



GEOTECHNICAL PROPERTIES OF MARINE SOIL OFF NORTH KONKAN COAST

Ilangovan, D. Jaya Kumar, S. Raghuveer L. Naik

Ocean Engineering Division, National Institute of Oceanography, Dona Paula, Goa-403 004, India.

SYNOPSIS : Construction of any coastal structure requires detailed investigations on the environmental parameters as well as on the foundation soil. Preliminary geotechnical investigations on the seabed sediment leads to a qualitative representation of the sediments present on the sea floor. Using a gravity corer, developed at the Institute, undisturbed seabed sediment cores were collected at six locations off North Konkan coast, at water depths between 6 and 20m. These sediment samples were tested for various geotechnical properties. These sediments were found to have less bulk density, low carbonate content, high plasticity index with very low undrained shear strength. Grain size distribution shows that the sediments consist of 60% to 80% silt with 18% to 38% clay. The sand content was less than 2%.

INTRODUCTION

Due to rapid industrialisation in India many industries are coming up and generally coastal areas are selected for industries as they provide better facilities like shipment of raw materials and finished products, effluent disposal, intake of sea water for cooling purposes, etc. To carry out the above operations, suitable structures are to be constructed. For the design of foundation of such structures and for the environmental impact assessment, geotechnical investigations on the nature of the seabed need to be carried out. In this paper geotechnical investigations were carried out on undisturbed sediment cores collected at six locations off North Konkan coast.

DESCRIPTION OF THE STUDY REGION

The coastal segment under investigation is bounded by western ghats in the east and the Arabian sea in the west. Number of headlands and cliffs protrude into the sea in this region. Continuous wave attack on the sea cliffs resulted in the disintegration of coastal rocks.

EQUIPMENT

A gravity corer, designed and fabricated at the institute for near shore sediment sampling with suitable design criteria to minimise sample disturbance, was used to collect undisturbed sediment cores (Bhat et al., 1992). The corer weighs about 25 kg without detachable weights and the core diameter is 56 mm.

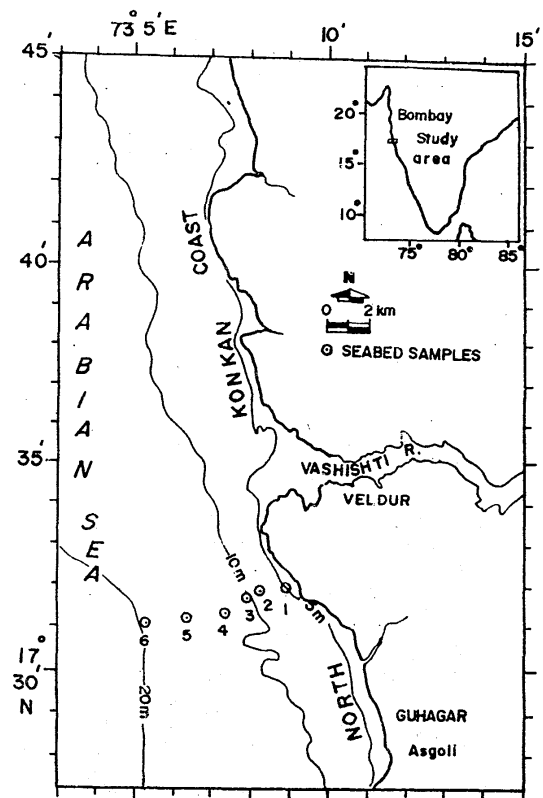


FIG. 1 MAP SHOWING THE STUDY REGION AND SEABED SAMPLING LOCATIONS

The corer penetrates 2-3 m in the soft clay soils. Acrylic liner, which is transparent and hence enables one to have visual inspection of the depth of the profile of the sediment, was used for collecting the cores.

SAMPLE COLLECTION

The locations of coring stations are shown in Fig. 1. Total number of sampling locations were six. The corer was operated from a boat with 2 t winch capacity. For effective penetration with minimum disturbance, coring was done by free fall method. As soon as the corer was retrieved, the sediment core with the acrylic liner was removed and sealed on either ends. All possible precautions were taken to maintain the natural conditions of the soil till the completion of all investigations. Details pertaining to the sampling locations are presented in Table. 1.

Table. 1 Sampling details

Location of cores	Water Depth (m)	Latitude	Longitude	Depth of core penetration (m)
1	6	17° 31.95'	73° 09.05'	0.8
2	9	17° 31.86'	73° 08.29'	0.8
3	11	17° 31.63'	73° 07.99'	0.15
4	14	17° 31.31'	73° 07.43'	1.35
5	16	17° 31.18'	73° 06.37'	0.75
6	20	17° 31.01'	73° 05.32'	1.45

EXPERIMENTAL METHODS

The cores were cut in the laboratory into desired lengths. Undrained shear strength was found by operating pocket vane shear device on the adjoining sub sections and the average of the two values was considered.

Natural moisture content was determined by the standard oven drying method. Three representative samples were taken to minimise the error. Atterberg limits were found out by standard methods. Necessary salt correction was applied for all the water content measurements to account for a salinity of 35 ppt in the pore water (William, 1988).

For grain size analysis, moist soil of equivalent dry weight of about 30 g was taken. Wet sieving was done through 75 micron sieve to separate sand sized particles (>75 µm). Particles sized below 75 microns were subjected to pipette analysis. Sodium-hexa-meta-phosphate was used as dispersing agent. As per Indian Standard Classification, IS-1498, the size ranges were classified as,

Sand	-	4.75 mm to 75 µm
Silt	-	75 µm to 2 µm
Clay	-	< 2 µm

For determining the amount of calcareous material, 30 g of oven dried sample was treated with hydrochloric acid till effervescence stopped. The concentration of the acid necessary for the complete dissolving of calcareous matter was decided by trial and error. The loss of weight of the sample was taken as the carbonate content present in the sample.

Bulk density, ρ , was calculated using specific gravity and void ratio (Monty, 1989),

$$\rho = \frac{(G+e) \rho_w}{(1+e)}$$

where, G = specific gravity,
e = void ratio and
 ρ_w = density of sea water

DISCUSSION

The sediment sample cores collected at the six locations were highly compressible clayey silts characterised by high Atterberg limits and high natural water content (Bernard 1982). Liquid limit values were found to be very close to the respective natural moisture contents. Due to high natural moisture content, the surface sediments were heavily disturbed and were not considered for testing. These sediments, in general, were having less bulk density 1.2-1.5 g/cc, low carbonate content 12-30 %, high plasticity index 60-130 % and very low undrained shear strength of 1-6.5 kN/m².

Location 1:

The core at location 1 showed a sudden decrease in the natural moisture content at the depth of 60cm (Fig. 2). This was due the presence of hard black coloured lumps of about 4 cm diameter. Because of these lumps, bulk density of the core at this depth is too high compared to the cores at other locations. It is seen from the investigations that calcareous matter establish good particle bondage and its influence can be seen in the gradual increase of undrained shear strength with the depth. The entire core is of clayey silt with more than 70 % silt.

Location 2:

Liquid limits of the core sections at this location were close to respective natural moisture contents. There was little change in the natural moisture content of the core sections. Atterberg limits, carbonate content, bulk density and grain size distribution showed uniform soil structure with depth (Fig. 3). The increase in the undrained shear strength could be due to certain materials with cementing properties.

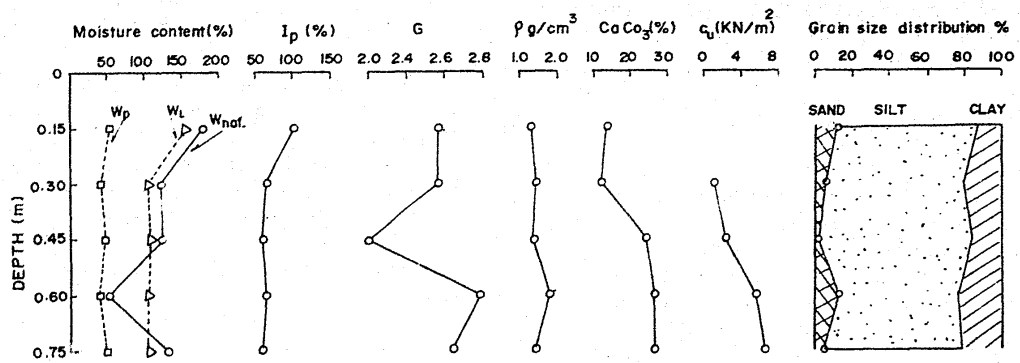


FIG. 2. GEOTECHNICAL PROPERTIES OF CORE 1

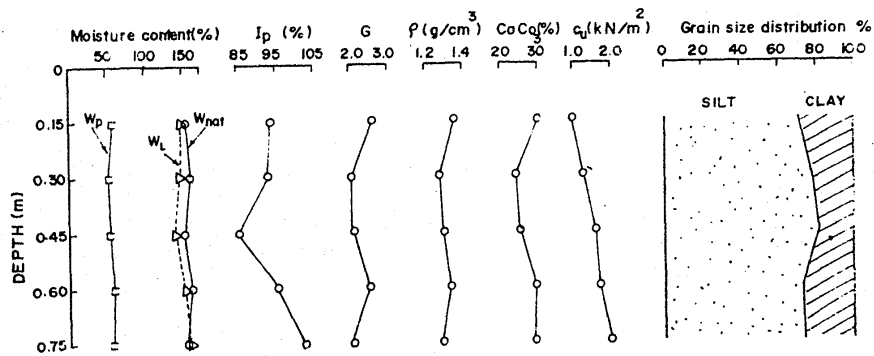


FIG. 3 GEOTECHNICAL PROPERTIES OF CORE 2

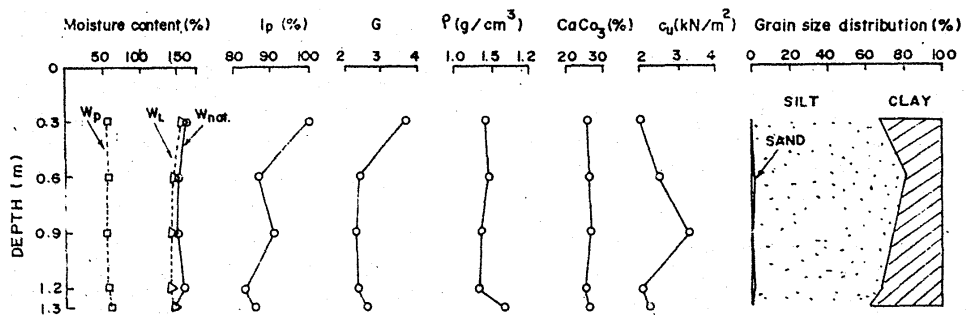


FIG. 4. GEOTECHNICAL PROPERTIES OF CORE 4

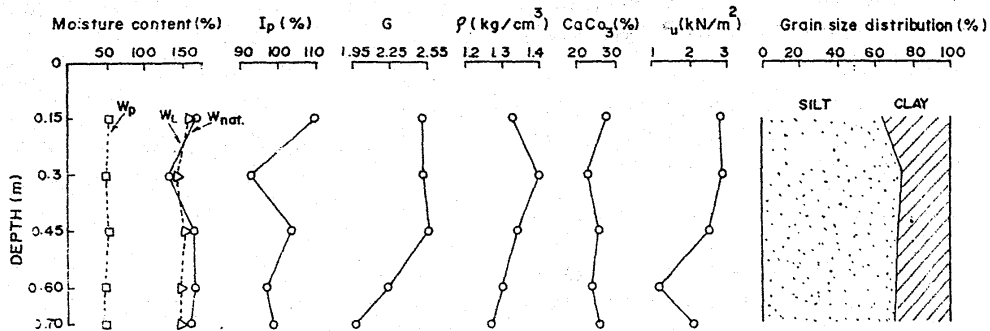


FIG. 5 GEOTECHNICAL PROPERTIES OF CORE 5

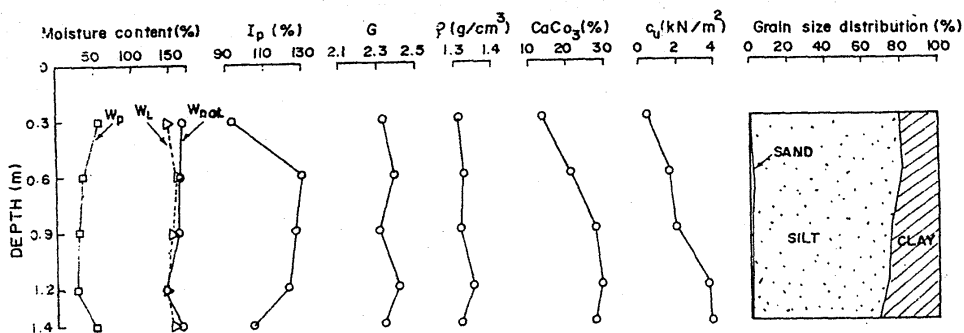


FIG. 6 GEOTECHNICAL PROPERTIES OF CORE 6

Location 3:

Due to the presence of hard bottom at this location, the gravity corer could not penetrate beyond 10 cm depth. The sample collected at this location was clayey silt with about 70 % silt and 30 % clay. Natural moisture content was 111 % with liquid limit of 63%. Calcareous matter was about 46 %.

Locations 4 & 5:

The cores at these locations also showed uniform structure throughout the entire core lengths. There is not much difference in physical and engineering properties of the sediments at these locations. The sediment is of clayey silt with more than 60% silt and negligible amount of sand (Figs. 4&5). Carbonate content varied between 24% and 28% and bulk density varied between 1.2 g/cc and 1.6 g/cc.

Location 6:

At this location the sediments exhibited almost uniform values of natural moisture content. The specific gravity was almost constant. These parameters kept the bulk density at 1.3 g/cc (Fig. 6). The increase in the undrained shear strength with the depth could be attributed to cementing by the calcareous matter as its content increases with the depth and the parameters which influences shear strength are not changing considerably with the depth.

CONCLUSIONS

Investigations showed that the top 1 m layer of the seabed soils in the study location was clayey silt in nature with very low shear strength, high compressibility and uniform soil structure. The sand content was negligible. Cementing materials like calcium carbonate play considerable role in increasing shear strength with depth.

ACKNOWLEDGEMENTS

Authors gratefully acknowledge the Director for his encouragement. Help rendered by Shri. P. Pednekar, Ms. Nisha Amonkar and Shri. Shantaram Mochemadkar in data collection and laboratory investigations is also acknowledged.

REFERENCES

Bhat, S. T., A. V. Sonawane and B. U. Nayak., (1992) Design of a Gravity Corer for Near Shore Sediment Sampling, Indian Journal of Marine Sciences, Vol. 21, pp. 83-84.

Bernard Chassefiere and Andre Monaco, (1982) On the use of Atterberg Limits on marine soils, *Marine Geotechnology*, Vol. 5, No. 2, pp. 153-179.

Monty A. Hampton, (1989) Geotechnical properties of sediment on the Kodiak continental shelf and upper slope, Gulf of Alaska, *Marine Geotechnology*, Vol. 8, pp 159-180.

Richards, A. F., T. J. Hirst and J. M. Parks, (1976) Preliminary Geotechnical Properties of North Central Pacific Nodule Mining Area, Ocean '76, Second Annual Combined Conference, The marine Technology and The Institute of Electrical and Electronics Engineers, pp. 2B-1 to 3.

William J. Winters, (1988) Geotechnical Testing of Marine Sediment, Open file Report 88-36, Department of the Interior U.S. Geological Survey.