

## GEOTECHNICAL STUDIES OF JAITAPUR MARINE CLAY

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### ABSTRACT

*A gravity corer was designed and fabricated for near shore sediment sampling. The corer was operated off Jaitapur, west coast of India, and 70 cores were obtained. The performance of the corer was quite satisfactory. The core samples were soft clays characterised by high water content and high Atterberg limits. Undrained shear strength varied from 1.8 to 6 KPa. These were moderately sensitive clays. Carbonate content which varied from 3 to 27%, was found to influence engineering properties of the soil. The samples with higher carbonate content possessed lower plasticity indices. Also, higher carbonate content seemed to induce apparent overconsolidation in the soil.*

### INTRODUCTION

Seventy shallow penetration cores were obtained for the investigation from near shore areas at Jaitapur, west coast of India where a Nuclear Power Plant is proposed to be installed. The laboratory test results of fifteen cores are presented in this paper.

### EQUIPMENT

A gravity corer was designed and fabricated for near shore sediment sampling. The corer could penetrate up to 2m depth in clayey soils (Fig.1). The design incorporates indigenously available raw materials. An attempt has been made to develop suitable design criteria so as to minimise sample disturbances (Bhat et al, 1990).

The corer weighs around 25 kg without detachable weights. Major components of the corer are illustrated in Fig.1 through Fig.3. The diameter of the core is 56 mm. Acrylic liner was used which is transparent and hence enables one to have visual inspection of the depth profile of the sediment. The core catcher which is a vital part of the corer was made of phosphor bronze (Fig.2). This material is found to give required resilience to the core catcher fingers. The connection between different parts of the corer are made very simple to save time in assembling and disassembling the corer in the field.

### SAMPLE COLLECTION

Fig. 4 shows the positions of coring stations. Coring was carried out at a grid spacing of about 1/2 km. The total number of stations were 70 and it took 10 days to finish coring under favourable weather conditions. The corer was operated from a boat with 2 t winch capacity. As soon as the cores were recovered, they were sealed on either ends. Coring was done up to a maximum water depth of 30m.

### EXPERIMENTAL METHODS

The core was cut in the laboratory at every 25 cm interval. Undrained shear strength was found by operating pocket vane shear device at each section. Remoulded shear strength could not be determined due to high water content

of the sediment. Undisturbed sample was also taken for oedometer test. Atterberg limits were determined by adding distilled water whenever necessary.

For grain size analysis, moist soil of equivalent dry weight of about 35 gm was taken. The same was first wet sieved through 63 $\mu$  sieve. +63 $\mu$  portion was dried and taken as sand. -63 $\mu$  portion was subjected to pipette analysis. Sodium hexametaphosphate was used as a dispersing agent. Distilled water was used for the analysis.

A part of the soil suspension containing less than 2 $\mu$  size particles, during pipette analysis was taken for x-ray diffraction studies. To this suspension, acetic acid and hydrogen peroxide were added to remove calcium carbonate and organic matters present in the soil. Excess acid was washed away by adding sufficient distilled water and keeping it for two days. The top water was removed and 5 to 6 drops of slurry was put on a glass slide and was air dried for 24 hours for study under x-ray diffractometer.

To determine the amount of calcareous material, about 25 gm of oven dried sample was taken and was treated with hydrochloric acid. Hydrochloric acid was added little by little till efflorescence stopped. The concentration of the acid necessary for fully dissolving the calcareous matter was decided by trial and error. The loss of weight of the sample was taken as carbonate content.

### TEST RESULTS

Shown in Table 1 is the summary of the physical properties of clay samples from 15 cores. Natural water content of all the samples was very high ranging from 100 to 150 and plasticity index from 40 to 75. The effect of increase or decrease in water content with increasing depth, was erratic. Liquidity index was generally more than one and in some cases went up to 3, indicating that natural water content was much higher than liquid limit. Specific gravity varied from 2.45 to 2.7. Undrained shear strength was low varying from 1.8 to 6 KPa. There was a small increase in undrained strength values with increasing penetration depth. Carbonate content ranged between 3 and 27%. Grain size analysis showed that the

sediments contained very low amount of sand sized particles. Major percentage was of silt. Clay content varied from 18 to 50%.

A typical x-ray diffraction pattern for samples is shown in Fig.7. Major clay minerals found are Montmorillonite followed by Kaolinite, Chlorite and Illite. Considerable amount of quartz was also found in clay sized fraction.

Fig. 6 shows results of consolidation of four samples.

The colour of the sediment was generally dark brown (10 YR 3/3 according to Munsell's colour chart) at the top layer and dark gray (5 Y 3/1) at the bottom layer. However, there was no uniformity of layers between different cores. For example, cores at stations 12, 13, 14, 17 and surrounding stations (Fig.4) showed a layer of fragmented shells, thickness of layer being 2 to 6 cm, at a penetration depth of around 80 cm. Some of the cores showed small pockets of sand at different penetration depths.

## DISCUSSION

The core samples were soft clays characterised by high Atterberg limits and high natural water content. The natural water content was considerably higher than liquid limit. Due to this, measurement of remoulded shear strength was not possible with the available vane shear device. It is reported that the shear strength at the liquid limit is unique for all soils and has a value of around 1.7 KPa (Wroth and Wood, 1978, Youssef et al, 1965). With this assumption, these clays can be considered to be moderately sensitive with sensitivity of more than 5. However, it was not possible to determine the exact magnitude of sensitivity without having remoulded shear strength values.

The mineralogical analysis of 30 number of samples showed that the mineral constituents are mostly same in the area as expected. Then, one expects that the variation of plasticity index could be explained by variation in percentage

of clay fraction. But, no clear relation could be established between these two parameters. This is because in this case, sand fraction in the sediment was negligible and hence the carbonate content which varied between 3% to 27% must be present in silt and clay sizes. Therefore, what we determine as clay percentage in grain size analysis is not fully clay minerals, but a part of it is only clay sized particles (i.e. less than 2  $\mu$ ) in the form of carbonate content. This carbonate fraction contributes to reduce the plasticity character of the soil. Hence, it was seen that samples with high carbonate content possessed low plasticity indices.

Consolidation test showed that the clays were highly compressible. The samples with higher carbonate content showed apparent overconsolidation (Fig.6). This is a characteristic behaviour of sensitive clay where due to breakdown of bonds large reduction of void ratio takes place within small pressure increments.

## ACKNOWLEDGEMENT

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## REFERENCES

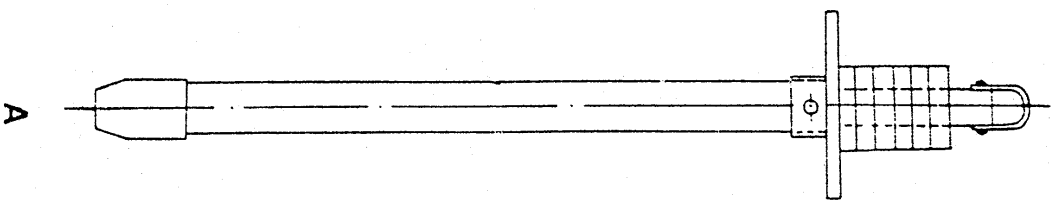
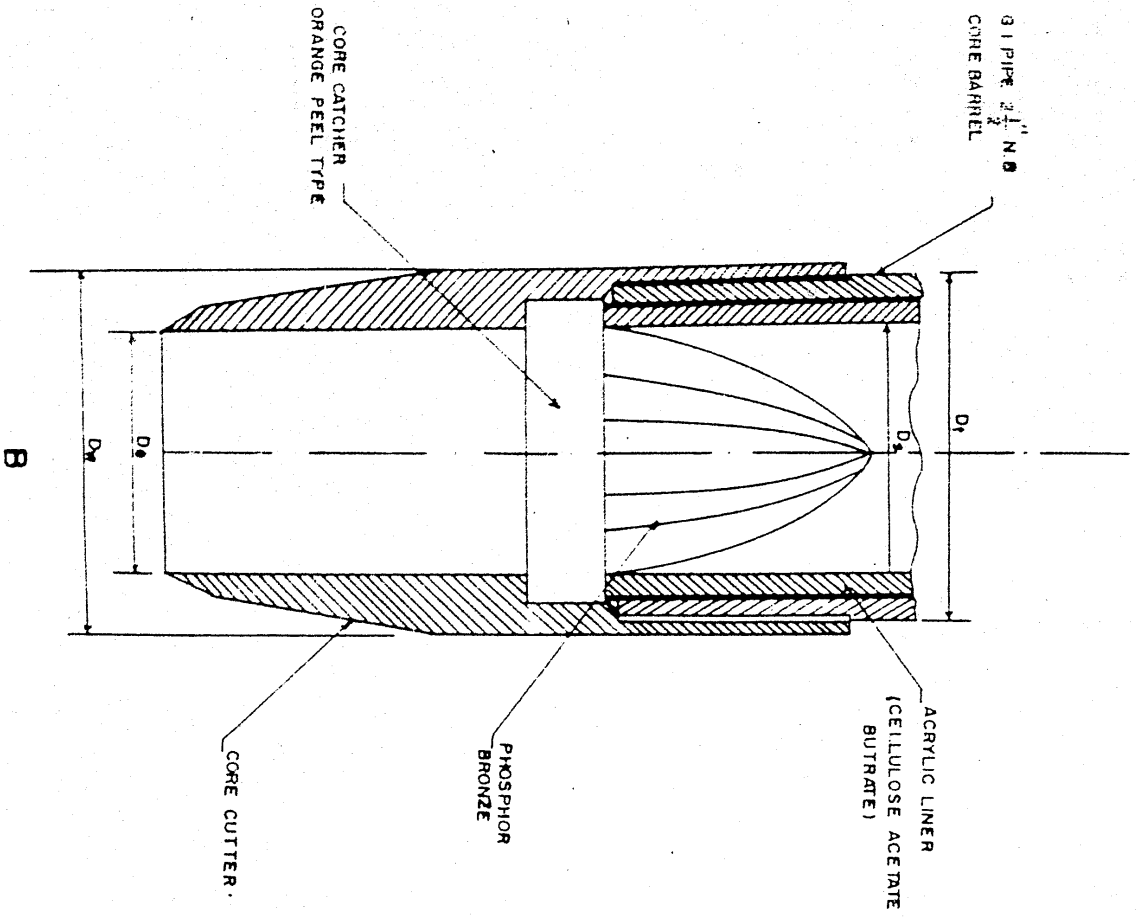
1. Bhat S.T., Sonawane A.V. and Nayak B.U., *Design of Gravity Corer for Near Shore Sediment Sampling*, Indian Journal of Marine Sciences - Communicated.
2. Wroth, C.P. and Wood, D.M., (1978), *The Correlation of Index Properties with some Basic Engineering Properties of Soils*, Can. Geotech. Journal 15 : 2: 137-145.

Table 1

Sample No.	Penetration Depth m	Natural water content %	Liquid limit	Plastic limit	Plasticity Index	Liquidity Index	Specific gravity	Undrained shear strength kPa	Carbonate content %	Grain size distribution sand silt clay %		
J3	0.00	155.50	120.00	45.00	74.00	1.50	2.49	3.80	11.00	2.50	65.00	32.50
	1.00	156.00	132.00	54.50	77.50	1.30	2.53	3.70	12.00	2.50	62.20	35.30
	1.50	155.00	124.00	43.00	81.00	1.40	2.53	1.50	9.00	2.60	81.80	15.60
J28	0.40	130.00	66.00	34.00	32.00	3.00	2.65	4.90	4.00	16.00	73.00	11.00
J29	0.40	100.00	110.00	56.50	53.50	0.80	2.71	2.20	19.00	3.00	64.00	33.00
	0.80	137.00	96.00	54.50	41.50	2.00	2.60	3.50	21.00	4.00	69.00	27.00
	1.20	136.00	128.00	53.00	75.00	1.10	2.59	4.10	25.00	3.00	61.00	36.00
J24	0.25	146.00	73.00	39.00	34.00	3.10	2.58	5.00	19.00	13.00	69.00	18.00
	0.50	149.00	140.00	64.00	76.00	1.10	2.67	6.20	26.00	1.00	57.00	42.00
	0.75	125.00	133.00	63.00	70.00	0.90	2.65	5.50	27.00	2.00	40.00	58.00
J15	0.25	110.00	90.00	51.00	39.00	1.50	2.55	-	20.00	1.00	69.00	30.00
J14	0.25	55.00	83.00	42.00	46.00	0.30	2.00	4.00	10.00	4.00	74.00	22.00
	0.50	135.00	120.00	56.00	64.00	1.20	2.63	4.00	15.00	3.00	67.00	30.00
	0.80	137.00	129.00	60.00	69.00	1.10	2.56	4.00	16.00	2.00	59.00	39.00
J12	0.25	138.00	91.00	36.00	55.00	1.90	2.63	2.80	7.00	2.50	83.00	14.50
	0.50	145.00	127.00	63.00	64.00	1.30	2.62	4.20	5.00	2.00	78.00	20.00
J11	0.50	136.00	111.00	36.00	75.00	1.33	2.60	2.80	7.00	1.00	74.00	25.00
	1.00	130.00	120.00	57.00	63.00	1.16	2.55	4.20	8.00	2.00	67.00	31.00
	1.40	125.00	122.00	54.00	68.00	1.04	2.59	2.60	8.00	1.00	70.00	29.00
J16	0.25	109.00	108.00	44.00	64.00	1.00	2.62	1.80	3.00	2.00	68.00	30.00
	0.50	113.00	81.00	40.00	51.00	1.43	2.68	2.50	5.00	2.00	69.00	29.00
	1.10	157.00	115.00	51.00	64.00	2.70	2.65	2.00	9.00	3.00	60.00	37.00
J17	0.35	150.00	93.00	43.00	50.00	2.10	2.61	3.20	5.00	3.00	81.00	16.00
	0.70	126.00	117.00	42.00	75.00	1.10	2.63	3.60	5.00	1.00	63.00	36.00
	1.10	140.00	146.00	58.00	88.00	0.90	2.42	5.30	6.00	1.00	66.00	33.00
J18	0.30	81.00	99.00	46.00	53.00	0.70	2.70	3.00	21.00	2.00	72.00	26.00
	0.70	120.00	90.00	41.00	49.00	1.60	2.52	3.70	21.00	5.00	74.00	21.00
	1.10	148.00	127.00	51.00	76.00	1.30	2.60	4.50	24.00	2.00	65.00	33.00
J9	0.60	128.00	107.00	47.00	60.00	1.40	2.55	1.60	8.00	2.00	80.00	18.00
	1.80	148.00	101.00	43.00	58.00	1.80	2.64	1.60	12.00	1.00	66.00	33.00
J21	0.25	113.00	107.00	52.00	55.00	1.10	2.51	2.50	5.00	1.00	71.00	28.00
	0.50	148.00	108.00	48.00	60.00	1.70	2.45	2.50	5.00	2.00	73.00	25.00
	0.90	113.00	118.00	66.00	52.00	0.90	2.65	4.70	6.00	1.50	67.00	31.50
J8	0.75	140.00	113.00	50.00	63.00	1.43	2.54	1.80	8.00	1.00	73.00	26.00
J22	0.25	135.00	123.00	58.00	65.00	1.18	2.57	2.20	9.00	1.00	70.00	29.00
	0.50	133.00	126.00	61.00	65.00	1.10	2.59	2.90	4.00	0.00	68.00	32.00
	0.80	160.00	128.00	50.00	78.00	1.30	2.45	3.30	3.00	1.00	69.00	30.00

BOTTOM CROSS-SECTION OF GRAVITY CORER

GRAVITY CORER FOR

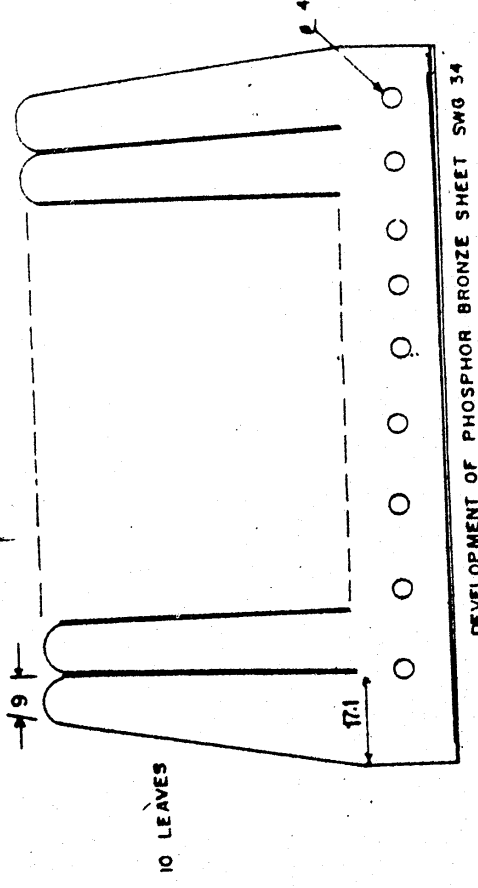
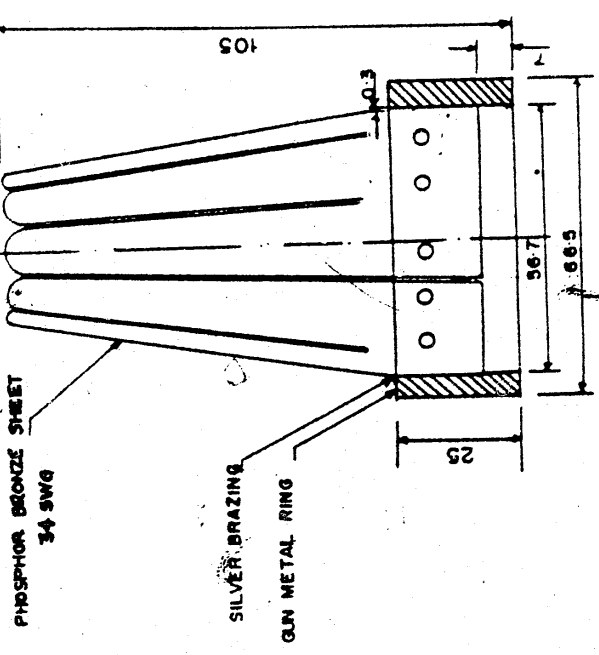


NEAR SHORE SAMPLING  
 CORE DIAMETER : 56.2 mm  
 CORE LENGTH : 1800 mm

Fig. 1

**CORE CATCHER (ORANGE PEEL TYPE)**

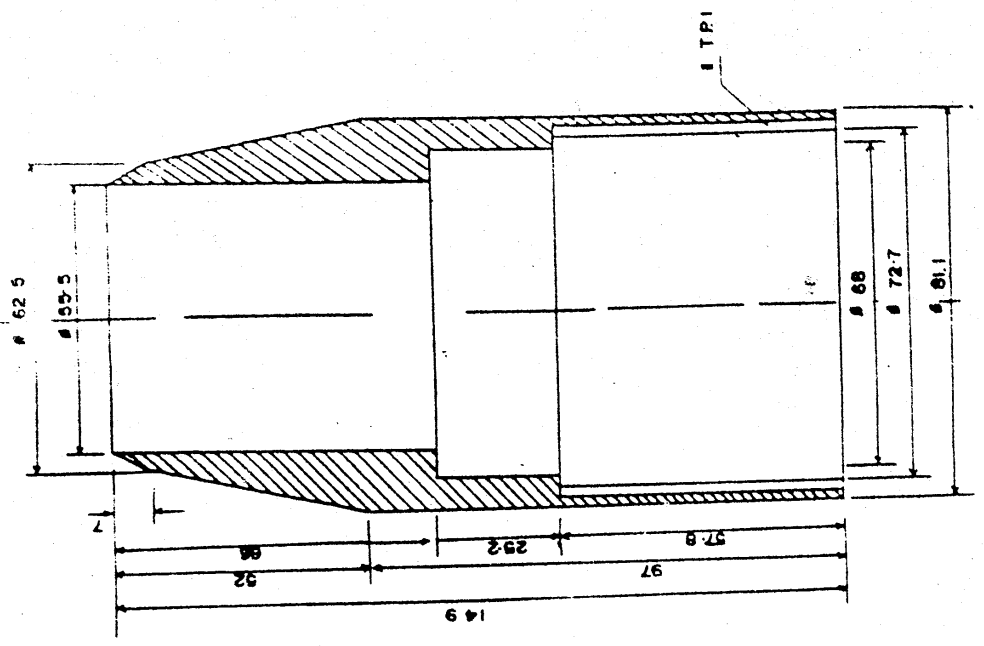
**MATERIAL: 1. GUN METAL  
2. PHOSPHOR BRONZE**



DEVELOPMENT OF PHOSPHOR BRONZE SHEET SWG 34

**A**

**CORE CUTTER  
MATERIAL M.S. I.S. 226**

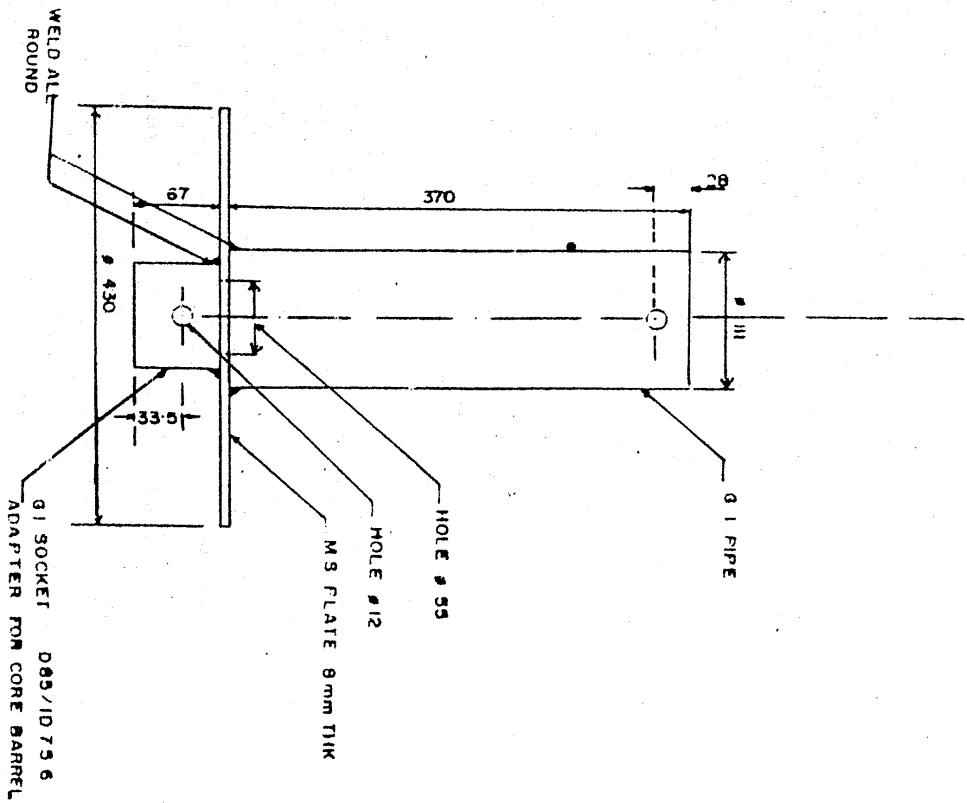


**B**

ALL DIMENSIONS IN MM

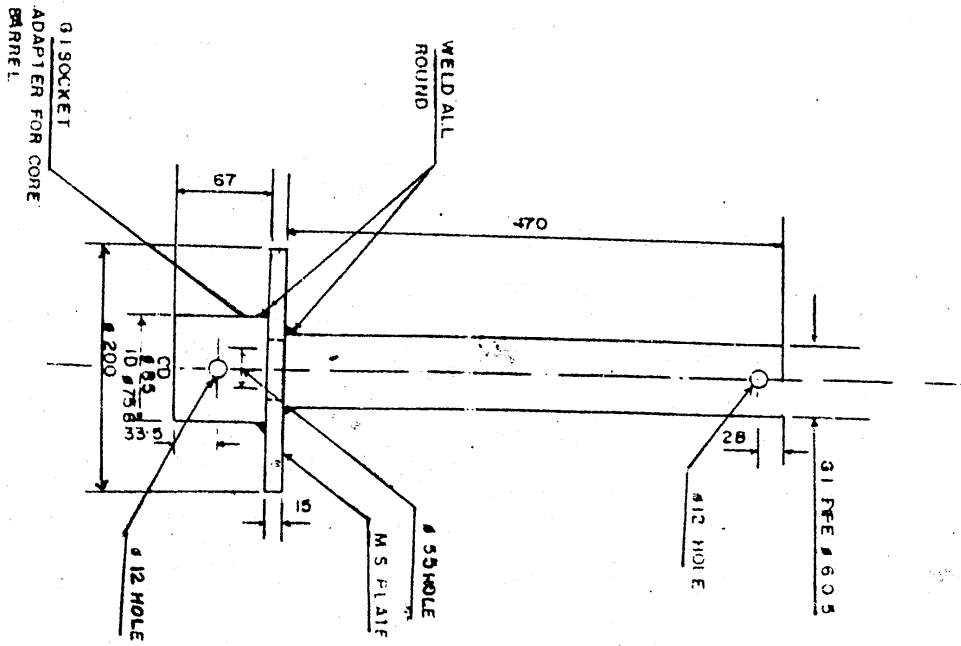
**Fig. 2**

WEIGHT STAND B  
Material G.I.



B

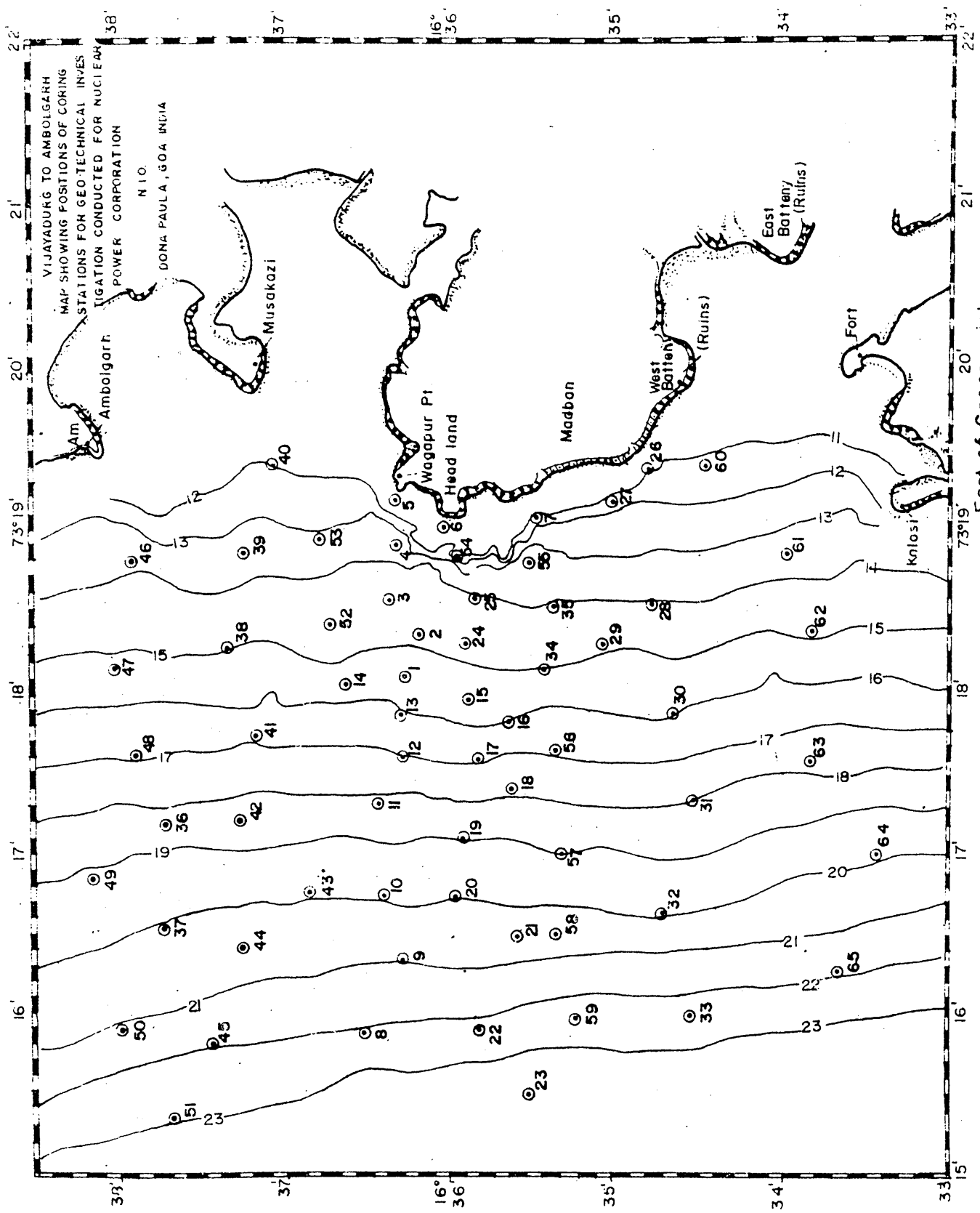
WEIGHT STAND A  
Material G.I.



A

ALL DIMENSIONS ARE IN MM

Fig. 3



East of Green wick

Fig. 4

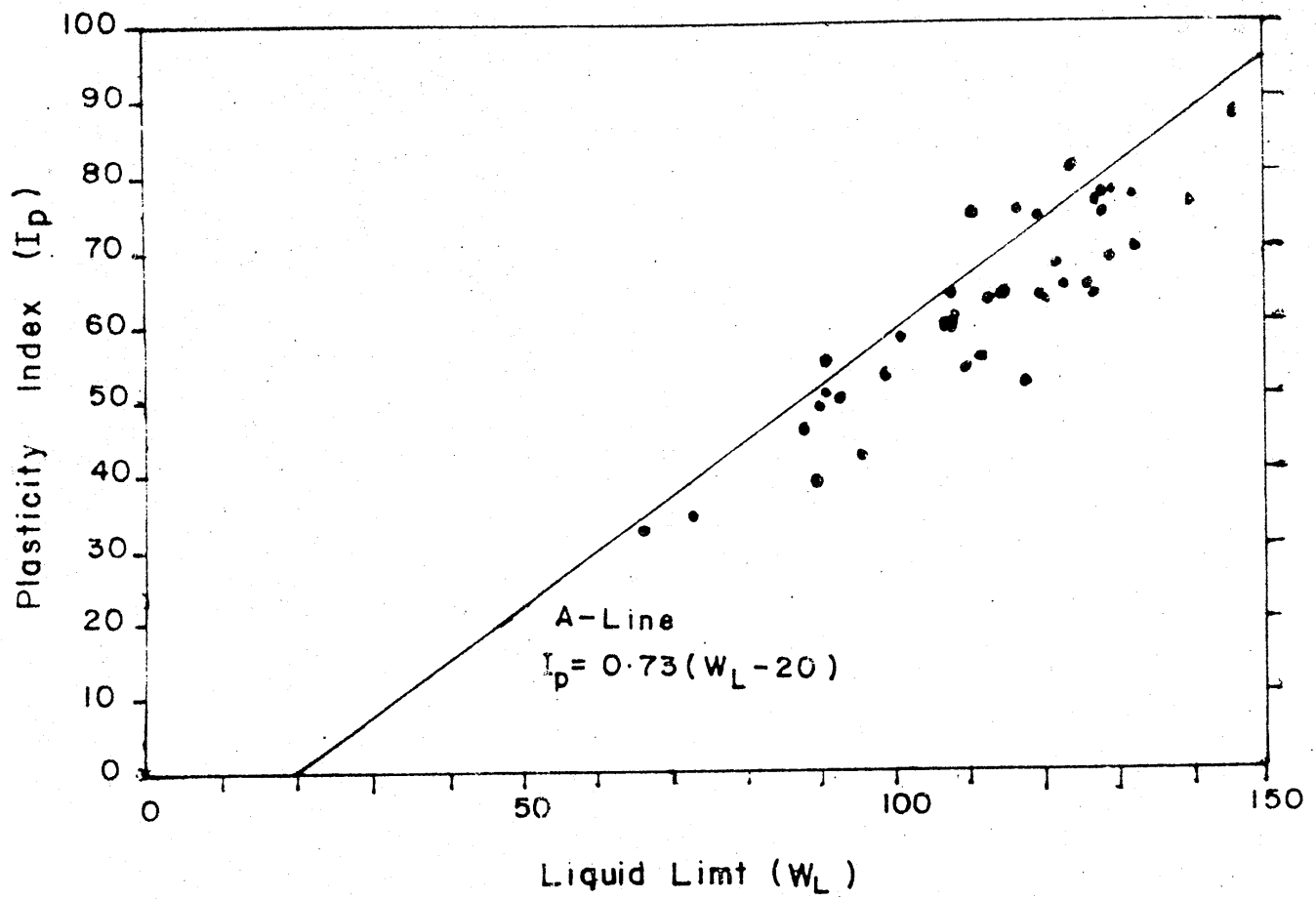


Fig.5 Plasticity Chart (After Casagrande)



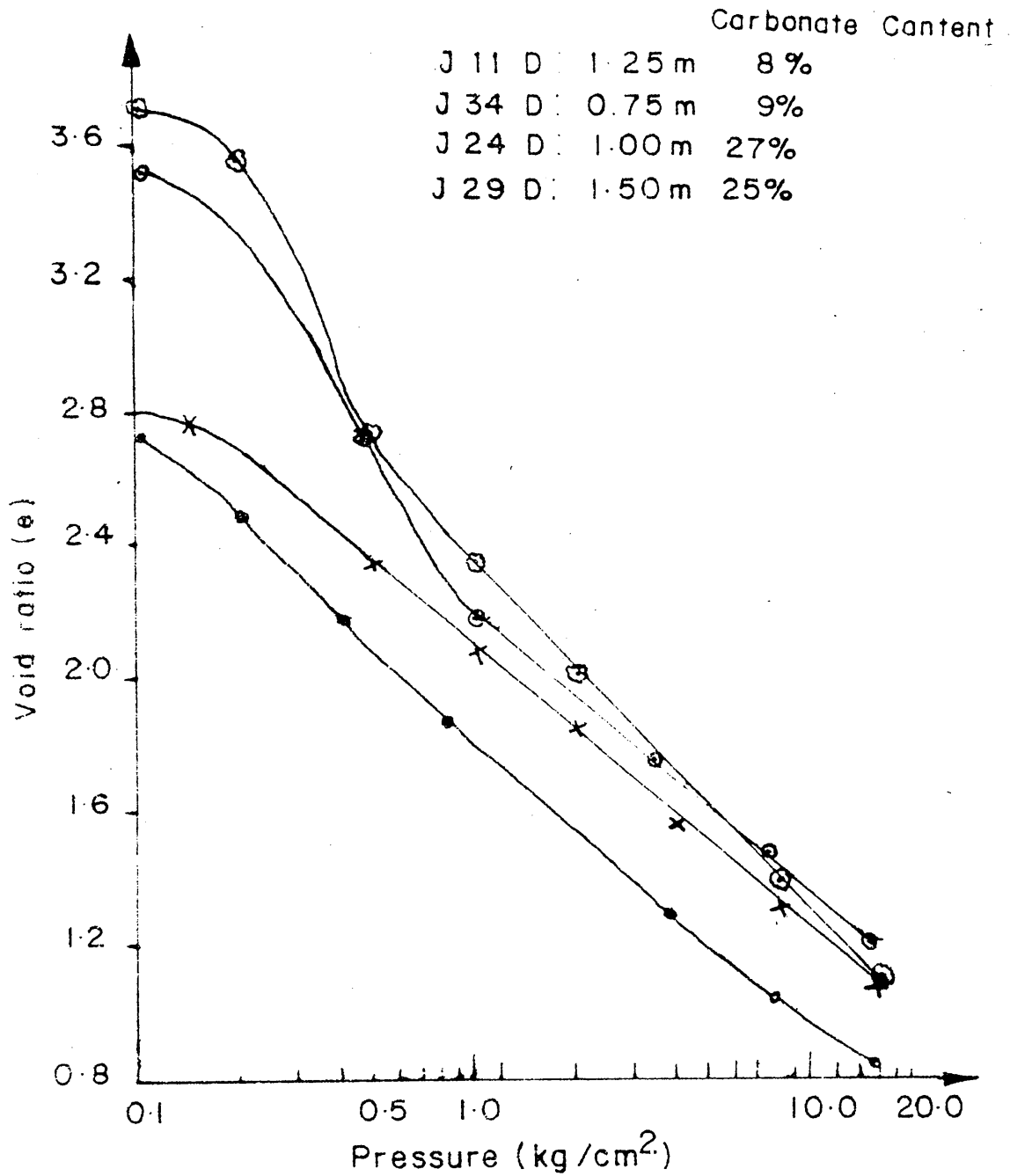


Fig.6 One dimensional Consolidation

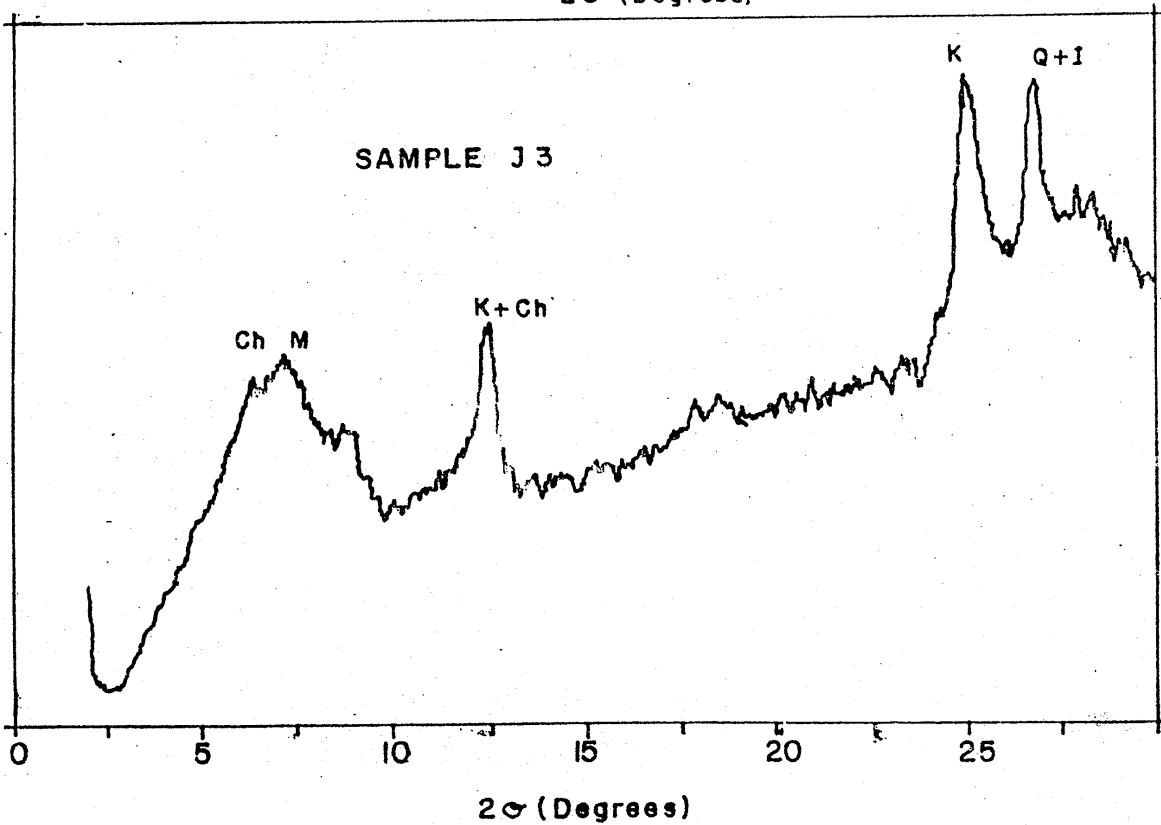
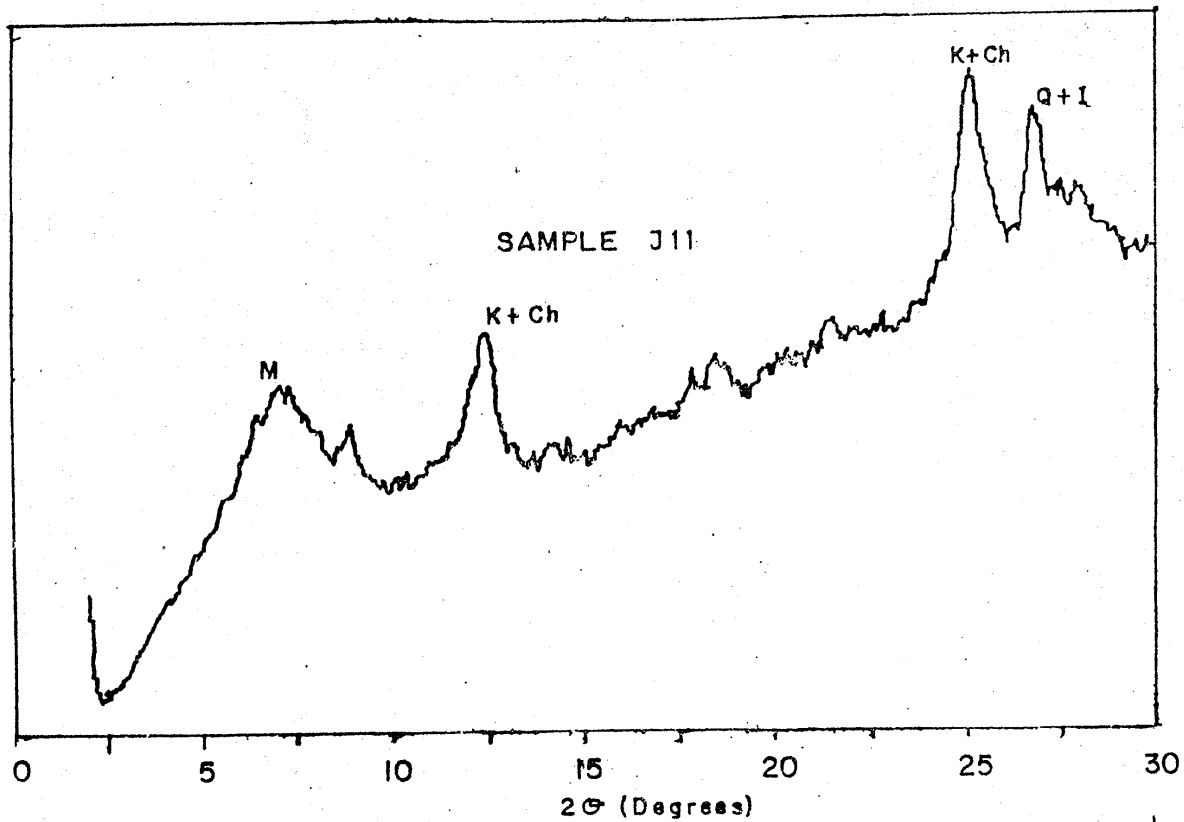


Fig.7 : X-Ray Diffraction Pattern