FI:SF/IND 55
TECHNICAL REPORT 2

PRE-INVESTMENT SURVEY OF FISHING HARBOURS

INDIA

MALPE

ENGINEERING

SOIL INVESTIGATIONS

SURVEY

DESIGN

REPORT PREPARED FOR
THE FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ACTING AS EXECUTING AGENCY FOR THE UNITED NATIONS DEVELOPMENT PROGRAMME
BY
SCANDIACONSULT

SCANDIACONSULT INTERNATIONAL AB
GOTHENBURG SWEDEN
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PREFACE

The Pre-Investment Survey of Fishing Harbours is being conducted by the Food and Agriculture Organization of the United Nations in cooperation with the Government of India. The Food and Agriculture Organization of the United Nations, on this Project, is acting as the Executing and Participating Agency for the United Nations Development Programme. The Agency has subcontracted certain professional and other services to Scandia-Consult International AB, Sweden.

The Project has its Headquarters at Bangalore, India. This Technical Report constitutes one of a number of reports which will be issued during the life of the Project. The contents of this Report are based on the work of ScandiaConsult personnel and of other professional and technical staff provided by the Government of India and the Food and Agriculture Organization of the United Nations.

This report is in two volumes. The first volume contains the text and the second volume the relevant drawings.

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SOIL INVESTIGATIONS

SOIL INVESTIGATION REPORT

ASSIGNMENT

The purpose of this investigation was to obtain information for the general planning and design of a fishing harbour.

METHODS OF WORK

The methods used for carrying out the work were as follows:-

A - Penetration Test Borings

- Swedish Motorsounding
- Swedish Weightsounding
- Hammersounding

B - Sampling

- Post Hole Auger
- Side Intake Sampler
- Swedish Piston Sampler

A - Penetration Test Borings

Motorsounding

This drilling method is classed as one of the penetration tests, similar to the Standard Penetration Test and Dutch Cone Sounding. The method has been developed in Scandinavia and provides information as to the relative compactness of the various soil layers, and gives a good idea of the granular size of the soil.

The equipment consists of a portable motor unit with a fixture for 22 mm diameter flush jointed steel rods. The rods are in pieces of 1 metre length and at the end there is fitted a 32 mm diam. screwbit 200 mm long.

During the borings the motor is used for rotating the rods, and is held in place by two operators. Special handles are used for holding the motor unit and those handles are connected to a pressure gauge instrument, which indicates the pressure load exercised by the operators on the boring rod.

When starting a boring, the rod with the bit is put into the ground and the distance the rod sinks without any extra load on the handle is measured and recorded. The operators then press the motor unit down using the handles and the load is increased in steps to 10 kg, 25 kg, 50 kg, 75 kg and 100 kg, measurements of the penetration under each individual load being noted. When the screw bit does not sink further under a load of 100 kg the motor is used to rotate the rods and the number of half revolutions for which the bit penetrates a depth of 20 cm is noted. This is repeated until the required depth is reached. Additional 1 m long rods are added as needed. The number of half revolutions per 20 cm penetrated are recorded and drawn up in the form of a diagram of resistance to penetration at each depth.

Weightsounding

This method of sounding is similar to Motorsounding except that the load is provided by weights and the turning of the bit is carried out manually.

Hammersounding

This method of drilling is also classed as one of the penetration tests. The equipment consists of 3 m long 32 mm diam. flush-jointed steel rods, with a square drill bit 40 x 40 mm the tip of which is turned to a conical point. The rod and bit is put into the ground, cylindrical wedges are locked on to the rod about 1.50 m above the ground. A 65 kg weight is lifted 60 cm above the locked wedges and allowed to fall freely onto them, driving the bit and rods into the ground. The number of blows required to drive the bit each step of 20 cm is noted. The locked wedges are released and lifted up along the rods and re-locked for further driving, additional 1 m or 3 m long rods being added as required.

General

The above methods of sounding are carried out without casing. No allowance is made for the increased weight of drilling rods or the increased friction on the surface of the rods at increasing depths. These methods of sounding provide information for drawing resistance - to - penetration diagrams and indicate the general nature of the soil penetrated.

Samples are taken at points determined from the results of the soundings. The samples are examined and tested to establish the characteristics of the soil, which information is read in conjunction with the sounding diagrams.

B - Sampling

Post Hole Auger

This is used above the water table in cohesionless soils and in all but the hardest cohesive soils, to obtain disturbed samples.

Side Intake Sampler

Where small disturbed samples are required solely for identification purposes, this sampler can be used in soft deposits of cohesive and cohesionless soils with particle sizes not exceeding approximately 2 mm.

Swedish Standard Piston Sampler (designation St II)

This sampler is used for taking 50 mm diam undisturbed samples. The sampler containing 3 Nos 170 mm long and 50 mm diam. reinforced plastic sample tubes is forced into the ground without using any casing. A conical ended piston pushes the soil to the side so that it does not enter the sampler. When the desired depth is reached the rods are rotated in an anticlockwise direction thereby forcing out past the piston a thinwalled metal tube with a hard metal cutting shoe containing the sample tubes. The sampler is withdrawn and after removal of the cutting shoe, a clockwise rotation of the sampling rods extrudes the samples in the tubes, each end of which is then covered with a plastic disc and an air right rubber cap. The numbers permanently marked on the sides of the tubes are recorded together with the depth from which the sample was taken.

Recording of Borings and Test Results

The symbols indicated on the enclosed pages: Soil Mechanics Symbols Sheet Nos 1 and 2 are used on all plans, sections and diagrams describing the borings.

BORINGS EXECUTED

The total number of borings in the harbour area was

59 Motor and Weightsoundings
 3 Hammersoundings

Samples were taken at 10 boreholes.

Three samples were taken at Malpe and two on the shore at Bijardi, a village 30 km north of Udipi, to determine the grading of material if required for the manufacture of fluorescent tracers.

A sample of the water in the river was taken to ascertain the amount of material transported by the river.

The borings in water were carried out from a catamaran type workboat constructed on site.

The locations of the borings are shown on the plan, drawing No 09-200. The results from the soundings are drawn in diagram form on drawings Nos 09-210 to 219.

POSITIONING AND LEVELLING

The positions and levels of boreholes on land were obtained by measurement from survey stations. Sextant angles were used to fix the positions of boreholes in the water. Levels were obtained by measurements of the water depth and the water level at the same time, the latter being obtained from the automatic Tide Level Recorder. Small differences in the river bed-level as measured by the echo-sounder and for the Motorsounding are noticeable. These are due to the difficulty in measuring the distance to the top of the soft top layer by mechanical means which are affected by currents. Some of the boreholes are also located at specified distances from the sections on which they are represented.

LABORATORY TESTS

Preliminary laboratory tests were carried out on some samples, as shown in the Sample Schedule and Laboratory Results Diagrams by Quality Control Division of the Mangalore Harbour Project and Geotechnical Laboratory of ScandiaConsult International AB, Sweden. Testing of further samples is at present in progress.

DESCRIPTION OF SOIL LAYERS

The soils in the harbour area consist of deposits of fine medium to medium coarse sand, the lower layers of which contain some silt or clay materials. A description of the various soil layers encountered during the investigations can be made starting from borehole 34 (which is situated near the centre of the proposed harbour basin). This borehole contains the greatest number of layers, some of which can be identified in the other borings in the site. In borehole 34, the sequence of soil layers is the following:-

1. The top layer is medium sand which varies from fine medium to medium coarse. The top 2 m is loosely compacted, the next 4.4 m very densely compacted.

2. The next layer is of medium compacted fine sand 2.8 m deep, containing in places very many shells, also silt.

3. A layer of red sandy gravel with little clay 1.4 m deep is followed by:

4. 2,8 m deep layer of medium compacted sand.

5. Clay was located, being in some cases blue-grey and in others grey black with peat or otherwise yellow sandy silty in nature. The layer of clay was here found to be 2,2 m deep.

6. The boring in Bh 24 stopped at -17.5 on what is felt to be gravel.

7. In Bh 26 grey medium coarse sand was located below layer No 6.

Moving South West from borehole 34, the layers represented are similar in Bh 33, layers 3 and 6 having gone deeper. This trend continues in Bhs 32 and 31 but here the sand in layer 1 is not so densely compacted. The denser material having been washed away, the top part of Bh 31 is a more recent deposit. The thin hard layer in Bh 31 at 10.80 m appears to have increased in size in Bh 30, sufficient to provide the boring stop noted there. The hard part of layer 1 reappears in Bh 30. Towards the north east, the depth of the loosely compacted part of layer 1 increases with a consequential reduction in the depth of the dense part which appears almost completely by Bh 37. In this area, the gravel layers (No 3) appears to develop a split, the gravel moving higher up and the clay moving down.

Towards the south east, the gravel layers No 3 has disappeared, the sand under it being much thinner, the clay has come up to -7.50.

Bh 17 is very similar to Bh 26, except that a local layer of gravelly clay appears at -5.50 and the thickness of the clay increases.

Moving further SE beyond the canal, the dense part of layer No 1 has gone completely. Borehole 11 stopped on what appears to be a gravel layer which appears in Bh 10 and which continues to drop in level the further SE it moves. The material above it is generally loose fine sand.

Moving NW from Bh 34 to 40, there is little change, the borings having stopped on gravel layer No 3.

Further west Bh 50 has stopped on layer No 3 which however was not located a little further south in Bh 49 but appears again in Bh 46 at the bottom of the boring.

Out to sea, layer of medium compacted sand underlies a very soft sand thought to contain some organic material. The sand continues with some variations in compaction to a boring stop on layer No 6. With reference to the above, numerical characteristics for some of the layers are:-

Layer 1: This sand has a ϕ 28° - 30°, Sp. gr. 2.50

Layer 2: ϕ 26.5°, C = 0.08 Kg/cm^2 Sp. gr. 2.60

Layer 5: C = 0.55 Kg/cm^2 ϕ 4° in the lower stress range
0.25 " ϕ9.7° in the higher stress range
m/c 36-38% Bulk den. 1.84 - 1.88 kg/dm^3

LL = 78%, PL = 25%, PI = 53.

CONCLUSIONS

The permissible load on the sand at Bh 20 is about 10 t/m^2 after removal or replacement of the top 60 cm.

The figures describing the characteristics of the layers located are based on limited number of laboratory tests. These figures may be modified upon receipt of further test results.

The investigations show that soil conditions are suitable for use of steel sheet piled bulkheads or piled open work structures for construction of jetties and quays.

The results from the investigation are recorded on the following documents annexed hereto.

Borehole Schedules		3 Pages
Soil Sample Schedules		6 Pages
Laboratory Result Diagrams:	Sieve Analysis	7 Pages
	Shear Tests	3 Pages

DRAWINGS

09-200	Borehole Plan	
09-210	Sections	1 and 2
09-211	"	3 and 4
09-212	"	5 and 6
09-213	"	7 and 8
09-214	Section	9
09-215	"	11
09-216	"	12
09-217	"	13
09-218	"	14
09-219	Boreholes Nos. 60 and 61	

BOREHOLE SCHEDULE

Site Description	Borehole Number	Easting	Northing	Level	Depth	Remarks		
1/98/0	1	2828	1484	+ 2.20	9.69	M/S		Land
1/466/-2	2	3112	1718	- 0.64	10.50	M/S		Water
2/475/+2	3	3049	1817	- 0.73	8.25	M/S		Water
3/98/-3	4	2710	1642	+ 1.89	11.82	M/S		Land
3/446/+2	5	2944	1898	- 2.15	5.71	M/S		Water
3/533/0	6	3006	1960	+ 0.55	10.40	M/S		Water
4/449/+7	7	2877	2005	+ 0.13	10.40	M/S	S	Land
5/100/-20	8	2578	1812	+ 1.23	14.47	M/S		Land
5/427/0	9	2784	2065	- 0.38	9.10	M/S		Water
5/517/0	10	2844	2130	+ 0.55	13.60	M/S		Land
6/337/+2	11	2662	2124	- 0.36	5.70	M/S		Water
6/400/-2	12	2702	2172	+ 0.37	11.29	M/S	S	Land
7/72/0	13	2458	1943	+ 1.50	13.90	M/S		Land
7/136/+1	14	2487	1999	- 1.58	8.75	M/S		Water
7/212/+2	15	2524	2076	- 2.46	6.10	M/S		Water
7/320/-2	16	2578	2158	- 2.86	11.45	M/S		Water
7/362/0	17	2598	2195	+ 1.34	15.23	M/S	S	Land
7/478/0	18	2654	2296	- 0.41	8.93	M/S		Water
8/386/+2	19	2533	2227	+ 1.12	14.55	M/S		Land
8/390/-9	20	2544	2224	+ 1.46	16.20	H/S		Land
8/438/+2	21	2557	2270	+ 1.24	9.15	M/S		Land
9/89/+6	22	2320	2004	+ 1.83	17.16	M/S		Land
9/128/-1	23	2344	2034	- 1.73	6.85	M/S		Water
9/208/-1	24	2380	2105	- 2.26	7.76	M/S		Water
9/326/0	25	2434	2212	- 3.06	7.15	M/S		Water
9/421/0	26	2478	2297	+ 1.89	13.60	M/S	S	Land
9/527/0	27	2525	2390	+ 1.28	14.80	M/S	S	Land
9/654/+1	28	2583	2504	+ 1.02	8.60	M/S		Land
10/360/+34	29	2342	2312	+ 1.08	8.70	M/S		Land
11/90/0	30	2154	2127	+ 1.34	12.57	M/S		Land
11/166/-2	31	2195	2194	- 3.71	10.20	M/S		Water
11/273/0	32	2248	2288	+ 1.17	13.43	M/S	S	Land
11/339/0	33	2282	2344	+ 0.96	17.60	M/S	W/S	Land
11/440/0	34	2333	2430	+ 1.52	16.00	M/S	S	Land

Site Description	Borehole Number	Easting	Northing	Level	Depth	Remarks
11/546/-15	35	2400	2513	+ 0.90	16.20	M/S Land
11/618/-75	36	2445	2570	+ 1.37	10.48	M/S Land
11/890/+34	37	2532	2833	+ 1.62	11.97	M/S Land
12/278/0	38	2159	2330	+ 1.47	10.07	M/S Land
12/380/0	39	2210	2418	+ 1.88	10.89	M/S Land
12/480/0	40	2260	2504	+ 1.83	9.70	M/S Land
12/554/0	41	2298	2568	+ 1.59	9.41	M/S, H/S Land
13/77/0	42	1958	2187	+ 1.27	16.05	M/S Land
13/161/0	43	2001	2258	- 2.28	8.59	M/S Water
13/222/-1	44	2032	2312	- 3.53	10.30	M/S Water
13/268/0	45	2055	2352	- 1.97	12.76	M/S Water
13/323/-55	46	2129	2370	+ 1.29	9.50	M/S S Land
13/367/0	47	2103	2437	+ 1.76	3.90	M/S Land
13/372/-4	48	2112	2439	+ 1.72	16.30	H/S Land
13/430/-42	49	2174	2471	+ 1.53	17.00	M/S Land
13/470/0	50	2158	2525	+ 2.56	11.62	M/S Land
13/570/0	51	2209	2612	+ 2.07	9.40	M/S Land
13/684/0	52	2260	2714	+ 2.18	15.27	M/S Land
247/-9	53	1970	2419	- 1.90	9.84	M/S Water
274/-51	54	1925	2397	- 2.83	10.75	M/S Water
540/+1	55	1724	2579	- 1.14	7.42	M/S Water
569/-41	56	1678	2558	- 2.11	8.93	M/S Water
710/-13	57	1570	2655	- 1.55	9.28	M/S Water
776/+30	58	1536	2715	- 3.92	7.30	M/S Water
989/0	59	1340	2810	- 4.77	2.25	M/S S Water
15	60	1727	2191	+ 2.05	5.0	M/S Land
17	61	1602	2288	+ 0.35	3.0	M/S Land
	T.S.1	2116	2265	- 3.1	-	Bed level sample
	T.S.2	1922	2065	+ 0.4	-	"
	T.S.3	1932	2076	+ 1.4	-	"
	WS	1470	3065		RIVER WATER SAMPLE FOR FILTRATION	
	T.S.4	BED LEVEL SAMPLES TAKEN AT BIJARDI, A VILLAGE,				
	T.S.5	JUST SOUTH OF COONDAPUR.				

SOIL SAMPLE SCHEDULE

Depth below GL (M)	Sample Description	M/c %	Density D=Dry B=Bulk W=Wet	Specific gravity	LL %	PL %	PI %	C Kg/cm^2	ϕ^o	Remarks Tested by
BOREHOLE 7 1.73 - 2.07	grey silty fine SAND									Field Description
BOREHOLE 12 1.5 - 2.10	grey silty medium fine SAND with some shells									" "
BOREHOLE 17 1.20	fine SAND with shells									" "
2.83 - 3.34	grey fine medium coarse SAND with some shells									" "
4.00 - 4.17	yellow fine medium SAND with shells									" "
4.83 - 5.34	yellow fine medium SAND with shells									" "
5.83 - 6.17	grey silty fine SAND with many shells									" "
6.83 - 7.34	brown gravelly silty CLAY with shells									" "
BOREHOLE 26 1.0	yellow fine medium SAND with shells									" "

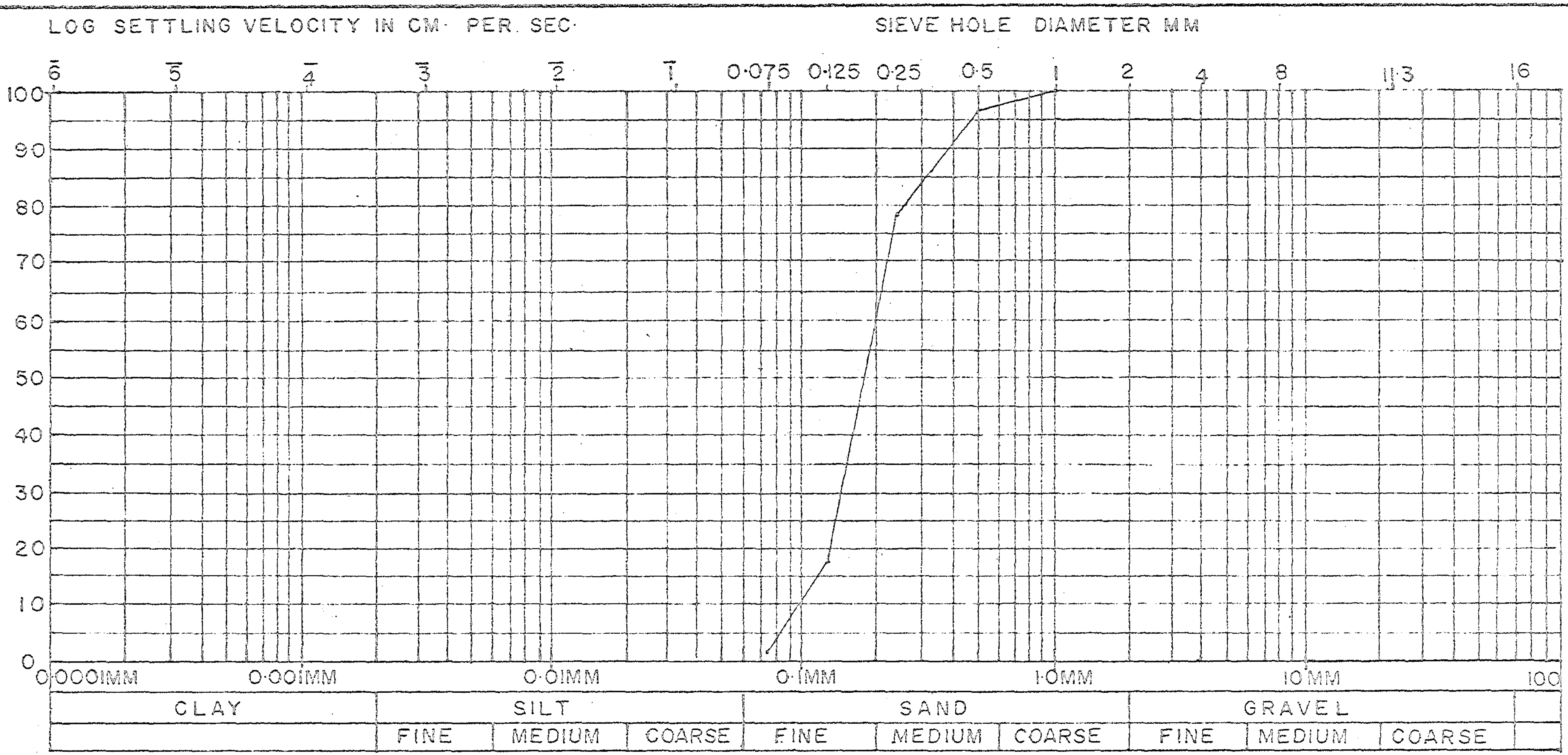
Depth below GL (M)	Sample Description	M/c %	Density D=Dry B=Bulk W=Wet	Specific gravity	LL %	PL %	PI %	C Kg/cm^2	$\emptyset^{o}$	Remarks Tested by
2.31 - 2.65	yellow silty fine medium SAND with shells and little gravel									Field Description
3.27 - 3.55	medium fine SAND			2.50	NON-PLASTIC			0	28-32	Consolidated drained direct shear test. P.S.D. ScandiaConsult
3.56 - 3.71	silty gravelly medium coarse SAND with shells									Field Description
6.60 - 7.11	fine medium SAND mixed with shells of coarse sand size and some clay	20		2.60				0.08	26.5	Consolidated drained direct shear test. P.S.D. ScandiaConsult
7.60 - 8.11	yellow silty fine SAND/ditto grey									Field Description
9.10 - 9.61	top of sample fine SAND rest: blue grey silty CLAY with brown spots	36-38	B 1.84 - 1.88		78	25	53	0.55 0.25	4 9.7	Lower stress range Higher " " Quick undrained direct shear test ScandiaConsult
10.68 - 11.19	grey/black CLAY with fiberous peat dispersed through it									Field Description
12.60 - 13.11	yellow sandy silty CLAY									" "
13.87 - 14.38	grey medium coarse SAND									" "

Depth below GL (M)	Sample Description	M/c %	Density D=Dry B=Bulk W=Wet	Specific gravity	LL %	PL %	PI %	C Kg/cm^2	ϕ^o	Remarks Tested by
BOREHOLE 27										
0.70	yellow fine SAND with shells									Field Description
1.88 - 2.34	yellowish fine to medium SAND with grey lens and no shells	22	D 1.71 W 2.08						40	Consolidated drained direct shear test. P.S.D. Mangalore Harbour Project
2.90 - 3.07	yellow fine medium coarse SAND with some shells									Field Description
5.25 - 5.67	grey silty SAND with shells	26	D 1.59 W 2.00						41.5	Consolidated drained direct shear test. P.S.D. Mangalore Harbour Project
7.00 - 7.34	grey silty SAND with shells	21	D 1.59 W 1.93						41.5	Consolidated drained shear box test. P.S.D. Mangalore Harbour Project
8.86 - 9.34	yellowish CLAY with blue and red marking with small fine sand lens. Inorganic clay high plasticity	39	D 1.26 W 1.75		65	29	36	0.42		Undrained triaxial Mangalore Harbour Project
BOREHOLE 32										
1.0	yellow fine medium SAND									Field Description
2.16 - 2.67	grey medium SAND with shells									" "
7.21 - 7.84	grey organic silty fine SAND with many shells /±20-less shells									" "

Depth below GL (M)	Sample Description	M/c %	Density D=Dry B=Bulk W=Wet	Specific gravity	LL %	PL %	PI %	C Kg/cm^2	ϕ^o	Remarks Tested by
10.00 - 10.17	yellow silty fine SAND									Field Description
BOREHOLE 34										
1.0	yellow medium coarse SAND with shells									" "
3.00 - 3.34	yellow fine medium SAND									" "
4.74 - 5.08	- " -									" "
5.96 - 6.34	yellow fine medium coarse SAND with shells									" "
6.96 - 7.34	yellowish fine SAND with grey silt with some hard lumps	19	D=1.67 W=1.98					0.35	5^o	Consolidated undrained triaxial, PSD Mangalore Harbour Project
8.15 - 8.57	yellow silty fine SAND									Field Description
10.00 - 10.34	red sandy GRAVEL with little clay									" "
BOREHOLE 41										
1.0	yellow fine medium coarse SAND with many shells of sand and gravel size									" "
3.00 - 3.30	yellow fine medium coarse SAND									" "

Depth below GL (M)	Sample Description	M/c %	Density D=Dry B=Bulk W=Wet	Specific gravity	LL %	PL %	PI %	C Kg/cm^2	Ø°	Remarks Tested by
5.0 - 5.17	yellow fine medium coarse SAND with shells									Field Description
8.25 - 8.84	yellow fine SAND/ sandy GRAVEL									" "
BOREHOLE 46										
0.65	yellow medium coarse SAND with shells									" "
2.63 - 3.14	yellowish fine SAND with grey silt	22	D 1.69 W 2.07						40	Consolidated drained shear box test Mangalore Harbour Project P.S.D.
4.65 - 4.98	slightly organic fine SAND	28	B 1.81		NON PLASTIC					ScandiaConsult
BOREHOLE 59 on sea bed	dark brown very soft organic clayey SILT									Field Description
BEDLEVEL SAMPLE 1	yellow fine medium coarse SAND with some shells and recent organic material									" "
BEDLEVEL SAMPLE 2	greyish fine medium SAND with some organic material									" "

Depth below GL (M)	Sample Description	M/c %	Density D=Dry B=Bulk W=Wet	Specific gravity	LL %	PL %	PI %	C Kg/cm^2	$\emptyset^o$	Remarks	Tested by
BEDLEVEL SAMPLE 3	grey/yellow fine medium SAND with some organic material									Field	Description
BEDLEVEL SAMPLE 4	yellow medium coarse SAND with some shells									"	"
BEDLEVEL SAMPLE 5	yellow fine medium SAND with some shells									"	"



SIEVE SIZE M.M		16	11·3	8	4	2	1	0·5	0·25	0·125	0·075	<0·075	
GRAMS RETAINED								6	29	98	26	2	161
% RETAINED								3·7	18·0	60·9	16·2	1·2	100
W % PASSING							100	96·3	78·3	17·4	1·2		

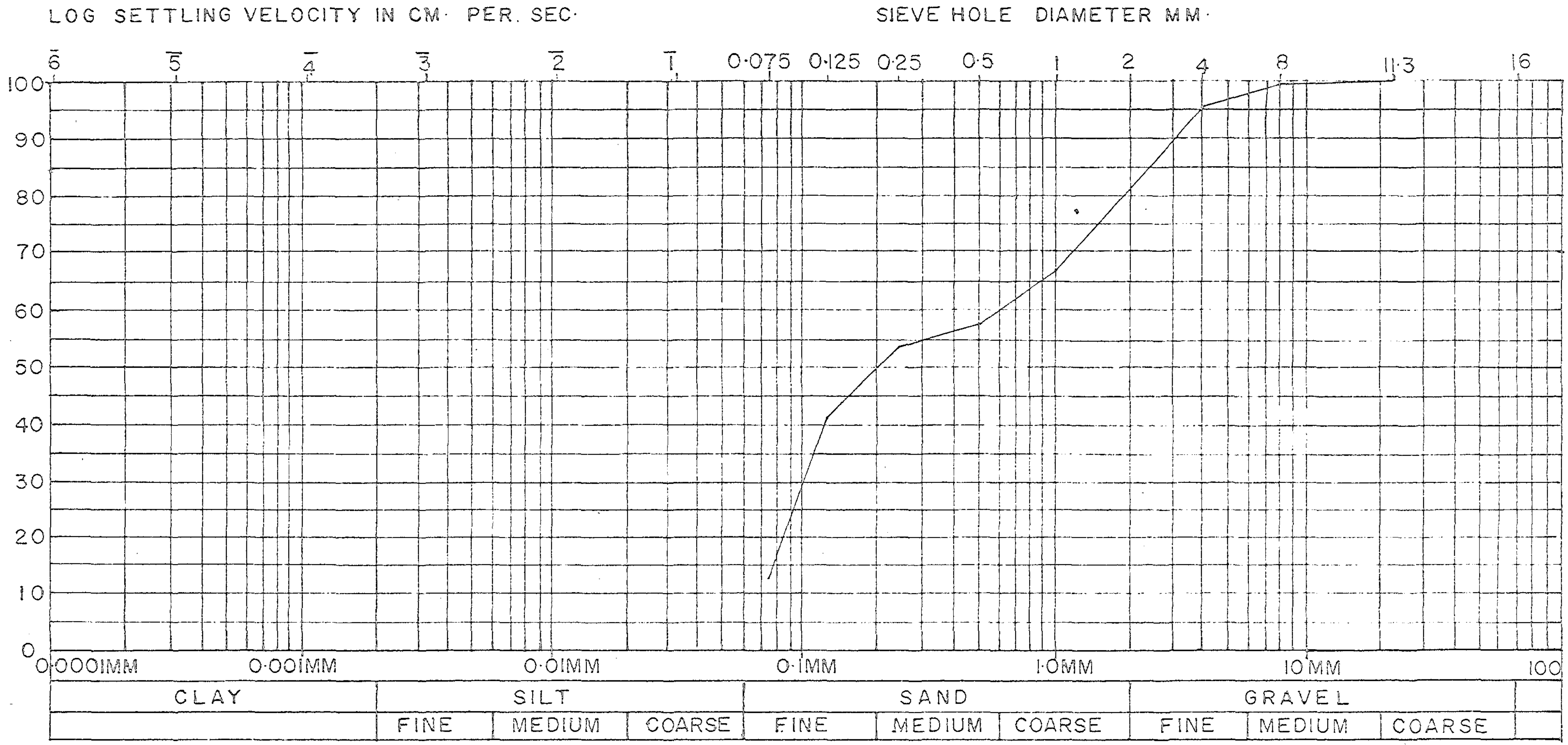
SAMPLE DESCRIPTION medium fine SAND

SITE MALPE

BORE HOLE 26 DEPTH UNDER G.L. 3·36

WASHING:
WEIGHT BEFORE 161 g
WEIGHT AFTER 159 g
WASHED AWAY 2 g

PARTICLE SIZE DISTRIBUTION ANALYSIS CARRIED OUT BY SCANDIACONSULT INTERNATIONAL AB SWEDEN



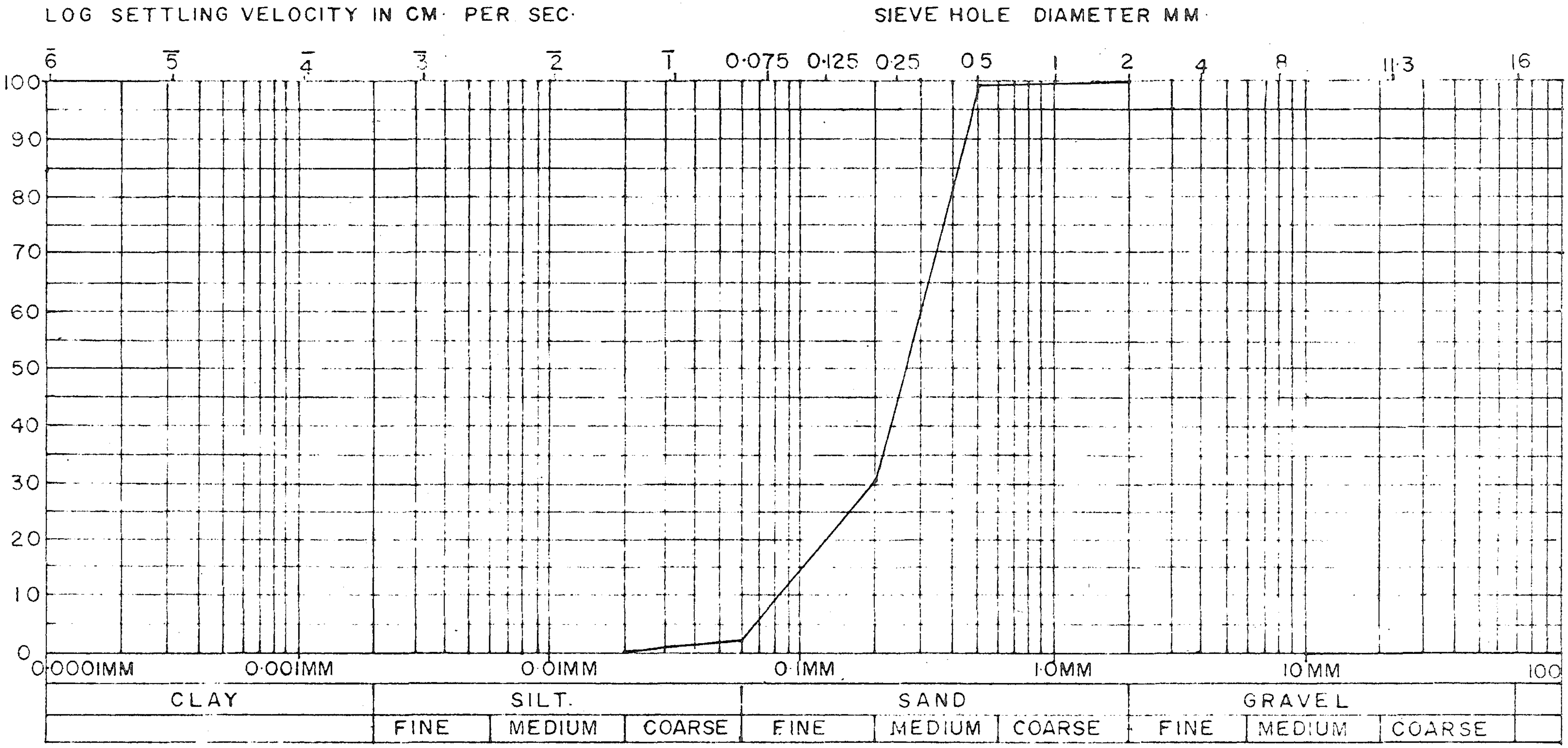
SIEVE SIZE M.M		16	11·3	8	4	2	1	0·5	0·25	0·125	0·075	<0·075	
GRAMS RETAINED				1	7	24	30	17	7	24	54	23	187
% RETAINED				0·6	3·7	12·8	16·1	9·1	3·7	12·8	28·9	12·3	100
Σ % PASSING			100	99·4	95·7	82·9	66·8	57·7	54·0	41·2	12·3		

(8 – 1: shells)

SAMPLE DESCRIPTION ... slightly ... clayey ... fine ....
SAND ... with ... many .. shells ....
SITE ..... MALPE ....
BORE HOLE .. 26 ..... DEPTH UNDER G.L. 6·86 ..

WASHING:
WEIGHT BEFORE ... 187 .... g
WEIGHT AFTER ... 164 .... g
WASHED AWAY .... 23 ..... g

PARTICLE SIZE DISTRIBUTION ANALYSIS CARRIED OUT BY. SCANDIACONSULT INTERNATIONAL. AB. SWEDEN

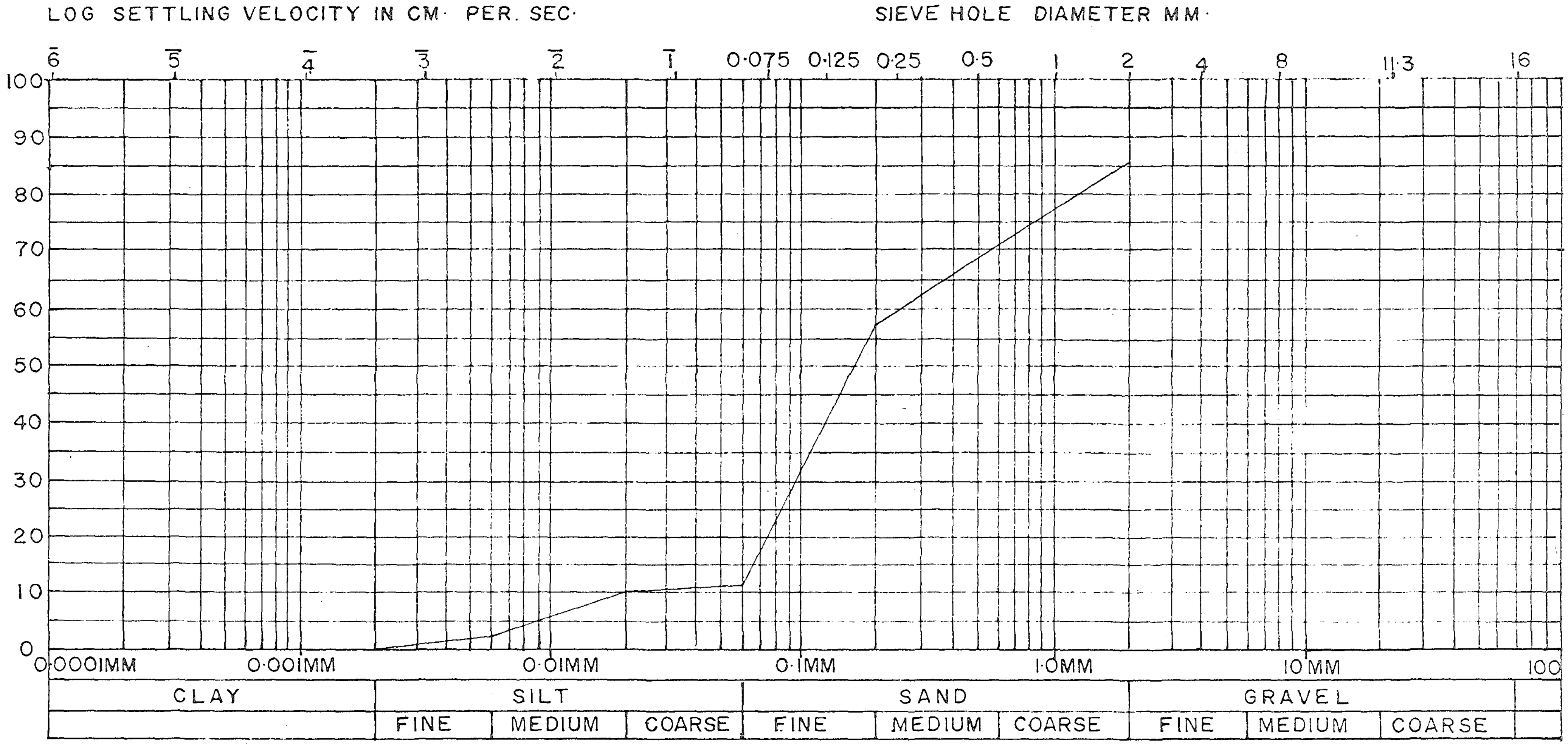


SIEVE SIZE M.M		16	11·3	8	4	2	1	0·5	0·25	0·125	0·075	<0·075
GRAMS RETAINED												
% RETAINED												
% PASSING												

SAMPLE DESCRIPTION yellowish fine to medium
SAND with grey lens, no shells, dense
SITE MALPE
BORE HOLE 27 DEPTH UNDER G.L 2·08

WASHING :
WEIGHT BEFORE .... g
WEIGHT AFTER .... g
WASHED AWAY .... g

PARTICLE SIZE DISTRIBUTION ANALYSIS CARRIED OUT BY **MANGALORE HARBOUR PROJECT**

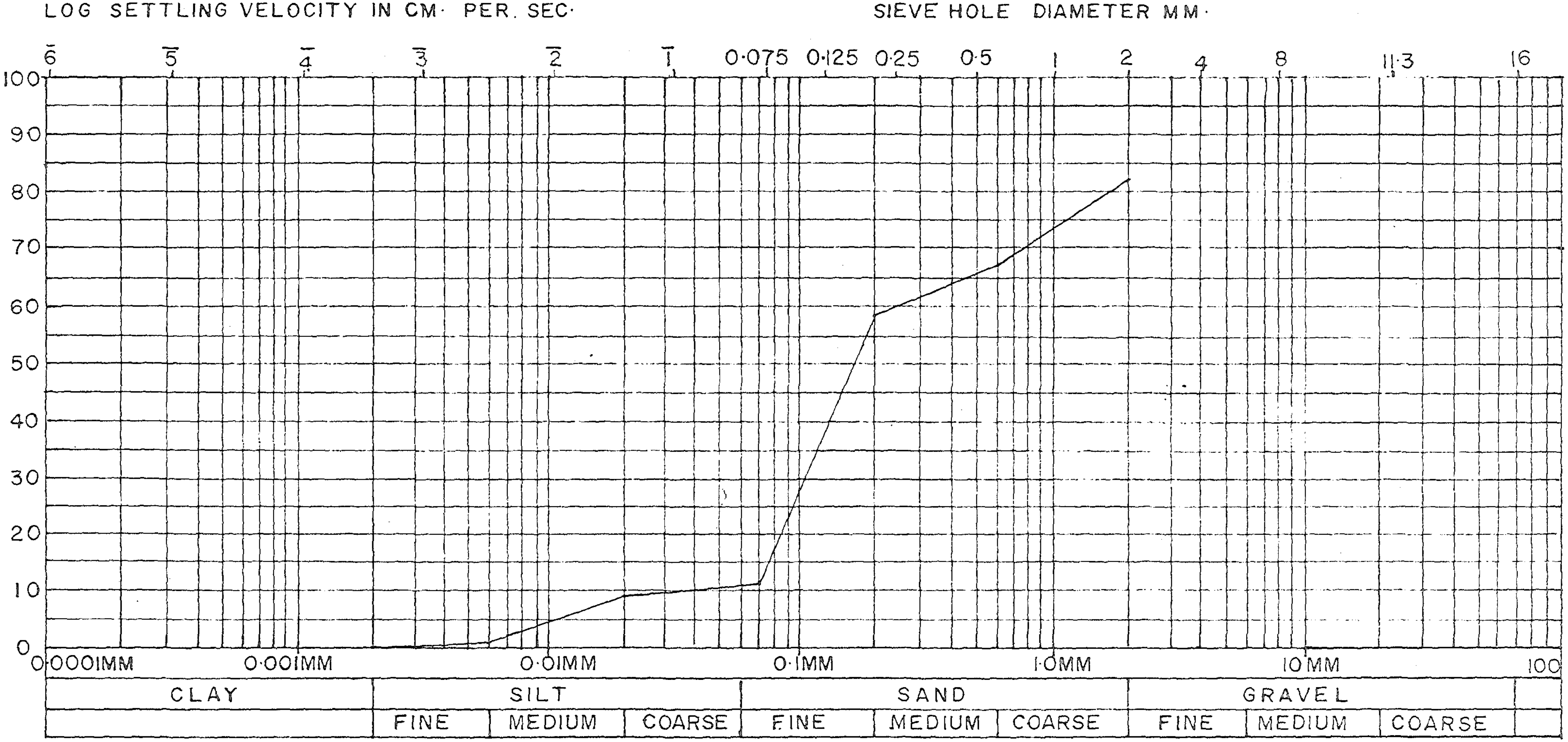


SIEVE SIZE M.M		16	11·3	8	4	2	1	0·5	0·25	0·125	0·075	<0·075
GRAMS RETAINED												
% RETAINED												
W % PASSING												

SAMPLE DESCRIPTION: grey silty SAND
with shells
SITE MALPE
BORE HOLE 27 DEPTH UNDER G.L 6·83-7·34

WASHING:
WEIGHT BEFORE .... g
WEIGHT AFTER .... g
WASHED AWAY .... g

PARTICLE SIZE DISTRIBUTION ANALYSIS CARRIED OUT BY MANGALORE HARBOUR PROJECT



SIEVE SIZE M.M		16	11·3	8	4	2	1	0·5	0·25	0·125	0·075	<0·075
GRAMS RETAINED												
% RETAINED												
W % PASSING												

SAMPLE DESCRIPTION...dark....grey...fine..medium

SAND....with...many...shells..............................

SITE...MALPE..

BORE HOLE....27.....DEPTH UNDER G.L.5:16-5:66

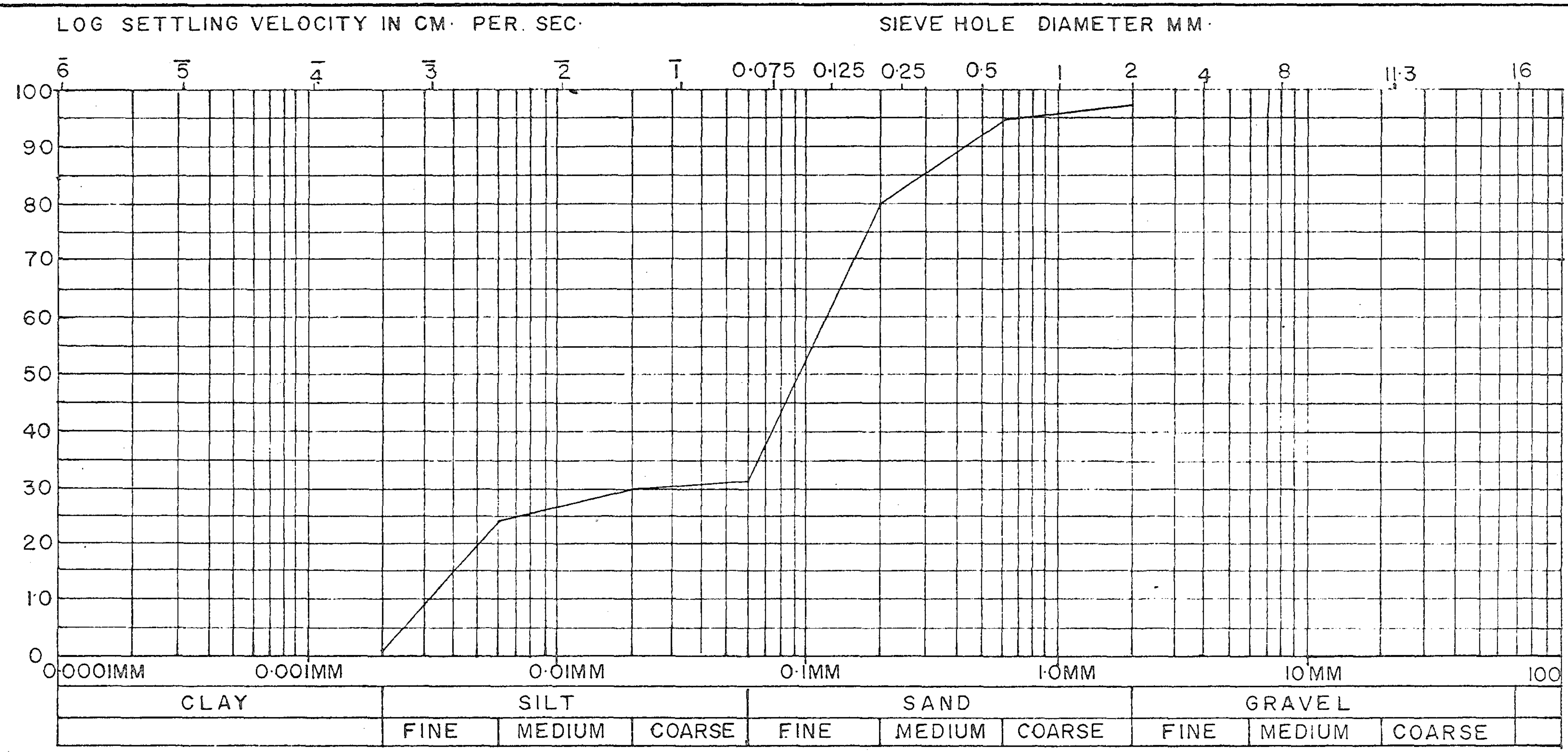
WASHING :

WEIGHT BEFORE .... g

WEIGHT AFTER .... g

WASHED AWAY .... g

PARTICLE SIZE DISTRIBUTION ANALYSIS CARRIED OUT BY..MANGALORE . . HARBOUR . . PROJECT

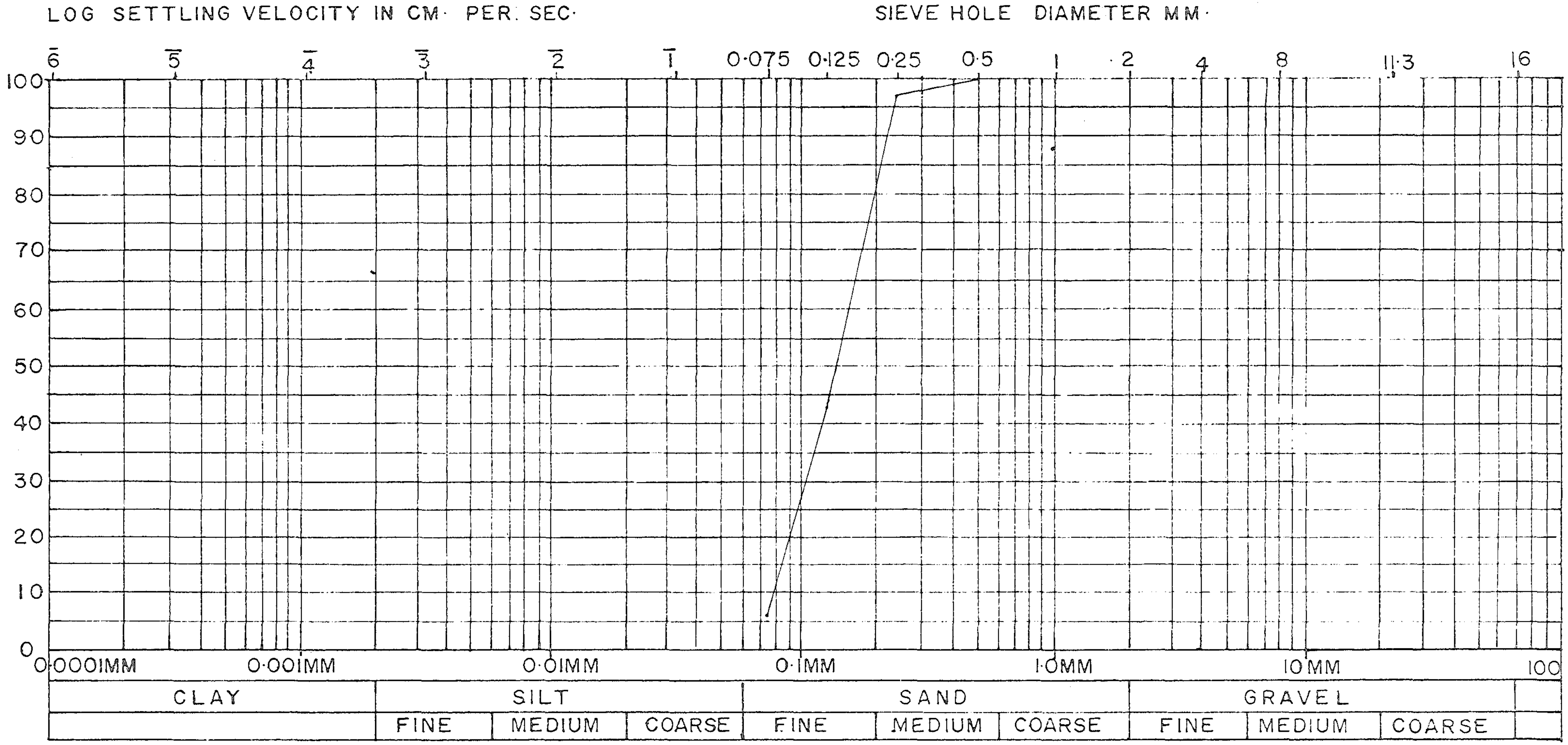


SIEVE SIZE M.M		16	11·3	8	4	2	1	0·5	0·25	0·125	0·075	<0·075	
GRAMS RETAINED													
% RETAINED													
W % PASSING													

SAMPLE DESCRIPTION ... yellowish ... fine ..... SAND ....
with ... grey ... silt ... with ... some ... hard ... lumps ....
SITE ... MALPE ....
BORE HOLE ... 34 ..... DEPTH UNDER G.L 6·66-7·34

WASHING :
WEIGHT BEFORE .... g
WEIGHT AFTER .... g
WASHED AWAY .... g

PARTICLE SIZE DISTRIBUTION ANALYSIS CARRIED OUT BY .. MANGALORE .. HARBOUR ... PROJECT.



SIEVE SIZE M.M		16	11·3	8	4	2	1	0·5	0·25	0·125	0·075	<0·075	
GRAMS RETAINED									2	41	28	4	75
% RETAINED									2·7	54·7	37·3	5·3	100
W % PASSING								100	97·3	42·6	5·3		

SAMPLE DESCRIPTION fine-medium SAND mixed with shells of coarse sand size & some clay

SITE MALPE

BORE HOLE 41 DEPTH UNDER G.L. 4·73

WASHING:

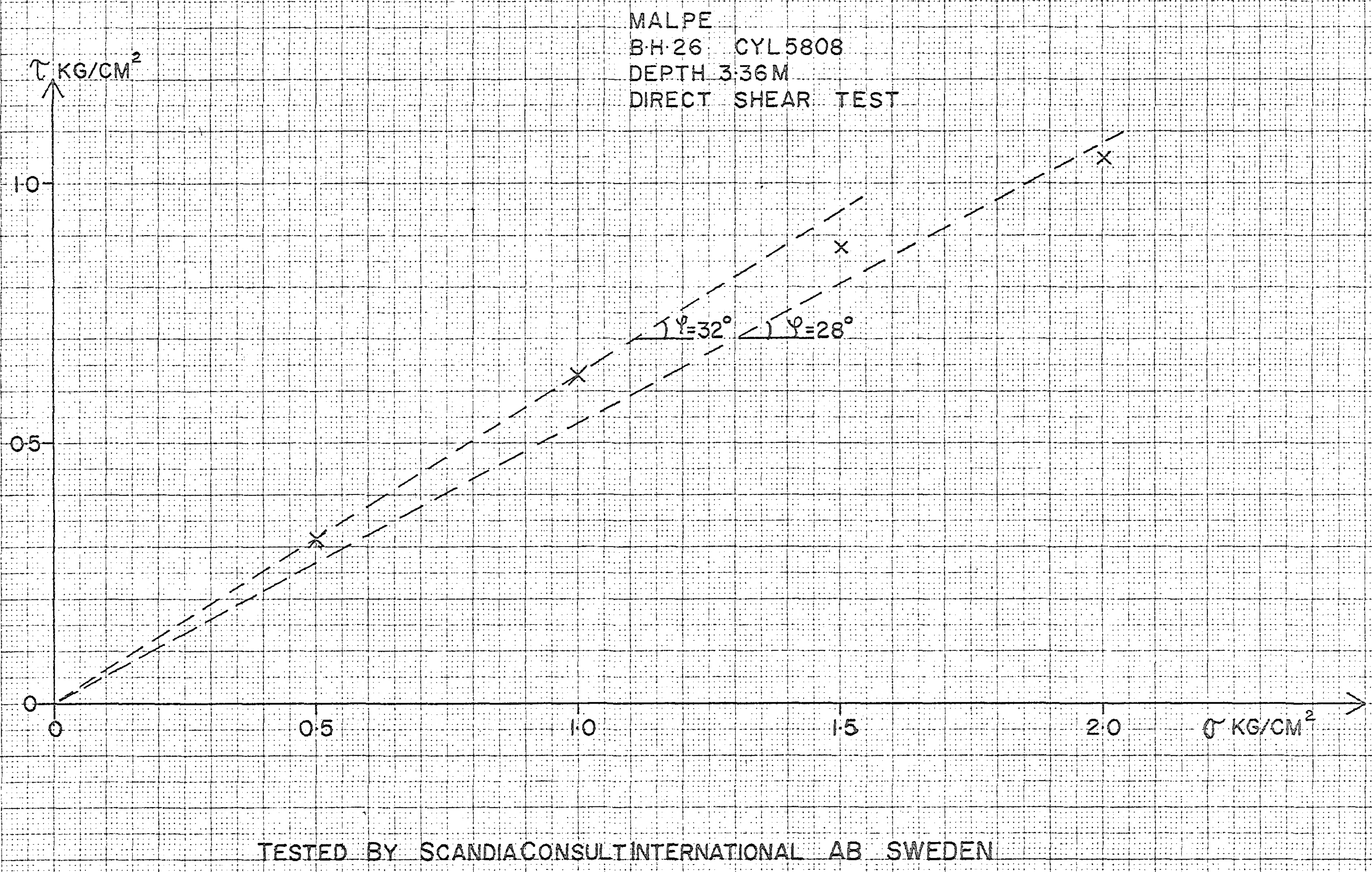
WEIGHT BEFORE 75 g

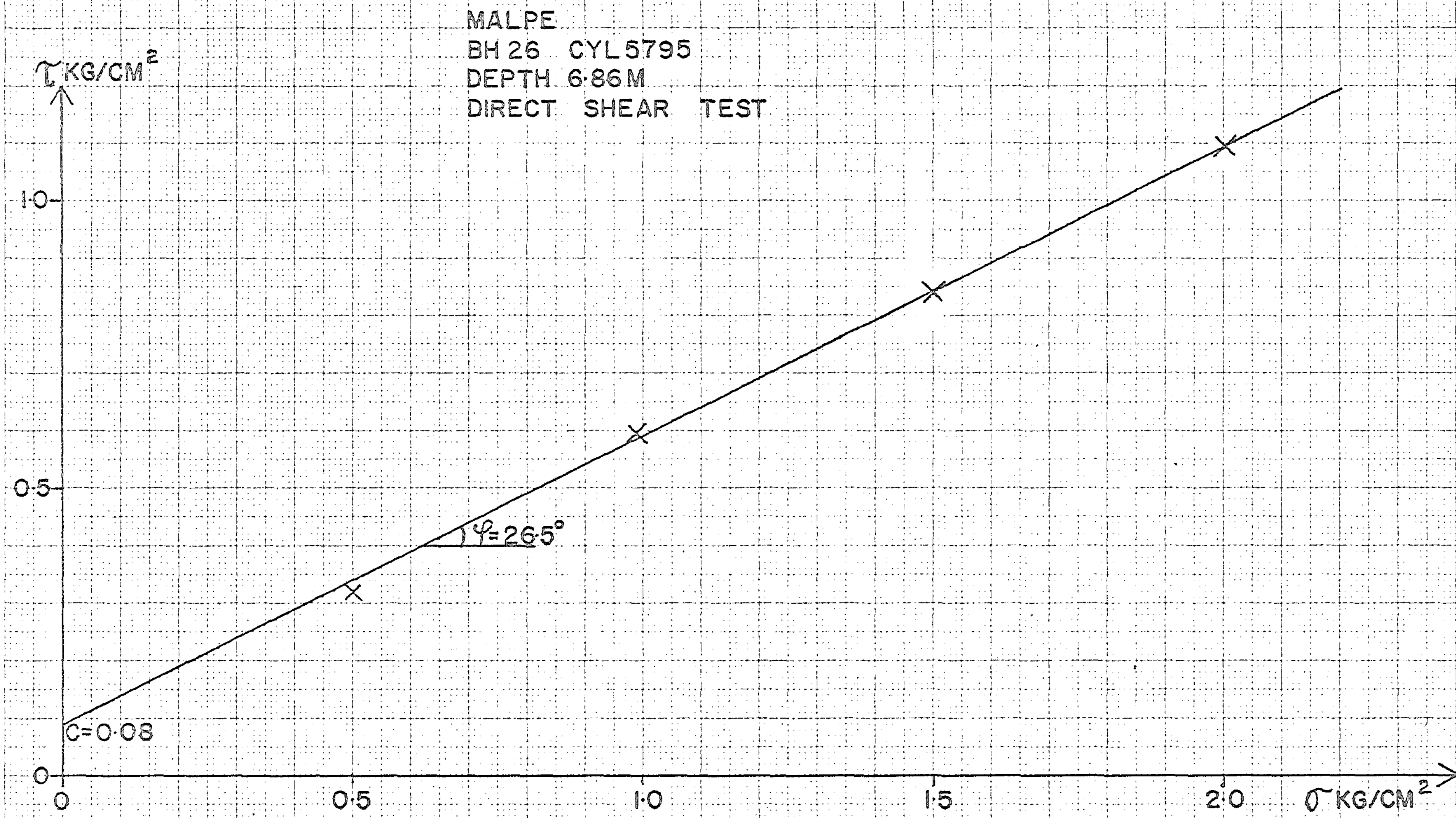
WEIGHT AFTER 71 g

WASHED AWAY 4 g

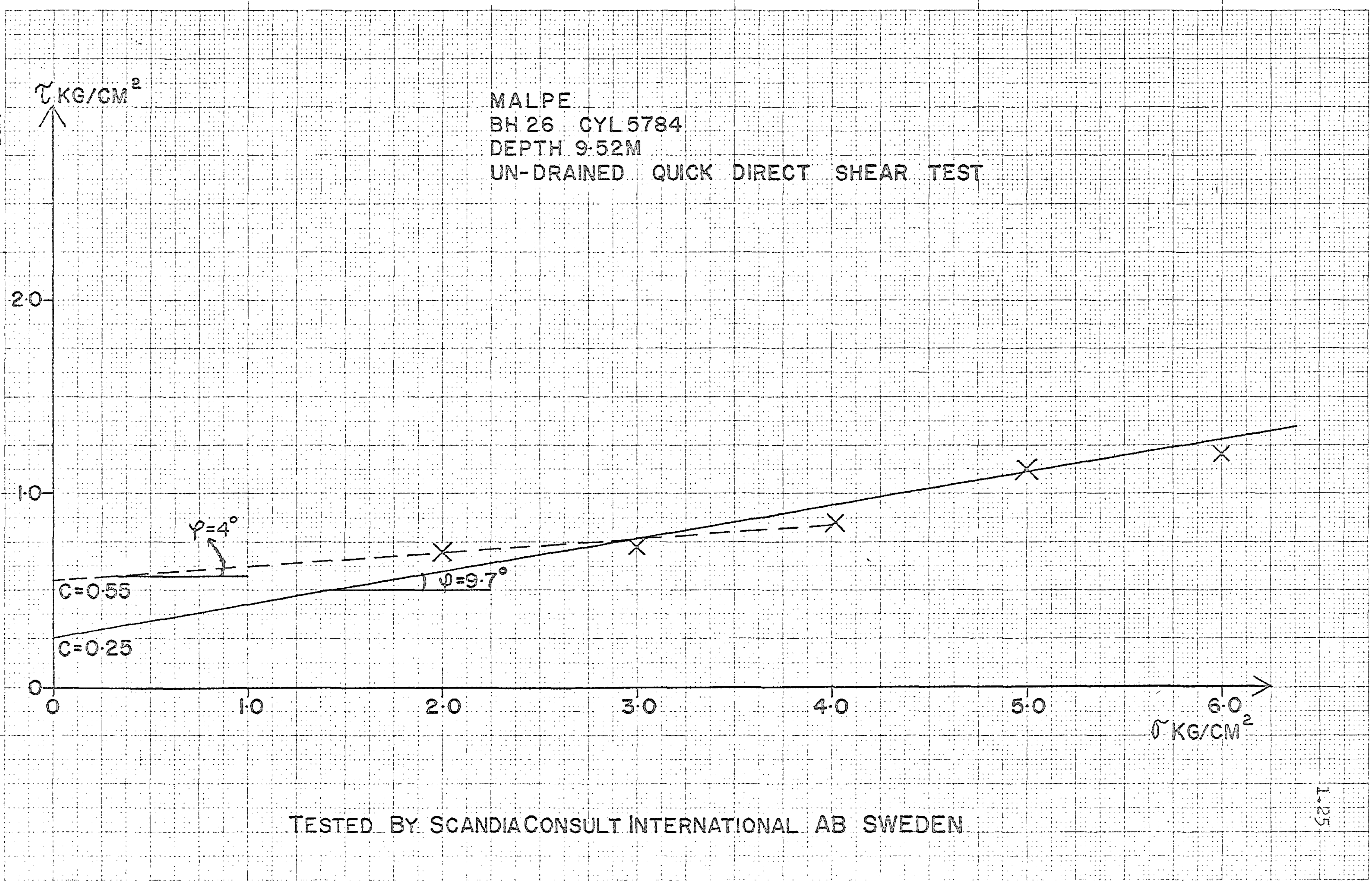
PARTICLE SIZE DISTRIBUTION ANALYSIS CARRIED OUT BY SCANDIACONSULT INTERNATIONAL AB SWEDEN

1.22


MALPE
B·H·26 CYL 5808
DEPTH 3·36 M
DIRECT SHEAR TEST
τ KG/CM²
σ KG/CM²
1·0
0·5
0
0·5
1·0
1·5
2·0
φ=32°
φ=28°
TESTED BY SCANDIACONSULT INTERNATIONAL AB SWEDEN



TESTED BY SCANDIA CONSULT INTERNATIONAL AB SWEDEN


τ KG/CM²
MALPE
BH 26 CYL 5784
DEPTH 9·52M
UN-DRAINED QUICK DIRECT SHEAR TEST
2·0
1·0
0
φ=4°
C=0·55
φ=9·7°
C=0·25
0
1·0
2·0
3·0
4·0
5·0
6·0
σ KG/CM²
TESTED BY SCANDIACONSULT INTERNATIONAL AB SWEDEN

1.25

SOUNDING

Sticksounding

Weightsounding, Press-sounding
Motorsounding

Hammersounding

SAMPLING

Disturbed Sample

Undisturbed Sample

IN-SITU TESTS

Vane Test

Sounding to hard stop

Sounding to presumed Rock

Rock boring at least 3m. under presumed Rock surface

- Ditto - with examination of the dust

Rock coring at least 3m.

HYDROLOGICAL MEASUREMENTS

Ground Water Level measured

Ground Water Level recorded over long /period

- Ditto - short period

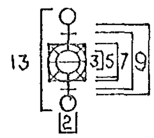
Pump or Infiltration Test

Pore Pressure Measurement

Deformation Measurement

Trial Pit or other test point e.g. Test Loading

Measurements (mm)



Detailed Plan Symbol	Simple Plan Symbol
81	81

+4.10 20.09.69
+3.15 22.09.69
A
+6.86
Cl +5.20
Sa +3.60
Si +3.10
Sa +1.60
Cl -2.10
Gr -4.45

A indicates Chemical or Special anaylisis carried out.

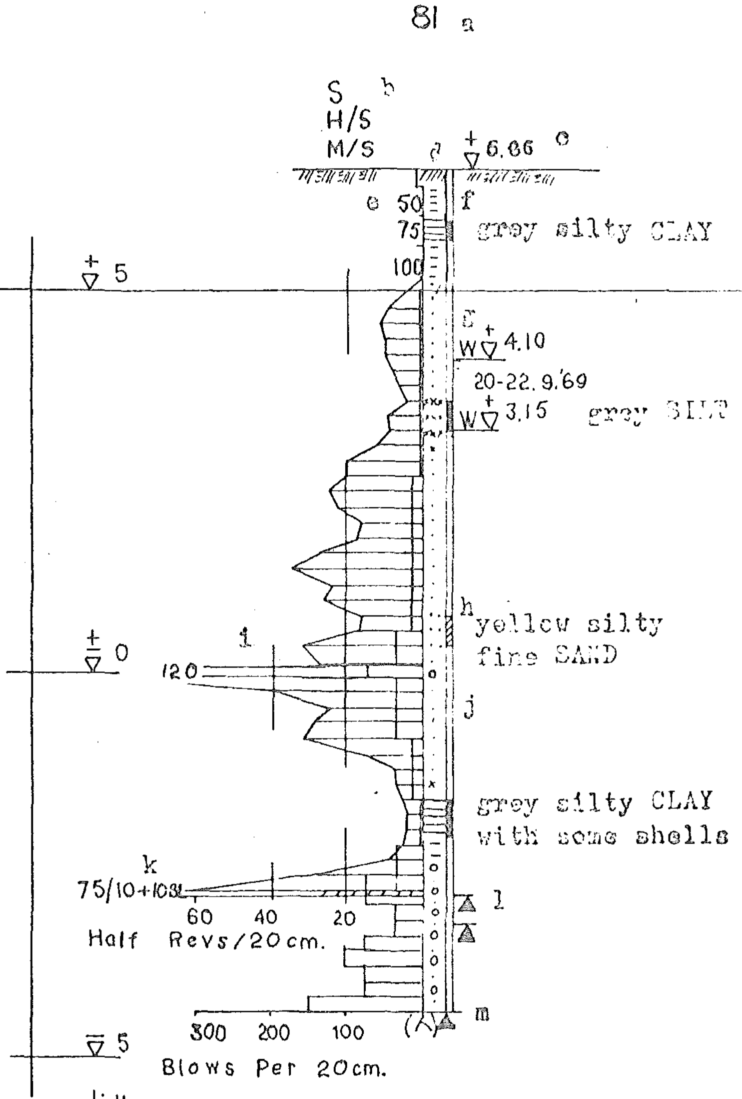
SECTIONS

Filling
Topsoil
Peat
Shells

Clay
Silt
Sand
Gravel

BOREHOLE STOPS

Section	Plan		Section	Plan	
		Probably Rock			Boring discontinued can be driven deeper without hammering
		Probably Stone or Block			- Ditto - but only with Hammering
		Stone Block or Rock			Rock Drilling
		Non-Rock, Stone or Block stop			



a Borehole number 81

b S Sampling carried out
H/S Hammersounding carried out
M/S Motorsounding carried out

c Ground level in metres above or below Datum

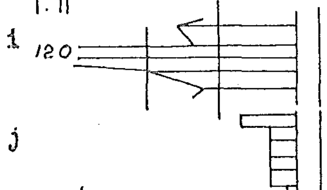
d Hole made in ground with auger or crow-bar. 20cm deep

e 50, 75, 100, pressures in Kg. applied for Motorsounding. The rods were not turned.

f Fully shaded area indicates undisturbed sampling. The adjectives describing the sample are in small letters. Nouns are in capital letters. Borehole ledgend across the whole section indicates that the material has been sampled and seen. Ledgend in the centre of the section only indicates the material present, in the opinion of the engineer.

g W + 4.10 Highest water level measured over the period shown.
20-22.9
W + 3.15 Lowest waterlevel measured over same period.

h Position of disturbed sample shown cross-hatched.



i Motorsounding, half revs./20 cm., recorded in numbers when the figure is very high.

j Hammersounding, number of hammer-blows / 20 cm.

k 75/10+10 Bl, 75 half turns, Motorsounding penetrated only 10 cm. 10 blows of a sledge hammer were applied.

l Previous boring attempt discontinued at a hard stop.

m Boring stopped on Stone, Block or Rock.

Hammersounding results are represented as follows:

Free sinking is drawn as 0 blows/20 cm.

1 - 10 blows	as 5 blows/20 cm.
11- 20 blows	as 15 blows/20 cm.
21-550 blows	as 35 blows/20 cm.
51-100 blows	as 75 blows/20 cm.

SURVEY

SURVEY REPORT

Datum

All levels have been referred to a Datum which is 2.210 m below Benchmark on existing R.C.C. jetty. This Datum is said to be CHART DATUM (Ref. Ports Division P.W.D. Karwar Drawing No 66/69-70 dated 18.7.1969) which is given on Admiralty Chart No 2014 as being 18.446 metre (60.52 feet) below Benchmark out on top step at base of Malpe Light House.

Topographic Survey

The survey was started on 2nd July 1969 in the monsoon period. Sufficient information about grids used in previous surveys was not available at the start of the survey and the fix point near the Light House on St. Mary's Islands was not accessible due to adverse weather conditions. It was therefore decided to establish a local co-ordinate grid system.

The grid with eleven main stations is shown on the Survey Index Map, Drawing No 09-100. It was built up by a system of traverse and triangulation surveys which included the measurement of eight baselines. The fixed points were marked on firm foundations whenever possible, but some of the points had to be marked where no such foundations were available. The markings for those points consist of 1" G.B. Pipes cast in concrete pillars which due to the loose nature of soil are liable to dislocation. It is recommended that the position of such points be checked before use for other works. In fact one of the points (No 11) was washed away due to beach erosion during the latter part of the survey.

Hydrographic Survey

Hydrographic survey was carried out using Kelvin Hughes Echo Sounder MS 36 MB Mk. 1. with outboard rig mounted on local fishing boats. Position fixing was generally done by reading of sextant angles to shore stations which were established within the grid system of the topographic survey.

Echo-sounding has been carried out in the river from the river mouth to about 600 metres upstream thereof. In the sea the soundings have covered the area from the shore out to St. Mary's Islands including the gaps between the islands.

In the shallow parts of the sea along the shores the bottom levels have been determined by tachymetric survey. The soundings were taken in sections roughly perpendicular to the shoreline with distances of about 200 m between sections. The reason for this grid is that a marine chart was available which showed the detailed soundings made by the Indian Navy in 1949 and the new soundings were intended mainly as a check on changes in the bottom level since then. Comparison of results of surveys of 1949 and 1969 are shown on Drawing No 09-194.

The river mouth and bar area is subject to much seasonal movement as evidenced by Drawing No 09-195 which shows extract from surveys made by State of Mysore P.W.D. in 1963 and 1964.

Maps

The results from the hydrographic and topographic surveys have been plotted on maps at a scale of 1:1000. The areas covered by this mapping are indicated on the Survey Index Map. The base material from these maps has been used for compilation of all other maps.

The survey of the proposed harbour area and the sea approaches including St. Mary's Islands is shown on a map 1:5000, Drawing No 09-196.

Tide

For continuous observations of tide variations, a water level recorder was installed near the river mouth and records taken from 2nd August to 9th October 1969. The records are shown on Drawing No 09-307.

The highest water level observed during the above period was +1.33 m (on 28.8.1969) and the lowest water level as -0.56 m (on 12.11.1969). The tide predictions for Mangalore indicated for 12.11.1969 one of the twenty lowest predicted water levels of 1969 (the lowest one being 0.19 m lower) and it can therefore be assumed that the low water level of -0.56 m at Malpe also represents one of the lowest water levels of the year.

The following average water levels have been calculated from the records for the short period observed:-

MHHW	+0.94 m
MLHW	+0.77 m
MHLW	+0.14 m
MLLW	-0.26 m

It should be noted that the observations were made during the monsoon period. According to the Tide Tables of the British Admiralty, there is a seasonal variation in the tide at Malpe, and the water levels should be about 0.09 m lower during the monsoon months than the average for the year.

Winds

The velocity and duration of winds have been observed in Mangalore over a long period. The results of those observations for period 1956-62 are represented on Drawing No 09-900. Malpe is situated quite near to Mangalore and it can be assumed that the above wind records can be regarded as applicable to Malpe also.

Waves

An instrument for continuous recording of deep water wave heights has been in operation for a few years in the sea outside the new harbour site near Mangalore. The variations of the water surface levels is measured by a pressure-cell connected by cables to a writing instrument in land.

The highest wave registered by the instrument so far was a 4.8 m high wave recorded in June 1968. The period of that wave was 9 seconds.

In the absence of long term wave measurements at Malpe, the maximum wave observed in Mangalore can be taken as valid for Malpe and used for preliminary design. Detailed analysis of wave recordings from Mangalore will be used for final design.

Tidal Flow Studies

Observations were made to determine such tidal characteristics as tidal prism, water discharge and current velocities required for evaluation of "inlet stability".

Two methods, current measurement by float tracking and tide gauge recordings have been used simultaneously to obtain a maximum amount of data and to allow an estimate of the accuracy of the calculations.

The first method was to measure the current through the narrowest section of the river mouth by float tracking. Continuous level readings were made on a tide gauge near the actual section. The section had been determined beforehand by means of echosounding and levelling. A graph giving the cross section area at various levels was prepared. This area multiplied by the current velocity will give the flow in m^3/s. Integration over a time period gives the total flow during the period.

The second method involved the reading of staff gauges in the river at points indicated on the enclosed sketch, Drawing No 09-300. Each series of observations was reduced to an arbitrarily chosen datum, giving the level changes over the reading period. The surface area between two gauges multiplied by the mean level change represents the water volume change for that area. Assuming the freshwater flow being constant, the method gives the change in tidal volume over a period. After adding up the volumes at all the areas for each period and dividing the sum by the time the various mean flows in and out of the estuary for the actual period are obtained.

This method gives no information about the freshwater flow, but the tidal prism appears immediately as the difference between maximum and minimum volume.

If the two methods are combined, the amount of freshwater flow can be estimated.

The following symbols are used in the calculations.

Q_G^F and Q_G^E - Total change in water volume (m^3) over a period of flood and ebb.
Gauge method.

Q_C^F and Q_C^E - Total change in water volume (m^3) over a period of flood and ebb.
Current method.

f - Freshwater flow (m^3/s)

t^F and t^E – Periods (s)

k – Coefficient representing the systematic error involved when assuming constant velocity over the section area and/or a scale error in area determination. The same coefficient is assumed for flood and ebb.

$$Q_C^F \times k + f \times t^F = Q_G^F$$

$$Q_C^E \times k - f \times t^E = Q_G^E$$

Note that during flood tide (inflow) the freshwater is added to measured inflow to obtain the change in water volume in the estuary and vice versa for ebb (outflow). For the determination of k and f the full period of tide or ebb is not necessary, but if the tidal prism is wanted a full or next to full period is essential.

Operations were carried out in the Udiyavara River (Malpe) on 28/8 (full moon spring tide) and 12/11 (new moon spring tide).

The Udiyavara has three affluents of approximately equal importance (Drawing No 09-300). Water level gauges were set out as shown on the drawing. Gauges No 00, 0, 1, 2, 3 and 6 were levelled to the project survey datum. During the float tracking the gauges were read four times per hour from 7.00 to 18.30.

Floats with drogues at respectively 0.9 and 3.0 metres under the surface were dropped from a motor boat and were allowed to drift with the current. Time was recorded when the floats passed sections marked on the river banks.

The first float tracking was carried out on 28 August 1969, which was during the monsoon period but the weather during the preceding week had been fair with very little rain. No large fresh water flow could therefore be expected.

The second operation on 12 November 1969 was preceded by a long period of quite dry weather.

Summary of results obtained.

(Current observations at Section 9)

			Date 28/8	Date 12/11
1)	Tidal prism "Gauge Method" (10^6 m^3)	Flood	5.8	2.2
2)	" " " " "	Ebb	5.1	5.0 x)
3)	" " Current Method"	Flood	-	2.6
4)	" " " "	Ebb	7.8 x)	5.9 x)
5)	Computed fresh water flow f (m^3/s)		12	8.9
6)	Coefficient k		0.69	0.83
7)	Mean Max velocities xx) Flood (m/s)		0.90	0.43
8)	" " " Ebb "		0.92	0.82
9)	Max Discharge (Total) (8) x section area (m^3/s)		566	360
10)	" " (Corrected total) (9) x (6)		390	300
11)	" " (Tidal) (10) - (5) approx.		380	290
12)	Section area at observation point at midwater (+ 0.50) (m^2)		560	560
13)	Section area at gorge at midwater (m^2)		370	370
14)	Mean water velocity over gorge section at midwater and max discharge (11)/(13) (m/s)		1.03	0.79

x) Estimated only as readings had to be interrupted before the current turned.

xx) Mean over the depth in one point only.
Note that current observations were made in Section 9 which is not equal to gorge section (12). The values are reduced to gorge section in line (14).

Maximum discharge at spring tide (Qm) would normally be around 350. m^3/s, excluding freshwater, giving mean velocities of approx. 1.0 m/s at gorge section.

SURVEY REPORT DRAWINGS

Drawing No	Title
09 - 100	Survey Index Map. Scale 1:12500
09 - 194	Echosoundings in 1949 and 1969
09 - 195	Shoreline Pre- and Post-monsoon 1964
09 - 196	Harbour Area. Scale 1:5000
09 - 900	Wind Observations at Mangalore 1956-1962
09 - 300	Map showing the position of Gauge Stations
09 - 307	Tide Recordings at Gauge Station 0

DESIGN OF THE HARBOUR

Introduction

Malpe is a small port on the coast of South Kanara about 55 km north of Mangalore. It is located at the mouth of the Udiyavara River about 5 km from Udipi.

The commercial traffic in the harbour of Malpe is at present rather limited, but the fishing activity of boats from this port is quite intensive during the non-monsoon months, when considerable quantities of fish is landed.

Malpe enjoys the advantages of some natural protection from the open sea due to a string of islands (St. Mary's Islands) which form natural breakwaters and give some shelter from waves, particularly those coming from south-west and west. The wave pattern is changed due to the presence of the islands and the littoral drift is thereby reduced resulting in accretion of sand south of the river mouth.

It would be possible to construct a large port inside the islands, and Malpe was in fact considered a suitable site for a major commercial port on the Mysore Coast, but the final choice was Mangalore, where a new commercial harbour is now under construction.

There is adequate land area available for development of a fishing harbour, which can be located either with entrance through the river mouth or with entrance direct from the Arabian sea. After due consideration as to technical advantages and to costs involved a harbour with entrance through the river is proposed.

The installations for landing of fish and for berthing of the fishing boats should be constructed as close to the river mouth as possible. The north bank of the river was chosen for location of the proposed harbour basin to take advantage of the large area available and the existing roads.

Entrance Channel

The Malpe entrance is a tidal inlet located on a littoral drift shore subjected to mainly tidal flow during the dry season and to a combination of tidal flow and freshwater flow during the monsoon period. The existence of the outlet is due to an equilibrium condition between flow and littoral drift by which ebb flow pushes material deposited during the flood flow out of the entrance depositing the material in a half-moon-shaped bar. The stability and the possibilities for improvement of such an entrance depend on the magnitude and direction of the littoral drift and on the tidal flow characteristics of the estuary. Tidal flow studies have been undertaken in the field as described in the Survey Report, after which the following conclusions were reached.

The tidal prism varies in accordance with the tidal range and mode. The semi-diurnal tide is predominant, however, and causes a tidal flow of approximately $5.10^6 m^3$ per cycle during a spring tide. This flow may increase when the tide is skewed e.g. causing higher ebb flow and less flood flow. The flow decreases during periods of diurnal tides of smaller amplitudes. For design purpose a typical spring tide should be used. One must then count on some deposits during periods of lower tidal ranges and some extra scour during periods of higher ebb flows. The fact that the bottom in the area of the present jetties is covered with fine sand and not silt without shoals indicates that, although movement of sand takes place, the gorge area is probably rather stable. There is a tendency to meandering because present curvature is a little too sharp. The mean max. velocity of 1 m/sec recorded for the gorge area of approximately 350 m^2 to M.S.L. corresponds well to a mean max. discharge of approximately 350 m^3/sec.

The freshwater discharge which may vary from nil to about 20 m^3/sec and occasionally for a short while reach 100 m^3/sec, may increase the discharge at ebb flow by around 20 to 30 percent.

A peculiar situation may exist in the way that according to the tide table the mean sea level during the monsoon period is upto ab 0.2 m lower than the highest mean sea level during the non-monsoon period. The increased freshwater flow and the lower mean sea level both tend to increase discharge which is an advantage during the heavy drift period.

Most part of the littoral drift to the inlet takes place during the monsoon period when flow is insufficient to flush the entrance area adequately. Consequently a bar builds up. The situation with respect to entrance stability must be classified as "poor". Based on observation of the character of the shoaling, the conclusion is made that the Malpe entrance is comparable to the inlet at Big Pass, Florida, Ponce de Leon Inlet, Florida and Oregon Inlet, North Carolina (Ref. 1. P 120-121).

The conclusion of the above mentioned results of field surveys of tidal prism and discharge is that the Udiyavara River entrance behaves as a normal tidal inlet in a littoral drift shore and is not in any way an estuary type inlet, although it carries a considerable quantity of fresh-water flow for short durations, with apparently very limited quantities of silt.

Experience from dealing with similar river inlets elsewhere makes it evident that an improvement of the stability of such a tidal inlet must be based on a decrease of the quantity of littoral drift carried to the entrance. This may be accomplished by training wall protection, trap protection or best by a construction of both to avoid sudden shoalings. A decrease of the littoral drift could, in the case of Malpe, be accomplished by closing the gaps between the islands.

Ref. 1. Tidal Inlets and Littoral Drift by P Bruun, 1966.

Improvement of the Channel

In order to get a stable entrance channel training walls and remodelling of the present channel will be required. It is desirable that the channel should function as a self flushing channel without hampering safe navigation.

The first condition calls for mean maximum current velocities of approximately 1 m/sec at normal spring tide conditions assuming a fairly regular predominantly semi-diurnal tidal cycle. The latter is not exactly correct for the Udiyavara River but in the other hand a semi-diurnal not too skewed tide still prevails and as mentioned previously the entrance seems to behave as a normal tidal entrance in alluvial material with sand bottom.

The second condition is that the absolute maximum water velocity should not exceed about 1.5 m/sec so as not to endanger navigation for mechanised boats. There must also be sufficient space for the traffic.

The training walls should be designed in such a way that safe conditions for the navigation will be obtained in the area of the inlet. The entrance of the channel should be located in an area where wave action is not severe. The heads of the training walls should be given such a form that the penetration of currents carrying littoral drift material into the inlet will be kept at a minimum and with minimum wave action.

The proposed channel with training walls is shown on Drawing No 09-43.

In order to achieve the optimum conditions with respect to current and wave action, arrangements are being made to submit the proposed channel to model study. The results of the field survey, indicate that the model study can be restricted to tests on a model of fixed bed, continuous flow type, and the study may therefore be carried out on the Malpe model which exists at Mysore Engineering Research Station, Krishnarajasagar.

Reduction of littoral drift carried to the entrance channel

It is proposed to reduce the littoral drift to the entrance channel by construction of training walls and provision of sand traps of capacities 150.000 m^3 updrift (South) and 50.000 m^3 downdrift (North) of the channel as shown on Drawing No 09-43.

Fluorescent tracer study and wave study by aerial photography planned for later this year will provide further information about the mode of bypassing and the relative magnitude of drift.

The drift to the inlet entrance will decrease after the completion of the training walls. However, some maintenance dredging will be required. This quantity may be of the order of 50.000 m^3 per year.

The possibility of reduction of the drift to the entrance channel be closing the gaps between the islands offshore has been considered. The results of closing of the gaps would be a build up of land on the south bank and reduced maintenance dredging. The closing of the gaps (by construction of breakwaters) estimated to cost about Rs. 45 lakhs is not recommended at present. In the future closing of the gaps might again be considered if use could be found for the area of land which would build up south of the entrance channel as a result of closing of the gaps and/or if maintenance dredging proves to be much in excess of 50.000 m^3 per year.

THE PROPOSED HARBOUR

The proposal is shown on the following drawings:

No P-09-40	Coastline of India with location of proposed harbour Scale 1:10000000.
No P-09-41	Map showing Malpe and District. Scale 1:63000
No P-09-42	Harbour Area. Scale 1:5000
No P-09-43	General layout. Scale 1:2000
No P-09-44	Channel and Training Walls. Cross sections
No P-09-45	Landing Quay. Plan and cross section
No P-09-46	Berthing jetties. Plan and cross section
No P-09-47	Jetty with Sheet Piled Face.. Plan and Cross Section
No P-09-48	Revetted slopes in Harbour Basin
No P-09-49	Landing Ramp Plan and Cross Section
No P-09-50	Slipway. Plan and Cross Section
No P-09-51	General Layout (Alternative Boatyard)

The main parts of the proposed harbour are the following:

Harbour Basin:

Berthing in the river itself would not be desirable because of the comparatively strong current and it is therefore proposed that a harbour basin covering an area of about 50.000 m^2 should be constructed on the north bank of the river immediately inside the river mouth.

The basin should be dredged to -4.5 m below Datum. In the basin are proposed a landing quay and jetties for berthing of the fishing boats. On the surrounding land, areas have been set aside for auction and packing halls for processing plants and for a shipyard with slipways and a launching ramp. An area is reserved for net drying and repairs and a location is proposed for service stations for supply of fuel, oil and water to the boats. Sufficient land area is further available to allow for an extension of the basin if required later.

Approach Channel

At the river mouth there should be constructed training walls to guide the river flow out into the sea. The channel between the walls should

TABLE 3

Estimate of length of Landing Quay based on month with peak catch

Size of vessel m	Required berthing length per vessel m	Number of vessels year 90/91	Fishing trip Nos. of days	Catch per trip kg	Total catch per day tonnes	Unloading capacity tonnes/hour	Required length of landing quay m
10	10.5	10	1	200	2.0	2	$\frac{2.0}{2x12}$ x 10.5 = 0.9 m
14	14.5	90	1	600	54.0	3	$\frac{54.0}{3x12}$ x 14.5 = 21.8 m
18	18.5	75	3	3000	75.0	4	$\frac{75.0}{4x12}$ x 18.5 = 28.9 m
23	23.5	40	5	11000	88.0	5	$\frac{88.0}{5x12}$ x 23.5 = 43.1 m
28	28.5	20	6	24200	80.7	6	$\frac{80.7}{6x12}$ x 28.5 = 47.9 m
							142.6 m
					Reduction for vessels on repair and maintenance 10%		14.3 m
					Nett length required		128.3 m

DETAILS OF THE PROPOSED HARBOUR

1. Training Walls

Various types of training walls have been considered, but preliminary cost estimates show that rockfill walls will be the most economic construction. The proposed training walls are shown on drawings Nos 09-43 and 09-44. The alignment shown may be somewhat modified depending upon the results of model tests.

The outer parts of the training walls are designed to resist waves from directions between west and north with wave heights of 2.0 m.

The channel between the training walls will be deepened to -5.0 m for the outer position where the bottom of the channel should be at -6.0 m. The width of the deep part of the channel will according to our proposal be 36 metres, which is equal to about six times the beam width of the largest fishing boats, that can enter the harbour.

2. Harbour Basin

The proposed harbour basin has a total area of about 50000 m^2.The bottom of the basin will be at -4.5 m. As the basin will be excavated through layers of sand, it is proposed that the side slopes of the basin shall be revetted with rubble as on drawing No 09-48.

3. Quays

The proposed type of landing quay is shown on drawing No 09-45. It consists of a reinforced concrete deck on a foundation of R.C.C. piles. The deck of the quay will be brought to the level +2.50 m. The quays as well as the berthing jetties have been designed for a vertical live load of 1 tonnes/m^2 on the quay surface and a horizontal live load from berthing boats of 1 tonne per m length of quay. These horizontal loads are considered to act perpendicular to the quay line and will in this case be taken up by raking piles. The quays will be provided with 10 tonnes bollards at 10 m centres and with wooden fenders at 2 m centres. The proposed Landing Quay has a length of 250 m.

4. Berthing Jetties

The proposed berthing jetties are shown on drawing No 09-46. The construction of the jetties is similar to that of the quays described above. The deck surface of the jetties will be at level +2.50 m.

Two jetties separate the harbour basin from the river. A wall of concrete sheet piling will be constructed along the southern side of these jetties and thus provide a guidance for the current in the river.

5. Boat Yard and Repair Jetty

The proposal includes a boatyard located on the river bank upstream of the harbour basin. It should be furnished with two slipways with capacity for taking up fishing boats weighing up to 200 tonnes. There also should be a launching ramp for smaller boats (up to 15 tonnes).

A special jetty with a 10 tonnes crane is located downstream of the slipways. The area set aside for the boatyard is shown on drawing No 09-43.

The boatyard will be an integrated part of the project but be separated from the landing and berthing area and fenced in as a separate unit.

An alternative boatyard arrangement with boatlift is shown on Drawing No 09-51.

6. Navigation Lights

Two light buoys will be placed at the outer end of the approach channel and one fixed light on each of the two pierheads. Leading marks with lights will be placed upstream of the harbour marking the centreline of the approach channel.

Lighting of the approach channel and the harbour basin will be provided.

7. Water Supply

Fresh water should preferably be provided by extension of the water supply system from the Town of Udipi. If this is not possible water will have to be provided from wells.

An elevated watertank and if necessary a pump station will be located in the immediate neighbourhood of the harbour basin. From the elevated tank fresh water will be distributed to the various tap-stations in the auction hall, the ice plants, the packing hall, the offices, etc.

For washing down of jetties and other outdoor areas, sea water will be used. The water will be distributed through a system of pipes in which the pressure will be maintained by means of a pressure tank system.

8. Sewage and Drainage

The drainage of the site will be on the partially separate system. The drainage water from the area in front of the auction hall and from the landing quay, which water is polluted with organic debris, fish offal etc will be disposed of through the sewage disposal system.

The sewage will be conducted to settling tanks, from which the effluent will be pumped out to sea.

9. Buildings

The proposed locations of Harbour Office, Auction Hall, etc. are indicated on drawing No 09-43.

10. Ice Plants, Cold Storage and Processing Plants

Space has been reserved for one Ice Plant and Store as shown on drawing No 09-43. Areas have also been indicated where processing plants can be established. A special area north of the harbour basin has further been reserved for drying fish.

Cost of ice, cold storage and processing plants have not been included in the engineering cost estimate. It is understood that these plants will be constructed separately from the harbour works.

11. Fuel Supply

On their way out to the fishing grounds the boats can stop to get their supply of fresh water, ice and fuel from the quay in the river downstream of the entrance to the basin. The storage tank for fuel oils will have a storage capacity equal to 15 days consumption.

12. Power and Lighting

A transformer station will be located near the road entrance to the harbour area. Besides providing electricity to the ice plants, processing plants, workshops, etc. it will cater for electricity for lighting of wharfes, piers, roads and areas for landing and handling of fish.

To ensure continuous power supply for essential services, some form of standby generating plant is desirable.

13. Net Drying and Repairs

The areas to the west of the harbour basin can be used by the fisherman for net drying and repairs. To some extent, it can also be used for drying of fish. It is expected that the shore here will build up after the training walls have been constructed, thus gaining larger area for net drying.

An area has been provided for sheds to store fishing gear.

14. Fencing

The border of the harbour area will be marked with a fence. In addition to that, the boatyard will be fenced in separately. It is further assumed that the processing plants will be surrounded with their own separate fencing.

15. Commercial Harbour

A 100 m long quay in the river immediately upstream of the harbour basin has been set aside for the use of the enterprises loading and/or unloading cargo other than fish. This quay will replace the quay of corresponding length but with improved depths compared to that presently being used for commercial purpose. The river at the quay will be dredged to -4.0 m.

16. Future Extension

North of the harbour basin, there is an area available which can be used for extension of the basin if later on required. If the basin should be extended 80 m to the north, that would mean an enlargement of the basin by about 17000 m^2, additional 280 m length of berthing jetties and an 80 m extension of the landing quay.

COST ESTIMATE

Description	Unit	Quantity	Cost per unit Rs.		Estimated cost Rs.
1. Dredging	m^3	1170000	6.50		7 605 000
2. Earthwork	L.S.				300 000
3. Training Walls Rock 1.2 ton blocks	m^3	9600	32	307200	
Rock 0-200 kg	m^3	163000	20	3260000	3 567 200
4. Quays and jetties					
Quays section A 45	m	632	4700	2970400	
Jetties Section A 46	m	280	3100	868000	
Jetties Section A 47	m	160	4600	736000	4 574 400
5. Stone Revetment of slopes	m	330	540		178 200
6. Slipway and Landing Ramp					
Repair jetty with					
10 tonne crane	L.S.				1 235 000
7. Roads and Hard Surfaces					
Roads	L.S.				552 500
Hard Surfaces	L.S.				805 200
Concrete Slabs for fish drying	L.S.				252 000
8. Improvement to Existing Irrigation Channel	L.S.				91 000
9. Water Supply	L.S.				550 000
10. Drainage and Sewage	L.S.				380 000
11. Electricity Substation	L.S.				350 000
12. Harbour Office	L.S.				250 000
13. Auction Hall	L.S.				1 200 000
14. Fuel Station	L.S.				50 000
			Carry forward		21 590 500

Description	Unit	Quantity	Cost per unit Rs.	Estimated cost Rs.
			Brought forward	21 590 500
15. Toilets	L.S.			60 000
16. Lighting	L.S.			170 000
17. Navigation Lights and Marks	L.S.			60 000
				22 230 500
Contingencies about 10%				2 223 000
				24 453 500
Supervision Charges about 12.5%				3 046 500
GRAND TOTAL				27 500 000