Geotechnical Investigation of the Proposed Transhipment in the Great Nicobar Island

M Ravichandran[#1], A G Sharanya[*2], Dr.D.Suji [*3]
#1 Research Scholar , Dept.of Civil Engineering ,Karpagam University
Pollachi Main Road ,Eachanari ,Coimbatore, Tamilnadu, India
#2ME, Geo Technical Engineering, GCT, Coimbatore.
[#3]HOD, Department of Civil Engineering,
Aditya Institute of Technology, Coimbatore.

Abstract

World over containers are being handled by a system of transhipment i.e. large container carriers are unloading the containers in a particular port (Transhipment Port) from where the containers are further shipped to the final destination ports by feeder vessels. Large containers carriers (mother ships) with deep draft are unable to call on smaller ports and therefore, take equatorial shipping lines (East to west or vice versa) and call on such transhipment ports and leave the containers to be picked up by feeder vessels to the smaller ports. The containers to Indian Sub-Continent ports are presently transhipped from Dubai, Colombo and Singapore. At present 65% of the 1,720,000 containers received at Singapore port are further transhipped to the ports in the Asian Region including Indian Ports. The advantage of Colombo and Singapore for container traffic is their geographic locations adjacent to the equatorial shipping line stretching from Gulf/Red Sea to the South - East China Sea. The southernmost point of India, the Great Nicobar Island, (GNI) enjoys the same geographical advantage as being extremely close to this equatorial shipping line used by large container carriers (mother ships). The most obvious benefit is the income generated from operations of a transhipment port because of the double handling of containers. More importantly, transhipment ports provide local importers and exporters direct access to line haul service, reducing transportation time (and possibly freight rates) to and from overseas markets. Reduced transport time directly impacts the competitiveness of exporters and the cost of imports, in turn creating jobs and income throughout the economy. Many developing countries have created free trade zones in combination with the hub port as engines for economic growth. For development of transhipment port the adequate geotechnical investigations has been carried out in Great Nicobar Island. Based on the field and laboratory investigations of the soil sample collected at each borehole it is found that the subsurface profile consists of deposits of sandy silt, sandy clay, cemented sand & soft rock generally varying with depth were noticed. The boreholes were terminated at a maximum depth of 28.80m below sea bed level. Bored cast insitu concrete piles resting on very hard stratum having SPT >100 with varying lengths in the range of 24.50m to 34.00m at different borehole locations is recommended to enable the berthing of large inter- continental vessels.

Keywords— *Berths, Bored cast in-situ concrete piles, Borehole, SPT N-value, Subsurface profile, The Great Nicobar Island, Transhipment port.*

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I. INTRODUCTION

The Andaman & Nicobar Island comprises of a chain of 572 Islands which extends from 6˚ to 14˚ North latitude and 92˚ to 94˚ East longitude. The Indian mainland from A & N islands is connected by ship and air. The shipping sector of the Island provides services for tankers, containers, passenger services and many more which provides Indian government with substantial revenue.

Transshipment port facilitates the shipping of goods or containers to an intermediate destination, then to yet another destination [1]. Port facilities at A&N Islands can be modernized with the creation of transshipment port. As a part of creation of port infrastructure various possibilities towards development of these Islands has been looked into and decided to carry out detailed research towards the possibilities of developing a transhipment port in Great Nicobar Island. The proximity of Great Nicobar Island to the international shipping route has drawn the attention of Govt. of India, since 1970. Hence time and again the, possibility of establishing transhipment Port in Great Nicobar Island on the map of Global maritime trade have been explored.

II. NEED FOR RESEARCH IN THIS AREA

In the Indian sub-continent, due to geographical and logistic constraints, deep water berths in the ports existing on its East & West Coast could not be developed for berthing large inter-continental vessels of drafts over 15m. This situation has resulted in depending on transshipment ports which are available in other countries such as Sri Lanka, Singapore, Hong Kong etc. Due to these limitations on available facilities, transshipment are done in other countries, India is thus loosing substantial revenue in terms of facilities and higher rate of landings. The quantum of such losses is enormous considering the cargo being presently handled on the Indian ports. With the passing years, the situation is expected to be more severe. In addition, from the logistic point of view, it is preferred that transshipment port facilities exist within Indian waters so that sustained maritime trade can be brought to India ports. It has also been observed that there are some indications that other countries like Myanmar, China and Srilanka are gearing up their resources to develop deep water facilities for taking major share of trade by developing suitable harbor facilities. From the forgoing, it is quite evident that it is high time India also moved towards setting up dedicated deep water berths for primarily, transshipment activities in its waters and thereby generates revenue.

III.OBJECTIVE OF THE STUDY

- To determine the suitability of the locations in Great Nicobar Island for the construction of Transshipment Port.
- To perform borehole investigation for determining the soil profile and collecting the soil sample at the locations
- To conduct laboratory tests on the soil sample collect and to arrive at the adequate Foundation type needed.

IV. LOCATION OF THE STUDY

The South Bay Island and the Campbell Bay Island which are very close to each other and more or less same distance from the international shipping route i.e. Malacca strait in Great Nicobar Island were chosen. It is a blessing in disguise that a locations in Great Nicobar Island such as South bay & Campbell Bay are available which is embracing an international sea route (East West Corridor) i.e. Malacca straits which links Japan, South Korea, Hong-Kong, Malaysia Singapore on one side giving assess to Australia, New Zealand on one side and outer routes towards Mideast. The East West Shipping Corridor route is shown in Fig.1. If India institutes a transhipment terminal at this location world shipping companies would take advantage by cutting short their travel distance to south bay /Campbell Bay and other countries will pick-up/dispatch their containers to South Bay /Campbell Bay. Thus taking advantage of an optimisation in logistics.

The Great Nicobar Island situated towards the south of Nan cowry group of Islands, forms the ideal site being a nodal point, in the Australia, Japan and Korea navigational route for creating a transhipment port. The topography of the island is the best suited, which has not been damaged much even by recent Tsunami on 26.12.2004.

Fig.1 East West Shipping Corridor

Thus in consideration with the requirements for a transhipment port, the location proposed in Great Nicobar Island of Andaman & Nicobar Islands, prima-facie appears quite appropriate / reasonable. Accordingly the Great Nicobar Island has been chosen for set up for creating a container transhipment port. The index map of the study area is as shown in Fig.2

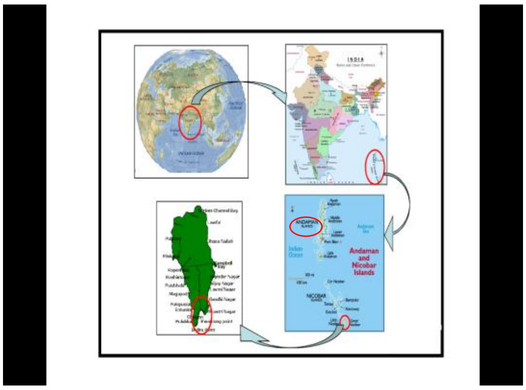

Fig.2 Index Map

V. GEOTECHNICAL INVESTIGATION

A. *Bed Sediment*

Generally, the Soils of the Andaman and Nicobar Islands have been classified into orders Entisols, Inceptisols and Alfisols. The main agricultural soils are found in the valleys and are of alluvial and colluvial origin. The coastal areas prone to tidal floods may have acid sulphate soils. On the whole soils of these Islands are nutritionally poor and their organic matter content is on decline.

B. *Seabed Sediment*

The coastal areas prone to tidal floods may have acid sulphate soils. Soil of this Island is nutritionally poor and their organic matter content is on decline. Seabed sediment samples were collected at 7 locations (stations S1 to S7) using a Van Veen grab sampler.The collected samples were transferred to polythene bags, and properly labeled and stored. On reaching the laboratory the sediment samples were dried and sieved. The sediment size distribution for all the samples is presented below in Table 1

C. *Field Investigations*

TABLE 1: SEDIMENT SIZE DISTRIBUTION

Depth (m)	Classif i-cation of Soil	D_{50} mm	Natural Moisture content %	Medium Sand%	Fine Sand %	Silt %
	Class	D_{50} mm	NMC	MS	FS	silt
S1	SP	0.11	14.92	0.35	94.0	5.6
S2	SP	10	14.91	0.35	88.7	10.9
S3	SP	0.09	14.92	0.14	85.4	14.4
S4*	-	-	-	-	-	-
S5*	-	-	-	-	-	-
S6	SP	0.1	15.2	0.28	86.4	13.3
S7	SP	0.13	16.31	0.38	91.1	8.56

1) The field investigations were carried out at proposed locations and consist of total ten (10) nos. of Boreholes. Out of the 10 boreholes, 4 nos. of boreholes were carried out on land with depths varying from 25.0m to 27.0m below bed level and 6 nos. of boreholes were carried out in sea with depths varying from 21.7m to 28.8m below sea bed level. The details of Borehole locations and depths of Boreholes are tabulated below in Table 2.

2) The sub-surface investigation was carried out as per IS: 1892-1979. The boring was carried out using two rotary rigs. The rig deployed had an arrangement for driving and extracting of casing, boring, and drilling by mud circulation method, conducting SPT tests.

3) The land and marine boreholes of 150mm diameter were conducted by deploying the rotary rigs. Position fixing was carried out by Differential Global Positioning System (DPGS) with horizontal positional accuracy of $\pm$ 10 m. Casing was used to support sides of borehole until stiff strata is encountered. Stabilization of boreholes was achieved by flush jointed seamless casing as well as bentonite slurry.

4) Standard Penetration Tests (SPT) were conducted in soil at maximum intervals of 1.5m in accordance with IS: 2131-1981 by using the Standard split-barrel sampler as per IS: 9640-1980. The 'N' values or "penetration resistance" were obtained by counting the number of blows required to drive the sampler from 15cm to 45cm penetrations. The N values are indicative of the relative density of cohesion less soils and consistencies of cohesive soils. The depth wise variations of 'N' value are shown in the Soil Profile drawn for the Boreholes given below in Fig.3

5) Select soil samples were subjected to laboratory testing. Laboratory tests on SPT samples included mechanical analysis and Atterberg's Limits conducted according to IS: 2720 relevant parts.

TABLE 2 : BOREHOLE LOCATIONS

BH No.	Geographical						Depth of Bore Hole below Ground Level / Sea Bed Level (m)
	Northing			Easting			
Land Boreholes							
1	6^0	47'	53"	93^0	50'	36"	27.00
2	6^0	46'	24"	93^0	50'	24"	26.00
3	6^0	45'	40"	93^0	49'	36"	25.00
4	6^0	46'	22"	93^0	49'	23"	25.70
Marine Boreholes							
1	6^0	48'	23"	93^0	51'	24"	24.20
2	6^0	47'	50"	93^0	51'	50"	22.60
3	6^0	46'	40"	93^0	50'	55"	25.00
4	6^0	45'	20"	93^0	50'	03"	21.00
5	6^0	45'	07"	93^0	50'	58"	28.80
6	6^0	45'	20"	93^0	49'	03"	21.70

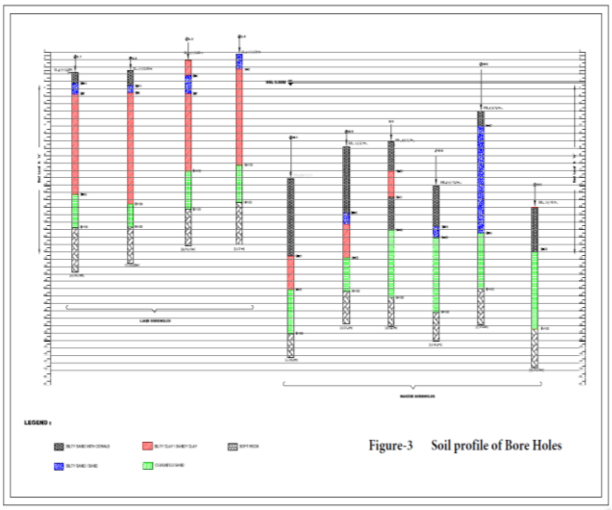

Fig.3 Soil Profile

VI. FOUNDATION RECOMMENDATIONS

This section covers the foundation type recommended based on the subsoil investigations and also includes the bathymetric survey carried out at Campbell Bay Island to find out the depth of water at the berthing place and turning circle of the ships.

A. *Land Boreholes*

From the land boreholes studies and results it is observed that the soil stratum is found to be loose or medium stiff up to 10.50 m depth at L1, L2 and up to 9.00 m depth at L3. Bored cast in situ concrete piles resting on very hard stratum having SPT >100 are recommended. Safe vertical load capacities of piles of different diameter are given below in Table 3.

TABLE 3 : SAFE CAPACITY OF PILES BASED ON PILE DIAMETER

Pile Diameter (mm)	Safe Capacities of Piles installed up to a depth where SPT value of at least 100 is obtained	
	Bored Cast Insitu Piles (Tons)	Driven Cast Insitu Piles (Tons)
600	220	275
750	335	415
900	426	500

The safe vertical load capacities of the piles in terms of pile material strength with different grades of concrete and of different diameter are given below in Table 4.

Table 4: Safe Capacity of Piles Based on Material

Pile Diameter (mm)	Safe Capacities Of Pile For Different Grades Of Concrete (Tons)			
	M20	M25	M30	M35
600	141	169	226	254
750	220	265	353	397
900	318	471	628	572
1000	392	471	628	707

B. *Marine Boreholes*

Bored Cast in situ concrete piles, end bearing on very hard stratum having SPT>100 are recommended. The length of piles at the different bore hole locations are given below in Table 5.

Table 5 : Length of Pile

Borehole location	Water Depth (m)	Depth at which SPT>100	Length of pile below water level (m)
M1	13.00	21.00	34.00
M2	10.00	16.50	26.50
M3	8.00	16.50	24.50
M4	14.00	16.50	30.50
M5	14.00	24.00	28.00
M6	16.90	16.50	33.40

C. *Berthing At Campbell Bay Island*

The dredging being most important part in the Campel Bay project, it needs to be carried out meticulously. The entire development at Campbell bay Island is planned in two phases, so that present shipping activities are not disturbed. The Dredging of more than 10 meters close to the shore has to be done in step formation or with proper slope, to maintain the stability of the shore and reduce the wave refraction in the basin. It is proposed to dredge the basin up to -16.00 meters (Below LLWL) and approach channel (1 Km long & 500 meter wide) up to -18.00 meters (Below LLWL). The estimated quantity of dredging shall be 314.13 Lakh Cum. (133.79 Lakh Cum. In 1st Phase), of which 50% shall be utilized for filling the backup area, subjected to suitability, which shall be affirmed by soil investigations. A sheet pile wall has been proposed, 150 meters off the existing deep water wharf & passes 20.0 meters front of the existing Jetty, right up to the shore towards Airstrip. The area, inside of the wall and between the existing shores, is proposed to be filled equally by borrowed earth by the dredged material.

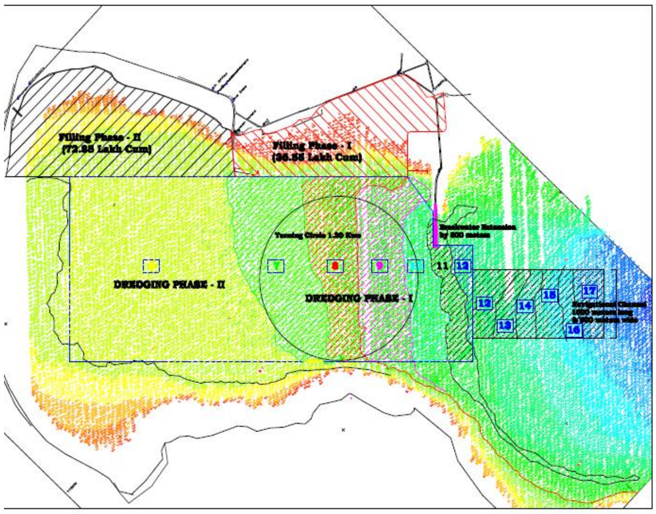

Fig.4 Dredging and Filling at Campbell Bay Island

Development of Campbell Bay Harbour through Phase – I, consists of following:

- Dredging of seabed to 16 meters depth in the basin.
- Dredging of navigational channel to a depth of 18 meters (up-to the mouth of breakwater, 1.0 Kms long & 500 meters wide).
- Sheet pile wall of 2.53 Kms length, to provide 1.30 Kms long Quay.
- Development of an area of 75.60 Hectares, through back filling.
- Extension of Breakwater by 300 meters.

Development of Campbel Bay Harbour through Phase – II, consists of following:

- Dredging of sea bed to 16 meters depth.
- Sheet pile wall of 2.08 Kms length, to provide 1.73 Kms long Quay.
- Development of an area of 106.0 Hectares, through back filling.

VII. CONCLUSIONS

Shipping is a major link between the global economy and international trade. More than 90% of world merchandise trade is carried by sea and over 60% of that volume is containerized. The increasing number of container shipments causes higher demands on the seaport container terminals, container logistics and management as well as on technical equipment. As ship size increases and shipping line mergers and alliances continue, the economic advantage of reducing the number of port calls has become more pronounced, and this has resulted in a rapid rise in transshipment.

As Nicobar will be required to cater to transshipment cargo on the E-W route between Singapore and Colombo, the port should be designed to accommodate traffic on this route, which includes the largest vessel currently in operation. This would also increase Nicobar's competitive edge as a transshipment hub and will also provide shipping lines the required economies of scale. To carry large vessels the foundation for transshipment port is designed as Bored cast insitu concrete piles.

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