value of 5 ohms as earth resistance shall be desirable but in no case, it shall be more than 10 ohms.

For earthing of installations on approach trestle, jetty area and for equipment on control room and pump house etc. the earthing strips shall be terminated by clamping on to the piles below water level. For more effective earthing the earth strips shall be embedded in the foundation of piles.

As a minimum, lightning protection shall be provided for the equipment, structures and buildings as per IS-2309. Self-conducting structures may not be provided with aerial rod and down conductors, they shall however be connected to the earthing system at minimum two points at the base. An independent earthing network shall be provided for lightning protection and this shall be bonded with the main earthing network only at the buried electrode.

Lighting System

Plant lighting system shall comprise;

Normal lighting

Emergency lighting

Critical lighting

Aviation lighting (applicable for taller structure considering ICAO & DGCA guideline)

Normal and emergency lighting shall be fed by AC supply (415 / 240V, three phase four wire) while critical lighting shall be fed by AC UPS supply. Critical lighting in remote location (i.e. away from the substation or control room) shall be provided with fixtures containing with battery back suitable for ninety minutes (i.e.1.5 hour). The emergency lighting load shall be fed from EDG supply.

The lighting fixtures on various circuits shall be suitably interlaced so that failure of any one circuit does not result in complete darkness. All outdoor lighting shall be automatically controlled by means of photoelectric cell / synchronous timers with manual overriding control. .

Normal lighting system shall provide enough illumination so as to enable plant operators to move safely within the accessible areas of plant to perform routine operation including reading of field instruments, operation of all valves etc. and to carry out all the necessary maintenance and adjustment to equipment.

Areas requiring AC critical lighting shall include, but not be limited to the following for the duration of one hour;

- Control rooms
- Terminal Building and pontoon areas
- Exit lighting
- Emergency Escape corridor

Areas requiring AC emergency lighting shall include, but not be limited to the following;

- All Areas requiring critical lighting (mentioned as above)
- Strategic locations in process, utility areas where specific safety / shutdown operation are to be carried out.

The illumination lux level for normal and emergency lighting shall comply with the relevant standard.

Lighting design shall conform to relevant International Codes and Standards, IES Hand Book and shall take into consideration the requirements from point of view of safety and ease in operation and maintenance. The maintenance factor shall be considered as per area of installation.

LED lamps shall generally be used for outdoor plant lighting & indoor buildings. Also, AC critical lighting shall be with LED fittings. Tall structures shall have LED aviation obstruction lighting as per statutory requirements.

Lighting system shall consist of lighting transformers for reduction of fault level, lighting distribution boards (LDBs), lighting and power panels, fixtures, junction boxes etc.

Depending on the nature of job activities carried out, the minimum illumination levels for various areas shall be as follows as recommended by Indian Standard.

8. DESIGN BASIS – FIREFIGHTING

Fire Detection & Protection system is provided to meet following requirements:

a). To detect Fire Situation

b). To Protect - Control and Extinguish Fire.

An effective Fire Detection & Protection System results in minimizing the loss of property, human-life and downtime. The system is proposed for the following

a). Transformer Area

b). DG Room Area

c). Switchgear & Control Room

d). Office Room

e). Ticketing Room

f). Store

g). Pathway to Pontoon

h). Pontoon

GENERAL CONDITIONS

ENVIRONMENTAL CONDITIONS

Electrical Equipment Design temperature 40 °C

ELECTRICAL NETWORK DATA

Auxiliary power supplies

LV AC power supply:

- Rated Voltage415/240 V AC
- Variation Range ± 10 %
- Rated Frequency 50 Hz +5 %
- Earthing Mode Solidly Earthed

DC Power 24 V DC

System Description

Fire Detection, Alarm and Control System

The fire detection, alarm and control system are proposed to consist of different types of fire detectors, fire alarm panels, repeater panel (in electrical room), local panels etc. Panels It shall be microprocessor based, analogue addressable type.

Fire Detection System

The system is suitable to detect the presence of fire's smoke / heat in the room or around the equipment. Following are the fire's smoke / heat detectors:

Ionization type Smoke Detector is proposed for automatic water sprinkler / Inert gas system in (a) Office room, Ticketing Room, Meal room, Security room, Store Electrical room, Control & switchgear room to be installed below the ceiling or below the false ceiling, as the case may be, depending on civil design

Quartzoid bulb heat detection system is proposed to be provided for 11/0.415kV Transformer protected by HVW spray.

Electrical type Heat Detector is proposed for Battery Room.

Manual Break Glass Boxes is proposed to have a push button element kept in pressed condition by the glass fitted in the front of the box. Break glass boxes shall be used as manual call points.

b) Fire Alarm System

The Fire alarm panel, which monitors the smoke / heat detectors line, fire / fault condition in the "building (Office, Ticketing room, Electrical room, Store, etc.) & Transformer area, DG room, Control & Switchgear room, Battery room, etc." is proposed to be provided. The Fire alarm system consist of following

Hooters, in the event of fire, shall raise pulsating audio alarm and lamp shall flash.

The panel is also proposed to consist of solid circuitry on a printed circuit board, a loudspeaker and flashing lamp housed in weatherproof dust tight, wall mounted type enclosure. Fire Alarm Panel and operate with DC supply.

Siren shall be industrial type of 2.5 km (min) against the wind direction.

In case of any Multi Sensor Detectors or Manual Call Points being actuated a signal is transmitted to the Fire Alarm Panel which in turn actuates an Audio / Visual alarm in the Fire alarm panel and simultaneously initiate the signal for external hooters at the various places - such as on Pontoon, Pathway to Pontoon, Security room, control & Switchgear room, etc.

c) Control System

The control system is proposed to be provided to offer total flexibility for effective fire protection operations on the Pontoon; pathway to Pontoon; Building; Auxiliary area. The system shall enable control / operation of all systems from the electrical-room (except the hydrant valves).

d) Cables and Wires

The cables are proposed to be braided sheathed and laid down in suitably sized conduits, electrical tubings, metal moulding or metallic race ways and shall offer protection against fire and mechanical injury as per relevant standards and specifications. The use of wire nut type construction for wiring shall be prohibited. Screw terminal boxes shall be preferably used. All the cables and wires shall be suitably tagged for proper identification by colour bands and by ferrules at junctions respectively.

e) Public Address / Talk Back System

The public address & talk back system proposed for the Pontoon, Building, etc., shall consist of a main communication console located in the control room and speaker / talk back units located along the above said area. The spacing proposed is two nos., one at FWPH, and one every 100 meters on the approach trestle.

<u>Fire Protection System</u>

Fire protection layout and Fire protection scheme are described in drawing numbers "P.013223-P-20318-251 & 252" and "P.013223-P-20318-250".

Fire protection systems of following types (as applicable) is proposed to be provided.

- Water Filling Arrangement
- Jockey pumps and Hydro Pneumatic Tank
- Hydrant system and Water Spray system
- Inert gas system
- Portable fire extinguishers
- Piping layout and schematics

a) Water Filling Arrangement

Firefighting water storage tank is proposed to be filled by water drawn from Primary sump. The water-filling pump-motor sets shall be of two Nos (One main and other as standby) of vertical type, each of approximate 145 m^3/hr capacity.

Filling water from the primary-sump to fire-water-storage-tank is proposed to be filtered and thus routed through the duplex-filter, necessary piping, valves, fasteners and instruments, as required, shall be provided

This fire water is proposed to be drown from water storage tank through a set of fire pump-motor sets each of 137 m^3/hr @ 7 kg/cm^2. The fire water is proposed to be discharged through hydrants & piping distribution system.

The water storage tank is proposed, as per NFPA 15 Clause 4.3.3.1.3, for one (1) hours water supply for the single largest hydrant.

The fire-water-storage tank is proposed to have level switches for automatic starting and stopping of fire pumps provided in primary-sump. When the water level in the water-storage tank goes beyond the pre-determined level then the water level indicator drives the signal to the panel and thereby stopping the operation of primary pumps.

b) Jockey pumps and Hydro-pneumatic tank

Pressurization of water feeding lines/mains of both (1) hydrant system and (2) water spraying / sprinkling system is proposed to be done through the combination of hydro-pneumatic tank and Jockey pumps, of 15m3/hr capacity, two (2) numbers (1 working and 1 stand-by, both electric motors driven) and air compressors (2x100% capacity, 1 working and 1 stand-by, both electric motors driven).

Hydro-pneumatic (HP) tank is proposed to be filled up with water up to 2/3rd portion of its height. Air space will be kept above the water-filled portion. The HP tank will be equipped with necessary level switches and pressure switches and other instruments as required. Minor leakage in the pressurised fire water system will be replenished from hydro-pneumatic tank. When the level of hydro-pneumatic tank will be low, jockey pump will be started automatically to replenish the level of water in the tank. Jockey pump will be cut-out automatically when the level of water in the hydro-pneumatic tank reaches its higher pre-determined limit. Pressure switches provided in the hydro-pneumatic tank will be inter locked with the cut-in / cut-out operation of compressors, which will be used to maintain a constant pressure in the hydro-pneumatic tank.

In the event of fire, pressure in the hydrant or spray system will drop due to water flow. In this event, water loss in the system will be replenished by jockey pump. However, if this is inadequate to meet the demand and results in drop in pressure further to pre-set low pressure in the mains, first electric driven pump of the respective system will start automatically. In case of failure of starting of fire pump or due to increased demand of flow, the system pressure will reduce further, this will enable starting of subsequent (second) fire pumps in a sequential manner through means of various pressure switches. Failure to start the fire pump will be indicated as an alarm.

c)Hydrant System and Water spray system

The System comprises of a reliable source of water supply; network of pipe, combination of underground and above ground piping throughout the project. The system includes Hydrant arrangement, water mains network, hydrant valves, landing valves at each landing locations, water monitors. Hose cabinets with hoses, branch pipes, nozzles, hose boxes, central hose houses etc, at strategic locations.

The Hydrant system, along with Hose Reel and wet riser, is proposed to be provided for the complete project, including at least the following:

- Transformer (Oil Type) area
- DG set / Switchgear Rooms and Control rooms etc.
- Around Building area
- Pontoon Area
- Pathway to Pontoon

The hydrants shall be preferably double-headed type mounted on a 150 NB (Nominal Bore) dia. stand post connected to the fire mains. Each stand post shall be provided with an isolating valve & orifice plate and a Hose box.

Hose box containing 2 Nos hoses (each of 15-meter-long & 63 mm size) branch pipe and nozzle is proposed to be provided along with hydrant valve on each Pontoon, Pathway to Pontoon, around building area, around auxiliary equipments / rooms.

Fire hydrants shall normally in closed position & can be opened manually during occurrence of fire. Whenever there is a fire, the number of hydrant-valve is to be opened and depending upon the magnitude and location of fire. In this case water is directed towards the seat of fire through the hoses and branch pipes.

Line pressure will continue to drop due to opening of hydrants / monitors. The amount of water required will be catered from the storage water tank through fire pumps.

d) Sprinkler System

Automated water spray through sprinkler system comprises of network of underground and above ground piping, control valve, deluge valve), sprinkler bulbs, nozzles / projectors.

This system is proposed for Office, Security room, Baby Care room, First-aid room, Dining room, Shop, Janitor room.

e) High Velocity Water Spray (HVWS) System

Water spray systems are most commonly used for locations where liquids with flash point of 65 degree C and higher constitute fire hazard. Typical example here is Oil-Type Transformer.

The system comprises of network of underground and above ground piping, control valve, deluge valve,HVW Spray Nozzles / Projectors.

In HVWS system the deluge Valve which is normally in closed position. Whenever the fire breaks down and temperature around the protected equipment goes beyond the temperature rating of Q.B. detector (79 °C), installed around the equipment), then Q.B. detector will collapse, and it reduces the pressure in the detection line by draining the water, which results in opening of deluge valve and water will rush to spray water network, through the opened Deluge Valve. The DV operation makes the diaphragm in action to spray the water on protected transformer. Deluge valve shall also be provided with a local panel for manual electrical operation.

In addition to above, HVWS system will also be actuated by Transformer PRD (Pressure relief device) status from transformer marshalling box by the transformer manufaturer. If PRD in transformer reaches its predefined set pressure, FAP will receive this signal through DV panel. FAP will give command to solenoid valve of DV through DV panel for spraying through its respective control module. Operation of DV shall initiate unit shut down through command from control system.

Water motor alarm gong shall be provided to sound a continuous alarm while spray system is in operation.

Deluge Valve shall be manually reset to initial position after completion of entire operation. Each deluge valve shall be provided with a local panel for manual electrical operation of valve.

Butterfly valve with limit switches are provided on the inlet and outlet of DV for isolation at the time of maintenance. These valves shall be normally open. Gate valve shall be provided at bypass line.

f) Inert gas-based Fire Extinguishing System

This system is proposed for Control and Switchgear room, Electrical room, Ticketing Room.

This system comprises of gas cylinders, piping and control system. The inert gas (Nitrogen, etc), as recommended in NFPA 2001, is released in a controlled manner to dilute the oxygen content and consequently to control fire.

g) Portable Fire Extinguisher

Portable Fire Extinguishers, fire suit and first aid box are proposed to be provided, as per NFPA / LPA guidelines, at all strategic points of the building / DG Set & Transformer Area / Electrical Room / Battery Room / Pathway to Pontoon/ Pontoon, etc..

h) Piping Layout and Schematic

Piping for all the protection systems will generally be laid over ground, on RCC pedestals, except in locations such as road or in main plant area where it may not be feasible to route over ground.

8.1. SHOP AND SITE TESTS

8.1.1 Shop Tests

Shop tests of all major equipment such as pump-motor sets, diesel engines, Transformer, Batteries, piping, valves and specialties, pressure and storage vessels, electrical panels, controls, instrumentation etc. shall be conducted as specified in various clauses and as per applicable standards/codes.

Shop tests shall be carried out at manufacture's works, where the raw materials supplied for manufacture of equipment. All tests to be carried out including the tests described as follows:

a) Materials analysis and testing.

b) Hydrostatic pressure test of all pressure parts, piping, etc.

c) Dimensional and visual check.

d) Determination of performance characteristics of pumps, diesel engines, etc.

e) Calibration tests on instruments and tests on control panel.

f) Destruction/burst tests on 2% of total quantity of each type of hoses / fire-extinguishers or minimum one (1) no. of hoses and portable type fire extinguishers for each type as applicable. Any fraction number shall be counted as next higher integer.

g) Performance test on fire extinguishers as required in the code / standards.

In the absence of any Code/Standard, equipment shall be tested as per mutually agreed procedure between the supplier and the Employer.

Comprehensive visual and functional check for panels is proposed to be conducted and will include a thorough check up of panel dimensions, material of construction, panel finish, compliance with tubing and wiring specifications, quality of workmanship, proper tagging & locations of instruments/accessories. The wiring check shall be complete point to point ring out and check for agreement with installation drawings and equipment vendor prints of the complete system and an inspection of all field connection terminals and levelling.

8.1.2. Site Tests

General

a. All piping and valves, after installation will be tested hydraulically at pressure of 1.5 times that of the maximum attainable pressure in the system.

b. All manually operated valves/gates is proposed to be operated throughout 100% of the travel and these should function without any trouble.

c. All pumps are proposed to be running with the specified fluid from shut off condition to valve wide open condition. Head developed will be checked from the discharge pressure gauge reading. During the test, the pumps and drives shall run smoothly without any undue vibration, leakage through gland, temperature rise in the bearing parts, noise, flow pulsation etc.

d. Painting shall be checked by dry type thickness gauges.

e. Visual check on all structural components, welding, painting etc. and if doubt arises, these will be tested again.

f. All Test's instruments and equipment shall be furnished

g. Operation of entire annunciation system.

h. After erection at site, the complete hydrant system shall be subject to test, in line with NFPA requirement, to show satisfactory performance

8.2. SPARE PARTS

A set of recommended spare parts for five year of trouble-free operation shall be supplied.

8.2.1 Air Conditioning and Ventilation

Spilt Air Conditioning unit of 1.5Ton capacity is proposed to be provided in the Office, Ticketing rooms, Control & Switchgear room and Electrical room, as per requirement. It is covered in Electrical section.

Exhaust fans are proposed to be provided in Battery Room, Meal room, Wash room. Layout of Fans are shown in Electrical drawings.

Ceiling fans are proposed to be provided in Office, Security room, Waiting Hall area, Shop, Ticketing rooms, Electrical room. Control & Switchgear room. Layout of Fans are shown in Electrical drawings.

Bill of Quantity and Cost for Air conditioning and Ventilation equipment are covered in electrical chapter.

9. FRONT END ENGINEERING DESIGN OF TERMINALS (FEED)

9.1 Detailed Geotechnical Design

9.1.1 Design of Pile Foundation

Owing to the high scour and large lateral loads on the structure, steel pile foundation has been proposed for riverine structures such as dolphin and bank seat. In case of Terminal building, concrete cast-in-situ bore piles has been adopted as it is located on bank. The capacity of the piles has been estimated on the basis of the base resistance of the pile developed at the pile termination elevation and shaft resistance developed by friction between the soil and pile shaft. As Indian standard code for driven steel piles are not available therefore globally accepted guidelines for steel pile provided by American Petroleum Institute (API) has been referred for design of steel pile. For design concrete pile relevant IS code has been referred. The various inputs considered for estimation of pile capacity and the pile capacities thereby obtained are as described below.

The load intensity applied on piles is calculated in accordance with IRC recommendations. In the absence of relevant Indian codes for computation of pile capacity for steel piles, the applicable API standard is used. The consideration of closed end pile is ruled out since the length of pile to be driven is so high that it will be impossible to drive pile with base plate welded at the end. The detailed geotechnical capacity of piles as per codal requirements.

A. Subsoil Condition and Soil Parameters

The subsoil condition of the project is investigated by conducting exploratory borehole. The soil properties are determined from the various tests conducted at site and at laboratory. The subsoil condition and soil properties are discussed in Section 3.3. The design soil profile i.e the soil stratification and the soil properties considered for pile design are described in the Table 6-1.

Table 9-1: Design Soil Profile

Sl. No.	Predominant Class	Elevation from RBL (m)		R.L from RBL (m)		Layer Thk. (m)	Field SPT	Cohesion (kPa)	Angle of Internal Friction Φ-Value (Deg)	γ_{Sub} (kN/m^3)
		From	To	From	To					
1	Sand	37.255	36.255	0	-1	1	5	0.00	30	16.1
2	Sand	36.255	34.255	-1	-3	2	12	0.22	32	17.2
3	Sand	34.255	32.755	-3	-4.5	1.5	28	0.72	34	18.1
4	Sand	32.755	26.755	-4.5	-10.5	6	14	0.22	32	17.5
5	Sand	26.755	22.255	-10.5	-15	4.5	22	0.82	34	18.1
6	Sand	22.255	20.255	-15	-17	2	24	0.56	35	18.3
7	Sand	20.255	16.255	-17	-21	4	35	0.36	36	18.6
8	Silt	16.255	13.255	-21	-24	3	28	180	0	20.7
9	Sand	13.255	11.755	-24	-25.5	1.5	50	0.25	37	19.5

Sl. No.	Predominant Class	Elevation from RBL (m)		R.L from RBL (m)		Layer Thk. (m)	Field SPT	Cohesion (kPa)	Angle of Internal Friction Φ-Value (Deg)	γ_{sub} (kN/m^3)
		From	To	From	To					
10	Sand	11.755	7.255	-25.5	-30	4.5	89	0.65	40	19.8
11	Sand	7.255	5.755	-30	-31.5	1.5	57	0.55	39	19.8
12	Sand	5.755	2.755	-31.5	-34.5	3	51	0.25	37	19.5
13	Sand	2.755	-1.745	-34.5	-39	4.5	63	0.14	39	20.1
14	Sand	-1.745	-7.745	-39	-45	6	93	0.45	41	20.6
15	Sand	-7.745	-8.135	-45	-45.39	0.39	100	0.45	41	20.9

B. Pile Details

The details of the Steel pile proposed for the project are as follows

Table 9-2: Pile Details

Description	Value	
Type of Pile	Open ended Steel pile	Cast-in-situ Concrete Bore pile
Dimension of pile	Φ1.52m, thk. 25 mm Φ1.52m, thk. 31.8 mm Φ1.22m, thk. 31.8 mm	Φ1.00m
Unit weight of steel	78.5 kN/m^3	25.0 kN/m^3

C. Scour

As per the Hydrology and Hydraulic report for the project area, the Scour level has been considered at EL. 11.44 m for computation of geotechnical capacity of the pile.

D. Pile Capacity

The capacities of the piles estimated for the project have been tabulated in Table 9-3.

Table 9-3: Pile Capacities

Sr. No.	Structure	Dimension of Pile	Cut-off Level (m)	River Bed Level (m)	Scour Level (m)	Termination Level (m)	Penetration Depth below Scour Level (m)	Axial Compressive Capacity (kN)	Axial Tensile Capacity (kN)
1.	Dolphins for Berthing Pontoons	Φ1.520m, thk.25 mm	+57.0	+37.255	+11.44	-4.56	16	3278 (3201)	3580 (824)
2.	Dolphins for Intermediate Pontoons	Φ1.520m, thk.31.8mm	+57.0	+37.255	+11.44	-8.56	20	5266 (5121)	5505 (3335)
3.	Bank Seat	Φ1.220m, thk.31.8 mm	+51.0	+37.255	+11.44	-7.56	19	3818 (3517)	3954 (940)
3.	Terminal Building	Φ1.00m	+51.5	+37.255	+25.41	+10.41	15	3896 (2570)	1131 (---)

Typical pile capacity calculation has been provided in Annexure 9.1.

9.2 Design of Riverine Terminal Infrastructure

The layout and components of the riverine infrastructure have been planned as described in Section 4.4 and the structural design of these components follow the design basis as per Section 5. The following sections describe the methodology adopted for the analysis and design of each component of the riverine infrastructure.

As an alternative to the steel tubular piles, RCC bored piles with sacrificial MS liners installed vertically and in rake are checked and it is observed that RCC bored piles are not working for the extreme current forces.

9.2.1 Berthing pontoons

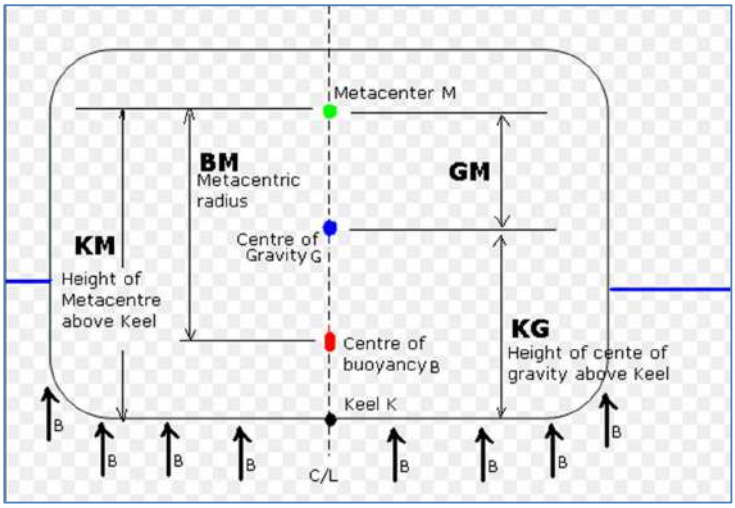
Three berthing pontoons have been planned for Phase 1 while two berthing pontoons have been planned for Phase 2 in Guwahati Gateway Ghat.

The floating pontoon shall be of structural steel with the following minimum requirements.

- 60m x 15m in plan
- Deck stiffened for uniformly distributed load of 5kN/m^2.
- Deck of high yield steel plate of at least 10mm thickness.
- Pontoon to be divided into buoyancy chambers, all with sealed access hatches.
- Pontoon to be profiled adjacent to link-span and vessel ramps to accommodate angle variations as a result of current forces.
- Guide frames with piles/ dolphins to hold the pontoon on position.
- Lifesaving equipment, safety ladders and fire control for small fire
- 2 No. Potable water hydrants.
- Water jet system to be installed beneath pontoon to prevent silt build up.
- 15year protective paint system to all steelwork.
- Fitted with sacrificial anodes (near low water mark) with 10yr life
- 20lux lighting mast illumination
- The walking/bike lane surface preparation on top of 12 mm plate shall comprise of anti-skid high grade abrasion resistant polyurethane resin based designed to give strength, flexibility and long life durability of minimum 5 years duly approved by engineer in charge.
- Safety restraints to IRC guidelines
- Fresh water hydrants for vessels and also for washing the pontoons.

The floating stability of the pontoon has been checked for 15m (width) and 60 m (length) of the pontoon. The loads including self-weight and live loads of 5 kN/m^2 have been considered in two load cases, with live loads on half the cross section (load case 1) and live loads fully loaded (load case 2). The metacentric height (> 0), the max angle of heel (10°) and minimum freeboard (>0.3 m) of the pontoon have been checked to be within the permissible limits.

The Metacentric height is a measure of the vessel's stability under small heeling also called the initial stability. The higher the value of GM, the better the vessel's initial stability. Thus, harder it is to get the vessel to heel.



The detailed floatation stability calculations for the berthing pontoons are given in Annexure 9.

9.2.2 Dolphins for berthing pontoons

A 3-D model of the dolphin is prepared in STAAD-Pro software and linear elastic analysis is carried out for the following loads:

- Dead load
- Live load
- Wind load
- Current load (on the structure and on the berthing pontoon)
- Seismic load
- Berthing reaction onto the pontoon

Detailed calculations of the above loads are presented in Annexure 9. Logical combinations of the above loads in line with the IS 4651 Part IV are used to obtain the results of the analysis.

The following figure shows the 3D analysis model prepared in STAAD-Pro.

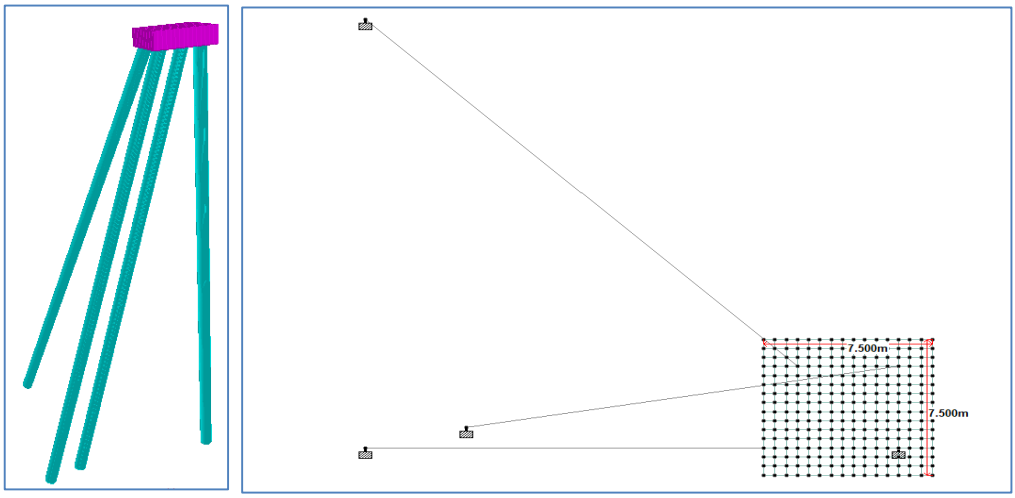


Figure 9-1: STAAD-Pro analysis model of dolphins for berthing pontoons

Reinforced concrete member sizing and design are carried out by Limit State approach as laid down in IS 456. Design of tubular steel piles is carried as per IS 800. The foundation shall consist of 1520 mm diameter x 25 mm thickness tubular steel piles. The deck shall be 2.0m thick reinforced concrete slab. The analysis and detailed calculations are presented in Annexure 9.

9.2.3 Linkspans

The linkspan bridges the gap between the two structures i.e approach trestle and the intermediate pontoon & the intermediate pontoon and the berthing pontoon. The link span shall be steel pratt truss/ steel bridge structure and shall cater for the differential level between the approach trestle & intermediate pontoon and between intermediate & berthing pontoon during high and low flood levels, by adjusting in a slope of 1 in 12. Five linkspans are proposed for this riverine infrastructure development with details as below.

Table 9-5: SALIENT FEATURES OF LINK SPAN

S.No	Location	Span
1	Link Span -1	32 m
2	Link Span- 2	32 m
3	Link Span -3	32 m
4	Link Span -4	32 m
5	Link Span -5	20 m

The link-span shall be of structural steel with the following minimum requirements.

- Steel Pratt Truss Linkspan Bridge formed in box or enclosed built up sections.
- Link-span to provide minimum 3.7 m headroom.
- Minimum clear road width is to be 5 m with 1.5 m walkway on each side with corrugated crash barriers
- Deck stiffened for a uniformly distributed load of 5 kN/m^2.
- Deck of high yield steel plate of at least 12mm thickness.
- The ends of linkspan should be equipped with hinge and roller support at either ends to ensure that linkspan bridges adjusts to a slope in case of lowering of intermediate pontoon.
- The walking/bike lane surface preparation on top of 12 mm plate shall comprise of anti-skid high grade abrasion resistant polyurethane resin based designed to give strength, flexibility and long-life durability of minimum 5 years duly approved by engineer in charge.
- 20lux lighting illumination supported on truss work
- Service lines to run down link-span for potable water, electrical supply and communications.
- 15year protective paint system to all steelwork.
- Safety restraints to IRC guidelines

The linkspan bridge design allows for the movement of the both intermediate & berthing pontoon and subsequent transfer of vertical, horizontal and rotational loads into the bridge through a pinned hinge with the others free to slide horizontally and pivot through the vertical.

The linkspan shall be positioned laterally by winches and vertically through adjustment of buoyancy in the transportation vessel with further assistance from winches, cranes and jacks.

The structural analysis of steel truss has been carried out considering the following forces (or primary loads):

- Dead load including self-weight
- Live Load including dust loads
- Wind Load
- Seismic Load
- Temperature loads

Based on the structural arrangement and loading explained above, a 3-D model of link span has been developed in STAAD Pro software. Linear elastic analysis has been carried out using the Staad model for estimating the actual forces in the members for all loads considered. The design is carried out the most critical load combination.

Design of steel bridge is done as per the provisions of IS 800 considering the following parameters:

a) Maximum yield strength of steel is considered as 250 N/mm².
b) Slenderness ratio has been considered as per the provision of IS 800.
c) Wind load has been calculated considering the solidity ratio.
d) Design has been done considering the built up channel sections.
e) Maximum normalized ratio considered is 1.0.

The following figure shows the 3D STAAD-Pro model considered for analysis and design of the linkspan.

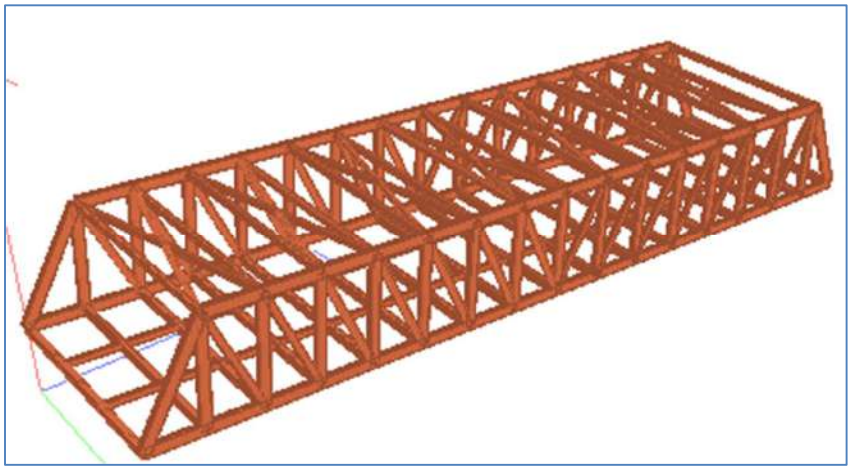


Figure 9-2: Perspective view of 3 dimensional model prepared in STAAD for 32 m Link Span

The member section properties considered for analysis and design of the steel linkspan is shown in the table below:

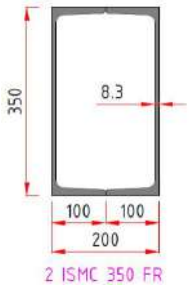
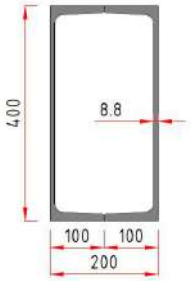
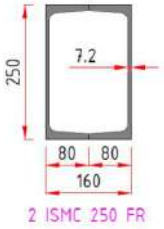
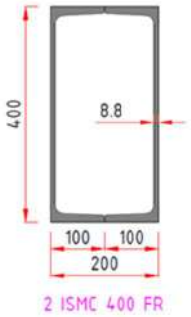
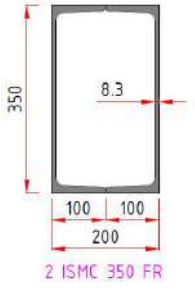
Table 9-4: Section properties of member components of steel linkspan

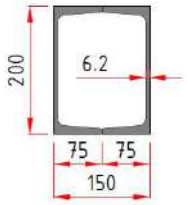
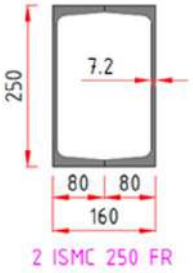
Prop	Section	Area (cm^2)	I_{yy} (cm^4)	I_{zz} (cm^4)	J (cm^4)	Material
1	ISMC250 FR	78.000	2.8E+3	7.68E+3	35.771	STEEL
2	ISMC250 FR	78.000	2.8E+3	7.68E+3	35.771	STEEL
3	ISMC350 FR	108.800	6.63E+3	20.2E+3	45.632	STEEL
4	ISMC200 FR	57.000	1.76E+3	3.66E+3	17.812	STEEL
5	ISMC350	108.800	6.63E+3	20.2E+3	45.632	STEEL
6	ISMC400 FR	127.600	7.9E+3	30.4E+3	65.232	STEEL
7	ISMC400 FR	127.600	7.9E+3	30.4E+3	65.232	STEEL
8	ISMC250	78.000	2.8E+3	7.68E+3	35.771	STEEL

The shape and sizes of the members and their respective locations in the steel linkspan are listed in the table below.

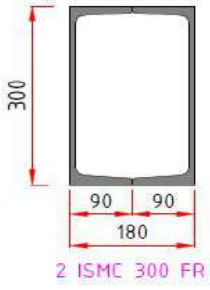
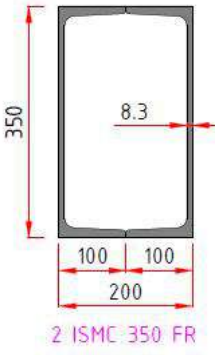
Table 9-5: Member shapes, sizes and locations in the steel link span

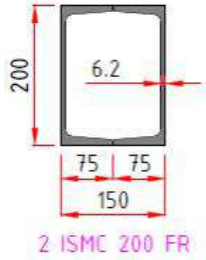
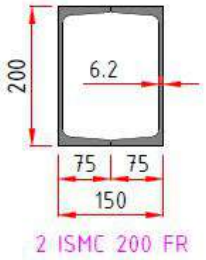
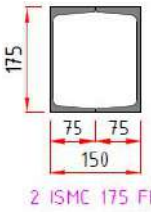
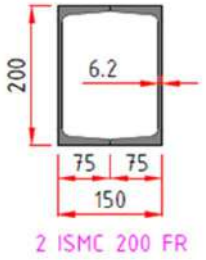
For Link Span Length = 32 m

S. No.	Member Location	Shape & Size
1	Main Girder Bottom Chord	 
2	Main Girder Top Chord	 
3	Vertical Member	

S. No.	Member Location	Shape & Size
4	Top Chord Cross Bracing	
5	Bracing (Vertical)	

For Link Span Length = 20 m

S. No.	Member Location	Shape & Size
1	Main Girder Bottom Chord	
2	Main Girder Top Chord	

S. No.	Member Location	Shape & Size
		
3	Vertical Member	
4	Top Chord Cross Bracing	
5	Bracing (Vertical)	

The steel bridge has been analysed for all the above specified load cases and designed using STAAD.Pro software with IS 800:2007 (Limit State Design) for the most critical load combination.

The allowable ratio =1

The utilisation ratio (i.e actual ratio / allowable ratio) as obtained from STAAD software is as shown in the figure below.

The utilisation ratio (i.e actual ratio / allowable ratio) as obtained from STAAD software is as shown in the figure below.

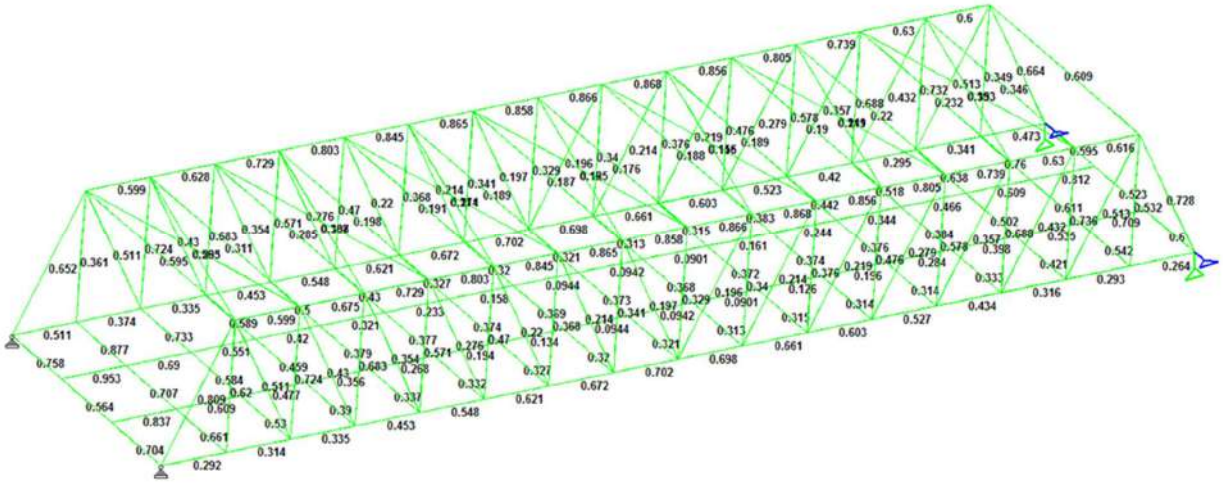


Figure 9-3: Utilization ratio of members in steel linkspan for 32 m span (as per STAAD-Pro analysis)

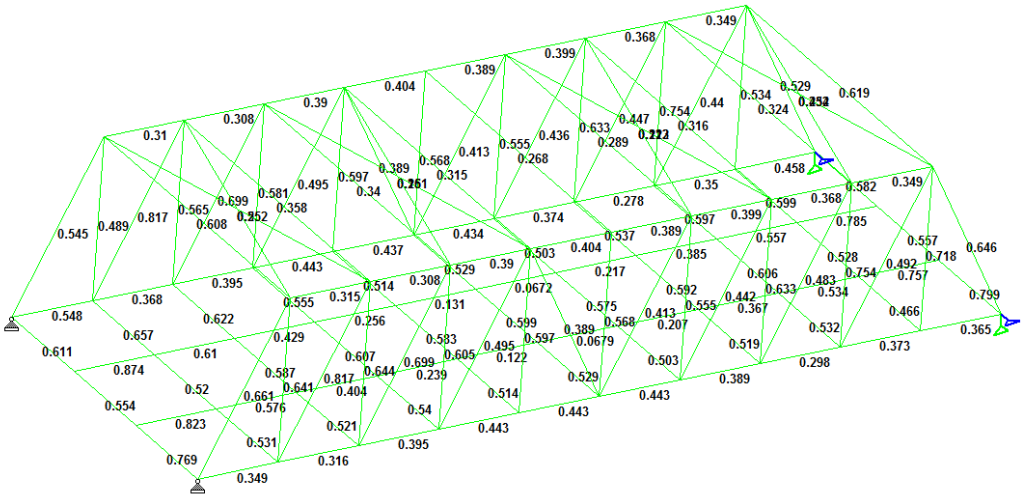


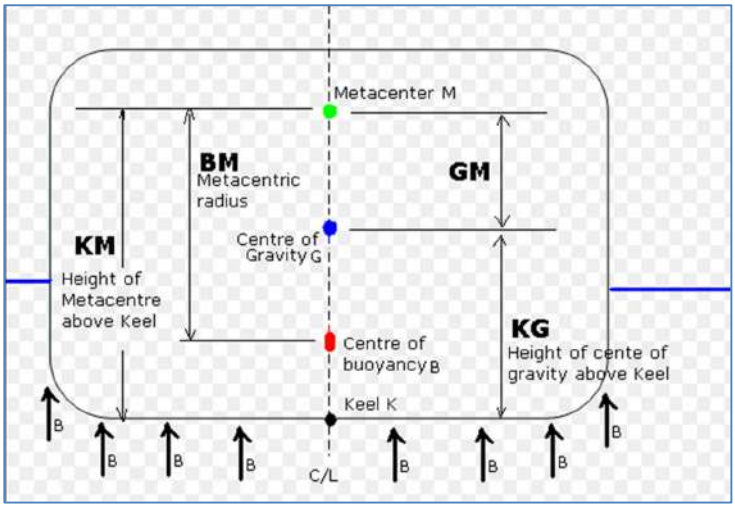
Figure 9-4: Utilization ratio of members in steel linkspan for 20m span (as per STAAD-Pro analysis)

9.2.4 Intermediate pontoons

Four Intermediate Pontoons have been planned to facilitate riverine infrastructure facility in Guwahati Gateway Ghat.

The floating stability of the pontoon has been checked for 9m (width) and 20 m (length) of the pontoon. The loads including self-weight, loads from link span and life loads of 5 kN/m^2 have been considered. The metacentric height (> 0), the max angle of heel (10 deg) and minimum freeboard (>0.3 m) of the pontoon have been checked to be within the permissible limits.

The Metacentric height is a measure of the vessels's stability under small heeling also called the initial stability. The higher the value of GM, the better the vessel's initial stability. Thus harder it is to get the vessel to heel.



The detailed floatation stability calculations for the intermediate pontoons are given in Annexure 9.

9.2.5 Dolphins for intermediate pontoons

A 3-D model of the dolphin is prepared in STAAD-Pro software and linear elastic analysis is carried out for the following loads:

- Dead load (of the structure and the intermediate pontoon)
- Live load
- Wind load
- Current load (on the structure and on the intermediate pontoon)
- Seismic load

Detailed calculations of the above loads are presented in Annexure 9. Logical combinations of the above loads in line with the IS 4651 Part IV are used to obtain the results of the analysis.

The following figure shows the 3D analysis model prepared in STAAD-Pro.

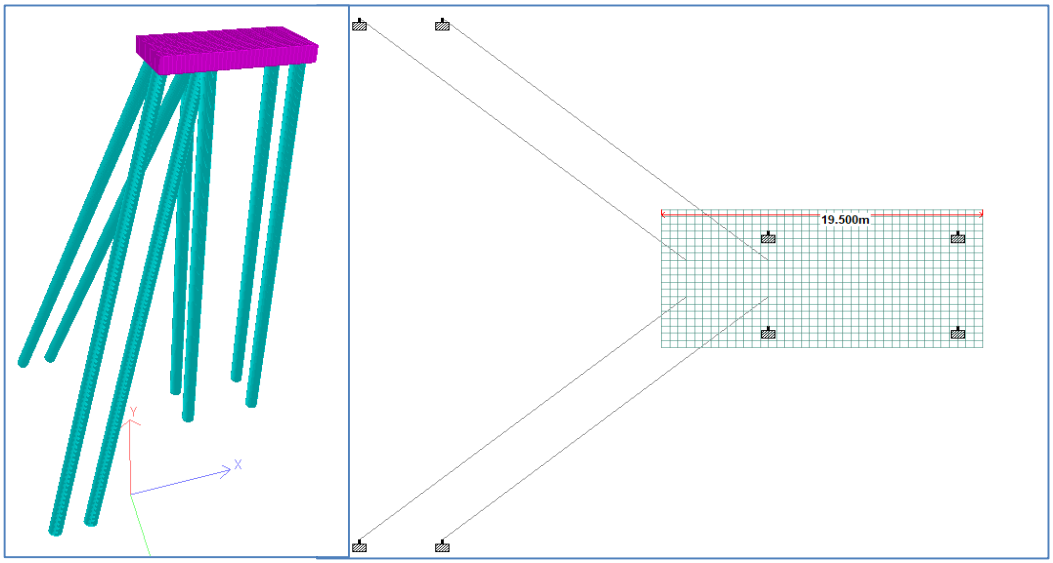


Figure 9-5: STAAD-Pro analysis model of dolphins for intermediate pontoons

Reinforced concrete member sizing and design are carried out by Limit State approach as laid down in IS 456. Design of tubular steel piles is carried as per IS 800. The foundation shall consist of 1520 mm diameter x 31.8mm thickness tubular steel piles. The deck shall be 2 m thick reinforced concrete slab. The analysis and detailed calculations are presented in Annexure 9.

9.3 Design of Terminal Utilities and Services – Water Supply, Sewerage and Drainage

9.3.1 Drinking water quality

Treated water quality standards shall be maintained as per CPHEEO standards, which are quite stringent compared to IS: 10500 and WHO. Summary of the Treated water quality requirement as per IS 10500, CPHEEO, and WHO is indicated table below.

Table 9-6: Treated water quality standards

Parameters	IS:10500	CPHEEO	WHO
TURBIDITY (NTU)	1	1	1
COLOUR (Hz)	5	5	5
TASTE	Agreeable	Agreeable	Agreeable
ODOUR	Agreeable	Agreeable	Agreeable
pH	6.5-8.5	7-8.5	6.5-8.5
TOTAL DISSOLVED SOLIDS (mg/l)	500	500	500
TOTAL HARDNESS (as CaCO3) (mg/l)	300	200	100
CHLORIDE (mg/l)	250	200	200
SULPHATE (mg/l)	200	200	200
FLUORIDE (mg/l)	1	1	0.7-1.0
NITRATE (mg/l)	45	45	45
CALCIUM (mg/l)	75	75	75
MAGNESIUM (mg/l)	30	≤ 30	30
IRON (mg/l)	0.3	0.1	0.3
MANGANESE (mg/l)	0.1	0.05	0.1
COPPER (mg/l)	0.05	0.05	0.05
ALUMINIUM (mg/l)	0.03	0.03	0.1
ALKALINITY (mg/l)	200	200	200
RESIDUAL FREE CHLORINE (mg/l)	0.2	0.2	0.2
ZINC (as Zn) (mg/l)	5	5	5
MERCURY (as Hg) (mg/l)	0.001	0.001	0.001
Coliform Count MPN/100 ml	-	Absent	Absent
Fecal coliforms MPN/100 ml	-	Absent	Absent

9.3.2 Water Supply System

9.3.2.1. SOURCE OF WATER

At present there is no municipal water supply in the city. In absence of municipal water supply, the main source of water is considered from the Bore well. In future, the city Water Mains will be the main supply source and for any shortage, the water shall be augmented from the tube well for the proposed building. Tapping shall be made from the mains to the underground sump will done as per site condition.

Also envisaged to use treated water from Sewage Treatment Plant (STP) for washing & irrigation system.

9.3.2.2. WATER STORAGE TANK

The water will be drawn from Bore well and transferred first to fire water tank. The overflow from the fire water tank will be taken to adjacent water storage tank. A compartmented storage tank is proposed with minimum half day's requirement due to space constraint. A dedicated storage of 30 KL each for Raw water and clear water storage will be provided. Raw water will be taken, treated and stored in adjacent clear water tank after tertiary treatment. From clear water tank, it will be distributed to each building thru hydro-pneumatic system. Water treatment plant is to be decided after receiving the analysis report of the water at site.

Table 9-7: Storage Tank

S. No	Description	Type	Capacity in KL
1	Clear Water Storage Tank (terminal building 1)	RCC	30 KL
2	Clear Water Storage Tank (terminal building 2)	RCC	30 KL
		Total Storage (in KL)	**60 KL**

9.3.3 Water Treatment Plant

The raw water will be treated to produce water as per CPHEEO and IS 10500 drinking water norms. The water will be pumped through sand filter followed by activated carbon filter. The filtered water will be disinfected by chlorine treatment and finally stored in Treated water tank. The treated water will be finally pumped to the various point of usage by hydro pneumatic system.

The treatment process involves the following steps;

- Raw water is pumped (1 working + 1 standby)
- Pressure sand filter
- Activated carbon filter
- Filter Backwash System
- Disinfection - the chlorination shall be done for domestic water with displacement pump
- The system shall be designed for rated capacity with 16 hours operation.
- Hydropneumatic system

Hydro-pneumatic system has been proposed for Domestic water supply distribution system subject to approval by regulatory bodies.

Pressurization shall be achieved by hydro-pneumatic pumping system. Hydro-pneumatic pump set will have pumps with variable speed drive to maintain constant pressure at variable flow. Pressure sensor shall be located at the most remote fixture on the top floor or in the plant room. Automatic air vent at topmost of each riser of the pressurized piping is proposed.

9.3.4 Sewerage System

A dedicated sewage treatment plan is proposed to treat the water generation from the terminal building. A package type STP has been proposed to treat the sewage generation from each terminal. The water will be collected at sump near terminal building. The collected water will be pumped to sewage treatment plant. The waste water will undergo several steps of Treatment mainly Screening, Equalization, Aeration Unit (MBBR/MBR), Gravity Settling, Filtration Unit, Disinfection and finally treated water will be stored in treated Water Tank. The treated water will be used to horticulture and Excess water will be finally discharged. As per CPHEEO norms, the sewage generation is taken as 80% of the water demand. A package type STP is 60 KLD has been proposed. The tentative space required for setting up STP is 50 sqm (10m x 5m). Location of STP plant is demarked in the layout drawing.

The treatment plant will be designed to ensure that treated water characteristics are well below the permissible limits, even under varying flow conditions which are typical for such systems. This implies that the selected process shall be able to withstand the shock load situation. The STP will be based in MBBR technology. The MBBR is an aerobic attached growth process, which uses cylindrical shaped polyethylene or polypropylene carrier elements for biological growth. The moving media increases the contact time between the micro-organisms and the organics. Since the media provide large surface area for micro-organisms to attach and grow, it has excellent characteristics for BOD/COD removal and nitrification/denitrification for all types of sewage. It is compact and requires comparatively lesser space than the conventional system.

In general, the process for treatment of domestic sewage involves:

- Primary Treatment (Screening, Grit Removal and Primary Settling Tank)
- Secondary Treatment (Aerobic /Anaerobic Biological Treatment and Secondary Settling Tank)
- Tertiary Treatment (Sand Filtration)
- Disinfection
- Sludge Treatment

Treated water quality will meet the specified norms of CPCB/SPCB for water reuse.

The STP shall be designed based on the following parameters:

Table 9-8: Design Parameters

S. No	Parameters	Raw Sewage	After tertiary treatment
1	pH	6.5-8.5	6.5 – 8.5
2	BOD_5 (mg/L)	250- 300	<30
3	COD (mg/L)	450 – 550	<100
4	TSS (mg/L)	250 - 350	<10
5	Total Nitrogen (mg/L)	45	<10
6	Total Phosphorous (mg/L)	8	<1
7	Residual chlorine	---	< 0.5

9.3.5 Storm Water Drainage System

Provision of adequate Storm water Drainage scheme is a basic necessity because improper storm water drainage schemes can cause serious problems like water logging and flooding.

Surface drainage will be designed with the following basic consideration:

- System will be designed considering the Intensity of rainfall 50 mm/hr with 10 minutes inlet time
- 90% imperviousness for estimating the runoff rates.
- The drainage system shall be planned to carry storm run-off from the proposed areas and no allowance for sullage shall be kept.

- Saucer type drain

Due to space constraint the terminal building is proposed on desk slab on pile foundation. The conventional storm water drainage system is not suitable for desk slab construction.

The storm water will be collected by saucer type drain all along the deck slab except building roof. The water collected from the rooftop will be free from oil and suspended solids and will be directed disposed off in river by providing drain pipe through slab.

The collected water will the directed towards the land side where the out fall of the storm water drains will be pass through Oil Interceptor and silt trap before going into the river. Oil Interceptor, silt traps and screens will ensure that no contaminated storm water will be discharged from the premises.

9.3.6 Solid Waste Management

The collection and removal of solid waste from terminal area is of great importance for effective vector control, nuisance abatement, aesthetic improvement and fire protection. The refuse from station includes Garbage, Rubbish and Floor Sweepings. In absence to solid waste generation for ferry terminal, the per capita solid waste generation of 0.1 kg/capita/day is considered.

SOUTH GUWAHATI @ Year 2035					
S.No	Type of Building	Annual Average Daily Numbers	Solid Waste Generation in Kg/capita/day	Total Demand in LPCD	
1	Average Number of Passenger	7381	0.1	738.10	
2	Vendor	82	0.1	8.20	
3	Staff	25	0.1	2.50	
			Total	748.80	Kg/day
			Say	0.75	Ton/day

The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered. The separate storage containers for this purpose will be provided for biodegradable and non-biodegradable waste. The capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals. Solid waste shall be stacked at designated place and when sufficient quantity accumulates it shall be disposed-off through covered trucks to land fill site designated and authorized by Municipal Corporation.

Management of solid waste shall be in the contractor scope both for construction as well as operation stage as per the EIA.

9.4 Design of Terminal Utilities and Services – Firefighting

Fire System mainly comprises of the following sub-systems:

- Fire detection, alarm and control system.
- Fire protection system.

The Fire Detection and Protection System for the Pontoon / Pathway to Pontoon / Building / Parking area/ Transformer / DG set etc.is proposed to be designed, manufactured and tested in accordance with the latest applicable Indian Standards (IS) / NFPA (National Fire Protection Association, an American national Standard) / LPA (Loss Prevention Association of India) Fire Protection Manual guideline as stated below except where modified and/or supplemented by this specification.

NFPA10 Standard for portable fire extinguishers

NFPA 13 Standard for Sprinkler System

NFPA 14 Standard for the installation of stand-pipe, private hydrants, and hose systems

NFPA 20 Standard for the installation of stationary fire pumps for fire protection

LPA Guide lines of LPA (Loss Prevention Association of India) Earlier known as TAC (Tariff Advisory Committee)

IS: 1684 Code of practice for fire safety of buildings (General), Firefighting equipment & its maintenance

IS: 1646 Code of practice for fire safety of buildings (General), Electrical Installations

IS: 2189 Code of practice for installation of automatic fire alarm system, using heat sensitive type fire detectors

IS: 2175 Specification for heat sensitive fire detectors for use in automatic electric fire alarm system

IS: 903 Specification for fire hose delivery, hose couplings, branch pipes, nozzles and nozzle spanner

IS: 325 Three phase Induction motor

IS: 2878 Specification for fire extinguisher- Carbon di-oxide

IS: 1239 Mild steel tubes, tubulars and wrought steel fittings

IS: 3589 Specification for electrically welded steel pipes for water, gas and sewerage (200 mm to 2000 mm).

1 Fire Detection alarm and control system

Fire Detection System of following types is proposed to be provided.

a) Fire Detection System

Following types of Fire detectors shall be used

(i) Smoke Detectors of Ionization Type

The radioactive source used in the Ionization type smoke detector shall not emit beta and gamma rays and strength of radio active material shall not be more than 1 micro curie. The sensitivity of the detector shall not vary with change in ambient temperature, humidity, pressure or voltage variation or air current of 5 m/second. It shall have inbuilt arrangement such that a time constant of about 4 seconds is provided so that puffs of smoke or hot air pockets do not inadvertently trigger the alarm.

These proposed detectors are installed below the ceiling or below the false ceiling, depending upon civil design for Control & Switchgear Room, Electrical Room, Ticketing Room, Office Room, Meal Area, Store, Security Room, Firewater pump house etc.

(ii) Quartzoid Bulb Heat Detector

Quartzoid bulb heat detection system is used for equipments protected by HVW spray system such as for Transformers (Oil Filled), etc.

(iii) Electrical type Heat Detectors are used for Battery Rooms.

(iv) Manual Break Glass Boxes

The break glass box is proposed to have a push button element kept in pressed condition by the glass fitted in the front of the box. Break glass boxes shall be used as manual call points.

Spacing of the detectors and manual call points shall be as per NFPA.

b) Fire Alarm System

Fire alarm systems shall be provided with at least two independent and reliable power supplies, one primary (230 V AC system) and another secondary (standby as 24 V DC system), each of which shall be of adequate capacity for the application and performance of the fire alarm system. The changeover from primary supply to secondary supply and vice-versa shall be fully automatic, without affecting the transmission of signal via the fire reporting system upon operation of the initiating devices.

System can also be actuated manually by pressing the push button on deluge valve control panel located near respective equipment.

Water motor alarm gong shall also be provided to sound a continuous alarm while spray system is in operation. One (1) no. water motor gong assembly shall be provided for each deluge valve.

Each fire alarm system shall consist of one central unit receiving the signals upon action of Smoke detector / Quartz-bulb detector / Electrical type heat detector grouped in lines for each supervised area separately. The supervised area shall be the same or part of the corresponding firefighting zone defined by the building.

All alarms coming from the detectors shall be line wise transmitted to the main fire alarm panel. The alarms of this system shall be transferred first to the pertaining panels for alarming and releasing and then be transferred to the main fire alarm panel for each line.

The fire alarm panel is proposed to have microprocessor based addressable type provided with a MIMIC layout diagram. It shall have zone wise LED display for FIRE & FAULT conditions. The LCD display shall provide details of various FIRE & FAULT conditions. Provision shall be made in the panel for providing repeat annunciation to any other location. The panel shall provide potential free FIRE & FAULT contacts. The panel shall also have auto telephone dial facility.

The fire alarm system is provided with addressable Manual Call Points (Flameproof type). These shall be spaced at every 60 meters. These MCP shall be connected to the fire alarm panel by means of PVC insulated copper control cables.

The zone / area along with detector of the fire will show in the main fire alarm panel. The system will be suitable for operation at 24 V DC or 230 V AC.

110VDC system has been covered in electrical system. 110 V DC to 24 V DC convertor is required.

The operational features of the modules shall have at least the following features required to make the system fully functional shall also be incorporated in accordance with relevant standards.

- Monitoring electrical supervision of different circuits viz. initiating device circuits, circuits used for supervisory signal services viz. water-flow, water level indicators etc.
- Monitoring electrical supervision of power supply, transmitter tripping circuit integrity etc.
- Monitoring of fire water filling pumps i.e. On/Off/Trip.
- Trouble buzzer and trouble LEDs/LCDs against any fault due to loss of power supply, single break, open, or ground fault condition, panel fault and panel door open etc. impeding the normal functioning of the system;
- Evacuation alarm signal switch and transmitter disconnect switch;
- Confirmation or verification of all smoke / heat detectors;
- Monitoring and control fire extinguishing system;
- Control panels and field panels is proposed to have suitable software programme enabling expansion and modification of the system without replacement of hardware or firmware viz. addition or deletion of zones etc.

An alarm condition in the circuit which shall automatically annunciate in the mimic shall have at least the following functions to make the system fully functional. These alarms shall also be printed out.

- Transmission of signal to the control system;

- Visual indication of the alarm device on the fire panel control panel display;
- Continuous operation and sounding of alarm notification appliances.
- Automatic discharge of the respective fire suppression system with maximum 30 seconds for wet pipe system.

Provision of necessary contacts/ports for control, monitoring, and supervision and alarm functions shall be made in the fire alarm control panels for duplicating these functions in control system.

Unacknowledged alarm signals shall not be interrupted if a fault on a fire detector circuit or a signalling line circuit occurs while there is an alarm condition on that circuit.

All major devices installed in the panel shall have 10% spare capacity. Fire alarms, supervisory signals and trouble signals shall be distinctively and descriptively annunciate.

c) Control System

The control system is proposed to offer total flexibility to the fire fighter for effective fire protection operations on the Pontoon, Pathway to pontoon, around the building area, around the parking area etc. The system shall enable the controlling / operating of FPS from the electrical room (except the hydrant valves).

The desktop of the panel is proposed to be provided with the following functions:

1. Auto / Manual selection of fire water pumps & water filling pumps.
2. Manual Start / Stop of fire water pumps & water filling pumps
3. Manual Open / Close of all electrical operated valves

The indications proposed on the remote-control panel are as follows:

1. ON / OFF / TRIP for fire-water pumps.
2. ON / OFF / TRIP for water filling pumps.
3. OPEN / CLOSE / TRIP for all electrical operated valves
4. Pressure in Fire Water Storage Tank

The control desk-top shall be also provided with a MIMIC Diagram of FF system. The control relays / starters and other components in the electrical control system shall be housed fully wired inside the bottom of the control desk with easy access for checks & maintenance.

d) Cables and Wires

Cables, wires and conduit raceways shall be in accordance with relevant standards. The cables shall be braided sheathed laid down in suitably sized conduits, electrical tubings, metal moulding or metallic race ways and shall offer protection against fire and mechanical injury as per relevant standards and specifications. The use of wire nut type construction for wiring shall be prohibited. Screw terminal boxes shall be preferably used. All the cables and wires shall be suitably tagged for proper identification by colour bands and by ferrules at junctions respectively.

e) Public Address / Talk Back System

The public address & talk back system is proposed for the Pontoon; Pathway to Pontoon Building area, Parking area, Auxiliary area shall consist of a main communication console located in the electrical room and speaker / talk back units located along the Pontoon; Pathway to Pontoon, Building area, Parking area. Auxiliary area. The spacing proposed is two nos., one at FWPH, and one every 60 meters on the approach path.

2 Fire Protection System

Fire protection systems of following types is proposed to be provided.

Water Filling Arrangement

Jockey pumps and Hydro Pneumatic Tank

Hydrant system

High Velocity Water Spray System

Automatic Water Spray System

Inert gas system

Portable fire extinguishers

a) Water Filling Arrangement

Fire water storage twin tank and fire pumps

The fire water is proposed to be discharged through hydrants & piping distribution system. This fire water is proposed to be drown from water storage twin tank through a set of fire pump-motor sets each of 137 m^3/hr @ 7 kg/cm^2. The water storage twin tank internally connected by pipes and isolating valve.

Fire pump's capacity is decided as per following consideration:

i. Fire pump capacity of 137m^3/hr having 7kg/cm2 delivery pressure for Ordinary Hazard is, as described later in this chapter, recommended as per Table 2 under section 7.4.1.4.1 of LPA for single largest risk at all strategic points and Crew of estimated 50 persons.

ii. Fire pump capacity of 56.76 m^3/hr (946 lpm) for Ordinary Hazard is recommended as per Table 11.2.3.1.2 of NFPA 13.

It is proposed to select the fire pump of higher flow-capacity, i.e 137 m^3/hr instead of 56.76 m^3/hr. Thus, selecting two (one main and other as standby) horizontal pump-motor sets having capacity of 137 m^3/hr operating under head of 7 kg/cm^2 for water-storage-tank.

Fire water pump's "inlet / suction pipe size" and "discharge pipe size" is selected as 150 mm and 125mm diameter respectively. Main pump shall be AC power operated and other stand by pump shall be diesel engine driven.

Fire water storage tank's capacity is decided as per following consideration:

i. Fire water storage tank capacity is recommended for operating duration "not less than 1 (One) hours aggregate pumping capacity , as per NFPA

ii. It is propped to select the higher duration of pumping time as 1 hours. Thus capacity of fire-water-storage tank works out to be 137 (137 *1) m^3. Considering 10% margin on 137, the water storage tank capacity works out to be 152 m^3.

The Fire water storage tank is divided into two equal compartments allowing easy cleaning, inspection, repair and maintenance of the tank Fire-water-storage-tank is proposed to have level-low/alarm/emergency alarm-switches, in each compartment, for automatic starting and stopping of fire pumps provided in primary-sump. When the water level in the fire-water-storage tank goes beyond the pre-determined level then the water level indicator drives the signal to the panel and there by operation of water filling pumps provided in primary-sump.

The Fire pump discharge pipe, each of 125mm diameter shall be connected to a common header of 300NB.

i. One 150NB delivery pipe shall be connected to hydrant system of Building

ii. Another 150NB delivery pipe shall be connected to hydrant system of Pathway to Pontoon / Pontoon

iii. Third -150NB delivery pipe shall be connected to hydrant system for auxiliaries (such as Transformer, DG set, Parking area, Parking area etc.) area

iv. Forth-100NB delivery pipe shall be connected to HVWS for oil type transformer.

v. Fifth- 100 NB delivery pipe shall be connected to sprinkler system

Water velocity in the pipes shall be limited to 2.5 to 3.0 m/s for pumping system and for gravity system at farthest point. Discharge water velocity shall be as per NFPA / TAC norms.

Primary water sump and water-filling pumps

Fire water pumps of 137 m³/hr water flow-capacity are selected, as stated above. It is proposed for water filling pumps having next higher available capacity in market, which is 145 m³/Hr. These two numbers (one main + another standby) water filling pump is proposed preferably of vertical-turbine-pump-motor set.

Underground-primary sump is proposed to be installed at a depth of approximately 6 metre below the minimum water level of river. Filling water from the primary-water-sump is proposed to be filtered and routed through the duplex filter. Necessary piping, valves, fasteners and instruments is proposed to be provided.

Water-filling-pump's discharge pipe is selected as 150mm diameter. The discharge of both the water-filling-pumps is discharged into duplex filter through 250 NB header.

The pumped-water is proposed to be filtered / cleaned in this duplex water-filters before water is stored in fire-water-storage-tank.

Two inlet pipes (one in each in twin tank) of 150mm diameters is connected to duplex filter, through 250 NB header. The system shall be connected with necessary pipes, flanges, isolating valves, non-return-vales, rubber seal, fittings, fasteners.

All the piping material used for water supply (both internal and external) shall be of HDPE pipes.

During commissioning/maintenance period, provision shall also be provided to operate pump manually from its MCC by selecting Local-Manual mode.

Duplex Filter

The discharge water from the water filling pumps shall be filtered by one (1) no.200 NB duplex filter of capacity 300 micron. Pressure indicator shall be provided at the Inlet and the outlet of the filter. Pressure drop across the filter shall be sensed through differential pressure switch for alarm. Changeover of filter element shall be done manually.

Jockey pumps and Hydro-pneumatic tank

Pressurization of feeding lines/mains of both hydrant system and water spray system will be done through the combination of Jockey-pump & hydro-pneumatic tank (upto 10% of Main-Fire Pump capacity). Jockey pumps (2x100% capacity, 1 working and 1 stand-by, both electric motors driven) and air compressors (2x100% capacity, 1 working and 1 stand-by, both electric motor driven).

Hydro-pneumatic tank will be filled up with water up to 2/3rd portion of its height. Air space will be kept above the water-filled portion. The HP tank will be equipped with necessary level switches and pressure switches. Minor leakage in the pressurised fire water system will be replenished from hydro-pneumatic tank. When the level of hydro-pneumatic tank will be low, jockey pump will be restarted automatically to replenish the level of water in the tank. Jockey pump will be cut-out automatically when the level of water in the hydro-pneumatic tank reaches its higher limit. Pressure switches provided in the hydro-pneumatic tank will be inter¬locked with the cut-in / cut-out operation of compressors, which will be used to maintain a constant pressure in the hydro-pneumatic tank and thereby to the whole firefighting system.

In the event of fire, pressure in the hydrant-spray or sprinkler-spray system will drop due to resulting in water- flow. In this event, water loss in the system will be replenished by jockey pump. However, if this is inadequate to meet the demand and results in drop in pressure further to pre-set low pressure in the mains, first electric driven fire-pump will start automatically. In case of failure of starting of this pump or due to increased demand of water-flow, the system pressure will reduce further,this will enable starting of subsequent fire-pumps in a sequential manner through means of various pressure switches. Failure to start a pump will be indicated as an alarm.

The TDH of Jockey Pump shall be equal to that of the hydrant/spray pumps.

b) Hydrants

The hydrant system basically consists of piping network, which is connected to the outlet of fire pumps. Major equipment and material of the hydrant system consist of the following:

i. Piping Network

ii. Isolation valve

iii. Hydrant valve

iv. Hose pipe with male / female coupling

v. Branch pipe with nozzle

vi. Hose Box

On the occurrence of fire, the guard valve provided on the hydrant shall be opened and the firefighting water supplies will be drawn from hydrants on the water distribution system. Hydrants shall be of a style and colour to accord with local fire department regulations and shall be located so as to be both accessible and protected from traffic damage.

The fire hydrant shall be designed to ensure operating pressure from 4.5 to 6.9 kg/cm² at the remotest hydrant. This is in line with clause No. 7.8.1 of NFPA 14.

Internal single hydrant points shall be provided inside control building.

The fire water system is proposed to be designed as per clause 5.2.5.5 (1) of NFPA 15 to permit at least six hydrants, in case hydrants are between 0 to 300 numbers, to operate simultaneously while maintaining both the specified pressure and discharge rate at each operational hydrant.

As per NFPA 14 (2010) Cl.no. 7.10.2.1.1 for class II hydrant system, minimum flow rate for most remote Hydrant is 22.74 m3/hr (379 lpm).

Minimum water spray required through hydrant is 6*22.74 m3/hr. It works out to be 136.44 ~ 137 m3/hr

As per NFPA 15, Clause No. 7.4.4.3.6, the water supply shall be capable of supplying both the design flow rate and 56.76 m3/hr [946 L/min (250 gpm)] for hose streams for a minimum duration of 1 hour.

Adopting the maximum quantity of water spray, which is 137 m3/hr

Hydrant is proposed to be provided at strategically locations as shown in “Fire Protection Layout” drawing number P.013223-P-20318051.

The fire hydrants are normally closed & can be opened manually during fire occurrence.

c) High Velocity Water Spray System

The High Velocity Water (HVW) Spray system employs the principle of oil emulsification. Water with high velocity, when mixed with oil forms an emulsion, which cannot burn. In addition, the fine droplets striking the hot surface, absorb the heat and impart cooling and smothering effect thereby extinguishing fire.

It gives the protection to Oil type Transformers. In the occurrence of fire, detector senses the fire’s temperature.

One Deluge valve system is provided for Fire protection of Oil type Transformer with HVW spray protection.

Each automatic HVW spray system shall be provided with two (2) separate pipe networks.

One, a wet detection pipe network over the protected equipment with temperature sensing detectors located at strategic locations. Other will be the fire water pipe network spread over the protected equipment, provided with water spray nozzles located at suitable points to spray water on to the equipment in case of fire. Both these piping shall end at the deluge valve (DV).

Water supply up to DV shall be provided through main header for fire water network. Detection pipe network between DV and detectors shall be kept pressurized with water tapped off from the upstream of deluge valve.

When temperature around the protected equipment goes beyond the temperature rating of Q.B. detector (79 °C, installed around the equipment), then Q.B. detector will collapse and reduces the pressure in the detection line by draining the water, which results in DV operation and makes the diaphragm in action to spray the water on protected equipment.

System can also be manually actuated by pressing the push button on deluge valve control panel located near protected equipment.

The system shall be designed as per relevant clauses NFPA 15 / TAC, whichever is stringent.

High velocity water spray requirement or transformer is selected as 23 m3/hr

d) Automatic water spray system

Automatic water spray system shall be provided for Office, Janitor Office, Security room, Baby Care room, First-aid room, Dining room, Shop, Janitor room or as required. In the occurrence of fire, the detector, installed under the roof, senses the fire's smoke. The sensed signal initiates the spraying the water on equipment / persons in the room. The system shall be designed as per NFPA. Automatic water spray is selected as 25 m3/hr

e) Inert gas system

This system is proposed to provide for Control & Switchgear room, Battery room, Dry Type Transformer, Electrical room, Ticketing Rooms.

This system comprises of gas cylinders, piping and control system. The inert gas (Nitrogen, etc), as recommended in NFPA 2001, is released in a controlled manner to dilute the oxygen content and consequently to control fire.

The quantity of inert gas system for "Control & Switchgear room, Battery room, Dry Type Transformer" and "Electrical room, Ticketing Room "are selected as 150 m3 and 70 m3 respectively.

100% stand-by / reserve cylinders (filled with gas) with stand-by / reserve selector switch will be provided. Common cylinder bank with use of directional valves will be used for protection of multiple risks. The design pressure for storage cylinders will be suitable for the maximum pressure developed at 55 Deg. C and will be designed to meet the requirements in NFPA-2001.

Minimum design concentration of INERET gas fire extinguishing system will be 37.5% (minimum) at 70 Degree F by volume and discharge time will be maximum 60 seconds. However higher concentration may be used if it is specified by the agent manufacturer / system supplier for the area protected.

The complete volume of the rooms including the above false ceiling will be considered for estimation of quantity of gas and containers.

f) Portable Fire Extinguisher

Portable fire extinguishers is selected for strategic locations considering easy access as per NFPA 10 & TAC. Guidelines at all strategic points of the building / DG Set & Transformer Area / Parking area / Pathway to Pontoon/ Pontoon

The portable extinguishers shall be operated manually. Sand bucket (MS painted) shall also be provided for extinguishment.

Various portable extinguishers are selected as per applicability as stated in below:

Sr. No	Class of Fire	Description	Type of Extinguishers
1	Class A	Fires in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics.	Water type, Multipurpose dry chemical type & Wet chemical type
2	Class B	Fires in flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases.	Aqueous film-forming foam (AFFF), Film-forming Fluor protein foam (FFFP), Carbon dioxide, and Dry chemical type.
3	Class C	Fires that involve energized electrical equipment where the electrical non- conductivity of the extinguishing media is of importance. (When electrical equipment is de-energized, fire extinguishers for Class A or Class B fires can be used safely.)	Carbon dioxide, Dry chemical type.

The proposed type, size and quantities are as follows:

Sl. No	Description	Quantities	Locations
1.	CO2 Portable -2kg	1 Lot	Electrical Room- 1 No. in each room Office-1 No Store 1 No Meal Room-1 No Transformer area – 1 No.
2.	CO2 Portable -5kg	1 Lot	DG Set area- 1 No. Each Pontoon 1 - One No. Each Pontoon 2 - One No. Each Pontoon 3 - One No. Each
3.	9 Lit Foam	1 Lot	
4.	DCP (Dry Chemical Powder) 6kg	1 Lot	Transformer area – 1 No.
5.	Fire Suits	2 Sets	Office
6.	First Aid Box	2 sets	Office – 1 set; Pontoon – 1 Set
7.	9-Litre Water/Sand Bucket	1 Lot	One set for every 100 Sq. m of the floor area One set on each Pontoon

g) Piping Layout and Schematic

Piping for all the protection systems will generally be laid over ground, on RCC pedestals, except in locations such as road or in main plant area where it may not be feasible to route over ground. Pipes will not be laid over pipe racks. At rail / road crossings, fire water pipes will be laid inside Hume pipes of suitable ratings. In main plant area, pipes will be buried with pre-cast RCC covers. The buried pipelines will be provided with coating and wrapping as per specification.

Underground piping shall be laid not less than 1 M below ground level.

Recirculation line with required valves will be provided for each of the jockey pumps and firewater pumps.

The headers of spray and hydrant system will be interconnected with an isolation and a non-return valve so that hydrant pumps can feed to spray system not vice versa. The feeding line of the spray system from the header will be provided with 2x100% capacity basket type filters to avoid any particles in the spray system.

Welded joints is not permitted for pipes of less than 50 mm diameter.

The distance between the pipe supports measured along the line of connected pipes (whether the pipes run vertically, horizontally or at angles) shall not be less than the following:

Diameter	Spacing for spray system
Up to 65 mm	4 M
Between 65 mm and 100 mm	6 M

Diameter	Spacing for hydrant system
80, 100 and 125 mm	3.5 M
150, 200 and 250 mm	5 M

Mains shall not be laid under buildings and shall not traverse ground that is under a public roadway.

The system shall be capable of withstanding for one hour a pressure equivalent to 150 % of the maximum working pressure. While hydro-testing inclusion of cut-off valves in the mains to be tested should be avoided.

Hydrant Mains shall be laid in rings (excepting as specified (in table below) and their sizes shall be as per following tables. But the size of the initial pipe shall not, in any case, be less than the internal diameter of the delivery outlet of the pump.

Sl. No.	Number of Hydrants in line for the whole system	Size of mains mm
1	1 to 20	100
2	21 to 55	125 110
3	56 to 100	125 100

The load on the Deluge valve shall not exceed the limits mentioned below:

Deluge Valve size in mm	LPM
150 mm	13,500
100 mm	5,000
80 mm	1,150
50 mm	520

6.4.6 HVAC

Spilt Air Conditioning unit of 1.5Ton units shall be provided in the Office, Ticketing rooms, Control & Switchgear room and Electrical room, as per requirement. It is covered in Electrical section.

Exhaust fans, suitable for 230 V AC power, are provided in Battery Room, Meal room, Wash room. Layout of Fans are shown in Electrical drawings.

Ceiling fans, suitable for 230 V AC power, are provided in Office, Security room, Waiting Hall area, Shop, Ticketing rooms, Electrical room. Control & Switchgear room. Layout of Fans are shown in Electrical drawings.

10. ENVIRONMENTAL AND SOCIAL ASPECTS

10.1 Introduction

The proposed development at Gateway Guwahati Ghat is a part of the project undertaken by the Government of Assam to modernize Inland Water Transport (IWT) services in Assam. The project is being implemented by the Assam Inland Water Transport Development Society (AIWTDS) with the assistance of the World Bank.

The project is proposed to be developed in a phased manner and includes upgradation of ferry infrastructure, fleet modernization, institutional capacity development etc. for 11 identified Terminal / Jetty / Landing points locations in Phase I.

As part of Phase 1 development, AIWTDS has proposed to develop & modernize terminal infrastructure initially at three locations i.e. Gateway Guwahati Ghat, North Guwahati Ghat and Aphalamukh Ghat.

The present chapter deals with the environmental and social aspects relating to the development of Gateway Guwahati Ghat on the right bank of Brahmaputra River in Kamrup District of Assam.

An EIA study for Phase 1 of the project has already been conducted by Arkitechno Consultants (I) Pvt Ltd, an independent environmental consulting agency. The assessment provided in this chapter is based primarily on the data provided in the EIA / EMP reports prepared by Arkitechno and the information generated as part of the DPR preparation by Tractebel Engineering Pvt Ltd.

World Bank's operational policy categorizes a project into Category A, B & C on the basis of nature and extent of the impacts anticipated on account of the project. This project is classified as Category "A" under the World Bank environmental screening procedures, specified under its operation policy 4.01. The Environmental Impact Assessment study has been undertaken for all the proposed components of the project to identify the environmental and social issues associated with the project.

The environmental impact assessment has been carried out in line with World Bank Operational Policies, IFC EHS Guidelines for Ports, Harbours, and Terminals, IFC General Guidelines for EHS, MoEF &CC EIA Guidelines for Ports and Harbours. Based on the outcomes of the EIA study, an Environment Management Plan has been prepared for the project.

As part of the EIA study, baseline environmental status around 10 km radius of the proposed terminals has been considered. Relevant primary and secondary data with respect to various environmental components have been collected and analysed to establish the baseline environmental status. In addition, consultations have been carried out with all key stakeholders including the community, the local business associations and NGOs active in the project area.

10.2 Baseline Environmental Conditions

The baseline environmental conditions, the impacts of the project on these and the management and monitoring plan along with cost estimates are described in the sections that follow.

10.2.1 Physiography

The Brahmaputra Valley, where the Gateway Guwahati Ghat site is located, has a uniform level alluvial Plain interspersed with low elevated hillocks scattered along the banks of the Brahmaputra River. The entire region is covered by alluvial deposits of recent and Sub-Recent origin. The alluvial fans formed by the coarse alluvial debris in the northern fringe of the Valley have given rise to semi-tame conditions where water percolates down resulting in wet soil and dense forest. In the South Brahmaputra plain, the meandering course of the tributaries is conspicuous only in the eastern part where there are numerous beels and oxbow lakes. The most striking physical characteristic of the Brahmaputra is that the river itself is highly braided due to its gradient. As a result, there are a number of Chars or riverine islands.

10.2.2 Land Use Pattern

Land use / Land cover maps are prepared for the study area using GIS Maps / Toposheet. The Indian Remote Sensing satellite data RESOURCESAT-2, LISS III is used for the analysis of Land Use and Land Cover around 10 km of the study area. The Survey of India Toposheets / OSMs on 1:50,000 scale covering study area is used for the preparation of Base Map, Drainage Map of the study area.

As per the EIA report, the land use within the study area with respect to Gateway Guwahati Ghat site comprises of agricultural land of about 2609.15 ha (8.31%) including fallow land 4647.21 ha (14.78%). Settlements in the study area cover an area of 5893.93 ha (18.76%) approximately. Forest in the study area comprises of about 8697.39 ha (27.68%) and Open Scrub / Grazing Land of about 3744.54 ha (11.92%). Study area has 488.91 ha (1.56%) of water bodies and 1336.3 ha (4.25%) of wetland. River and Sandy area covers an area of 2779.55 ha (8.85%) and 1218.88 ha (3.88%) respectively. The land use pattern and the respective coverage are given in Table below.

Table 10-1: Land Use/Land Cover – Gateway Guwahati Ghat – 10 km radius

Land Use / Land Cover	Area (Ha)	Area (Sq Km)	Area Percentage
Agricultural Crop Land	2609.15	26.09	8.31
Fallow Land	4647.21	46.47	14.79
Settlement	5893.36	58.93	18.76
Forest	8697.39	86.97	27.68
Open Scrub/Grazing Land	3744.54	37.45	11.92
Wetland	1336.30	13.36	4.25
Water body	488.91	4.89	1.56
River	2779.55	27.80	8.85
Sandy Area	1218.88	12.19	3.88
Total	**31415.31**	**314.15**	**100.00**

Source: EIA Report, AIWTP, March 2019

10.2.3 Water Environment

As per the water quality monitoring study carried out as part of the EIA study, the river water quality near Gateway Guwahati Ghat meets the Best Designated Use (BDU) Class C criteria of CPCB. Parameters such as pH & DO meet Class A criteria of CPCB. Observed values of Chloride, Sulphate, Nitrate, Calcium & Magnesium & metals are well within the acceptable limit of IS 10500 Drinking water standards.

Similarly, physico-chemical characteristics of the ground water samples collected from the project area were compared with prescribed drinking water standard, i.e. IS: 10500. All the parameters were within the permissible limits of drinking water as per IS: 10500.

10.2.4 Climate and Hydrometeorology

The climate of the project area is sub-tropical in nature. There are four distinct seasons. The monsoon and the dry seasons are prominent. The southwest monsoon lasts from June to September. Almost 90% of the annual rainfall occurs during this timeframe. The northeast monsoon that extends from November through March defines the cool dry season of winter. The transition from monsoon to the dry season of October-November is fairly smooth, marked by declining temperatures, humidity and storm frequency. This season is associated with variable convectional storm that occasionally produces severe cyclonic storm events.

Mean daily temperatures in the project area are fairly constant between the months of April to September in the order of 250C. From October onwards, temperatures begin to decline. Mean daily temperatures reach a minimum of about 180C in January, occasionally dropping in some cold years below 100C. In April, maximum daily temperatures often exceed 350C. Rainfall in the early and late monsoon periods is highly variable.

10.2.5 Ambient Air Quality

Ambient air quality monitoring was conducted at three sample locations in the study area during August – September, 2018 for PM10, PM2.5, SO2, NOx, CO and the observed values were compared with the National Ambient Air Quality Standards (NAAQS, 2009). Ambient air quality at all locations have been found to be well within the prescribed standards NAAQMS for all parameters. The area under study do not have major air polluting industries. Marginal contribution to air pollution near and around Gateway Guwahati Ghat is from domestic sources.

10.2.6 Ambient Noise Levels

Noise monitoring was conducted at three locations in the project area by using Sound Level Meter. Noise levels were monitored for day time (06.00 AM to 10.00 PM) and night time (10.00 PM to 06.00 AM).

The noise monitoring results for Gateway Guwahati Ghat site show that the day and night time noise levels at all sample locations meet the norms for commercial zone. However, the noise level exceeds the standard (45 dBA) during day time for residential zone. The major source of the noise in the study area is vehicular movement as well as commercial activities. The ambient air quality standards in respect of noise are 75, 65, 55 and 50 dB (A) Leq in daytime and 70, 55, 45 and 40 dB (A) Leq during night time for industrial, commercial, residential and silence zone respectively.

10.2.7 Soil Quality

Soil map of Assam State reveals that the proposed Ghats / Terminal area is coming in alluvial soil zone of the Brahmaputra River. Soil is sandy loam to silty loam in texture. As part of the EIA study, three samples of soils were collected from the proposed terminal site. It is observed from the soil analysis results that the soil near the terminal site is alkaline in nature. Clay percentage varies between 67.2% and 72.4%. Heavy metals content in the soil are not significant.

10.2.8 Ecology and Biodiversity

Gateway Guwahati Ghat and North Guwahati Ghat are located on either side of the banks of river Brahmaputra. The study area of GGG and North Guwahati Ghat are also overlapping. It has been observed that the ecological profile for both the project sites are almost same. The same species have been observed in both the project sites, except the quantum of forest coverage under the study area. The ecology of 10 km zone around the project site was studied as part of the EIA study.

10.2.8.1. FLORA

As per the EIA study, there are four reserve forest areas present within the study area in Gateway Guwahati Ghat. The details are presented in Table below:

Table 10-2: Reserve Forest Location – Gateway Guwahati Ghat – 10 km radius

Sl. No.	Forest	Direction from Site	Distance in Km
1.	Sila R.F.	NW	4.9
2.	Divgeshwar R.F.	N	7.4
3.	Phatasil R.F.	S	1.9
4.	Kalapahar R.F.	SE	1.92

The forest in the study area are Sal forest and mixed deciduous forest. Sal is the dominant species associated with Ajar (Lagerstoemia species), Ghugra (Schimawallichii), Paruli (Stereospermumprsonatum), Haldu (Adina cordifolia), Sam (Artocarpus sp.), Bor (Ficus sp.), Uraim (Bischofiajavanica), Gomari (Gmelina arborea), Teetachampa (Micheliachampa), and Poma (Toona ciliate). In mixed forest the common trees observed are Ghugra (Schimawallichii), Tectonagrandis, Paruli (Stereospermumprsonatum), Haldu (Adina cordifolia), Sam (Artocarpus sp.), Bor (Ficus sp.), Uraim (Bischofiajavanica), and Gomari (Gmelina arborea).

The 10 km study area covers rural settings, riparian flora and agrarian ecosystem. In rural areas the vegetation is restricted along agriculture fields, road side and other open areas. The common trees observed in urban areas are gulmohar (Delonix regia), Supari (Areca catechu), banyan tree (Ficusbenghalensis), siris (Albizzia sp.), bakain (Melia azedarach), kadamba (Bauhinia malabarica), bakain (Melia azedarach), sissoo (Dalbergia sissoo), imli (Tamarindusindica), rubber tree (Ficuselastica), bamboo, amaltas (Crassia fistula), semal (Bombax ceiba), Jamun (Eugenia jambolana), coconut (Cocos nucifera) etc. The herbs and shrubs observed in the area are lantana (Lantana camera), Pragmites (Pragmiteskarkar), congress grass (Parthenium hysterophorus), dub grass (Cynodondactylon), jimson weed (Datura stramonium), barnyard grass (Echinochloa crus galli), Johnson grass (Sorghum halepense), Echinochloacolona, chick weeds (Ageratum conyzoides), and green giant (Alocasia sp.). The complete list of plant species observed in the study area is provided in the EIA report.

Gateway Guwahati Site is open sandy with no trees present on the proposed land. Few herbs like Ipomeasps, Parthenium and grass species are observed. Vegetation within 500 m radius area of proposed terminal site inludes gulmohar (Delonix regia), banyan tree (Ficusbenghalensis), siris (Albizzia sp.), bakain (Melia azedarach), kadamba (Bauhinia malabarica), bakain (Melia azedarach), sissoo (Dalbergia sissoo), imli (Tamarindusindica), rubber tree (Ficuselastica), amaltas (Crassia fistula), semal (Bombax ceiba), jamun (Eugenia jambolana), coconut (Cocos nucifera) and bamboo etc. The herbs and shrubs observed in the area are lantana (Lantana camera), Pragmites (Pragmiteskarkar), congress grass (Parthenium hysterophorus), dub grass (Cynodondactylon), jimson weed (Datura stramonium), barnyard grass (Echinochloa crus galli), Johnson grass (Sorghum halepense), Echinochloacolona, chick weeds (Ageratum conyzoides), and green giant (Alocasia sp.).

No extinct, endangered, vulnerable, rare and/or critical floral species has been found in the core zone and buffer impact zone.

10.2.8.2. FAUNA

No Reserved/ Protected and other forest land are present within 500 m area of the proposed Gateway Guwahati Ghat site. The land use of 500 m area is mostly, settlement, water body, garden and roads. Due to absence of any forest in this zone the fauna diversity is restricted to common mammal species and amphibians and reptiles.

Within the 10km radius of the Study area major landuse comprises of water bodies, settlements, hilly terrain and few patches of reserve forests. The wildlife is restricted to forest areas and away from the settlements. Wild life found within the reserve forest are of least concern status except Golden Langur which is endangered. The riverine island Umananda has been reported to be inhabited by Golden langur. However there is no direct impact anticipated from the proposed project activities to the Golden Langur or its habitat and suitable measures shall be taken as per the suggestions of the State Regulatory Authorities. These forest patches serve as a habitat for the wild fauna. List of fauna found in the study area is presented in EIA. The area is inhibited by large numbers of birds like sparrow, egret, dove, drongo and other birds.

Migratory birds from Siberia visit the area during winter. They arrive at DeeporBeel located within 10k radius of the Project Site. The route of migration is north-south direction. These birds arrive in large numbers due to suitable temperature and abundant availability of snails, slugs, fish etc. Local migratory birds from upper Assam migrate to DeeporBeel for breeding and to escape freezing winter. The most notable bird species found in the sanctuary are Kingfisher, Fishing eagles, plethora of ducks, Greater Adjutant Stork, Whistling Teal, Open Billed Stork, Shoveler, Pintail, Garganey and high concentration of Pheasant tail jacanas etc.

As per Government records there is no designated migratory route for terrestrial wild fauna identified within a radius of 10 km around the project site.

Details of the fauna observed are provided in the EIA report.

10.2.8.3. AQUATIC ECOLOGY

Aquatic ecosystem in study area comprises fresh water ecosystem comprising Brahmaputra River and still water bodies comprising of DeeporBeel. Aquatic ecology of Brahmaputra River at Gateway Guwahati Ghat includes a variety of plankton, fishes and benthos.

Phytoplankton is the dominant group of aquatic plants found near Gateway Guwahati site. Bacillariophyceae (diatoms) is dominant species and has maximum abundance as compared to Cholophyceae and Cyanophyceae. Submerged aquatic macrophytes are usually rooted in the bottom soil with the vegetative parts predominantly submerged. These plants are very important for the process of photosynthesise in aquatic ecosystem and act as primary producers. Zooplanktons are microscopic and motile organism usually present on the surface of water. These species are important and act as primary consumers feeding on phytoplankton. Samples for testing of phytoplankton and zooplanktons were taken from upstream and downstream of Brahmaputra River near the proposed terminal site. The list of observed species is presented in the EIA report.

The fish population of Brahmaputra River is largely dependent on phytoplankton, zooplankton, periphyton and zoo benthos which establish itself in the form of food chain. The common fishes observed in the study area are rohu (Labeo rohita), moa (Amblypharyngodon mola), puthi (Puntius sp.), singora (Mystus vittatus), kawoi (Anabus testudineus), goroi (Channa punctata), karati (Gudusia chapra), punga (Tetradon), chanda (Chanda nama), khalihona (Colisa fasciatus), Tora (macrognathus puncalus), Boriala (Aspidoparia morar) etc. The list of fish species reported /observed in the study area is provided in the EIA report.

The Brahmaputra supports over 200 species of aquatic fauna, including the endangered river dolphins. A detailed ‘’Gangetic Dolphin Survey" has been completed for the dry season during the month of March"2019 as part of the EIA study. As per the dolphin study carried out during dry season, Gangetic dolphins, which are a Schedule-I species under the Wildlife Act, 1972 of the Government of India, no dolphin were spotted at Gateway Guwahati Ghat. However the dolphins were spotted in the survey route of the study area. Secondary data indicates presence of dolphins at Guwahati. The presence of dolphins in Gateway Guwahati Ghat cannot be ruled out because of their constant movement. The dolphin study for the wet season is expected to be carried out by July, 2019. The existence of breeding and spawning areas in the project area shall be confirmed after the wet season study. The details of the dolphin survey are provided in EIA report.

No Chelonians (turtle) nesting ground is reported in and around proposed terminal site. But the secondary data indicates presence of a few species of turtles in the 10 km study area.

DeeporBeel, Ramsar site is also located within the 10 km area of the proposed site. DeeporBeel is a permanent, freshwater lake. As per the EIA, DeeporBeel is a large natural wetland having great biological and environmental importance besides major storm water storage basin for the Guwahati city and the only Ramsar site in Assam and among the third Ramsar site of the north eastern region of India. DeeporBeel is designed as “Wetlands of International importance” under the Ramsar Convention on wetlands, 1971 and was declared as Ramsar site in 2002. DeeporBeel is the rest house for migratory birds and known to be one of the largest aquatic bird’s habitats in Assam with 19,000 water birds counted on a single day in the winter season. DeeporBeel is listed in Birdlife International’s list of Important Bird Areas (IBA) for its diversity of bird’s habitat. DeeporBeel serves as major fish breeding. List of migratory birds reported in DeeporBeel has been presented in the EIA report.

Amchang wildlife sanctuary is located at extreme east of Guwahati City. DeeporBeel & Amchang WS are located at extreme 10km aerial distance from the “Gateway Guwahati Ghat”. These two places are separated by various anthropogenic activities undertaken by government and other sectors in the Guwahati city. There is no direct impact anticipated from the proposed project activities in DeeporBeel & Amchang Wildlife Sanctuary.

10.2.8.4. RIVERBED SEDIMENT QUALITY

The riverbed sediment is an integral component of the aquatic ecosystem. The sediment may absorb / adsorb natural and anthropogenic toxic substances from the water. The sediment quality influences benthic organisms, vegetative communities, and the aquatic food web. Secondary data on sediment quality from IIT, Guwahati for the project site indicates that the sediment is non-hazardous and is not contaminated.

10.2.8.5. SOCIO-ECONOMIC PROFILE

Gateway Guwahati falls under Kamrup district of Assam. Kamrup district occupies an area of 4,345 square kilometres. According to the 2011 census Kamrup district has a population of 1,517,202 with density of 436 persons per square kilometre and the population growth rate over the decade 2001-2011 as 15.67%. Kamrup has a sex ratio of 946 females for every 1000 males, and a literacy rate of 72.81%.

The district has people belonging to various indigenous Assamese communities like Keots/Kaibarta, Bodo, Rabha, Tiwa/Lalung, Amri Karbi, Dom/Nadiyal, Koch-Rajbongshi etc.

The economy of the project district is mainly dependent on agricultural and industrial sector. More than half of its population are engaged in agriculture in order to earn their livelihood. The chief agricultural products in the district are wheat, paddy, coconut, sugarcane, orange, pineapple, lemon, coconut, etc. Every year a huge portion of the revenue comes from the agricultural products in the district. Guwahati refinery and two major tea plantations in the district further alleviates its economy. Occupational pattern of the sample families in and around Gateway Guwahati shows that 31.2% of the families are engaged in small business, 6.4% working in private firms, 2.1% are labourers, 1.4% engaged in agriculture sector, 1.4% are technicians, 2.1% teachers, 4.3% Government employees etc. Among the work force 46.8% are men workers and only 6.4% are women workers, which further contributes to the lower status of women.

Gateway Guwahati Ghat lies in the midst of the Guwahati City. Guwahati city is hub of industries and educational facilities for the state of Assam as well as for the North Eastern part of India due to its well-connected transport network. There are numbers of designated industrial belt in the city. Fancy Bazar which is just opposite to the GG Ghat is major commercial centre of Assam.

There are numbers of universities, colleges both in government & private sectors in the city to nurture academic need of the entire region in all sectors including basic science, arts, medical science, engineering and other vocational courses. Cotton College University is the premier institute of the region and established on 1901 is located at 1km distance from the project site. Guwahati University and Assam Engineering College are located at a distance of approximately 8km from the GGG Ghat. Indian Institute of Technology (IIT) is located at north bank of the River Brahmaputra which can be reached through IWT ferry services in 15 minutes time.

There are numbers of government & private hospitals including government medical colleges close to GG Ghat. Mahendra Narayan Choudhury Hospital is located just opposite side of the road adjacent to the Guwahati Gateway Ghat. It is one of the oldest hospitals with all modern health care facilities. Guwahati Medical College Hospital is in 5km distance from the project location. Proposed AIIMS (All India Institute of Medical Sciences), Guwahati is at 10 km distance by road from the project location. People from different part of the state and other north eastern states of India come for better health care facilities to Guwahati.

This area is well connected through road, waterways, railways and airways. Guwahati Railway station is at 1.5 km distance from the GGG Ghat and the Guwahati International Airport is located at 21km distance from the project location.

10.2.8.6. SITES CULTURALLY SIGNIFICANT OR ARCHAEOLOGICALLY SIGNIFICANT

Sites of Archaeological importance, temples, monuments and mosques having cultural significance are not present within the Project Site. However Umananda Temple which is a State Protected monument (under Department Of Cultural Affairs, Government of Assam) is located within 1 km of the Site on the riverine island of Brahmaputra river. There shall be no adverse or direct impact on the temple or its cultural significance. However the concerned department shall be consulted and feedbacks shall be duly noted.

10.3 Assessment of Impacts and Mitigation Measures

The proposed development activities for the project involve development of existing terminals with necessary infrastructures and amenities including river bank stability.

For assessment of environmental impacts of the project, the EIA study has analysed the interaction between various project components and environmental elements. The impact assessment has been done with reference to the EMF Guidelines prepared for the project. Mitigation measures have been proposed duly taking into account the observations during field surveys and the feedback received during public consultations. An EMP has been designed to ensure the effective implementation of proposed mitigation measures.

There will be no change in drainage pattern & channel hydraulics due to the project activities. Valued or critical environmental components (VECs) identified for this project include climate, aquatic ecology, impact on sensitive species namely Dolphins and Turtles, water quality, terrestrial flora (cutting of trees at intervention sites, if any), avifauna, ambient noise levels and air quality, dredging etc. Each project activity has been analysed for its potential impact on environment and the same has been comprehensively assessed.

The impacts anticipated due to project design & construction on terrestrial ecology are low to moderate. Since the construction activities will be for a small area, the impact on climate will be negligible.

The land identified for terminal site at Guwahati gateway is entirely private and falls within the high flood zone. The identified land is largely barren and does not have any tree cover. Therefore, no adverse impact on account of land use change is anticipated due to the project.

There is no critical environment resource present in Gateway Guwahati Ghat study area. No major wildlife is reported or observed at the proposed site. Thus, no impact on wildlife is anticipated due to construction of the project.

The aquatic ecology is likely to be disturbed due to construction and piling activities along the bank and river bed. However, the impact is mostly confined to the construction sites and localised. As per the secondary data, Brahmaputra River is home to Dolphins, fishes and other aquatic fauna. Baseline study indicates no permanent habitat of dolphin is reported in study area. Thus, impacts anticipated on these eco-sensitive zones during design & construction phase are minimal.

10.3.1 Impacts of Noise due to Dredging

There is no dredging activity involved in this project and hence not applicable.

10.3.2 Impacts of Noise due to Piling Activity

Pilling activities will be carried out at a few locations for holding the floating pontoon and gangway. For the purpose, Jack-up piling-rig will be placed in the River which will occupy some physical space in the River. Apart from occupying the physical space, piling activity will generate significant noise. Exposure to low levels of sound for a relatively long period, or exposure to higher levels of sound for shorter periods of time, may result in auditory tissue damage in fish, though recovery is generally possible within 24 hours (Popper et al. 2005). However, the piling activity at proposed terminal site will be for a short duration and the biotic conditions of the area will normalize after the activity is completed.

Key mitigation measures proposed in the EIA report in this regard include the following:

- The area in which the piling is planned, it advisable to carefully determine drop sites before anchor placement to ensure that Dolphin and fish communities that could locally still be present in the area are not unnecessarily damaged.
- Before starting piling allow some time to aquatic fauna to displace from the piling area. Bubble curtains can be provided at the time of piling to displace the aquatic fauna prior start of construction activities. However, there should be no construction activities in water from mid-March to mis-June. This duration is referred as ‘no-construction period’.
- Fish exclusion devises shall be installed in water column around the pile driving area to prevent fish access.
- Noise reducing devices like mufflers, enclosures shall be fitted with the equipment as much as feasible. Noise barriers shall also be installed.

- Geo Textile synthetic sheet curtain & turbidity traps shall be placed around piling and construction area to prevent movement of sediments and construction waste.

10.3.3 Impacts of Sediment Release due to Piling and Other Construction Activities

Suspended sediment due to piling operations in the water column blocks available light for photosynthesis, reducing benthic primary productivity and inhibiting the ability of benthic plants to recover from dredging impacts. But the effect of suspended sediments and turbidity in open environment like river are generally short term (<1 week after activity).

Construction activities to be undertaken involves storage of raw material, debris, fuel, paints etc. There are likely chances that, the run-off from the site may get contaminated with these materials and when it will enter the water body may also degrade the water quality of the river.

Key mitigation measures proposed in the EIA report in this regard area as follows:

- To avoid the construction debris, wash or blown into the water, the area shall be surrounded by silt screens, which must be placed in the water before the work starts. Geo-Textile synthetic sheet curtain can act silt screen which should be placed around piling and construction area to prevent movement of sediments and construction waste. The screens should also be placed around storage areas, to prevent waste from blowing away and to prevent sediment run-off into the river.
- In addition to silt screens, storage areas for sand and soil, and all work areas, must be located at least 20 meters away from river. Construction equipment must not be cleaned or washed within 50 meters of the river.
- Piling should not be carried out during breeding and spawning season i.e. during rainy season. It should be carried out in low water season, i.e. pre-monsoon.

10.3.4 Impacts during Operation Phase

The projected population in each terminal after the completion of the project is expected to be around 2000/day. The quantum of solid waste generation could be around 200gm/capita. Adequately sized colour coded dust bins shall be provided at strategic locations for collection of segregated waste. Intermittent storage facility will also be a part of infrastructure development.

Sewage & wastewater too shall be generated at terminal site during operation phase. To mitigate their impacts on terrestrial or aquatic ecology, provisions for STP and storm water drain have been made in the terminal design.

Positive impact on ecology is anticipated during the operation stage as 3m wide peripheral green belt will be developed and avenue plantation will be carried out at the proposed terminal site.

Installation of pontoon, gangway and other off-shore structures will consume physical space in water reducing the available space for the aquatic organism. Planktonic population at pontoon and gangway and nearby area will reduce or will decrease drastically which will impact the primary productivity of the water body. Planktons is feed for various big fishes, thus reduction in plankton population will affect the aquatic food chain. However, the area to be covered by pontoon and gangway is very little as compared to the width of the river. Thus, reduction of this space is unlikely to have significant adverse impact.

Also, there is a possibility that aquatic organisms may collide with these newly constructed structures. But as behavioural response, instinctively aquatic animals at the first encounter avoid approaching the site of unknown object. This is done using echolocation, olfaction or chemo-reception, if the object is not making any sound. Thus, the space occupied by unknown structures will be avoided by aquatic organisms thereby reducing the chances of collisions and injury to aquatic organisms.

10.3.5 Socio-Economic Impacts

The total land required for the terminal construction at Gateway Guwahati is 341.58 sq. m. Dag no. wise land requirement is presented in Table below.

Table 10-3: Land Area to Be Acquired As Per Dag Number

S. No.	DAG No.	Area (m2)
1.	33	124.93
2.	41	216.65
Grand Total		**341.58**

Source: DPR for Gateway Guwahati Ghat Terminal, 2019

The land identified for Gateway Guwahati Ghat terminal site is owned by Government of Assam. As per the EIA report, no families or structures are going to be directly impacted due to the proposed Project.

All title holders and non-titleholders shall be compensated according to the entitlement matrix, prepared in line with the World Bank OP 4.12, the Right to Fare Compensation & Transparency for Land Acquisition, Rehabilitation & Resettlement Act, 2013 (RFCTLARR, 2013) and the Assam LARR Rules, 2015. The entitlement matrix is provided in the SIA / RAP prepared for the project by Arkitechno Consultants (I) Pvt Ltd.

10.3.6 Gender Based Violence

As per a study conducted by the Centre for Urban Equity, women in Guwahati listed general harassment by co-passengers, driver or conductor (47 %), eve-teasing (10 %), and stalking (7 %), as major constraints in use of public transportation.

The SIA carried out for the project and a World Bank study on gender-inclusive Assam IWT, revealed that women, particularly students (school/college), were susceptible to experiencing sexual harassment on board the vessel. The studies further revealed that most IWT terminals and vessels had limited seating facility; while waiting areas were mostly overcrowded. Few, if any, had clean toilets or drinking water facility. Based on the findings, the study provided the following recommendations to address these in project planning and development. Two of the recommendations that relate to facilities at terminals are as follows:

- Potential for sexual harassment of women and girls on IWT can be addressed by limiting overcrowding, providing sufficient seats and well-lit spaces. All terminals should have toilet facilities that are safely accessible to all individuals including the differently-abled. Designated space for nursing mothers to breastfeed and to look after infants at the terminal, should be considered as well.
- Display of women helpline nos., dedicated hotline for the project at prominent location of the terminals and ferries including deployment of security personnel at every terminal is needed.

The above recommendations have been duly taken into account in DPR preparation for the Gateway Guwahati Ghat terminal development.

10.3.7 Labour Standard Compliance and Labour Influx Mitigation Framework

Based on the assessment of risks associated with labour influx relating to the project, potential adverse impacts of labour influx have been enumerated in the EIA report as below:

- Labour influx may influence the demographic composition of the existing mass of population in riparian areas, where there already seems to be a decline of man-land ratio, shortage of food, settlement pattern, and ethnic differences.
- Increased demand and competition for local social and health services, as well as for goods and services, which can lead to price hikes and crowding out of local consumers. SIA of the project area indicates low capacity of the community to manage and absorb the incoming labour force. This is particularly relevant for Assam, as it already deals with such risk from cross border and interstate migration.
- Bearing in mind the present socio-political environment, temporary labour influx due to the project may amplify social conflicts between the local community and the construction migrant workers.
- Project may result in increased rates of illicit behaviour and crime against women, which is a real threat for Assam where gender-based violence is rampant.
- SIA of the project site reveals that the project will directly impact the livelihood of affected families who earn their living through petty businesses and agricultural activities (marginal/small) in the project area. It is therefore imperative to ensure that the PAPs can reconstruct their livelihood. The temporary labour influx may increase competition for jobs and have an impact on wage distribution.

Following mitigation measures have been recommended in the EIA report to contain the labour influx risks:

- The contractor is responsible for recruitment of labourers for construction work. Specifications on employment of local workforce including women should be reflected in the civil works bidding documents and subsequent contracts to ensure that the contractors fulfil these commitments. Locals including women may be screened further for skills, and adequate orientations can be provided to recruit for the work. AIWTDS can prepare a roster of interested workers and their skills. The lists can be provided to contractors at the pre-bid meetings for recruitment consideration.
- The project contractor needs to prepare a site-specific Labour Influx Management Plan and/or a Workers Camp Management Plan. This plan will include specific measures that will be undertaken to minimize the impact on the local community, including elements such as worker codes of conduct, grievance redressal, skills development, training programs and awareness generation on HIV/AIDS and gender-based violence (GBV) for the workers and host community. A Workers" Camp Management Plan will also address specific aspects of the establishment and operation of the workers" camps in compliance with relevant labour laws. The plan should include appropriate screening and monitoring mechanisms for addressing non-compliance.
- Adequate measures will be taken to ensure safety and security of women within the community and at the construction site. A security personnel will be deployed at the construction sites, and emergency nos. including contact details of local law enforcement officers, project's helpline no., existing state-run women helpline nos. will be prominently displayed at the site. The contractors will ensure that an Internal Complaints Committee (ICC) for each establishment is set-up to meet their corporate requirement and legal mandate under the Sexual Harassment at the Workplace Act, 2013.
- Health problems of the workers should be taken care of by providing basic health-care' facilities through health centres temporarily set up for the construction camp. The health centre should have the requisite staff, free medicines and minimum medical facilities to tackle first-aid requirements or minor accidental cases, linkage with nearest higher order hospital to refer patients of major illnesses and critical cases.

- Awareness camps on HIV/AIDS for both, construction workers and neighbouring villages must be organised at regular intervals by NGOs empanelled with NACO.
- It is expected that among the women workers there will be mothers with infants and small children. The provision of a day care crèche as per the Building and Other Construction Workers (regulation of employment and conditions of service) act, 1996 is the contractor's responsibility. The crèche should be provided with trained women to look after the children.
- In case work schedule extents up till night, it should be ensured that women workers are exempted from night shifts.

10.4 Additional Studies

Additional studies have been conducted as part of the EIA study carried out for the project with respect to the following areas:

- Flood Assessment and Control Measures
- River Bank Profile and Bank Protection Measures
- Hazard Identification and Management
- Occupational Health and Safety
- Emergency Preparedness and Response Plan

Potential emergencies during the construction phase (Water and Land) could result from any of the following:

- Collapse of structure due to design fault, soils conditions, poor quality of construction material etc.
- Overturning of a crane during lifting / transportation of the materials
- Overturning of motorized boat / normal boat used for transportation of workers in off shore construction
- Leakage of Oil (HSD) in oil storage area leading to fire
- Gas leakage from Cylinders used for the purpose of gas cutting and welding (Dissolved Acetylene, LPG etc.) leading to explosion
- Bursting of cables due to cable breakage / over loading leading to fire
- Mass leakage of oils leading to land contamination
- Collapse of complete scaffolding leading to multiple fatalities

A comprehensive emergency response strategy has been proposed I the EIA report that comprises coordination and control of emergency, emergency prevention aids, oil spill management facilities, facilities at jetty, incident control room, assembly points during emergency, communication facilities and the organizational structure for prevention and control of emergencies.

The emergency management aspects applicable to the design phase have been duly taken into account in DPR preparation for the Gateway Guwahati Ghat terminal. Key among these are the firefighting system, storage areas for hazardous material, designated parking areas assembly points and incident control / first aid room.

10.5 Environmental Management Plan and Environmental Monitoring Programme

Based on the study of baseline environmental conditions and the assessment of potential impacts of the project, a site specific environment management plan (EMP) has been developed for the project as part of the EIA study.

In order to effectively implement the EMP, an institutional framework has been developed and roles and responsibilities of various relevant agencies have been worked out. Capacity development program are also identified and part of the EMP. In general, Assam Inland Water Transport Development Society (AIWTDS), (with assistance from Contractor and Independent Engineer/Supervision Consultant) is the responsible entity for ensuring that the mitigation measures as suggested in the EMP.

The mitigation measures proposed in the EIA report for the project have been suitably incorporated in the design of Gateway Guwahati Ghat terminal. However, the technical experts of the DPR consultants are of the opinion that some of the measures recommended for minimizing impacts on aquatic ecology due to the noise and turbidity generated on account of piling activities during construction stage are not feasible to implement mainly owing to the cost involved in making these provisions. The mitigation measures that are not found feasible from implementation perspective include the following:

- Provision of 'Bubble Curtains' at the time of pilling to displace the aquatic fauna prior to start of construction activities
- Noise reducing devices like mufflers, enclosures to be fitted with the equipment as much as feasible.
- Installation of fish exclusion devices in water column around the pile driving area to prevent fish access
- Placing of Geo Textile synthetic sheet curtain & turbidity traps around piling and construction area to prevent movement of sediments and construction waste

All other mitigation measures proposed in the EIA report have been incorporated in the DPR prepared for the terminal development.

To ensure the effective implementation of EMP, it is proposed to undertake environmental monitoring both during construction and operation period. A three-tier monitoring program has been proposed. These are:

- Compliance monitoring,
- Effects monitoring, and
- External monitoring.

The detailed environmental management and monitoring plan is provided in the EIA report prepared for the project.

TABLE 10.4: SUMMARY OF ENVIRONMENTAL AND OTHER LEGISLATION WITH APPLICABILITY SCREENING

Name	Key Requirement	Applicability	Type of permit and stage of applicability	Administrative Authority and indicative time frame for grant of permission	Responsibility
Environmental Protection Legislations					
Environment Protection Act-1986 and Rules there under including EIA Notification 14th Sep 2006 and amendment till date	To protect and improve overall environment. Requires prior environmental clearance for new, modernization on and expansion projects listed in schedule 1 of EIA Notification, 2006	Considered not Applicable (EIA Notification 2006 does not classify terminals/jetties/ floating terminals on river or dredging in the river as a project requiring environmental clearance. The applicability of this legislation should be reassessed periodically from the concerned authority during NW-2 project development and implementation stages to ensure conformity with changes in the regulations if any).	NA	MoEF&CC & SEIAA/SEAC	AIWTDS/ Contractor for obtaining environmental clearances as applicable. Contractor should also be responsible for EMP implementation and compliance to environmental clearance conditions.
Air (Prevention and Control of Pollution) Act, 1981, 1987	An act to prevent and control Air pollution	Applicable. The applicability is due to emission from operation of construction equipment like batching plants, hot mix plants, DG sets, and similarly, during operation stage backup power generation, material handling related aspects.	Consent to Establish (CTE) &Consent to Operate (CTO)	SPCB	Ccontractor should obtain CTE & comply its conditions for setting up each facility, batching plant, hot-mix plant, DG set as prior to its establishment from SPCB CTO should be taken by contractor for batching plant, hot-mix plant & quarry site as required prior to operation and it should be renewed before the expiry of permit.

					Contractor should also obtain CTE/CTO for each proposed facility under the project before its handover. Contractor and AIWTDS should be responsible to comply with the conditions as mentioned in CTO
Water Prevention and Control of Pollution) Act, 1974, 1988	An act to prevent and control water pollution.	Applicable. It is applicable for the projects having potential to generate effluent during any stage of the project. Effluents are expected to be generated during both the construction and operation phase of the project	Consent to Establish & Consent to Operate	SPCB	CTE should be taken by Contractor for disposal of sewage and construction of septic tank/soak pit prior to start of construction from SPCB. Compliance to the conditions mentioned in the CTE should be done by Contractor CTE/CTO for each proposed facility under the project should also be obtained by contractor along with CTE / CTO under Air Act. AIWTDS should ensure the conditions specified in CTO are complied with
Noise Pollution (Regulation and Control Act) 2000 and amendment till date	Ambient Noise Standards for different areas and zones	Applicable due to generation of noise during construction and operation stage	No permits issued under this act	SPCB & CPCB	Contractor and AIWTDS to ensure compliance to Ambient Noise Level Standards.

Hazardous & Other Wastes (Management and Trans boundary Movement) Rules, 2016	Protection to general public against improper handling storage and disposal of hazardous waste. The rules prescribe the management requirement of hazardous wastes from its generation to final disposal.	Applicable. Project has potent to generate hazardous waste (Waste Oil) during both construction and operation phase.	Authorization for storage and handling hazardous waste	SPCB & MoEF&CC	Contractor should obtain authorization for handling, storage and disposal of hazardous waste (Waste Oil) along with CTE/CTO for air and water act. Also compliance to the conditions mentioned in authorization should be ensured by contractor and AIWTDS
MSIHC Rules, 1989 Chief Controller of Explosives,	Usage and storage of hazardous material	Applicable only for storage of highly inflammable liquids like HSD/LPG	Specific permit is required for storage of Fuel. Also, precautions defined under the material safety datasheets should be followed for use of hazardous substances listed under the schedules attached to this notification if any proposed to be used. Safety audit and other requirements should have to be complied if storage quantity exceeds the egulated threshold limit	MoEF&CC and DC	Contractor and AIWTDS. Compliance to the rules should be ensured

The motor vehicle act 1988	To enforce standards for vehicular pollution.	Applicable	All vehicles used for construction and buses during operation phase will need to comply with the provisions of this act.	State Transport Authority	State Motor Vehicles Department, AIWTDS
The Bio Medical Waste Management Rules, 2016	To control storage, transportation and disposal of Bio Medical Waste.	Applicable Applicable for the disposal of bio-medical waste from first aid centres and dispensaries	No specific permit is required. Just comply with the handling and disposal requirements of the rule	Disposal through authorized disposal agency	Contractor and AIWTDS Compliance to the rules should be ensured
Construction and Demolition Waste Management Rules, 2016	To manage the construction and demolition waste	Applicable Applies to all those waste resulting from Construction, remodelling, repair & demolition of any civil structure of individual or organization who generates construction and demolition waste such as building material, rubble, debris.	Approval required from local authorities, if waste generation is >20 tons in a day or 300 tons per project in month	Local Authorities. Segregation, management and disposal of waste as per rules.	Contractor and AIWTDS. Compliance to the rules should be ensured

E-Waste (Management) Rules, 2016	To manage the E-waste but not covering lead acid batteries and radioactive waste	Not Applicable as project will not fall any of the categories. (Rule applies to every manufacturer, producer, consumer, bulk consumer, collection centres, dealers, e-retailer, refurbisher, dismantler and recycler involved in manufacture, sale, transfer, purchase, collection, storage and processing of e-waste or electrical and electronic equipment listed in Schedule I, including their components, consumables, parts and spares which make the product operational)	To obtain authorization from SPCB. Filing of return and maintenance of records in the forms given in the Rules	SPCB	Not Applicable
Plastic waste Management Rules, 2016	To manage the plastic waste generated	Applicable Rule applies to every waste generator, local body, Gram Panchayat, manufacturer, importers and producer.	No authorization to be obtained. Waste management and minimization to be done. Fee to be paid to local bodies, if applicable	Local bodies	Contractor and AIWTDS. Compliance to the rules should be ensured
The Batteries (Management and Handling) Rules 2010	To regulate the disposal and recycling of lead acid batteries	Applicable Applicable for disposal of used lead acid battery if likely to be used in any equipment during construction and operation stage	No specific registration required. Compulsion to buy and sale through registered vendor only.	MoEF&CC	Contractor and AIWTDS. Compliance to the rules should be ensured

Forest Conservation and Wildlife Protection Legislation					
The Forest (Conservation) Act, 1980 and amendments. The Forest (conservation) Rules 1981 and amendments till date	To protect forest by restricting conversion of forested areas into non-forested areas and deforestation	Forest area is not identified in the reconnaissance visits. All the sites will be confirmed for the forest areas from the relevant sources like forest departments in the respective districts. Also tree cutting is envisaged at some locations for which NOC from forest department as per applicable rules of the state. (it will be required as per current rules of the state for cutting of the trees).	Forest Clearance / Permission for tree cutting	Forest Department, MoEF&CC	NOC should be obtained from forest department prior tree cutting. Compensatory forest policy. 1:8 is recommended for thus project if any forest diversion is proposed. NOC should be obtained by contractor. All the conditions mentioned in Forest NOC should be complied with.
Biological Diversity Act, 2002	Conservation of biological diversity, sustainable use of its component s and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto	Not Applicable	No permit issued under this Act.	National Biodiversity Authority and State Biodiversity Board	Not Applicable
Wild Life Protection Act, 1972, 1993	To protect wildlife through notifying National Parks and Sanctuaries and buffer areas around these zones	Not Applicable as no development is being undertaken within the buffer zone of the Eco sensitive zone notified under this act.	Wildlife clearance	Chief Conservator Wildlife, Wildlife Wing, Forest Department, MoEF&CC	Necessary permission should be obtained for any intervention if planned at any stage within the buffer zone of eco sensitive zones.
Safety and other related legislations					
Chemical Accidents (Emergency Planning,	Requirement of preparation of on-site and off-site Disaster	Not Applicable.	No permits issued under this act	Central, State & District Crisis Group	Not Applicable

		The project does not involve handling of any hazardous chemical during both construction and operation phase which may lead to continuous, intermittent or repeated exposure to death, or injury.			
Preparedness and Response Rules, 1996	Management Plans for accident-prone areas.				
Public Liability and Insurance Act 1991	Protection from liability arising due to accidents from handling of hazardous chemicals.	Not Applicable. The project does not involve storage of any chemicals (HSD) beyond the threshold limit during construction	No permits issued under this act. Owner of project should take out insurance policies providing for contracts of insurance so as he is insured against liability to give relief, before handling any such hazardous material	Collector of the Area	Not applicable
Explosive Act 1884 & Explosive Rules, 2008	Safe transportation, storage and use of explosive material	Not Applicable as no explosive (as described in act & rules) should be used in the construction and operation stage of the project.	Permission for storage and usage of explosive	Chief Controller of Explosives	Not applicable
Petroleum Rules, 2002	Use and Storage of Petroleum products	Applicable as storage of HSD/LPG or any other petroleum product may be required for the project purpose	License to store petroleum beyond prescribed quantity.	Chief Controller of Explosives/DC	Contractor / AIWTDS. Compliance to the rules should be ensured

Central Motor Vehicle Act 1988 and amendment Central Motor Vehicle Rules, 1989 and amendments till date	To minimize the road accidents, penalizing the guilty, provision of compensation to victim and family and check vehicular air and noise pollution.	Applicable, for all the vehicles at site during Construction & operation phase.	No permit issued under this Act	Motor Vehicle Department (Licensing) authority, registration authority & State Transport Authorities)	Contractor to follow Rules for all the construction vehicles being used at site during construction purpose. AIWTDS should follow the rules for all its vehicles at site during operation phase and should also monitor that loading & unloading vehicles also complied these rules Compliance with the rules should be ensured.
The Gas Cylinder Rules 2004	To regulate the storage of gas / possession of gas cylinder more than the exempted quantity	Applicable if contractor store more than the exempted quantity of gas cylinder.	License to store gas cylinder more than the regulated quantity	Chief Controller of Explosives	Contractor. Compliance to the rules should be ensured

Ancient Monuments and Archaeological Sites and Remains Act, 1958	Conservation of cultural and historical remains found in India. According to this Act, area within the radii of 100m and 300m from the "protected Property" are designated as "protected area" and "controlled area" respectively. No development activity (including building, mining, excavating, blasting) is permitted in the "protected area" and development activities likely to damage the protected property is not permitted in the "controlled area" without prior permission of the Archaeological Survey of India (ASI).	Applicable only if any intervention is planned within 300 m of archaeological protected sites falling along the NW-2	No objection certificate	Archaeological Dept. GoI, Indian Heritage Society and Indian National Trust for Art and Culture Heritage (INTACH).	May be Applicable. Umananda Island is also an archaeologically important site. But, since it is yet to be notified as a protected archaeological site, it has remained a Government-owned area and the civil administration itself can handle the matters related with this island. But the island's location remained within the regulated area of the protected monuments of Urvasi Island, Necessitating the National Monuments Authority's clearance.
Guidelines for evaluation of proposals / requests for ground water abstraction for drinking and domestic purposes in Notified areas and Industry / Infrastructure project proposals in Non- notified areas, 2012	To regulate extraction of ground water for drinking and domestic purpose	Applicable if ground water is extracted for meeting drinking/domestic water needs of employees and visitors at proposed facility& vessels	No objection certificate	Central ground Water Authority/Board & MoEF&CC	Contractor / AIWTDS should obtain NOC from CGWA/CGWB prior digging any bore well during construction & operation phase. Compliance to the rules should be ensured by AIWTDS and contractor

TABLE 10.5: REGULATIONS APPLICABLE ON VESSELS/ BARGES PLYING IN INLAND WATERWAYS

Name	Key Requirements	Applicability	Authority
Prevention of Collision on National Waterways Regulations, 2002	Regard to precautions required by the ordinary practice of Seamen and limitation of the vessel	Applicable for all the vessel plying in NW	IWAI, AIWTDS
National Waterways, Safety of Navigation and Shipping Regulations, 2002	Ensuring safety of navigation and shipping on the national waterways	Applicable for all the vessel plying in NW	IWAI, AIWTDS
The National Waterway Act, 1982	Provision for regulation and development of that river for purpose of shipping and navigation on the NW-2 and for the matters connected therewith or incidental thereto	Applicable for all the vessel plying in NW	IWAI, AIWTDS
New Inland Vessel Act, 2015 & Rules Under IV Act	Economical and safe transportation through inland waters	Applicable for all the vessel plying in NW	IWAI, AIWTDS

TABLE 10.6: ENVIRONMENTAL MANAGEMENT PLAN FOR PROPOSED TERMINAL PROJECT (CONSTRUCTION PHASE)

Component	Environmental Attribute and potential impacts	Remedial Measure	Relevant laws and Contract Documents	Approximate Location	Time Frame	Institutional Responsibility	
						Implementation	Supervision
1. Site Preparation: Levelling of Terminal Site, Base cap, Construction Camp & Labour camp							
1.1 C & G and levelling of site	ü Loss of vegetation. ü Loss of top soil. Loss of natural resource (Earth/ soil)	Tree cutting, if any would be carried out only after obtaining NOC from Forest Department ü Top soil (15 cm) would be stripped and kept separately in stockpiles for use in landscaping. ü Excavated materials would be preferably used for site filling/low lying area filling and the surplus	Solid Waste Management Rules, 2016, Hazardous & Other Waste (Management and Transboundary) Rules, 2016 C & D waste Rules, 2016. The Water (Prevention & Control of Pollution) Act, 1974 and amendme	Construction site Labour and construction Camp Locations	During design and Construction Stage	Contractor	TSC & PMU

		material would be disposed as per norms. ü Green belt/landscaping would be developed at the site and as per the Green Belt management Plan. ü Survival rate of tree would be regularly monitored. It should be minimum of 70%. ü Sedimentation tanks shall be provided for storm water drain to arrest the sediments and these sediments shall be removed and stored with remaining excavated soil. ü Shore protection works like stone pitching along the bank shall be undertaken.	nts thereof.				
1.2 Setting of Labour & Construction Camps:	Contamination of land and water resources from waste generation.	ü Construction camp location would be as per proposed Construction & Labour Camp Management Plan. ü Labour camps would be	Solid Waste Management Rules, 2016, Hazardous & Other Waste (Management and Transboundary) Rules, 2016	Labour and construction Camp Locations	Construction Stage	Contractor	TSC & PMU

		located close to the construction sites to the extent possible. ü Top soil (15 cm) would be stripped and kept separately in stockpiles for use in landscaping. ü Excavated materials would be preferably used for site filling/low lying area filling and the surplus material would be disposed as per norms.	C & D waste Rules, 2016. The Water (Prevention & Control of Pollution) Act, 1974 and amendments thereof.				
1.3 Sanitation, Health & Safety:	Unhygienic and unsafe living and working condition.	ü Hygiene in the camps would be maintained by providing good sanitation and cleaning facilities. ü Camp would be well ventilated withadequate provision for illumination, kitchen and safe drinking water. Proper drainage to be maintained around the sites to avoid water logging. ü Proper sanitation with toilet					

		and bathing facilities would be provided at the sites and labour camps. Wastewater generated from these facilities would be disposed through septic tanks and soak pit. ü Preventive medical care to be provided to workers. ü Segregated solid waste would be disposed of at municipal solid waste disposal location. If municipal solid waste site not available then waste should be land fill following local regulations. ü LPG will be used for cooking inconstruction camps. ü Provision would be made for day crèche for children. ü First aid facilities, with room, personnel and ambulance would be available at the site. Also, tie-up with local hospitals						

		would be done to handle emergency case, if any. ü Rest area would be provided at the site where workers can restafter lunch and should not lie on site anywhere. ü Working hours of labourers would not exceed than standard norms as per Factory Act. ü Wastewater from construction site would not be allowed to be accumulated as it may lead to breeding of mosquitoes. Septic tanks/soak pits would be provided for its disposal. ü Temporary storm water drainage system would also be provided at camp site so that no water logging takes place.					
1.4 Waste Management	Generation of solid, liquid and hazardous	ü Arrangement should be made for segregatio					

	waste	n of waste into recyclable and non-recyclable waste. ü Non-recyclable waste generated should be disposed regularly through authorized agency. Recyclable waste should be sold to authorized vendors.					
		ü Construction waste generated should be segregated at site into recyclable, reusable & rejected fraction. Recyclable should be sold to authorized vendor, reusable waste should be stored at site for usage and rejected fraction should be disposed at designated sites of the municipal authority. ü If no debris or waste disposal site exists in the area then a site would be identified with approval of AIWTDS and would be used & manage for the same as					

		per the Debris Management Plan. ü Any waste oil generated from construction machinery, should be stored on concrete platform and disposed off to authorized recyclers.					
2. Climate							
2.1 Climate Change	Project is unlikely to cause negative effect on climate. However, project can contribute positively for climate	ü Daily monitoring of the CWC Gauge data at Pandu Ghat (for North Guwahati & GGG Ghat) & Neamati Ghat (for Aphalamukh ghat). ü Regular interaction mechanism with Indian Meteorological Department (IMD) for early forecasting to avoid casualties. ü Working jointly with State Disaster Management Authority, State Disaster Response Force (SDRF) & National Disaster Response Force (NDRF) during	Kyoto Protocol, Forest Conservation Act & National Forest Policy	Construction site	During Design and construction stage.	Contractor	TSC & PMU

		emergency situation. ü Awareness programme with staff, passengers and contractors on Climate Change. ü Project would be designed in a way to minimize the tree cutting. As far as possible trees along the terminal boundary will be retained as part of greenbelt. ü If any tree cutting will be required at any terminal it shall be carried out only after obtaining NOC from Forest Department. ü Shifting to alternative energy options like solar energy, ü Adoption of best practices to cut down resources and energy requirement.					
3. Air Quality							
3.1 Air Pollution	Dust Generation due to construction activities and material handling. Emission	ü No crushers or Batching plants will be located at the sites. Ready	Environmental Protection Act, 1986 and amendments thereof; The Air	Construction sites, Loading areas, storage areas,	During the Construction phase	Contractor	TSC & PMU

from machinery, DG and vehicular movement.	mix concrete will be used. These considerably reduce the emission. ü Low sulphur diesel would be used for operating DG sets and construction equipment. ü Periodic monitoring of air quality for PM_{10}, $PM_{2.5}$, SO_x, NO_x, and CO shall be carried out quarterly at construction site. ü Regular water sprinkling/fogging to suppress the dust generated at site, approach road & haulage roads. ü Proper servicing and maintenance of earth moving vehicles and other machinery to minimize the emission generation. ü Vehicles transporting the loose and fine materials like sand and	(Prevention and Control of Pollution) Act, 1981 and amendments thereof					

		aggregates shall be covered. ü Masks and other PPE shall be provided to workers in high dust generation area. ü Loading and unloading of construction materials shall be made at designated locations with provisions of water sprinkling. ü Construction vehicle, machinery & equipment shall be regularly serviced and maintained and would have valid PUC certificate. ü Monitoring of air quality shall be carried out on quarterly basis to check the level of pollutants and effectiveness of mitigative measures.					
4. Noise							
4.1 Noise Pollution	ü Noise generation from construction activity. ü Noise generation	ü Protection devices (earplugs or ear muffles) shall be provided to the workers operating	Noise Pollution (Regulation and Control) Rules, 2000 and amendments thereof	Terminal site and access roads.	During the Construction stage	Contractor	TSC & PMU

	from operation of vehicle, equipment and machinery.	near high noise generating machines. ü Barricading (Temporary noise barrier) around the construction site to minimize the noise level. ü Restriction of high noise generating activity between 10:00 PM to 6 AM. ü Restriction on Honking at the project site. ü Job rotations systems for workers, working in high noise level areas ü Periodic monitoring of noise levels to check the level of pollutants and effectiveness of proposed EMP.					
5. Water Quality							
5.1 Water pollution	Surface water pollution and Depletion of Groundwater due to abstraction for construction purpose. Siltation due to construction of terminal and contaminat	ü Preference would be given to use river water for construction with permission from concerned authorities ü In case of use of ground water, permission will be obtained from	Water Act, 1974	Terminal site	During Construction stage	Contractor	TSC & PMU

ion due to disposal of domestic waste	CGWA/CGWB ü Water monitoring to be carried out as per monitoring plan. ü Natural Drainage pattern of area shall be maintained by making a proper drainage network in project site. ü Washing of vehicle and equipment shall not be carried out in river or nearby place. Washing area would be in a designated area with oil & grease trap. ü Storage of debris and raw materials would be in designated area clearly demarcated. ü Site would be regularly cleaned ü Septic tank/soak pit shall be provided for the toilets at both construction site as well as workers camp. Adequate toilets & bathrooms shall be						

		provided to prevent open defecation. Use of mobile toilets with anaerobic digestion facility would be explored. No domestic wastewater shall be allowed to be discharged to river. ü Wastewater, generated from the washing/cleaning area after passing through oil & grease trap shall be re-used for water sprinkling. ü Fuel shall be stored in leak proof containers and containers shall be placed on paved surface under shed. ü The piling work in river shall be undertaken during low flow period. ü Turbidity traps/curtains/ Geo-Textile synthetic sheet curtain would be placed around piling and construction area to prevent					

		movement of sediments and construction waste. ü Sedimentation tanks shall be provided for treating run-off from site before discharging into the river. ü Proper collection, management and disposal of construction and municipal waste from site shall be made to prevent mixing of the waste in run- off and entering the water bodies ü Monitoring of surface water quality shall be carried out on quarterly basis to check the level of pollutants and effectiveness of proposed EMP					
6. Accident, Incident and Safety Risks							
6.1 Health & Safety	Accident and Incident risk from construction activities and safety of workers Impact on Social life.	ü Local labour would preferably be employed for construction. ü Site would be barricaded and would have	BOCWA & BOCWR Central Motor Vehicle Act 1988 EP Act 1986 Noise Rules 2002	Terminal Site and the material source areas and haulage roads Construction sites	During Construction stage	Contractor	TSC & PMU

		security guards. ü Resister would be maintained for entry to the construction sites. No unauthorized person would be allowed to enter the site. ü A board in local language at entrance of site would display name of project, area and hazards associated for public awareness ü Adequate illumination would be provided at site during evening and night time till the work is being carried out ü Rest area for workers would be provided. ü Personal protective equipment like helmet, gum boots, safety shoes, safety jackets, ear plugs, gloves etc to be provided to workers. Fines would be levied if they are found not using PPE ü Noise level in the work zone						

		would be maintained and followed as per OSHAS norms ü Contractors would adopt and maintain safe working practices. SOPs would be prepared and followed for all activities under supervision of site engineer ü Training would be given to workers to handle the heavy equipment so as to prevent accidents ü Complete medical check- up would be done for workers prior to joining and after six months of joining ü Emergency telephone nos.of hospitals, ambulance and doctors would be displayed in first aid room. ü Working hours of labour should not exceed norms as per state factory law ü Speed limit of vehicles would be						

		restricted at site to prevent any accidents and fines would be imposed for violation. All construction vehicles would follow the designated routes & timings. ü Arrangement of fire-fighting would be made at site and workers would be trained on their use. ü Maintenance and repair of any local village road used for the project activities should be carried out both before and end of construction by contractor.					
7. Protection of Flora and Fauna							
7.1 Loss of Biodiversity	ü Loss of terrestrial flora & fauna. ü Loss of Aquatic Fauna including Dolphins and macrophytes	ü Caution sign shall be placed to prevent hunting of animals ü Construction activities shall be restricted to 6:00 Am-10:00 Pm especially noise generating activities. ü No hazardous material or waste shall	Wild Life (Protection) Act, 1972, Bio-diversity Conservation Act, 2002	Terminal site/construction camps Around Piling/dredging Area	During design and construction stage	Contractor	TSC & PMU

		be disposed in the land or nearby area as it may harm the animals, if consumed accidently ü Site should be barricaded to prevent entry of the animal in the site ü Illumination at the night time should be reduced (if no activity is going on) as it may disturb the nocturnal animals ü Workers should not use any timber or firewood as fuel for any purpose ü The river area in which the piling is planned, advisable to carefully determine drop sites before anchor placement to ensure that Dolphin and fish communities that could locally still be present in the area are not unnecessarily damaged. ü Before starting piling allow some time to aquatic fauna to						

		displace from the piling area. ü Bubble curtains can be provided at the time of pilling to displace the aquatic fauna prior start of constructio n activities ü The piling activities must be carried out in shortest possible timeframe. ü All the debris should be disposed away from river course. ü Noise reducing devices like mufflers, enclosures shall be fitted with the equipment as much as feasible. ü Fish exclusion devices shall be installed in water column around the pile driving area to prevent fish access ü Geo Textile synthetic sheet curtain &turbidity traps shall be placed around piling and constructio n area to prevent movement of						

		sediments and construction waste ü Use of Bentonite in Piling should be discouraged. Instead of Bentonite, polymers should be used for pilling. ü Proper disposal plan like storage in leak-proof container and disposed at landfills as designated by the municipal authority. Spillage shall be checked and monitored periodically. ü Piling/dredging should be stopped for some time, if any dolphin/turtle/RET species is sighted in activity area ü Aquatic ecology monitoring should be carried out prior to start of construction and after completion of construction to assess the impact of construction activities on aquatic						

		life.					
Dredging	NA	ü					
Cultural & Heritage Resources	ü Temporary diversion of Access towards cultural resources, temples; ü Safety issues to devotees during the construction stage various construction activities. etc. ü Chances of vibration impact to these cultural resources during the construction work;	ü Adequate diversion signs shall be displayed in the access route for the devotees towards these cultural heritage and temples. ü Warning signs shall be given if there is any large excavation work done or scaffoloing put thereof		Near the Heritage Site	During design and construction stage	Contractor	TSC & PMU
Labour Influx	ü Influence in the demographic composition ü Increased demand and competition for local social and health services ü Social conflicts	ü Specifications on employment of local workforce including women should be reflected in the civil works bidding documents and subsequent contracts to ensure that the contractors fulfil these commitments. Locals including		Construction Area	During design and construction stage	Contractor	TSC & PMU

	between the local community and the construction migrant workers. ü Increased rates of illicit behaviour and crime against women, which is a real threat for Assam where gender-based violence is rampant ü Increase competition for jobs and have an impact on wage distribution	women may be screened further for skills, and adequate orientations can be provided to recruit for the work. ü AIWTDS can prepare a roster of interested workers and their skills ü The project contractor needs to prepare a site-specific Labour Influx Management Plan and/or a Workers" Camp Management Plan. ü Security personnel will be deployed at the construction sites, and emergency nos. including contact details of local law enforcement officers, project's helpline no., existing state-run women helpline nos. will be prominently displayed at the site. The contractors will ensure that an Internal Complaint					

		s Committee (ICC) for each establishment is set-up to meet their corporate requirement and legal mandate under the Sexual Harassment at the Workplace Act, 2013. Health problems of the workers should be taken care of by providing basic health-care' facilities through health centres temporarily set up for the construction camp. The health centre should have the requisite staff, free medicines and minimum medical facilities to tackle first-aid requirements or minor accidental cases, linkage with nearest higher order hospital to refer patients of major illnesses and critical cases.						

		ü Awareness camps on HIV/AIDS for both, construction workers and neighbouring villages must be organised at regular intervals by NGOs empanelled with NACO. ü It is expected that among the women workers there will be mothers with infants and small children. The provision of a day care crèche as per the Building and Other Construction Workers (regulation of employment and conditions of service) act, 1996 is the contractor" s responsibility. The crèche should be provided with trained women to look after the children. ü In case work schedule extents up till night, it should be ensured					

		that women workers are exempted night shifts.					
Social							
8. Repairing & Retrofitting of vessels of IWT:							
Repairing & Retrofitting of vessels of IWT	The reparing and retrofitting of vessels involve replacement of old machineries with latest one. In the process the waste water is likely to be generated from the washings and contaminated with oil and grease. The waste generated from repairing will be asbestos, ferrous and non ferrous scraps, plastics, packings, oil contaminated cotton, paint waste etc. in addition to this, used engine oil and oily sludge are likely to be generated.	ü Wastewater will be passed through oil and grease trap and treated in STP. ü The contaminated waste will be seggregated and kept in separate drums/bins under shed. ü The used oil will be collected in leak proof drums and kept under shed. ü The waste will be categorised as recycleable, incinerable and land disposable. ü Used oil and mettalic waste will be sold to authorised recyclers. ü The incinerable waste such as oil contaminated cottons, filters, waste oil sludge, paint waste etc will be disposed	Hazardous & Other Waste (Management and Transboundary) Rules, 2016 The Water (Prevention & Control of Pollution) Act, 1974 and amendments thereof.	Pandu	Design & Construction Phase	Contractor	TSC & PMU

		ü of in authorised common incinerator. ü Land disposable waste such as wood, fibers etc. will be disposed of in authorised common hazardous waste treatment, storage and disposal facilities (TSDF).					

TABLE 10.7: ENVIRONMENTAL MANAGEMENT PLAN FOR PROPOSED TERMINAL PROJECT (OPERATION PHASE)

Component	Environmental Attribute and potential impacts	Remedial Measures	Relevant laws/ Contracts	Approximate Location	Time Frame	Institutional Responsibility	
						Implementation	Supervision
1.0 Climate							
Climate Change	Project is unlikely to cause negative effect on climate. However, project can contribute positively for climate	ü Greenbelt shall be developed all along the terminal premises. ü Energy efficient measures in the terminal buildings will be implemented ü Solar power will be used in potential area.	Kyoto Protocol, Forest Conservation Rules & National Forest Policy	Terminal site	Operation and maintenance	IWT	IWT
2.0 Air Quality							
Air Pollution	Emission from machinery, ferry, DG and vehicular movement.	ü Only Passenger ferry will be handled in the terminal hence no dust pollution anticipated. ü Green belt shall be developed and maintained as per lay out · Local Species selected for development of green belt. ü Water sprinkling would be provided in dust generating areas.	Environmental Protection Act, 1986; The Air (Prevention and Control of Pollution) Act, 1981	Terminals	Operation and maintenance	IWT	IWT

		ü DG exhaust will be minimised by regular maintenance in AMC ü Monitoring of air quality shall be carried out on quarterly basis to check the evel of pollutants and effectiveness of EMP ü Ferries, deployed, will have efficient fuel combustion system with minimum emission.					
3.0 Soil Erosion							
Soil Erosion and manag ement.	ü Soil erosion of emban kment during heavy rainfall.	ü Periodic checking of the slope stabilization measures (stone pitching or otherwise) would be carried to assess the damage if any. Necessary measures for repair shall be followed wherever there are failures	Project require ment	Along river bank and Embank me nt	Regul ar survei llance during operat ion	IWT	IWT
4.0 Wastewater Management							
Water pollutio n	ü Surface water pollutio n. ü Siltatio n and erosion and contami nation due to disposa l of domesti c waste	ü STP (10KLD) would be provided to treat the sewage generated. Treated water would be used for horticulture and plantation purpose at the site ü Storm water drainage system would be provided at the site. ü Rain water harvesting facility would be developed and maintained ü Oil interceptors shall be provided with the storm water drains in the parking lots & loading &unloading areas ü Fuel shall be stored in leak proof containers and containers shall be placed on	Project require ment	Termina l and vessels	Opera tio nal Phase	IWT	IWT

		paved surfaces so that no spill occurs ü Fuelling of vessels will be leak proof system ü Quarterly Monitoring of surface water quality shall be carried out to check the level of pollutants and effectiveness of EMP.					
5.0 Noise Control							
Noise Pollution	ü Noise generation from operation of vehicle, Equipment and machinery.	ü Timely maintenance and servicing of transportation vehicles and the machinery/pumps/ vessels to be used during operation phase to reduce the noise generation. ü Honking shall be prohibited at the project site ü Hearing test for the workers shall be undertaken before employing them and thereafter shall be done after every six months ü DG sets shall be provided with acoustic enclosure ü Monitoring of Noise levels shall be carried out on quarterly basis to check the level of pollutants and effectiveness of proposed EMP.	Noise Pollution (Regulation and Control) Rules, 2000	Access Road & Terminal Site	Operational phase	IWT	IWT
6.0 Accidental Risk							
Accident and Incident.	Accident risks associated with traffic movement.	ü Traffic control measures, including speed limits should be enforced strictly.	Project requirement	Access Road	Operational phase	IWT	IWT
	Accidents due to Movement of Vessels and other hazards associated with site	ü Further encroachment of squatters within the ROW of approach road will be prevented. ü Monitor/ensure that all safety provisions included in design and construction	Project requirement	Throughout the Project route	Operational phase	IWT	IWT

		phase are properly maintained. ü Adequate illumination should be provided at the site during evening.					
7.0 Vessel Repairing							
Water pollution and waste management	Generation of wastewater and hazardous waste	ü Wastewater generated from washings is normally contaminated with oil. Therefore, wastewater will be passed through oil water separator and treated in STP. ü Bilge and other water will be treated as above ü Wastewater evacuation system would be leak proof and no untreated wastewater would be allowed to discharge to river ü Treated wastewater will be used for plantation, lawn and garden to the maximum extent possible ü Used and waste oil will be collected separately by adopting leak proof arrangements ü Used oil will be stored under shed and will be auctioned to authorised recycler. ü Hazardous waste will be stored separately under shed and disposed in Common TSDF ü Non-hazardous scraps, plastics will be collected separately and sold as scrap ü Domestic waste will be segregated and hand over to facility of local body.	HW Rules, 2016. EP Act, 1986	Vessel Maintenance Unit	Operational phase	IWT	IWT
8.0 Flora & Fauna							

Biodiversity loss	Loss of Aquatic Fauna including Dolphins and other macrophytes	ü Propeller shall have net system to avoid any accident with dolphins and other aquatic animals. ü No wastewater or waste shall be disposed in river from terminal site or from vessel into the water. Penalty shall be imposed on the vessels reported disposing waste/wastewater in the river ü Run-off from stockpile area, storage yards, parking areas & roads shall not be disposed directly in to river. ü Instruction should be given to all vessels and all employee and staff that no dolphin or any other endangered species shall be harmed due to any reason ü Instruction shall be given to vessel operator that in case any accident with dolphin occurs that should be reported immediately to terminal authority	Forest Conservation Act 1980, Wild Life Protection Act, 1972	Project tree plantation sites. Terminal site and surrounding area	Operational phase	IWT	IWT
		Waiting time of vessels shall be reduced at the terminal/lock sites by providing the adequate loading and unloading equipment and vehicles. Vessels shall be instructed for not using sharp lights and sounds all the time as they may disturb aquatic organisms. ü Regular monitoring and measuring the equilibrium between sediment erosion and deposition which is necessary to	Project Requirement				

		maintain essential habitat features. ü Access to floodplains should be preserved to ensure natural spawning and rearing habitat for fishes which are prey base of the dolphin and there should have the provision for Fish Ways. ü Monitoring of the operational aspects of projects as well as the effects on upstream and downstream populations of cetaceans and their habitat, on a regular basis. ü Capacity-building of the local stakeholder including the GovernmentOfficials through a combination of education and infrastructure improvement. ü Awareness campaigns to conserve the Dolphin Habitat and its ecological importance.					
9.0 Repairing & Retrofitting of vessels of IWT:							
Repairing & Retrofitting of vessels of IWT	The reparing and retrofitting of vessels involve replacement of old machineries with latest one. In the process the waste water is likely to be generated from the washings and contaminated with oil and grease. The waste	ü Wastewater will be passed through oil and grease trap and treated in STP. ü The contaminated waste will be seggregated and kept in separate drums/bins under shed. ü The used oil will be collected in leak proof drums and kept under shed. ü The waste will be categorised as recycleable, incinerable and land disposable. ü Used oil and mettalic waste will be sold to authorised recyclers.	Hazardous & other Waste (Management and Transboundary) Rules, 2016 The Water (Prevention & Control of Pollution) Act, 1974 and amendments thereof.	Pandu Repairing & Retrofitting of vessels of IWT	Design & Construction Phase	Contractor	TSC & PMU

generated from repairing will be asbestos, ferrous and non ferrous scraps, plastics, packings, oil contaminated cotton, paint waste etc. in addition to this, used engine oil and oily sludge are likely to be generated .	ü The incinerable waste such as oil contminated cottons, filters, waste oil sludge, paint waste etc will be disposed of in authorised common incinerator. ü Land disposable waste such as wood, fibers etc will be disposed of in authorised common hazardous waste treatment, storage and disposal facilities (TSDF).					

11. CONSTRUCTION METHODOLOGY AND IMPLEMENTATION SCHEDULE

11.1 Construction Planning

The project is located in the Indian state of Assam at the state capital, Guwahati.

For implementation of the project, the construction time has been estimated based on Central Water Commission guidelines, industry practices, standard norms, equipment's planned & employed, productivity of equipment and over and above the past project experiences. Construction work shall remain suspended during the months of March to June for four months every year as work of the project shall be affected with virtually no work at surface area. Hence no construction activity has been considered to take place during these months, Working period has been planned for the months of mid-June / start July to mid-March / start April for eight months for construction activities. Twenty-six (26) working days have been considered in a month and twenty (20) working hrs. have been considered per day for the construction activities.

A period of 2 to 3 months have been estimated after completion of Detailed Project Report for the tendering process in order to start the construction work. The construction activities for the development works are assumed to be commenced in 15 September 2021. The preparation of tender document along with finalisation and signing of the contract agreement for construction of the project shall be completed before the start of the construction. The zero date of the schedule has been taken as the date of signing of contract for construction. The project schedule and construction equipment details for implementation of the project are provided as Annexure 11.1 and Annexure 11.2 respectively.

The cycle time of operations is the criteria for hourly/ daily output of machinery/ work force. However actual progress of work is dependent upon several other factors such as interruptions of construction power, break downs of construction equipment, meal break and other needs such as work force, stray rains etc. Hence it is general practice to consider 50 min. as the actual working time per hour. Further where the work is carried out in more than one shift, there is further reduction in daily production hours due to time required for change in shift & for daily maintenance needs of plant & machinery. On the basis of the above computation, in accordance with "Guidelines for Detailed Calculations for the Requirement of Each Category and Size of the Production Equipment, August 2000 published by the Central Water Commission" following scheduled working hours has been considered in surface works.

The monsoon months in the project vicinity is considered as per the data obtained from India Metrological Department (IMD) and is observed from June to September with pre-monsoon and post monsoon effect.

Total days in a year: 365 days

Monsoon Period: 120 days (4 months)

Effect of Pre-monsoon and Post-monsoon: 30 - 45 days (15-20 days + 15-20 days)

Non-working days considered on account of holidays: 10-15 days

Thus Effective Working Days: 200 days per year (considered for planning purposes)

The scheduled working hours considering 26 working days per month accordingly works out as under

Table 11-1: Assumptions Considered in Project Schedule

No. of Shift	Total Time	Availability factor	Actual Available Time	Working Days/ Year	Schedule Machine Hour	Utilization factor	Schedule Production Hour
(No.)	(Hr.)		(Hr.)	(No.)	(Hr.)		(Hr.)
1	8	0.9	7.2	200	1440	0.85	1224
1.5	**12**	**0.85**	**10.2**	**200**	**2040**	**0.85**	**1734**
3	16	0.8	12.8	200	2560	0.8	2048
4	24	0.7	16.8	200	3360	0.75	2520

The main features of the construction schedule are as follows:

Project Period : 18 months (Including mobilization and investigations)

The construction of the project is planned to be constructed through award on single EPC (Engineering Procurement & Construction).

11.1.1 Pre-Construction Activity

11.1.1.1. INFRASTRUCTURE WORKS

The main infrastructure development work proposed to be carried out within a period of 3 months. During the infrastructure development period, construction/improvement of roads and arrangements for construction power of the project site will be undertaken. The construction power at all the project components is proposed to meet by Grid supply and in addition DG sets are proposed to meet the power backup supply, in case of failure of grid power supply. After the infrastructure setup has been created to the required extent, for start of the construction activities, the construction of civil components will be taken up.

The scope of pre-construction activities is to build site roads network including infrastructure facilities. A period of three months is proposed as preconstruction activities for the construction of the following:

- Roads and approach to work fronts.
- Temporary camp development for construction stage.
- Upgradation of the existing project approach road.
- Construction of site office, workshop, stores, QC labs etc. and installation of all temporary services.
- Erection & commissioning of stationary plants.
- Setting up of stationary equipment like Aggregate Crushing Plant / Batching Plant / DG sets.
- Colonies development for residence of project staff.

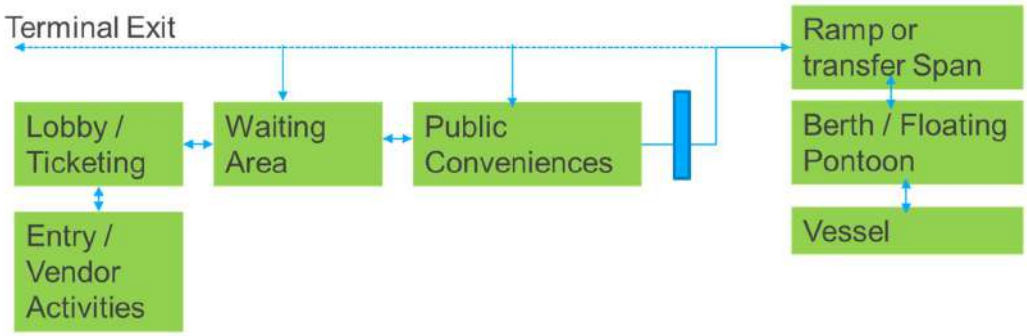
11.1.1.2. SETTING OUT WORK

The setting out comprises the work for establishment of permanent Benchmarks and reference Bench Marks along the Project and shall be approved by the client, before starting of the project construction. The Benchmark point and Coordinates shall be clearly carved and painted on the Benchmark stone. The reference line shall comprise of a base line marked on the ground with number of masonry pillar. The Benchmarks shall be of such material and shall be located at such place as to ensure execution for all the activities for all components of the project. The work shall be performed with layout in all levels/control points with respect to Benchmark and reference line and correlate levels and locations of the work to be performed. The Benchmark proposed to be re-checked at certain interval of time and if any discrepancies are found should be corrected and brought to the notice of the client.

11.1.2 Terminal Planning

It is proposed to develop Terminals accommodating necessary required facilities. Based on the traffic analysis and forecast, the terminal building areas and infrastructure requirement are finalised.

Typical elements/ Activities in terminal building are given below



The broad component of terminal building are as under –

- Ø Waiting areas for passengers
- Ø Emergency service facilities
- Ø Toilets facilities
- Ø Security check areas
- Ø Ticketing booths
- Ø Parking areas
- Ø Office and Meal Room
- Ø Shops
- Ø Open area
- Ø Entry exit routes
- Ø Access to ferry services by disabled persons
- Ø Space for utilities / infrastructure requirements
- Ø Control room for ferry services
- Ø Storage Areas

The various steps adopted for construction of buildings are -

a) Concrete Pile foundation and Pile cap concrete

The RCC bored cast in situ pile to be executed as illustrated below in Section 11.1.3.1. Thereafter, the pile cap are to be casted tying the concrete piles together.

b) Column Casting

Casting of columns is made by fixing the shuttering framework and concrete is poured in the formwork. The shuttering is usually removed after 24hr of casting and curing is done.

c) Construction of Walls

Walls are constructed using many materials such as brick, wooden, precast concrete and many other. Before starting the wall construction, the base of wall is constructed first using concrete or size stone masonry. The height of the walls depends upon the floor height. Necessary opening are to be given for doors, windows and ventilators.

d) Lintel

Masonry work of buildings is carried out in one go till roof. Openings for windows & doors are left during masonry works. Reinforced cement concrete beams are laid down on the top of openings. So, those loads of structure above openings not directly come on to the door frames.

e) Roofing

Roof slab of building is poured after completion of masonry works. Now a days, roofing is of reinforced cement concrete slab. Slab thickness & reinforcement details should be according to approved drawings.

f) Plastering Work

Form work is removed after 14 days of slab pouring. Now plaster work begins. Mortar for plaster work is generally of 1:3 or 1:4 is used. Thickness of plaster layer should not be more than 0.75 inch. Cure the surface about 7 days. So that, plaster gain proper strength. Generally, internal walls of buildings are covered with plastered layer and external walls with pointing. It is better plaster the external walls rather than pointing.

g) Fixing of Doors and Windows

Traditionally, doors and windows of woods are used. But, steel & aluminium is also not a bad choice. In case of wooden doors & windows, frames are fixed in walls during masonry work. Panels are then fixed with hinges after plaster work. Steel and aluminium doors are fixed after completion of paint works.

h) Fixing of Electrical and Plumbing Works

The necessary electrical and plumbing works are carried out before the final finishing works such as painting and tiles laying is done so as to reduce the damage.

i) Tiles Laying

Majorly tiles are laid in the bathrooms and kitchen area. First the wall tiles are fixed after which the floor tiles are fixed. For flooring works, granite, marble, tiles, epoxy are also used.

j) Painting

Painting consists of different sequences depending upon the type of finished required. 1 coat of primer and 2 coat of water based paint is also done or 2 coat of putty and 2 coats of painting is done for the smooth finish. It defers for outside and inside works.

k) Miscellaneous Works

Other than all these above mentioned works, there are other works that are carried as per the requirement of the consumer and design engineer such as Terrace water proofing, landscaping works, False Ceiling and Installation of Furniture etc.

11.1.3 Steel Pile Foundation - Riverine

The steel pile required for riverine structure is provided as below-

Sl. No.	Riverine Structure	Number of piles	Pile Type	Pile Diameter (mm)
1	Bankseat - Vertical - Raker	- 10 - 2	Steel tubular	1220x31.8mm Thk
2	Dolphins for Intermediate pontoons - Vertical - Raker	- 16 - 16	Steel tubular	1520x31.8mm Thk.
3	Dolphins for Berthing pontoons - Vertical - Raker	- 6 - 18	Steel tubular	1520x25mm Thk.

The primary function of a pile foundation is (a) to transmit the load of a structure through a material or stratum of poor bearing capacity to one of adequate bearing capacity; (b) in some instances, to improve the load-bearing capacity of the soil; and (c) to resist lateral loads and to function as a fender to absorb wear and shock. In addition, piles are also used in special situations (a) to eliminate objectionable settlement; (b) to transfer loads from a structure through easily eroded soils in a scour zone to a stable underlying bearing stratum; (c) to anchor structures subjected to hydrostatic uplift or overturning; and (d) to serve as a retaining structure when installed in groups or in a series of overlapping (cast-in-place) piles.

A detail subsurface explorations are necessary during the execution stage to determine the stratification of the foundation elements, including the depth to bedrock, if any and the density of granular materials measured by the number of blows recorded on a standard split spoon sampler, and to obtain undisturbed samples of cohesive strata to evaluate the shearing strength and compressibility characteristics by laboratory testing. The desirable number of exploratory borings depends on the size of the foundation area and the degree of uniformity of the foundation materials.

11.1.3.1. TYPES OF PILE FOUNDATION

Broadly depending on the location, requirement, economy, etc. the piles may be of the following kinds according to their material compositions.

- Concrete Piles
- Steel Piles

Commonly for Marine structures Steel piles are widely used. These have a load range of 1,000-6,000KN and can reach up to 60 m length. Steel tube piles are used on marine structures and foundations in soft sub soils over a suitable bearing strata. They are usually bottom driven with drop hammer.

There are different types of steel piles designs available, depending upon the project, Cost, Permanency of the pile the type of steel pile to be used can be decided. Some of the types of Steel piles mentioned below for reference.

- Steel Pipe piles
- Steel H – Pile
- Steel Rail pile
- Steel Box Pile
- Disk Pile
- Screw pile

Steel pipe piles are of two types. Open ended and Close ended. It is generally acknowledged that an open-ended pile requires less installation effort than a closed – ended pile under the same soil conditions.

11.1.3.2. VARIOUS METHODS OF INSTALLATION OF STEEL PILES

Displacements piles are either driven or jacked into the ground. Several different methods can be used.

- Dropping weight/Drop Hammer
- Diesel hammer
- Vibratory Driving

This method statement covers the methodology of driving of steel tubular pile of approach trestle and dolphins by Jack-up platform. The objective of this method statement is to clearly understand the job and the step-by-step procedures of the execution of the job along with safety precautions.

11.1.3.3. PERSONNEL ROLES AND RESPONSIBILITIES

Project Manager	Responsible for the activity mentioned. Scope to be Implemented as per this procedure.
Construction Manager Site Engineer	Shall report to Project Manager and shall be responsible for overall piling activity. Shall report to construction manager and shall be responsible for execution and implementation of all site activities related to this procedure. Shall also prepare and maintain all site records.
QA/ QC Engineer	Shall report to Quality manager & shall be responsible for checking all the quality aspects as per ITP (QCP) for piling work.
Quality Manager	Shall be responsible for implementation of all quality requirements for piling work.
Safety Engineer	Shall report to Safety in Charge, and shall be responsible for monitoring safety performance and where necessary initiating corrective actions through line of management (JSA, Tool box meetings)

11.1.3.4. LIST OF EQUIPMENT'S

Transportation of Piles to Platform

Sl.No.	**Equipment Type andCharacteristics**		**Minimum Number required**
	Equipment	**MinimumCapacity**	
1*	Crane(Tyre mounted/ Crawler)	100T	1 No.
2*	Crane(Tyre mounted/ Crawler)	50T	2 Nos.
3a*	Mobile Piling gantry capable to mount Hydraulic Rotary piling Rig of Minimum 15 Tonne-meter torque capacity.	-	1Nos.
3b*	Hydraulic Rotary Piling Rig of minimum 15 tonne-metre torque capacity.	15Tm	2 Nos.
3c	Piling Hammer and Crane with required capacity		1 no
4*	Hydra	10 to 12T	4 Nos.
5*	Trailer	-	2 Nos.
6*	Winches	7.5T	2 Nos.
7	Concrete Batching Plant	30cum/hour	As considered necessary by the Engineer
8	Transit Mixer	5cum	As considered necessary by the Engineer

9.	Concrete pump with adequate pipelines Or Truck mounted Boom placer	30cum/hour	As considered necessary by the Engineer
10	Jack-up Barge	-	1 Nos
11	Pontoon Barge/Crane Barge/Material Barge	-	2 Nos
12	Survey Boat/Inspection Boat	suitable for 6 persons	1 Nos
13	Drilling rig for Geotechnical Work	-	1 Nos
14	Welding cum Lighting DG	15 KVA	1 Nos
15	Total Station	-	1 Nos
*-These equipment must be owned /hired by the Bidder			

The transportation of Pile from splicing yard to load out point shall be done with the help of trailer and dolly arrangement. Barge will be brought near to load out point within the reach of crane boom. Pile will be loaded on the barge with the help of crane at load out point. Loaded barge will be towed with the help of tug near to pile location. Barge will be positioned within the reach of the crane on the jack-up and the barge will be anchored sufficient enough for its stability.

The most common form of impact driving is the drop hammer, which uses a falling weight to create the impact, spread to the top of the pile by a driving cap. The most common form of drop hammer in current use is the hydraulic hammer. Historically, air hammers and diesel hammers were used, which utilise an explosive force to drive the hammer, however, as the newer hydraulic hammers operate at significantly higher efficiencies and are far less noisy than older diesel hammers, the latter are now less frequently used.

A weight approximately half that of the pile is raised a suitable distance in a guide and released to strike the pile head. When driving a hollow pile tube the weight usually acts on a plug at the bottom of the pile thus reducing any excess stresses along the length of the tube during insertion.

Variants of the simple drop hammer are the single acting and double acting hammers. These are mechanically driven by steam, by compressed air or hydraulically.

Single Acting Hammer: In the single acting hammer the weight is raised by compressed air (or other means) which is then released, and the weight allowed to drop.

Productivity: This can happen up to 60 times (Blows) a minute.

Double Acting Hammer: The double acting hammer is the same except compressed air is also used on the down stroke of the hammer.

Hammer Type	**Efficiency (ηh)**
Single and double acting hammer	0.7 - 0.85
Diesel hammers	0.8 - 0.9

Drop hammers	0.7 - 0.9

Hammer Specification

Working Specifications

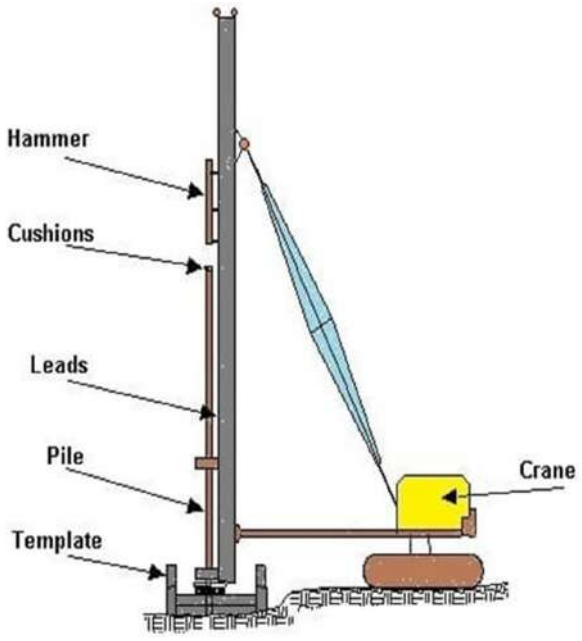
Rated Energy	5807 kg-m
Minimum Energy	2212 kg-m
Speed (blows per minute)	37-55
Bearing based on EN formula	210 tons

Weights

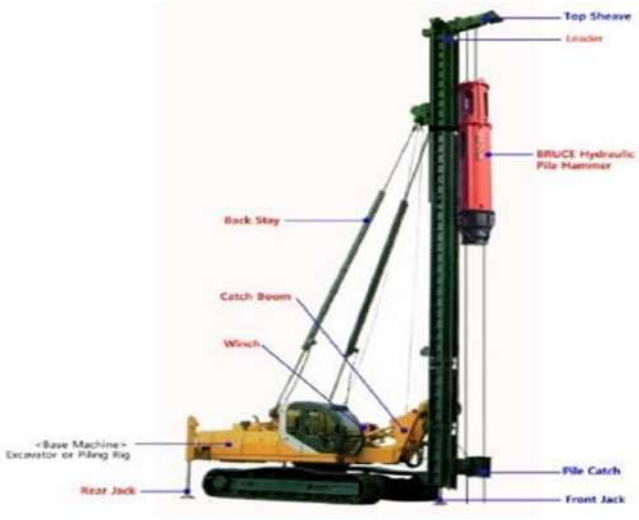
Bare Hammer	3452 kg
Ram	1854 kg
Anvil	247 kg
Typical operating weight with cap	3950 kg

Dimensions of Hammer

Width (side to side)	508 cm
Depth	737 cm
Centre line to front	349 mm
Centre line to rear	387 mm
Length (Hammer Only)	490 cm
Operating Length (Top of ram to top of pile)	846 cm



Crane mounted Hammer Piling Equipment

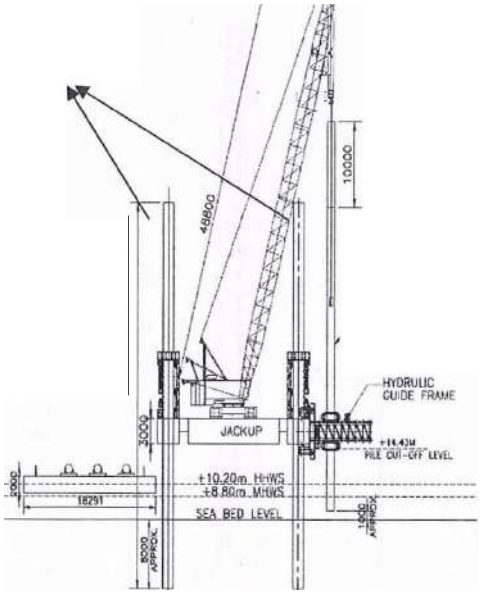


Rig mounted Hammer Piling Equipment

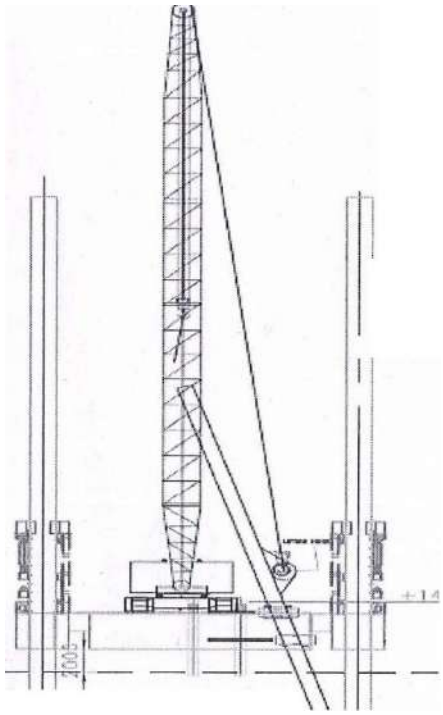
The point for the piles will be surveyed and the guides will be set up accordingly. The hydraulic frame will ensure the smooth pitching and driving of raker pile at required rake. The pile will be lifted from barge at its lifting point by crane on Jack-up. Ropes will be attached to pile to control movement of pile and for self-releasing shackle. The pile will be placed inside the guide frame and by self-releasing shackle it will be allowed to penetrate into river bed with its own weight at the time of pitching at required rake.

After Pile pitching, Vibro hammer will be lifted using crane and fixed on the pile top. The driving operation will commence with the help of Vibro hammer. Driving by Vibro hammer shall continue till the pile refusal.

The below figure shows Typical Vibro Hammering of a Vertical and a Raker Pile-



VERTICAL PILE



RAKER PILE

After pile driving completes with Vibro hammer, Crane will lift Hydraulic hammer and fixed it on top of pile. The pile shall be driven with the help of hydraulic hammer up to target toe level. After driving of the piles, bracings between the driven piles shall be provided (2 to 3m below pile cut-off level or up to required height) so as to avoid any possible sway due to the flow of currents in water. After pile driving, cut-off level marking to be done on pile with survey and pile will be cut at cut-off level marking.

Recommendation on Steel Pile Methodology

The most common form of steel pile driving is the drop hammer by use of hydraulic OR diesel hammer, which uses a falling weight to create the impact, spread to the top of the pile by a driving cap. The most common form of drop hammer in current use is the hydraulic hammer. During the construction stage the contractor will submit the methodology to be adopted for approval to the authority before commencement of work.

11.1.3.5. CYCLE TIME FOR DRIVING OF STEEL PILES

The proposed steel piles are 1220mm and 1520mm diameter in vertical and raker (1 in 3 slope) with length ranging 60.0m to 70.0m. As per the practice, for the given depth 1 pile is feasible to be driven per day. The shifting of equipment's and arrangement for pile driving from one bench to another bench will takes about 3 days.

Therefore, a period of 120 working days is estimated for driving of 74 piles along with shifting and arrangement of pile driving.

11.2 Pile To Pile In Splicing Yard

- The pipes from the stacking yard will be lifted by using cranes of suitable capacity. Pipes are placed over the beams in the designated position meant for cutting, bevelling and dimension and quality checking.
- After the preparation of pipes it shall be transferred to designated fit-up area for fit up and welding.
- The splicing of steel pile to pile shall be carried out in accordance with Specification.
- A weld numbering drawing is to be prepared indicating the length of each cut piece of the pipe both in coated and uncoated portions and the total length of the pile. This weld numbering, drawing also indicates the pile identification, joint numbers, applicable WPS and extent of NDT.
- The marking of pile shall be done as per dimension indicated in the final drawing.
- If required, Pipes are cut as per the marked up length calculated from the latest drawing by oxy- acetylene flame either manually or using mechanically guided equipment. The spiral seams in piles shall be staggered by not less than 75mm measured from adjacent weld caps. Each cut piece is identified by the heat number and piece number {if available) and the pile number. The heat number and the piece number are then transferred on to the remaining cut piece.
- After cutting the pipe the edge to be ensured Lamination free by conducting the NDT Test by DPT or MPT, the edge is prepared by using grinding machines, files etc. as per approved WPS.
- The bevel edge shall be visually checked and should defect free and parallel. Each joint is identified by its number as given in Weld numbering drawing.
- The fit up shall be inspected for dimensions, root gap, bevel angle, alignment etc. After fit up inspection, joints are released for welding and fit-up inspection report shall be prepared as per the "Fit up inspection report".
- The cleanliness of the joint is ensured free from rust, dirt, grease etc. prior to welding.
- Alignment and tacking shall be made by full penetration tack welds. The tacks are removed prior / during welding of joint. The welding shall be done as per approved WPS as per Method statement for qualification of welding procedures and welders. The ID or ID number of the welder shall be marked adjacent to the weld.
- The temporary welds shall subsequently be removed and ground flush with the base materials. The method of removing attachments shall not injure the metal surface. The metal surfaces shall be checked by LPT after attachments removal.
- After complete Root & Hot pass the pipe is shifted to SAW roller bed for finish of balance weld. The pile is then shifted by gantry crane to inspection area for weld visual inspection, final straightness checking and NDT.
- After completion of welding the joint is visually checked defect if any, shall be rectified. The comment of weld visual /acceptance are recorded in "Weld visual inspection report".

- Final dimensional survey shall be carried out at this point prior to NDT and before coating the pile.
- The final straightness of the piles shall be checked by theodolite and acceptance criteria will be as per API RP 2A. If the pipe is longer than 6m, readings are taken at the mid portion of the pile also. The readings are then reported in "Pile Final straightness report.
- Measurement is taken at least in two positions along the pile, 90 deg to one another. The joints of the pile are then subjected to RT.
- The piles cleared in RT are then coated at the joints where coating is required. The piles which are cleared in coating are dispatched / stacked for piling work. Any items which cannot be completed before the dispatch of the pile are mentioned in the punch list. Care shall be taken that only those work which can attended at a later stage are only mentioned in the punch list. All other works shall be completed prior to dispatch of the pile of piling.

11.2.1 Welding

- The welding shall be done by SMAW/ SAW/ GMAW / Combined process using approved welding procedure for pile-to-pile in the pile splicing yard.
- Adequate approved qualified welders are engaged.
- Before commencement of production, a weld numbering drawing shall be prepared. The weld numbering drawing indicates:
- The Weld number
- The applicable WPS number
- The class of weld
- Pipe and heat no of pipe
- All the joints welded must be visually inspected for the weld profile and surface defect such as undercut, slag, surface porosity spatter, surface finish etc .of the weld point to NDT.
- After attending to the surface defect, the surface shall be cross examined by DPT/MPI.

11.2.2 General Welding Requirement

- The pipe shall be cleaned by grinding to a width of 150 mm on either side of joint.
- The edges of the joint shall be inspected for any lamination in the pipe.
- All the welding machines shall be properly ground. The ground clamp connected to the pipe shall be steel.
- Manufacturer's mill certificates of welding consumables should be available in site of each heat, lot or batch.
- Electrodes and fluxes shall be kept clean dry, and properly stored according to manufacturer's recommendations.
- No electrodes and fluxes that are damaged, damp, greasy, or oxidized may be used.
- Welding electrode shall be issued for production from holding ovens only and shall be placed in heated quivers capable maintaining minimum temperature of 70 deg C.
- Welding consumable shall be controlled and issued by welding material controller. Refer consumable control procedure
- Piping component shall be adequately supported and aligned by the means of jigs, clamps or their suitable devices during tacking.
- All butts - groove welds in pipe piles shall be full penetration welds.
- Before performing the first run, the tack points are inspected for cracks. If any tack is found to have cracks, shall be removed and re-tacked.
- Weld passes shall not start or stop at the same point.
- Welding shall not be stopped before the completion of a bead whose thickness is equal to either half the joint thickness or two passes(R&H) .In case the welding stopped for certain obvious reasons, the joint shall be pre-heated before taking further welding as per approved WPS, partially filled joint is then power brushed before the commencement of next welding.
- Each bead shall be cleaned of slag and visually controlled by the welder. All break down surface defect shall be removed by grinding before continuing the welding .Cleaning of welding area shall not reduce the member wall thickness.
- Preheat and inter pass temperature shall be maintained as given in the approved WPS. The distance to preheat from the joint shall not be less than 2T with 50 mm minimum.

- No welding is carried out in abnormal weather conditions such as in high velocity winds, in abnormal moisture conditions, blowing sands etc. Hoods shall cover joints during welding.
- There shall be a smooth transition between the base metal and the capping the reinforcement of butt joints shall not be more than 3mm.
- The weld sequence shall be shown in the approved WPS.
- All the arc strikes shall be ground to the sound metal.
- All the spatters, visual weld defects are to be removed before NDT.
- The temporary welds attachments shall subsequently be removed and ground flush with the base materials and the method of removing attachments shall not injure the metal surface.
- The base metal surface shall be checked by LPT after attachments removal as per Procedure of LPT.
- All the basic coated electrodes/ fluxes shall be re- dried/baked as per the standard laid down procedure & Manufacturers Recommendations.

11.2.3 Visual Inspection and NDT

- Upon completion of the pile fabrication, the site QC engineer shall inspect the pile for100% visual inspection before carrying out RT.
- 100% inspection by NDT is carried out using RT on steel pile yard splicing joint as per submitted RT procedure.
- All weld preparation, fit-up, and weld assemblies will be visually inspected in accordance with approved ITP for pile splicing.
- Welding parameters in the WPS.

11.2.4 Weld Repairs

- The entire weld repair shall be as per the approved WPS for repairs.
- Surface defect shall be checked by MPI for 7-8mm Depth.
- The weld metal is removed by grinding till the defect is removed and after clearing the same is filled with the weld metal by SMAW.
- After repair, the weld is subjected to visual inspection & followed by NDT. The first repair is indicated by letter" R" and the subsequent ones by R1, R2 etc. With report. After R2, any further repair shall be attended after getting due permission from Engineer client representative.
- In case of temporary brackets to be welded on steel piles for the purpose of working platform, the brackets should not be directly welded on the pile. Doubler plates are to be providing to avoid any damage or notch on the piles. Qualified welders shall carry out welding .The portion of the steel pile where doublers & brackets are to be welded should be free from paint, rust, dirt, grease etc prior to welding. Welding shall be done by approved process. After completion of welding, the weld shall be subjected to visual inspection.
- While removal of temporary brackets welded the steel piles, cutting shall be carried out by oxyacetylene flame in such a manner that about 3mm of the bracket piece is retained on the steel piles. After removal of bracket, the portion of the pile on which bracket was welded shall be grinded till the base material of steel pile is exposed and a smooth surface is achieved. After completion of grinding, the surface of steel piles shall be subjected to visual inspection.

11.2.5 Quality Assurance / Quality Control

QA/ QC department shall be responsible to carry out stage wise inspections as per ITP-Pile splicing. Reports shall be prepared after completion of inspection and testing.

11.2.6 List of Equipment

60 Ton EOT crane	2 No’s
Welding Machines (SMAW)	10 No’s
Welding Machines (SAW)	05 No’s
Grinding Machines AG 4	6 No’s
Grinding Machines AG 7	6 No’s
Electrode backing oven 350°C Holding Oven 150 0C	1 No’s
Electrode backing oven 100°C	5 No’s
Propane blower	2 No’s

- Pipe rollers 2 Sets

11.3 Concrete Pile Foundation – Terminal Building

Concrete pile foundation of 1000mm diameter with a minimum of 41 meter length is proposed for foundation at terminal building. The total number of concrete piles are 66. The method statement for bored piling below describes the construction procedures including material and equipment required for the construction of bored cast-in-situ piles. Detail of the procedures contained herein may be reviewed periodically and modified based on actual requirement. The piles are designed by the Engineer to resist axial compressive loads.

The pile boring operations shall be performed using suitable rotary drill rigs. The bore-holes shall be stabilized with a temporary casing in the upper layer. In this case, the driving will be done for about 30 meter deep in soft strata with casing. The location of bored piles shall be set out and pegged by the surveyor based on approved setting out drawings and control points at site. The surveying details of each location to be recorded incorporating reduced level and coordinates. Each individually surveyed pile position shall be protected from disturbance prior to commencement of boring works. Two reference points to be installed equidistant at not less than 2.0m from the pile centre location. A pilot hole of about 3-6 metre deep shall be drilled at the pile location. The eccentricity and alignment of the pilot hole is then checked. The vertical accuracy of the casing will be checked during the installation process using 2 numbers of plumb bob.

Excavation of the soil inside the casing/bored holes will be carried out using the rotary kelly bar and the auger or bucket method. The drilling process will be continued to the designed founding depth by using augers and drilling buckets. Pile lengths shall be as per the construction drawings. The final toe level of the pile shall be verified by the client's representative. A detailed record of all encountered ground conditions together with the associated times and type of equipment and materials used will be recorded in the 'Pile Bore Log'. The base of the hole shall be checked by the measuring the depth of the base.

The bentonite is delivered to site in 50kg per bags, which are stored under cover. The bentonite is mixed by high turbulence mixers and the slurry is stored in a pool. The size of the pool shall have a storage capacity of about 400 cum. A laboratory is proposed on site for regular testing of the slurry.

The key apparatus required at the site laboratory is listed below:

- Mud balance (density test)
- Marsh cone (viscosity test)
- Sand screen set (sand content test)
- Paper for measuring Ph

Contaminated bentonite slurry will be discarded by mixing with the earth and transport to dumping area.

Bentonite will be used as a drilling fluid to stabilize the bored hole. During the boring process, the bentonite slurry is kept as high as possible within the casing and well above the existing ground water.

Upon completion of boring, the bottom of the bored hole is thoroughly cleaned with the cleaning bucket prior to recycling of the bentonite. A submersible turbine pump attached to the tremie pipe is lowered to the bottom of the bored hole. The bentonite, loaded with soil particles in suspension, is drawn off from the bottom of the bored hole and recycled through a Caviem or equivalent recycling unit. The process is continued until the bentonite arriving from the base of bored hole had been flush out.

The reinforcement cage will be fabricated in lay-down sections. The length, type and size of the steel cage will be according to contract drawings and specifications. The cages will be provided with stiffening rings and others accessories to enable handling, lifting and installation without permanent deformations.

Cages will be installed into the bored hole using a service crane of the required lifting capacity. Concrete spacers wired to the cage shall provide lateral support and ensure adequate concrete cover. Spacers shall be placed at minimum 6 equal levels of each 1.5m cage.

All pile shall then be concreted by using the 'tremie' method. Concrete of higher slump (=175mm+25mm) shall be used for 'tremie' method. The self-compacting mixed concrete will be discharged through a tremie pipe, which is lowered centrally to the bottom of the bored hole prior to filling it with concrete. Concrete level of the borehole was recorded after each concrete truck discharged and graph will be plotting against theoretical. One length shall be continuously embedded in the concrete during this process to ensure that the discharge of concrete is below the level of the impurities, which might be present in the top part of the rising head of concrete. A complete record of all cubes taken shall be maintained in a proper form and slump test results shall be recorded on the 'Delivery Order' and the 'Pile Bore Log'. For a continuous assurance of concrete quality and integrity, concrete will be poured to minimum 0.6m above the theoretical cut-off level. All completed piles shall be temporarily barricaded and to be backfilled to ground level with a suitable material the next day, if required.

Spoil from piles will be cleared from the boring locations by means of an excavator as boring proceeds. Depending on the volume of spoil excavated, it will be removed to stockpile area or spoil pit, for drying before loading and removed off-site.

Cycle time for RCC Bored cast-in-situ piles

- Total piles = 66 nos. (1000mm); min. length – 41m
- Coordinate checking: 30 mins.
- Excavation of hole including casing: 6 hrs
- Survey check (for depth): 30 mins.
- Flushing of hole: 1 hrs.
- Reinforcement (cage lowering): 60 mins.
- Concrete including arrangement: 5 hrs
- Pile top excavation and chipping for rebar extension including concreting: 4-5 hrs.

TOTAL TIME FOR 1 PILE: 19 – 20 HRS.

The activities at various piles will simultaneously proceed at different stages and therefore practically it may be concluded that completion of 134 piles will require about 120 days including pile capping.

11.4 Miscellaneous Activities

11.4.1 Soil and Concrete Laboratories

For testing of materials at quarry sites, construction materials, preparing concrete mix designs for checking the strength of the concrete after placement and to check other parameters, a full fledged and permanent soil and concrete testing laboratories shall be set up at the project. Besides, well equipped field Laboratories shall also be set up near the construction sites for sampling and field tests.

11.4.2 Inspection and Quality Control

Since quantum of concrete and fill placement involved in the barrage construction is massive, strict quality control will be exercised in the field works, quarry area, plants etc as per specifications. Quality control Laboratory will be established at the project site for conducting tests for the construction material (cement, fine & coarse aggregate), concrete mix etc. Quality Assurance system will also be established.

11.4.3 Soil and Concrete Laboratories

For testing of materials at quarry sites, construction materials, preparing concrete mix designs for checking the strength of the concrete after placement and to check other parameters, a full fledged and permanent soil and concrete testing laboratories shall be set up at the dam site along with sampling and field tests.

11.4.4 Inspection and Quality Control

Since quantum of earthwork and fill placement of pervious/impervious material involved in the barrage construction is more, strict quality control will be exercised in the field works, quarry area, plants etc as per specifications. Quality control Laboratory will be established at the dam site for conducting tests for the construction material. Quality Assurance system will also be established.

11.5 Man Power Requirement during Construction Phase

The in place available man power of the project (excluding those of contractors) has been estimated and given in the organization chart attached as **Annexure 11.2**.

All major Civil, Mechanical & Electrical works are proposed to be executed through EPC contracts while Project Management Consultant (PMC) shall be outsourced from an engineering consulting firm. The Department of IWT, Government of Assam will undertake construction supervision as owner's task and accordingly no provision of workshop from the owner end has been made. Inspection vehicles including ambulance for the use by Owner representative are proposed to be engaged.

The project is proposed to be headed by a Project Head. The manpower required to execute the Project is given in table below. The site team shall be extended as the work progresses.

Table 11-2: Key staff

Sl. No	Designation	No. of Staff Required
1	Project Head	1
2	Engineering Head	1
3	Assistant Engineer (Civil)	2
4	Junior Engineer (Civil, Electrical and Mechanical)	4
5	Administration Officer	2
6	Accounts Officer	2
7	Land Acquisition and Rehabilitation Officer	2
8	Q.C.Engineer & Safety Officer	2
	Total	16

Posting

Posting / recruitment of both technical and non-technical staff shall be carried out as per progress of works and actual requirement. 25% of balance manpower will be posted within one month of the date of start of the project. Another 75% of the balance manpower is proposed to be posted within the next 3 months. The O&M staff will be posted as per the standard practice adopted in other projects by IWT, Government of Assam

Training

It is proposed to impart periodical training to the employees in their respective fields during the construction period of the project. This training will go a long way not only in improving the quality of construction, but also to have proper supervision.

Consultants

During project construction stage, a competent PMC (Project Management Consultant) and Design Consultant for review of the detail design engineering shall be engaged.

11.6 Phasing of Construction Period

The construction period is estimated as 18 months from the date of awarding of the contract. The phasing of construction period is provided below

Phasing of Project Construction Period

Project Component	0 - 6	7 – 12	13 – 18

	months	months	months
Admin (Offices and facilities)	20%	40%	40%
Security Shed	100%		
Terminal Building	25%	50%	25%
Jetty and Pontoon	25%	50%	25%
Vehicle Parking Area		50.0%	50.0%
Public Utility		50.0%	50.0%
Mechanical facility		50.0%	50.0%
Public Health Arrangement		50.0%	50.0%
Open storage Area			100.0%
Covered Storage / Transit Shed		50.0%	50.0%
Electrical facility		50.0%	50.0%
Fire Fighting		50.0%	50.0%

12. REFERENCES

12.1 Reference Documents

- Report Module 1: Assam Transport Strategy 2018 – 2035 (ISDP Consultant)
- Report Module 2: Investment Strategy for Assam IWT Sector (ISDP Consultant)
- Report Module 3: Feasibility Assessment for Assam IWT Project (ISDP Consultant)
- Report Module 4: Feasibility Assessment for Pre-identified IWT Infrastructure (ISDP Consultant)
- DPR for Brahmaputra River Front Development (Guwahati Smart City Limited)
- Thalweg Survey Data (AIWTDS)
- Bathymetric Data of Pandu Area (Tractebel internal data from secondary sources)
- Soil Investigations Report (Guwahati Smart City Limited)
- Water Levels at Silchar Area (Tractebel internal data from secondary sources)

12.2 Codes and Standards

- IS: 1893 Criteria for Earthquake Resistant Design of Structures
- IS: 875 Code of Practice for Design Loads for Buildings and Structures
- IS: 456 Code of Practice for Plain and Reinforced Concrete
- IS: 2911 (Parts 1 to 4) Code of Practice for Design and Construction of Pile Foundations
- IS: 800 Code of Practice for General Construction of Steel
- IS: 4651 (Parts 3 and 4) Code of Practice for Planning and Design of Ports and Harbours
- IS: 13920 Code of Practice for Ductile detailing of reinforced concrete structures subjected to seismic forces
- IS: 1786 Specification for high strength deformed steel bars and wires for concrete reinforcement
- IS: 2062 Hot Rolled Medium and High Tensile Structural Steel
- IRC-37 Guidelines for the Design of Flexible Pavements
- IRC-5 Standard Specifications and Code of Practice for Road Bridges (SEC-I) – General Features of Design.
- IRC-6 Standard Specifications and Code of Practice for Road Bridges (SEC-II) – Loads and Stresses
- IRC-21 Standard Specifications and Code of Practice for Road Bridges (SEC-III) – Cement Concrete (Plain and Reinforced)
- IS 1080 Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell).
- IS: 1904 Code of practice for design and construction of foundations in soils- General requirements.
- IS: 6403 Code of practice for determination of bearing capacity of shallow foundations.
- IS: 8009 (Part-I) Code of practice for settlement of foundations.
- IS: 383 Specification for coarse and fine aggregates from natural source for concrete
- IS: 2386 Methods of tests for aggregates for concrete
- IS: 4326 Earthquake resistance design and construction of buildings.
- IS: 1566 Hard drawn steel wire fabric for concrete reinforcement.
- IS: 432 Specifications for mild steel and medium tensile steel bars and hard drawn steel wires for concrete reinforcement (grade I).
- IS: 13920 Ductile detailing of reinforced concrete structures subjected to seismic forces – codes of practice.
- IS: 3370 Code of practice for concrete structures for the storage of liquid.
- IS: 2212 Code of practice for brickwork.
- IS: 806 Code of practice for use of steel tubes in general building construction.

- IS: 808 Dimensions for hot rolled steel beam column, channel and angle sections
- IS: 2062 Steel for general structural purposes.
- IS: 3502 Steel chequered plates.
- IS: 1363 Hexagonal head bolts, screws and nuts of product grade C.
- IS: 1367 Technical supply conditions for threaded steel fasteners.
- IS: 5624 Specification for foundation bolts.
- IS: 2016 Plain washers.
- IS: 277 Galvanized steel sheet (Plain and corrugated)
- IS: 1230 Cast Iron rain water pipes and fittings
- IS: 1728 Specification for sheet metal rain water pipes, normal size gutters, fittings and accessories.
- IS: 14246 Code for continuously pre - painted galvanized steel sheets and coils
- IS: 814 Covered electrode for manual metal arc welding of carbon and carbon manganese steel.
- BS: 8110 Structural use of Concrete
- BS: 6031 Code of Practice for Earthworks
- BS: 6349 (Part 1 and 2) British Standard Code of Practice for Maritime Structure
- BS: 5493 Protective coating of Iron and Steel Structure against Corrosion
- IS-9676 : Reference ambient temperature for electrical equipment.
- SP-30 : National Electrical Code (NEC), BIS Publication.
- IS-13234 : Guide for short circuit calculations in three phase AC Systems.
- IS-4201 : Application guide for C.T.
- IS-4146 : Application guide for V.T.
- IS-3043 : Code of practice for earthing.
- IS-3716 : Application guide for Insulation Coordination.
- IS-10028 : Code of practice for selection, installation & maintenance of transformer.
- IS-10118 : Code of practice for selection, installation & maintenance for switchgear & control gear.
- IS-2309 : Code of practice for the protection of buildings and allied structures against lightning.
- IS-12360: Voltage bands for electrical installations including preferred voltages
- Geotechnical and Foundation Design Considerations ANSI/API RECOMMENDED PRACTICE 2GEO FIRST EDITION, APRIL 2011
- Planning, Designing, and Constructing Fixed Offshore Platforms—Working Stress Design API RECOMMENDED PRACTICE 2A-WSD TWENTY-SECOND EDITION, NOVEMBER 2014

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At the helm of the Energy Transition, Tractebel provides a full range of engineering and advisory services throughout the life cycle of its clients' projects, including design and project management. As one of the world's leading engineering and advisory companies and with more than 150 years of experience, it's our mission to actively shape the world of tomorrow. With about 5,000 experts and presence in more than 70 countries, we are able to offer our customers multidisciplinary solutions in energy, water and urban.

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