



## **SECTION - I**

### **GENERAL SITE CONDITIONS, TOPOGRAPHY AND NATURE OF INVESTIGATIONS**

#### **1. LOCATION AND TOPOGRAPHY:**

The site for the proposed Construction of Oil Jetties No: 8 and 9 at Old Kandla Port area. The sounding survey indicates that proposed major facilities are located between 7 m to 10 m contours.

The investigation program involves assessment of seabed exploration studies for construction of Construction of Oil Jetties No: 8 and 9 along the proposed alignment.

#### **2. DETAILS OF EXPLORATIONS:**

The site works were executed between 16<sup>th</sup> December 2017 to 13<sup>th</sup> January 2018. It included the drilling/coring of ten (10) marine exploratory boreholes in the water, from existing seabed level to a depth of 33.45 m, with related in-situ testing, using a jack-up drilling platform.

Field works were executed by experienced Geotechnical personnel, under the supervision of a Geotechnical Engineer/Engineer Geologist, in accordance with the Indian Standard IS1892, "Code of Practice for subsurface Investigations for foundations" and IS: 5313. The core drilling operations have been carried out as per IS: 6926-1973 "COP for diamond core drilling for site investigation for river valley projects.

The exploratory works at site were carried out by deploying dedicated certified Jack Up Barge "SAGARMANTHAN" with 36.00 m leg length. The jack up was equipped with Drillmax 625 hydraulic core drilling rig for rotary as well as diamond coring. All necessary arrangements for sampling and its storage was availed onboard vessel. Photo plates are attached in annexure for typical view of works in progress along with essential infrastructure.

150mm size bore holes were drilled in overburden and NMLC Tripple tube core barrel with diamond bit was adopted for drilling through rock formation to obtain Nx size core samples. The soft formation in overburden was cased using temporary casing. The field tests, sampling and specifications have been exclusively followed as per the directives and schedule of the specifications. The details of bore holes including collection of soil samples are given in Table - 1.1 of this report.

#### **3. SELECTION OF BOREHOLE LOCATIONS AND POSITIONING:-**

The bore hole locations were located using Lica 420MX DGPS to a accuracy of  $\pm 2.00$  m. The Jack up Barge was positioned at the marker bouy positions. For bore hole levels, water depths are measured by sounding at each location prior to commencement of drilling and level calculated

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with reference to tide predictions at Local. The bore holes for dredging, structural requirements and pipe line purpose have been executed. Total bore holes to be executed are about 10 nos. Table no. 1.1 specifies exploration bores with field location classification as per above description.

### 3.1. UNDISTURBED AND DISTURBED SOIL SAMPLES:

The undisturbed soil samples were collected from subsoil strata by means of a two tier open drive soil sampler. The internal diameter of the tube was slightly over 90 mm and both the outside and inside clearance were maintained at about 2% of the internal diameter of sample tube.

In all 8 nos. undisturbed, 203 nos. disturbed soil samples including S.P.T. samples have been collected from 10 nos. bore holes of proposed layout site. The details of have been presented in Table no. 1.1. The bore holes are grouped as hereunder in the table for the purpose of assessment and arriving at foundation requirements of the structure.

**TABLE NO. 1.1**  
**DETAILS OF BORE HOLES AND SOIL SAMPLES**

Sr. No.	B.H. No.	R.L., m	Co-ordinates, m		Depth, m Below G.L.	UDS S1	S.P.T. S2 (DS)	S3 DS	Water Sample
			E	N					
1.	MBH-1	-2.310	0624865	2550746	33.45	2	20	22	1
2.	MBH-2	-11.730	0624950	2550730	30.45	1	19	19	1
3.	MBH-3	-12.930	0624932	2550636	30.45	-	20	20	1
4.	MBH-4	-2.130	0624854	2550561	33.45	2	20	22	1
5.	MBH-5	-9.560	0624936	2550523	30.45	1	19	20	1
6.	MBH-6	-9.960	0624927	2550425	30.45	-	20	20	1
7.	MBH-7	-9.310	0624929	2550325	30.45	-	20	20	1
8.	MBH-8	-3.100	0624837	2550294	31.95	2	19	20	1
9.	MBH-9	-9.970	0624902	2550224	30.28	-	20	20	1
10.	MBH-10	-8.950	0624908	2550131	30.13	-	20	20	1
<b>Total</b>						8	197	203	10

### 4. FIELD TESTS CONDUCTED:

#### 4.1. STANDARD PENETRATION TESTS: (IS: 2131 - 1981)

Sampling was executed as per IS: 2132-1986 and IS: 8763-1978. Standard Penetration Tests (SPT) were conducted in all boreholes at 1.50 m interval in the overlaying soil layers and, occasionally, in the top weathered, very weak rock. SPT was conducted in accordance with Indian Standard IS: 2131:1981; "Method for standard Penetration test for soils". Standard Penetration Tests (SPT) were conducted in all boreholes at 1.50 m interval in the overlaying soil layers and, occasionally, in the top weathered, very weak rock to confirm/ ascertain the stratification strengths.

The test involves driving a 50mm external diameter thick walled tube (split spoon sampler) into the bottom of the borehole with successive blows of a 63.5 kg hammer falling freely through 760mm.

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The sampler is driven through 3 intervals of 150mm and the number of blows required to penetrate each interval is recorded.

The initial 150mm interval is intended to ensure “seating” of the sampler such that it penetrates beyond the zone of influence of any soil disturbance at the base of the borehole. The aggregate number of blows required to drive the sampler over the final 300mm is termed the “N” value and is considered indicative of the soil’s in-situ relative density. Where a penetration of 300mm was not achieved, due to the densities of the deposits encountered, the number of blows and distance driven are recorded on the borehole logs.

The details of bore holes including collection of soil samples are given in Table - 1.1 of this Report. The bore logs details and soil profiles have been presented in Annexure – I Figure 1.21. The core drilling presentations are based on IS: 4464-1967 COP for “presentation of drilling information and core description in foundation.”

The numbers of boreholes, S.P. tests and sample collection have been executed with adequate frequency as per the scope of works and the stratification encountered. In total 194 nos. of SP test have been conducted.

## 5. GEOLOGY:-

The rocks exposed in the area are of marine, non-marine and volcanic origin, ranging in age from upper Jurassic to later Tertiary. Following is the geological succession found in the area under study.

Recent and sub-recent Pleistocene		Alluvium, Miliolite Grits, consolidated sand, clays, wind borne sand and kankar.
Pliocene Manchar Burdigalian Gaj		Conglomerates, sand & Clays. Shales, marls and sandstones (Argillaceous group).
Eocene Supratrappean		Laterites, lateritic clays and bauxite.
Unconformity		
Upper cretaceous to Eocene		Deccan Trap flows and basic intrusives and sandstone dykes.
Unconformity		
Cretaceous ... Upper Bhuj		Friable, medium to coarse grained, often current bedded sandstone.
Upper Jurassic to lower Cretaceous	Lower Bhuj	Sandstones, shales and Silt- stones.
Upper Argovian to Aprian	Katrol	Hard, brown, blocky sandstones and gypseous shales.
Upper Bathonian to Divesian	Chari	Yellowish and olive green

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shales, calcareous sandstones  
and oolitic limestones.

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**Chari:** The rocks belonging to Chari series form the oldest geological formation in the area and consist of hard sandstones, gypseous shales and bands of oolitic limestones. These are exposed west of Ler in the anticline extending east to west along the Katrol hills.

**Katrol:** Overlying the Chari series are the rocks of Katrol series comprising shales and sandstones. The shales including veinlets of gypsum are predominant in the upper part which is capped by a thin band of hard sandstone. The Katrol series are exposed in the Khatrod and Habo hill ranges trending in W.N.W, to E.S.E. direction and around Adhoi in Wagur area.

**Bhuj series:** Bhuj series overlie the Katrol series and are composed of medium to coarse grained sandstones, ranging in colour from white, yellow, pink and brown with interbedded shales and sandy shales and silt stones. Dr. Rajnath (1932, pp.163) Included the plant bearing beds of the upper division of the Umia series of Waagen (1873, p. 1) which is approximately equivalent to the “Upper Jurassics” of Wynne (1872, pp, 51-53) under Bhuj series and estimates its age as post Aptian to Cretaceous. But Taylor and Pathak (1960, p.14) are of the opinion that the upper most part of the Bhuj stage may be of post Aptian age and the remaining part may range down to through the lower Cretaceous and into the upper Jurassic. It is difficult in the field to demarcate the boundary between the Umia and Bhuj in the area under study, as the passage from Umia to Bhuj is not distinct and there are similar lithological features. The Bhuj series is further divided into lower and upper series by Rajnath.

**Lower Bhuj Series:-** The lower Bhuj series consists of fine to medium grained, current bedded sandstones, variegated silty shales, shales, micaceous silt-stones and flaggy sandstones in equal proportion. The outcrops are seen along the flanks, of Khatrod, Habo and Adhoi hill anticlines. The thin bedded flaggy sandstones which are dark red or purple in colour due to ferruginous cementing – material form hard resistant ledges.

**Upper Bhuj series:** The upper Bhuj series are chiefly composed of sandstones with subordinate amount of shales and silt stones, forming less than ten percent. The sandstones are generally current bedded, soft and friable, medium to coarse grained, ranging in colour from white, to buff. The sandstone is composed predominantly of quartz grains, poorly cemented by fine argillaceous or feldspathic material.

**Deccan Trap:** Flows of the Deccan trap overlie the lower and upper Bhuj series with slight unconformity. The trap flows are seen around Kukma, between Kera and Chandia, Wondh and Lunwa and around Bharapur. They attain a thickness of 316.5 metres in the Khirgea hill east of Bharapur. Associated with traps are the basic – summarize in both the upper Jurassic and Cretaceous formations. The dykes are sometimes partly siliceous and partly trap as seen in the dyke running between Kukma and Reladi, The dykes are mostly of dolerite and range in thickness from 2 to 6 metres in general and run for miles.

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Supra trappean: The Supra trappean is chiefly composed of laterites, lateritic clays, aluminous shales and bauxite. These are generally exposed along the trap boundaries.

Gaj: The Gaj beds mi conformably overlies the Bhuj series and are composed of grayish and bluish green gypseous clays, mudstones and limestones. Outcrops are seen around Bhachau and there is a small outlier about 1.6 Kms., south of Kumbhardi.

Manchar: The sediments of upper Manchar series consists of buff to light grey clays (which are at places gypseous), mottled sandstones and laminated siltstones. The rocks of the Manchar series are well exposed near Padhar. The exploratory borehole drilled near Padhar has indicated the thickness of this series to be not less than 150 metres.

Sub-recent and Recent: Miliolite limestone of sub-recent age generally occurs along the hill slopes, faulted plains and on the river banks near Madhapur. The flaggy beds of Miliolite limestone are white or dull grey in colour with medium grained texture. These are generally, quarried for building stones.

Alluvium: Alluvium generally occurs along the banks of the rivers composing predominantly of sand and fine gravel with subordinate amounts of clay and silt and attains a thickness of about 7.5 metres.

## **6. SOIL PROFILE:**

The soil profile for bore hole nos. 1 to 10 is presented in Annexure - I. The profile confirms the subsurface conditions generally observed in the marine creek.

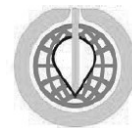
### **6.1. EXPLORATION BORES – BORE HOLE NOS. 1 TO 10:**

#### **SOFT STRATUM: (0.00 m to 33.45m from SBL)**

The soft stratification overburden depth variation for Terminal Jetty 0.00 m to 33.45 m. Almost for 10 nos. bores the overburden is 30.45 to 33.45 m thickness. The surface soils are brownish, grayish medium to high plasticity Clayey Silts to Sandy Silts with bands of silty clay or Sandy Clay at intervals. The observed SPT N values varies from 5 to 64 in B.H. No. 1 to 10. The soil is in CI, MI, CL, SM and CH category with high compressibility and high plasticity. The sand contents in the stratum increase with depth in majority of the bores.

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## **ANNEXURE – I**

### **SOIL PROFILE AND BORE LOGS DATA SHEETS**