

TENDER FOR "RE-CONSTRUCTION OF SOUTH COAL BERTH AT COCHIN PORT ON ENGINEERING, PROCUREMENT AND CONSTRUCTION CONTRACT BASIS" (Tender No. T9/T-1919/2020-C)

QUERIES FROM BIDDERS AND REPLIES / DECISIONS OF THE DEPARTMENT

Sl. No.	Item Description	Reference			As per Bidding Documents	Bidders' Comments / Queries	Employer's Clarification
		Bid Volume / Part	Page	Clause			
Bidder A							
1	Mode of invitation of Tender				Mode of invitation of Tender is Engineering, Procurement and Construction (EPC) Contract basis	Bidder requests to change the EPC mode to Ordinary Tender contract under two cover system.	Tender Condition shall prevail.
Bidder B							
2	Mode of invitation of Tender				Mode of invitation of Tender is Engineering, Procurement and Construction (EPC) Contract basis	Bidder requests to change the EPC mode to Ordinary Tender contract under two cover system.	Tender Condition shall prevail.
3	<u>Qualifying Requirements</u>	Volume I, NIT & Section 1	5 of 6 [NIT], 5 of 20 [Section I]	1.6(b)	QUALIFYING REQUIREMENTS To be eligible for Qualification, a Bidder shall fulfill the following Minimum Eligibility Criteria (MEC): (A) Technical Capacity (b) The Bidder should have experience in executing one Similar Work costing at least Rs.787.70 lakhs on EPC basis either for the projects qualified under (a) above or for any separate marine project.	Bidder requests to delete this clause	Accepted. Clause 1.6(b) of Section-I stands deleted. Also, Clause 11A(b) of NIT stands deleted.
Bidder C							
4	<u>Qualifying Requirements</u>	Volume I, NIT & Section 1	5 of 6 [NIT], 5 of 20 [Section I]	1.6(b)	QUALIFYING REQUIREMENTS To be eligible for Qualification, a Bidder shall fulfill the following Minimum Eligibility Criteria (MEC): (A) Technical Capacity (b) The Bidder should have experience in executing one Similar Work costing at least Rs.787.70 lakhs on EPC basis either for the projects qualified under (a) above or for any separate marine project.	Bidder requests to delete this clause	Accepted. Clause 1.6(b) of Section-I stands deleted. Also, Clause 11A(b) of NIT stands deleted.
5	Defects Notification Period	Volume I & III, NIT, Sections 8 & 9, GCC, Appendix To Tender	42 of 44 & 26 of 44	11.1 & 11.3	Clause 11.1 - Defects Notification Period - 12 months Clause 11.3 - Extension of Defects Notification Period - The Defects Notification Period shall be 24 months from the date of issuance of taking over certificate	Bidder requests to clarify the Defects Notification Period is 12 month or 24 months	Defects notification period is 12 months from the date of issuance of the taking over certificate and this provision will supersede other clauses on the same subject, wherever they are in variance
6	Time for Completion of Work	Volume I & III, NIT, Sections 8 & 9, GCC, Appendix To Tender	3 of 6 [NIT] & 42 of 44 [Sections 8 & 9]	1 [NIT] & 8.2 [Sections 8 & 9]	Time for Completion of Work is 12 months from the date of LOA	Considering complexity of EPC project and day to day issues related to Labour Unions in Cochin, Bidder request to allow Time for Completion at least 20 Months from date of LOA.	Time for completion is in order. Tender condition shall prevail.
7	Bank details				Not Mentioned	Bidder request to provide the Bank details (Bank Name, Branch, A/c No. and IFSC code etc.) of CochinPort Trust, as Bank details of beneficiary are necessary for obtaining the Bank Guarantee from bank for EMD or Bid Security as per the RBI new guidelines.	Bank Details are available in the CoPT web site under "GST Corner"

Sl. No.	Item Description	Reference			As per Bidding Documents	Bidders' Comments / Queries	Employer's Clarification
		Bid Volume / Part	Page	Clause			
Bidder D							
8	Soil Investigation Report	Vol IV, Section 11			Soil Investigation Report	Details of 2 bore holes are available. Bidder requests the details of 3rd borehole.	Updated Geotechnical Investigation Report is attached as Appendix - I
Bidder E							
9	Time for Completion of Work	Volume I, Section 1	19 of 20	1.34.5	The whole of the Works for the Project including essential Punch List items, if any, shall be completed within 12 months from the Date of LOA excluding Defects Liability Period for liquidation of all Punch List items.	Bidder request to clarify whether the entire design and construction shall be completed within this period or time may be given separately for doing design and getting approval.	Tender condition in this regard is self explanatory and the same shall prevail
10	Schedule of Payments	Volume I, Section 5	3 of 3	Table A	Table A - Schedule of Payment of Berth and Approach Trestle A1 - On completion of 20% of Piles and demolition of Berth and Piles at required portion at existing Berth – 12% A2 - On completion of 40% of Piles – 12% A3 - On completion of 60% of Piles – 12% A4 - On completion of 80% of Piles – 12% A5 - On completion of 1000% of Piles – 12% A6 – On completion of 50% area of Superstructure consisting of pile caps, beams, deck slab, screed, kerb, etc. – 10% A7 – On completion of the entire Superstructure – 10% A8 – On Installation of all jetty fixtures like fenders, bollards, ladder, etc. – 10% A9 – On handing over of the jetty after satisfactory completion of all works – 10% Total - 100%	Bidder requests to clarify whether the payment can be made on submission of running account bills on monthly basis or only after the scheduled completion as per tender.	The payment shall be released after stagewise completion, as given in Vol – 1, Schedule of Payments, Page. No .3 of 3 under Section 5 only. No other method of payments are acceptable.
11	Construction Facilities	Volume II, Section 6A	43 of 63	3	The entire Contractor's Site Compound (with 3 m high fencing) including Contractor's site offices, sanitary and first aid facilities, car parking, field laboratory, security facilities, and Employer's Field Offices and the like shall be confined within the area designated for the Contractor's site establishment as instructed by the Employer.	Bidder request to clarify whether the space for providing these facilities will be given free of cost or on chargeable basis.	During the tenure of the contract period including time allowed for clearing the site, the area designated for the Contractor's site establishment will be given free of cost, beyond this period, it will be chargeable as per the prevailing Scale of Rates.
Bidder F							
12	Soil Investigation Report	Vol IV, Section 11			Soil Investigation Report	Soil Parameters Soil data provides only bore log with N values. To make it common for all bidders, Bidder request to provide the following parameters in layer wise max. of five layers for pile design. a. Average N Value b. Bulk Density c. Angle of Shear Resistance d. Modulus of Elasticity of Soil e. Coefficient of active earth pressure f. Poisson's ratio of soil	Without prejudice to other related provisions in the Tender in this regard, the full and final report of the Updated Geotechnical Investigation Report is attached as Appendix - I , which shall be followed.
13	Berthing Load	Vol II, Section 7B	9 of 17	2.6.7	Table A.2 Parameters for calculation of Berthing Energy 11. Design Berthing Energy - 38 Tm	Calculated Berthing Energy as per vessel data is 75.68 T.M, which is double than the value mentioned in specification Table A.2 (38 T.M). Bidder request to clarify which value to be followed.	The berthing velocity has to be changed: instead of 0.15m/s to 0.1m/s in Section – 7B Table A-2 and calculated design berthing energy as 38T-m has to be followed.

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14	Bid Due Date	Vol II, NIT	1 & 3 of 6	1	Bid Due Date - 27-08-2020	As this tender EPC Basis, the given time is too short. To make a good design and competitive bid, Bidder request to kindly extend the bid submission date by one month till 27-09-2020.	The time duration given as per tender condition is sufficient. Hence tender conditions would prevail.

All other terms and conditions of tender remain unchanged

Sd/-
CHIEF ENGINEER

GEOTECHNICAL INVESTIGATION FOR RECONSTRUCTION OF SOUTH COAL BERTH AT COCHIN PORT TRUST, COCHIN

REPORT

Client
Cochin Port Trust

Consultant
Prof. S.A.Sannasiraj
Prof. K. Murali



NATIONAL
TECHNOLOGY
CENTRE
FOR PORTS
WATERWAYS
AND COASTS



National Technology Centre for Ports, Waterways and Coasts
Department of Ocean Engineering
Indian Institute of Technology Madras
Chennai – 600 036

AUGUST 2020

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1.0 INTRODUCTION

Cochin Port or Kochi Port is a major port on the Arabian Sea - Laccadive Sea – Indian Ocean sea-route in the city of Kochi and is one of the largest ports in India. The port lies on two islands in the Lake of Kochi: Willingdon Island and Vallarpadam, towards the Fort Kochi river mouth opening onto the Laccadive Sea. The International Container Transshipment Terminal (ICTT), part of the Cochin Port, is the largest container transshipment facility in India. The port is governed by the Cochin Port Trust (CPT), a government of India establishment. The modern port was established in 1926 and has completed 91 years of active service. The Kochi Port is one of a line of maritime-related facilities based in the port-city of Kochi. The others are the Cochin Shipyard, the largest shipbuilding as well as maintenance facility in India; the SPM (single point mooring) facility of the Kochi Refineries, an offshore crude carrier mooring facility; and the Kochi Marina. The aerial view of the Kochi Port is shown in Figure 1.1.

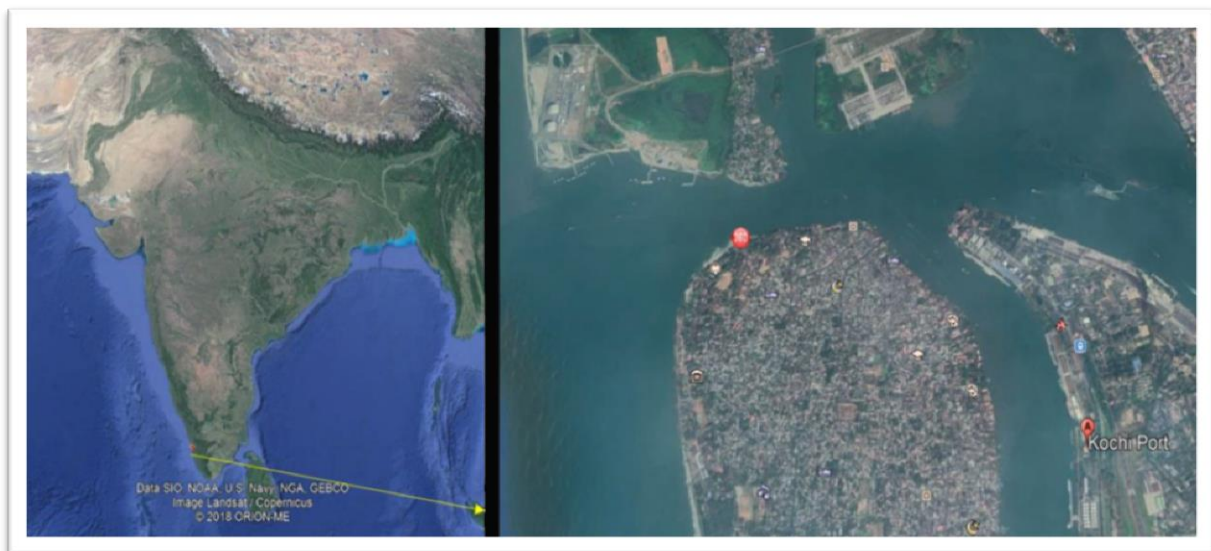


Figure 1.1 Ariel View of Cochin Port Trust

The main inward shipping channel of the port divides into the Ernakulam and Mattancherry channels. The Ernakulam Channel is 4.90 Km long, with the width varying from 250 to 500 m and has a draft of 12.5 m up to the Oil Terminal and Q8 / Q9 and a draft of 9.14 m up to the wharves and the north and south tanker berths. The 1024 m long Ernakulam Wharf has six alongside berths, five for general cargo and a fertilizer berth. Besides there are three oil berths in the Ernakulam channel. The Mattancherry channel is 4.08 Km long, with the width varying from 180 to 250 m and a draft of 9.14 m except at Boat Train Pier where the draft is

10.0 m. On the Mattancherry Channel there are four alongside berths, for general cargo, one Boat Train Pier and two jetties for miscellaneous cargo.

Cochin Port handles Chemical products like liquid Ammonia, Methanol and Ethylene Dichloride (EDC) at 2 berths viz. Q4 Berth and South Coal Berth (SCB). SCB was commissioned in the year 1953 and is in a dilapidated condition due to ageing and corrosion. A health check-up was conducted by NTCPWC, IITM and recommended, demolition and reconstruction of SCB to meet the durability and strength requirements. As SCB has already outlived its economic life, it is proposed to reconstruct the SCB with all ancillary structures. The proposed reconstructed SCB will cater all needs of handling Chemicals in Cochin Port Trust. In order to reconstruct the SCB, Geotechnical Investigation conducted with 3 marine boreholes along the jetty location up to a depth of (-) 70m CD or up to refusal.

2.0 SCOPE OF THE WORK

Geotechnical Investigation alongside the South Coal Berth in Cochin Port Trust, Cochin, Kerala are for identifying the sub bottom layers seabed, soil and rock types, determining the in-situ physical and mechanical properties of the materials and sampling of materials for laboratory tests to find out soil parameters as a part of structural design of the above berth.

3.0 DETAILS OF FIELD INVESTIGATION

3.1 Boring and Sampling

The drilling was advanced with the help of rotary drilling machine equipped with diesel engine and high-pressure water pump and other drilling accessories, rods, core barrels, etc., The drilling was conducted as per relevant IS Specifications.

3.2 Disturbed and Undisturbed Sample

Disturbed and Undisturbed soil samples were obtained depending upon the nature of soil from different depths in the bore hole. The Undisturbed samples were collected in sampling tubes. The ends of the tubes are sealed with molten wax to prevent evaporation. These samples were subsequently tested in the laboratory so as to determine the various index and engineering proportion of various sub soil strata met in the bore holes.

3.3 Standard Penetration Test

Standard Penetration Test (SPT) was performed in the borehole. The standard split spoon sampler, attached to a string of drill rods was lowered to the bottom of the hole and allowed

to rest under self-weight. The drill rods were connected to driving assembly which consisted of hosting equipment's, a drive weight of 63.5kg, and a guide to ensure a 75cm free fall of hammer on an anvil. The number of hammer blows that were required to penetrate the sampler through three runs of 150mm each was recorded. Initial driving of 150mm was disregarded and the number of blows required to drive the sampler through the remaining 300mm is called blow count or penetration number (N). At the end of the test, the sampler was withdrawn and the soil extracted for subsequent testing in the laboratory. If the penetration was less than 30cm for 50 blows, it is considered as refusal and the actual penetration was recorded.

4.0 GEOTECHNICAL INVESTIGATION

The borehole investigation has been done in 3 locations as shown in figure 4.1. The sub soil strata as per the bore-log at berth locations based on three number of bore holes. The bore holes were drilled up to -70 m depth.



Figure 4.1 Locations of Boreholes at South Coal Berth

Table 4.1 Co-ordinates of Boreholes

Sl. No	Description	Easting	Northing	UTM Zone
1.	Bore Hole – 1	638839.75	1100689.41	43P
2.	Bore Hole – 2	638840.18	1100664.64	43P
3.	Bore Hole – 3	638844.46	1100634.25	43P

In almost all bore holes shows that the soil up to -6 m very loose silty clay with sea shells with N value of 1. From (-) 6m to (-) 16.5m the layer consist of blackish silty clay with N values of 13. From (-) 16.5m to (-) 25.5m the layer consist of grayish silty clay with fine particles of whitish yellow colour with N values of 35. From (-) 25.5m to (-) 28.5m the layer consist of silty clay in whitish grey colour with N values of 69. From (-) 28.5m to (-) 36m the layer consist of grayish silty clay with shells and kankar with N values of 55. From (-) 36m to (-) 51m the layer consist of blackish silty clay with N values of 59. From (-) 51m to (-) 58.5m the layer consist of blackish silty clay with N values of 92. From (-) 58.5m to (-) 70m the layer consist of blackish silty clay with decayed coal particles with N values of 100.

Table 4.2 Soil Profile

Depth below E G.L (m)	Soil Profile Encountered
ESBL to 6.0	Very loose silty clay with sea shells
6.0 to 16.5	Blackish silty clay with sea shells
16.5 to 22.5	Grayish silty clay with fine particles of whitish yellow colour
22.5 to 25.5	Grayish silty clay with fine particles of whitish yellow colour
25.5 to 28.5	Silty clay in whitist grey colour
28.25 to 33.0	Grayish silty clay with shells and kankar
33.0 to 36.0	Silty clay in greenish gray colour
36.0 to 45.0	Blackish silty clay
45.0 to 46.5	Blackish silty clay with decayed coal particles

Depth below E G.L (m)	Soil Profile Encountered
46.5 to 51.0	Blackish silty clay with decayed coal particles
51.0 to 58.5	Grayish silty clay with mica
58.5 to 61.5	Blackish sandy silty clay with mica
61.5 to 64.5	Blackish silty clay with decayed coal particles
64.5 to 70.0	

5.0 RECOMMENDATION

Based on the physical observation from three bore holes, it is observed that N – Value is greater than 70 from (-) 25.50m to (-) 31.50m. Tentative founding level of pile may be fixed beyond (-) 31.50m and further it can be finalized based on detailed analysis during design stage.

The detailed Report containing bore log data and laboratory test result is annexed.



[Prof. S. A. Sannasiraj]

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REPORT



Client
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Consultant
Prof. S.A.Sannasiraj
Prof. K. Murali

Service Provider
Water Forefront Engineering Infrastructures Pvt Ltd.,



NATIONAL
TECHNOLOGY
CENTRE
FOR PORTS
WATERWAYS
AND COASTS



National Technology Centre for Ports, Waterways and Coasts
Department of Ocean Engineering
Indian Institute of Technology Madras
Chennai – 600 036

DISCLAIMER

The authors of this report are in no way responsible for the behavior of materials used by contractors or the drawbacks that may occur in the assessed structure with time, and depending on the environment to which the structure may be exposed, and also safety of men and public at large, who use the structure. This report containing assessment of portions of the Marine soil test conducted from the Seabed level to 70m depth alongside of existing South Coal Berth at Cochin Port Trust, Cochin, Kerala.



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Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL



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1.0 INTRODUCTION

1.1 General

M/s National Technology Centre for Ports Waterways and Coasts (NTCPWC), Department of Ocean Engineering, Indian Institute of Technology Madras intended to identify the properties of soil underneath the existing ground level to a depth of 70m alongside of the existing South Coal Berth at Cochin Port Trust, Cochin, Kerala. In this regard tender has been called and awarded to M/s Waterforefront Engineering Infrastructure Pvt Ltd., to take up the Geotechnical Investigation at the specified locations towards lee-side of the existing South Coal Berth vide work order no: OE/NTCPWC/8117/2020/1694/SPLX/126. M/s Water Forefront Engineering Infrastructure Pvt Ltd., carried out the geotechnical investigation for the aforesaid project and the details of the investigation are furnished in this report.

2.0 PURPOSE OF INVESTIGATION

It has been proposed to conduct the Marine Soil Investigation to construct a berth adjacent to existing south coal berth at Cochin Port Trust, Cochin, Kerala. For the construction of any structure, a detailed soil investigation is essential for collecting the relevant data required for preparing the design. The sub surface investigation reveals the presence and the extent of soil and rock stratum in the region likely to be affected by the proposed work and determines the nature of each stratum and engineering properties of soil which may affect the design. The data collected provide reliable, specific and detailed information to facilitate a safe and economic design of the proposed structure. These details were only used for estimating the preliminary foundation size and type of foundation.

3.0 ABBREVIATIONS

The following abbreviations may be found in this document

- MBH – Marine Bore Holes
- SPT – Standard Penetration Test
- UDS – Undisturbed Sample
- DS – Disturbed Sample
- WS – Washed Sample
- CD – Chart Datum



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MSL – Mean Sea Level

ESBL – Existing Sea Bed Level

UTM – Universal Transverse Mercator

4.0 SCOPE OF WORK

- Conducting Geo-Technical Investigation up to a depth of 70m below the existing sea-bed level.
- Conducting laboratory tests on the samples collected and thereby determining various index and engineering properties and summarising the details of soil classification.

To accomplish the above, the following parameters were taken.

- a) Bore logs were drilled to up to 70.00m from the existing seabed level, for laboratory testing for assessing the engineering properties.
- b) Soil Investigation and Soil Analysis Properties were analysed to develop the foundation design information for the proposed building foundation.

5.0 SCOPE AND DEPTH OF EXPLORATION

It is determined to conduct the field and laboratory test to assess the safe bearing capacity till reaching N Value of the soil present in the proposed site. Boring locations are presented in the report. Bore drill was terminated at 70.00 m depth below seabed after reaching N Value more than 100.

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6.0 LOCATION

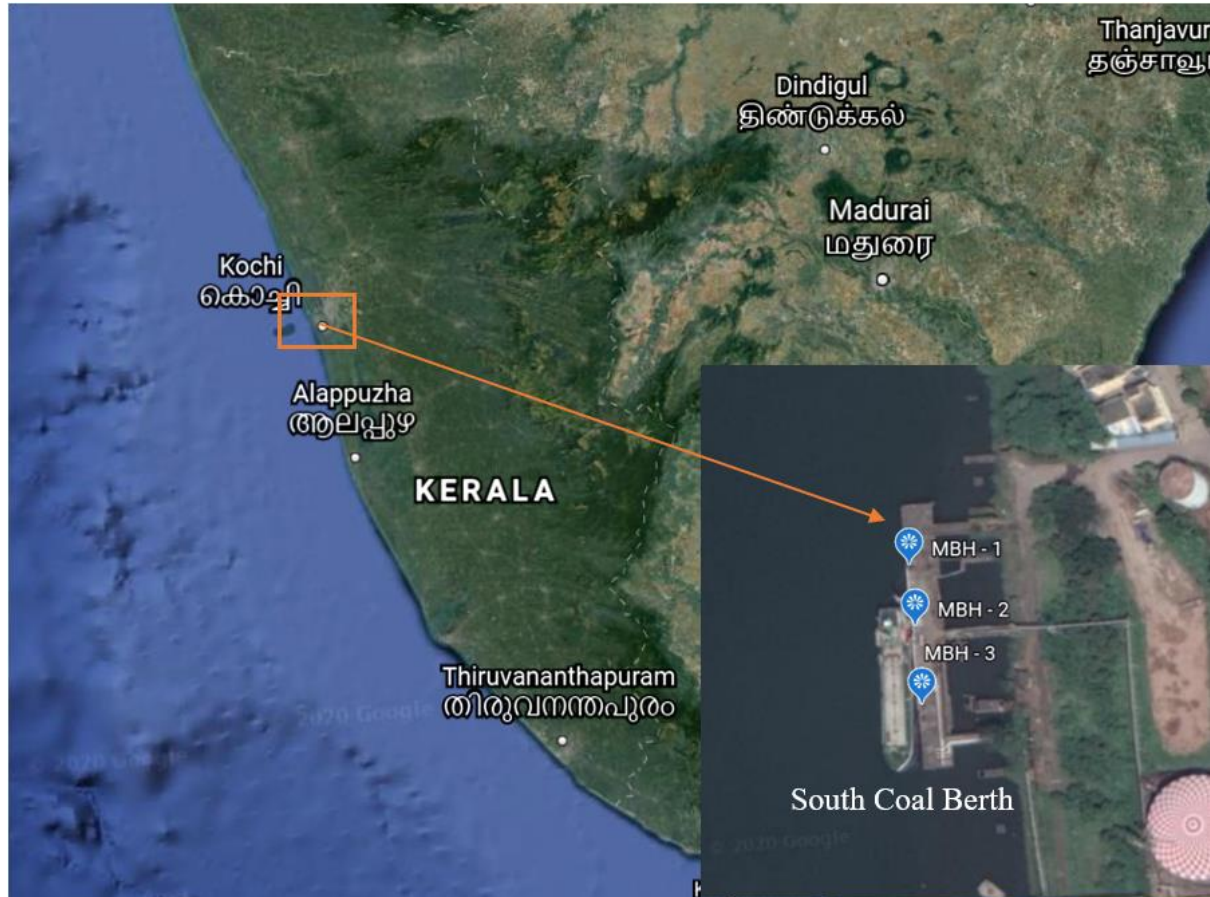


Figure 1 Map showing the marine borehole locations at South Coal Berth

Table 1 Co-ordinates of Marine Boreholes

Sl. No	Description	Easting	Northing	UTM Zone
1.	MBH - 1	638839.75	1100689.41	43P
2.	MBH - 2	638840.18	1100664.64	43P
3.	MBH - 3	638844.46	1100634.25	43P

7.0 EQUIPMENTS USED

1. Rotary Drilling Rig – 01 No
2. Power winch – 01 No
3. Drilling tools – 01 No
4. SPT Sampler – 01 No
5. SPT Hammer – 01 No



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6. Single tube core barrels – 01 No

7. UDS Sampler – 01 No

8.0 DETAILS OF FIELD AND LABORATORY INVESTIGATION

8.1 Boring and Sampling

Boreholes were drilled using Rotary drilling Unit of dia.150mm for making bore holes duly circulating bentonite slurry. In this method, the advancement of boring is made by the cutting action of a rotating bit that is kept in firm contact with the bottom of the hole. SPT consists of driving a standard Split Spoon Sampler, 51 mm outside diameter and 38-mm inside diameter into soil under the blows of a drop hammer of 63.5 kg falling weight freely through 75-cm. The number of Blows required for 30 cm penetration of sampler in soil is designated as N value and it is termed as SPT blow count.

The bit is attached to the lower end of hollow drill rod, which is rotated by a suitable chuck. Drilling mud, (viz) bentonite is continuously forced down the hollow drill rods. The mud returning upward through the annular space between the drill rods and side of the hole brings the soil particles to the surface. The soil exploration consists of three stages i.e., boring, sampling and testing which includes both field and lab tests. The Samples were collected at every 1.50 m depth of the bore hole. Samples were properly labelled for lab tests.

The drilling was conducted as per relevant IS Specifications (IS 2131-1980).

8.2 Disturbed and Undisturbed Sample

Disturbed and Undisturbed soil samples were obtained depending upon the nature of soil from different depths in the bore hole. The Undisturbed samples were collected in sampling tubes at 9.50m and 15.50m on each borehole. The ends of the tubes are sealed with molten wax to prevent evaporation. These samples were subsequently tested in the laboratory so as to determine the various index and engineering proportion of various sub soil strata met in the bore holes.

8.3 Standard Penetration Test

Standard Penetration Test (SPT) was performed in the borehole IS 2131-1981 (RA: 2007). The standard split spoon sampler, attached to a string of drill rods was lowered to the bottom

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of the hole and allowed to rest under self-weight. The drill rods were connected to driving assembly which consisted of a hosting equipment's, a drive weight of 63.5kg, and a guide to ensure a 75cm free fall of hammer on an anvil. The number of hammer blows that were required to penetrate the sampler through three runs of 150mm each were recorded. Initial driving of 150mm was disregarded and the number of blows required to drive the sampler through the remaining 300mm is called blow count or penetration number (N). At the end of the test, the sampler was withdrawn and the soil extracted for subsequent testing in the laboratory. If the penetration was less than 30cm for 50 blows, it is considered as refusal and the actual penetration was recorded.

8.4 Laboratory Test

The samples collected at the field were subjected to laboratory tests to determine the Natural Moisture Content, Particle size analysis and Bulk density/Specific gravity etc. The test results are tabulated in this report.

9.0 SOIL PROFILE

Table 2 Soil Profile

MBH - 1, MBH - 2, MBH - 3	
Depth below E G.L (m)	Soil Profile Encountered
ESBL to 6.0	Very loose silty clay with sea shells
6.0 to 16.5	Blackish silty clay with sea shells
16.5 to 22.5	Grayish silty clay with fine particles of whitish yellow colour
22.5 to 25.5	Grayish silty clay with fine particles of whitish yellow colour
25.5 to 28.5	Silty clay in whitist grey colour
28.25 to 33.0	Grayish silty clay with shells and kankar
33.0 to 36.0	Silty clay in greenish gray colour



Client	Cochin Port Trust, Cochin	Date	05/08/2020
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36.0 to 45.0	Blackish silty clay
45.0 to 46.5	Blackish silty clay with decayed coal particles
46.5 to 51.0	Blackish silty clay with decayed coal particles
51.0 to 58.5	Grayish silty clay with mica
58.5 to 61.5	Blackish sandy silty clay with mica
61.5 to 64.5	Blackish silty clay with decayed coal particles
64.5 to 70.0	



Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

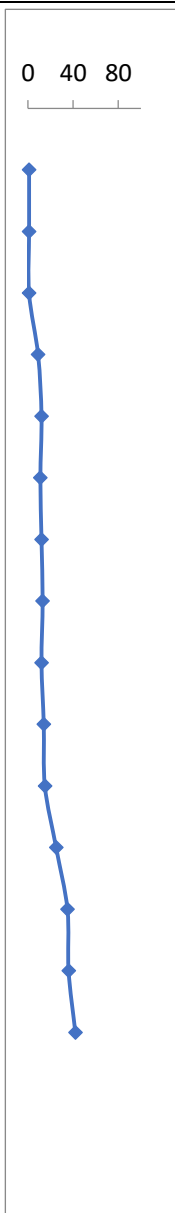


Laboratory Test Results and Bore log Details

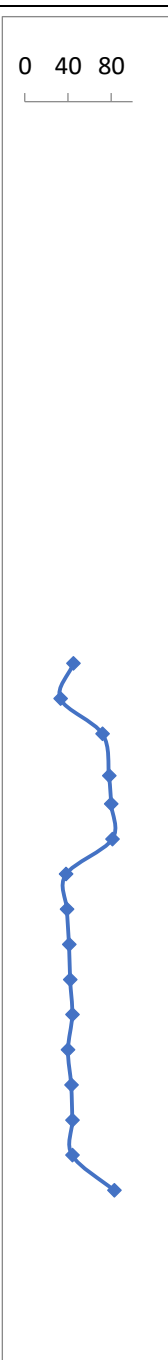
Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

10.0 BORELOG DATA

Table 3 Bore log data of Marine Bore Hole – 1


MARINE SOIL BORE LOG 1							
Drilling method		Rotary Drilling					GWL
Diameter of Bore		150 mm					Top Level
Depth below G.L (m)	Soil Profile	Sample type SPT/UDS	SPT Details			“N” Value	Graphical representation of penetration resistance
			15	30	45		
0m to 1.50m	Very loose silty clay with sea shells	1.50m	1	0	1	1	
1.50m to 3.00m		3.00m	1	0	1	1	
3.00m to 4.50m		4.50m	1	1	0	1	
4.50m to 6.00m		6.00m	2	4	5	9	
6.00m to 7.50m	Blackish silty clay with sea shells	7.50m	2	5	7	12	
7.50m to 9.00m		9.00m	2	4	7	11	
9.00m to 10.50m		10.50m	3	5	7	12	
10.50m to 12.00m		12.00m	3	6	7	13	
12.00m to 13.50m		13.50m	3	5	7	12	
13.50m to 15.00m		15.00m	3	6	8	14	
15.00m to 16.50m	Grayish silty clay with fine particles of whitish yellow colour	16.50m	5	6	9	15	
16.50m to 18.00m		18.00m	6	10	15	25	
18.00m to 19.50m		19.50m	9	15	20	35	
19.50m to 21.00m		21.00m	10	15	21	36	
21.00m to 22.50m	22.50m	13	18	24	42		

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

MARINE SOIL BORE LOG 1							
Drilling method		Rotary Drilling					GWL
Diameter of Bore		150 mm					Top Level
Depth below G.L (m)	Soil Profile	Sample type SPT/UDS	SPT Details			“N” Value	Graphical representation of penetration resistance
			15	30	45		
22.50m to 24.00m	Grayish silty clay with fine particles of whitish yellow colour	24.00m	15	20	25	45	
24.00m to 25.50m		25.50m	9	15	18	33	
25.50m to 27.00m	Silty clay in whitish grey colour	27.00m	18	31	41	72	
27.00m to 28.50m		28.50m	20	33	45	78	
28.50m to 30.00m	Grayish silty clay with shells and kankar	30.00m	22	35	45	80	
30.00m to 31.50m		31.50m	23	35	46	81	
31.50m to 33.00m		33.00m	15	18	20	38	
33.00m to 34.50m	Silty clay in greenish gray colour	34.50m	16	18	21	39	
34.50m to 36.00m		36.00m	16	19	22	41	
36.00m to 37.50m	Blackish silty clay	37.50m	10	18	24	42	
37.50m to 39.00m		39.00m	12	19	25	44	
39.00m to 40.50m		40.50m	12	17	23	40	
40.50m to 42.00m		42.00m	14	18	25	43	
42.00m to 43.50m		43.50m	15	18	26	44	
43.50m to 45.00m		45.00m	15	19	25	44	
45.00m to 46.50m	Blackish silty clay with decayed coal particles	46.50m	27	35	48	83	

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

MARINE SOIL BORE LOG 1

Drilling method		Rotary Drilling					GWL
Diameter of Bore		150 mm					Top Level
Depth below G.L (m)	Soil Profile	Sample type SPT/UDS	SPT Details			“N” Value	Graphical representation of penetration resistance
			15	30	45		
46.50m to 48.00m	Blackish silty clay with decayed coal particles	48.00m	30	38	50	88	 <p>0 40 80 120</p>
48.00m to 49.50m		49.50m	48	>100	>100	>100	
49.50m to 51.00m		51.00m	50	>100	>100	>100	
51.00m to 52.50m	Grayish silty clay with mica	52.50m	17	30	43	73	
52.50m to 54.00m		54.00m	19	31	45	76	
54.00m to 55.50m		55.50m	37	48	>52 for 14cm	>100	
55.50m to 57.00m		57.00m	39	50	>50 for 13cm	>100	
57.00m to 58.50m		58.50m	12	30	36	66	
58.50m to 60.00m	Blackish sandy silty clay with mica	60.00m	14	32	37	69	
60.00m to 61.50m		61.50m	21	60	>40 for 5cm	>100	
61.50m to 63.00m	Blackish silty clay with decayed coal particles	63.00m	22	62	>38 for 5cm	>100	
63.00m to 64.50m		64.50m	22	60	>40 for 5cm	>100	
64.50m to 66.00m		66.00m	23	63	>37 for 5cm	>100	
66.00m to 67.50m		67.50m	22	64	>36 for 4cm	>100	
67.50m to 70.00m		70.00m	23	65	>35 for 4cm	>100	

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

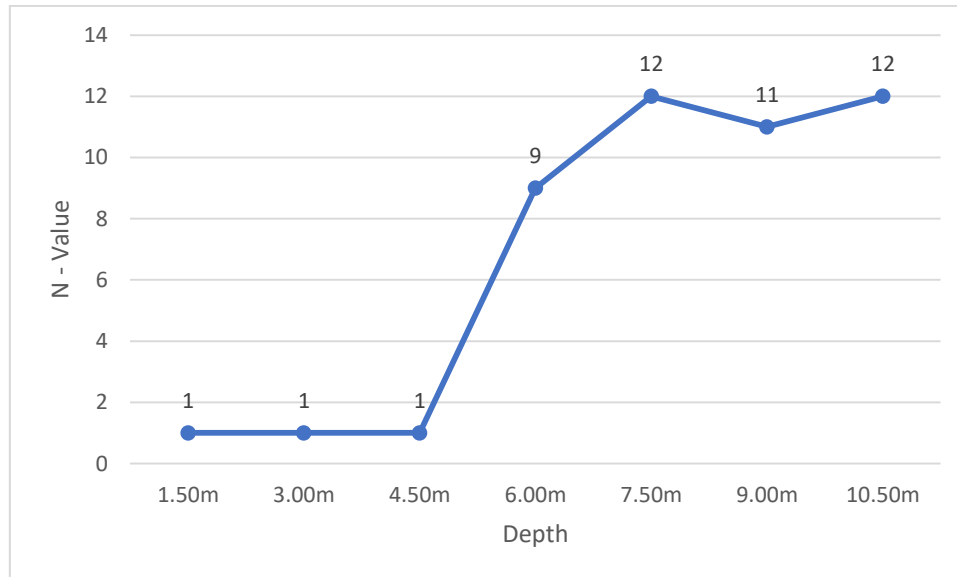


Figure 2 Depth vs N Value for MBH – 1 (0.00m to 10.50m)

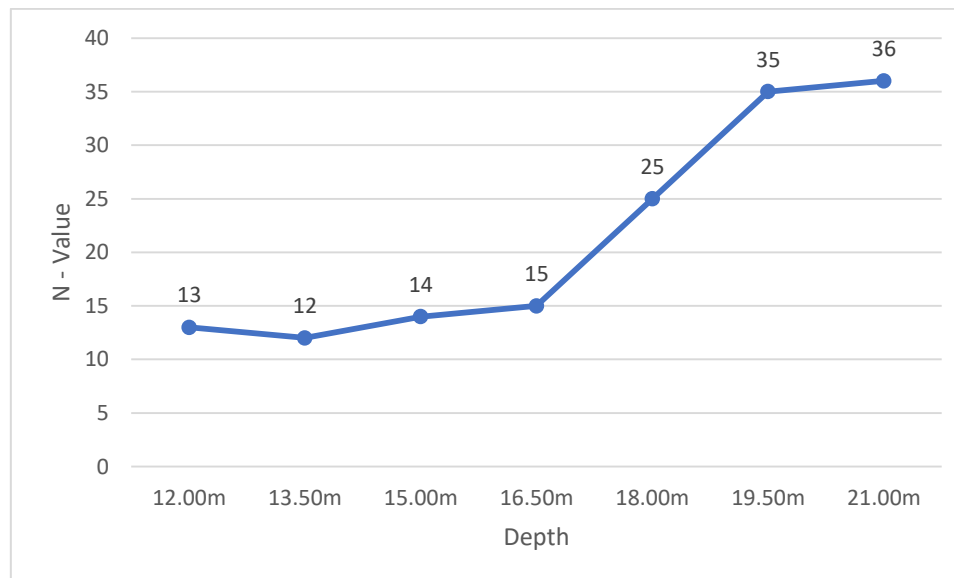


Figure 3 Depth vs N Value for MBH – 1 (12.00m to 21.00m)

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

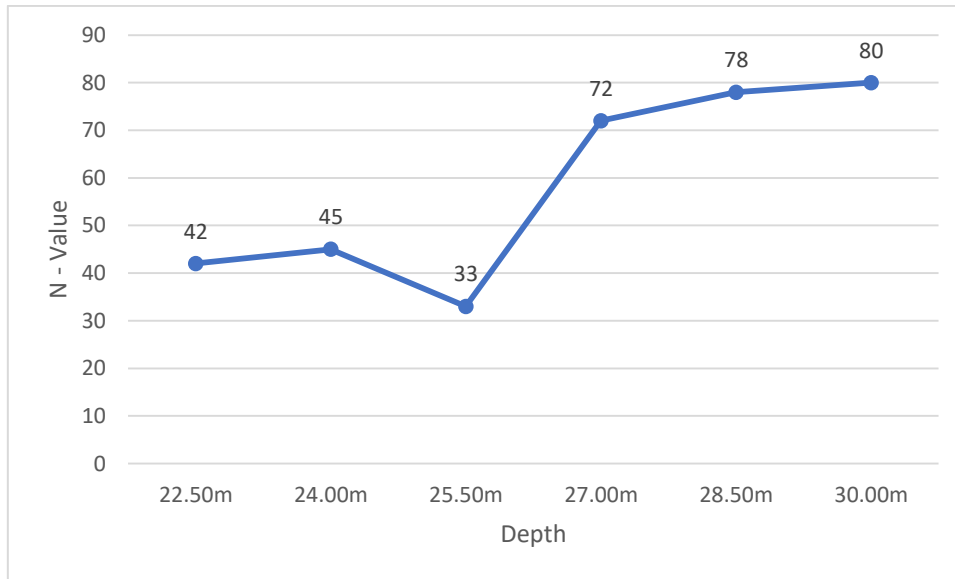


Figure 4 Depth vs N Value for MBH – 1 (22.50m to 30.00m)

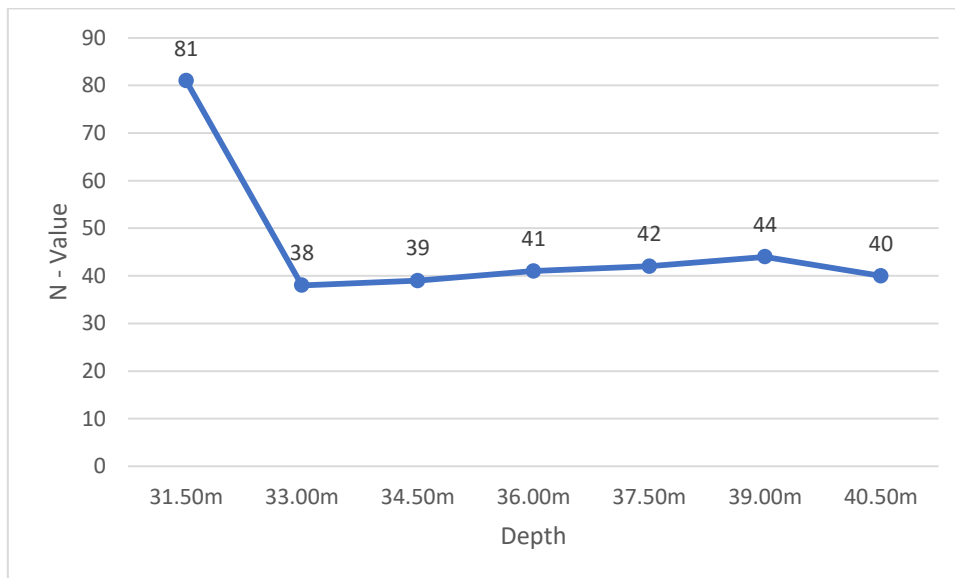


Figure 5 Depth vs N Value for MBH – 1 (31.50m to 40.50m)

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

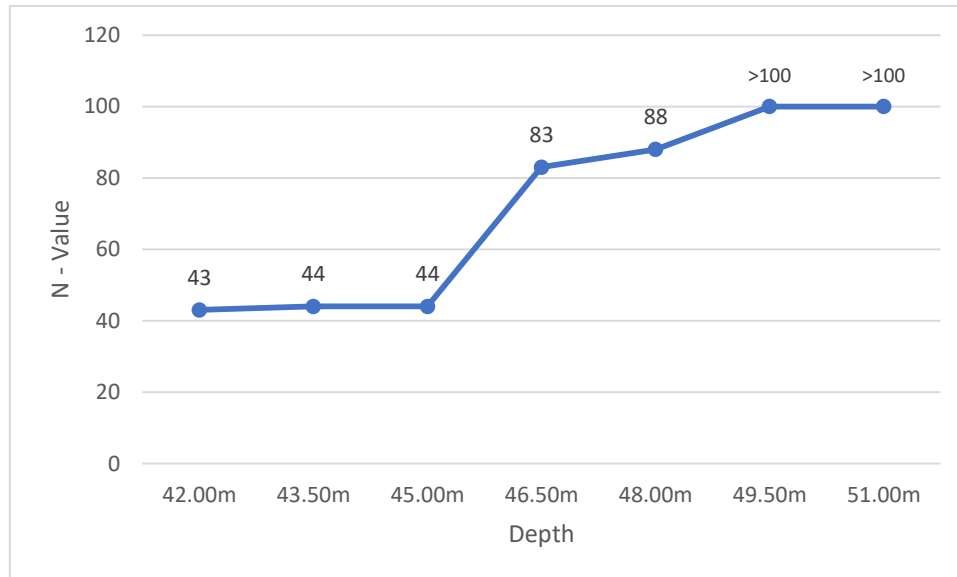


Figure 6 Depth vs N Value for MBH – 1 (42.00m to 51.00m)

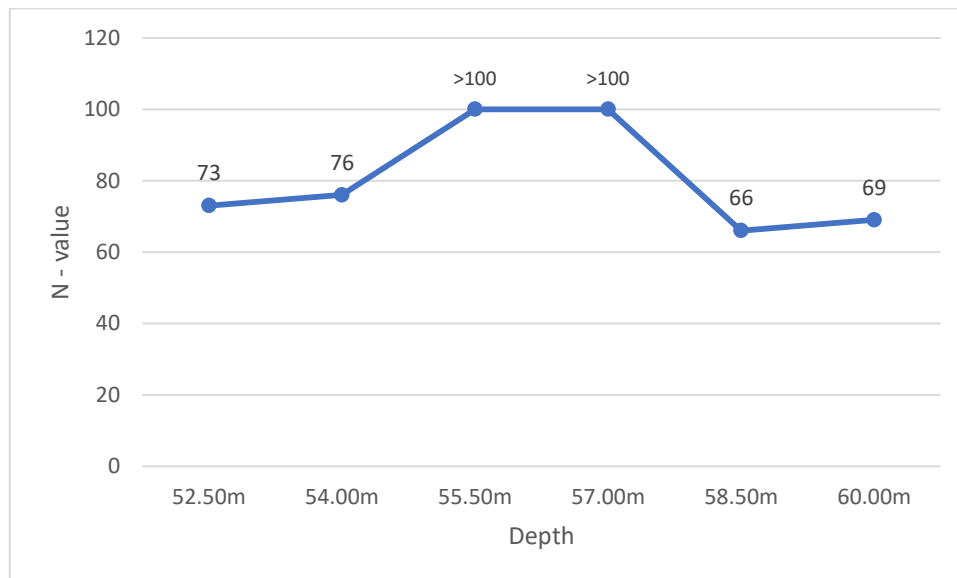


Figure 7 Depth vs N Value for MBH – 1 (52.50m to 60.00m)

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

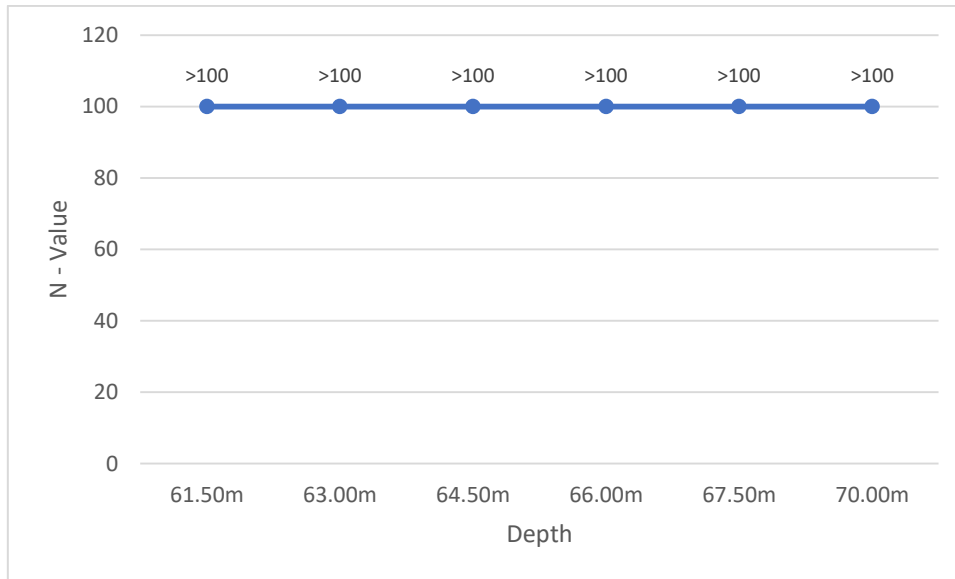
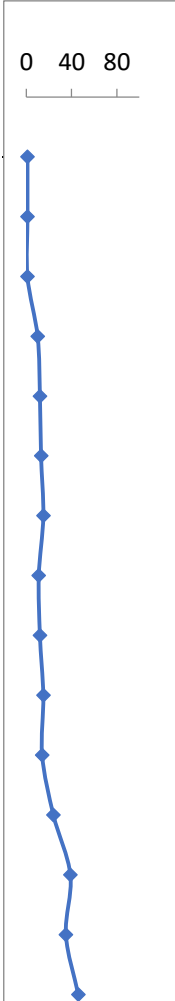


Figure 8 Depth vs N Value for MBH – 1 (61.50m to 70.00m)

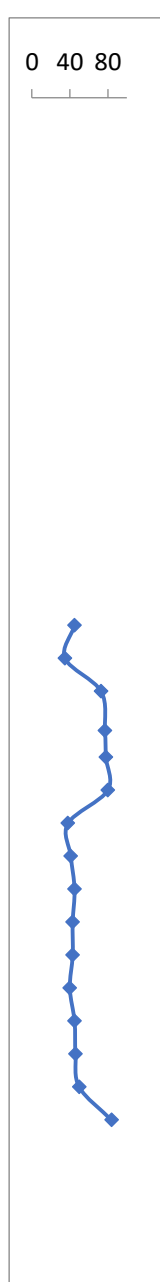
Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

Table 4 Bore log data of Marine Bore Hole – 2

MARINE SOIL BORE LOG 2							
Drilling method		Rotary Drilling					GWL
Diameter of Bore		150 mm					Top Level
Depth below E G.L (m)	Soil Profile	Sample type SPT/UDS	SPT Details			“N” Value	Graphical representation of penetration resistance
			15	30	45		
0m to 1.50m	Very loose silty clay with sea shells	1.50m	1	1	0	1	
1.50m to 3.00m		3.00m	1	0	1	1	
3.00m to 4.50m		4.50m	1	1	0	1	
4.50m to 6.00m		6.00m	3	4	6	10	
6.00m to 7.50m	Blackish silty clay with sea shells	7.50m	2	6	6	12	
7.50m to 9.00m		9.00m	3	5	8	13	
9.00m to 10.50m		10.50m	4	7	8	15	
10.50m to 12.00m		12.00m	3	6	5	11	
12.00m to 13.50m		13.50m	4	7	5	12	
13.50m to 15.00m		15.00m	4	7	8	15	
15.00m to 16.50m	16.50m	5	8	6	14		
16.50m to 18.00m	Grayish silty clay with fine particles of whitish yellow colour	18.00m	7	11	13	24	
18.00m to 19.50m		19.50m	8	17	22	39	
19.50m to 21.00m		21.00m	9	16	19	35	
21.00m to 22.50m		22.50m	10	20	26	46	


Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

MARINE SOIL BORE LOG 2

Drilling method		Rotary Drilling					GWL
Diameter of Bore		150 mm					Top Level
Depth below G.L (m)	Soil Profile	Sample type SPT/UDS	SPT Details			"N" Value	Graphical representation of penetration resistance
			15	30	45		
22.50m to 24.00m	Grayish silty clay with fine particles of whitish yellow colour	24.00m	14	22	23	45	
24.00m to 25.50m		25.50m	10	17	18	35	
25.50m to 27.00m	Silty clay in whitist grey colour	27.00m	16	30	43	73	
27.00m to 28.50m		28.50m	19	35	42	77	
28.50m to 30.00m	Grayish silty clay with shells and kankar	30.00m	21	37	41	78	
30.00m to 31.50m		31.50m	27	33	47	80	
31.50m to 33.00m		33.00m	19	17	21	38	
33.00m to 34.50m	Silty clay in greenish gray colour	34.50m	17	16	25	41	
34.50m to 36.00m		36.00m	19	20	25	45	
36.00m to 37.50m	Blackish silty clay	37.50m	13	19	24	43	
37.50m to 39.00m		39.00m	14	21	22	43	
39.00m to 40.50m		40.50m	14	19	21	40	
40.50m to 42.00m		42.00m	16	16	29	45	
42.00m to 43.50m		43.50m	13	17	29	46	
43.50m to 45.00m		45.00m	14	23	27	50	
45.00m to 46.50m	Blackish silty clay with decayed coal particles	46.50m	28	37	47	84	

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

MARINE SOIL BORE LOG 2

Drilling method		Rotary Drilling					GWL
Diameter of Bore		150 mm					Top Level
Depth below G.L (m)	Soil Profile	Sample type SPT/UDS	SPT Details			"N" Value	Graphical representation of penetration resistance
			15	30	45		
46.50m to 48.00m	Blackish silty clay with decayed coal particles	48.00m	32	35	52	87	
48.00m to 49.50m		49.50m	49	>100	>100 for 10cm	>100	
49.50m to 51.00m		51.00m	52	>100	>100	>100	
51.00m to 52.50m	Grayish silty clay with mica	52.50m	16	>100	>100 for 12cm	>100	
52.50m to 54.00m		54.00m	21	35	49	84	
54.00m to 55.50m		55.50m	34	48	>49 for 13cm	>100	
55.50m to 57.00m		57.00m	42	50	>46 for 15cm	>100	
57.00m to 58.50m		58.50m	15	35	32	67	
58.50m to 60.00m	Blackish sandy silty clay with mica	60.00m	13	32	37	69	
60.00m to 61.50m		61.50m	27	60	>38 for 7cm	>100	
61.50m to 63.00m	Blackish silty clay with decayed coal particles	63.00m	31	62	>42 for 6cm	>100	
63.00m to 64.50m		64.50m	35	60	>45 for 7cm	>100	
64.50m to 66.00m		66.00m	34	63	>45 for 4cm	>100	
66.00m to 67.50m		67.50m	38	64	>42 for 6cm	>100	
67.50m to 70.00m		70.00m	43	65	>46 for 8cm	>100	

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

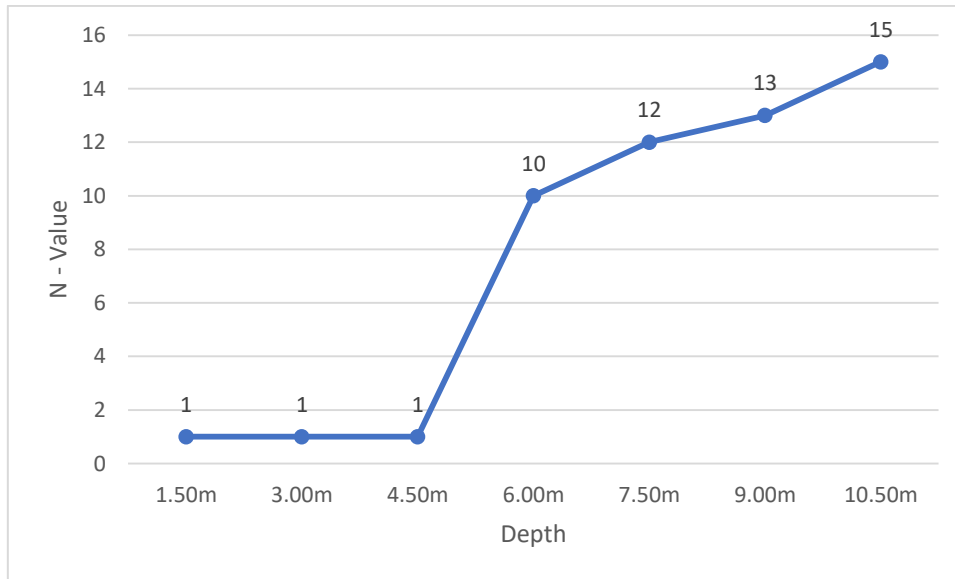


Figure 9 Depth vs N Value for MBH –2 (0.00m to 10.50m)

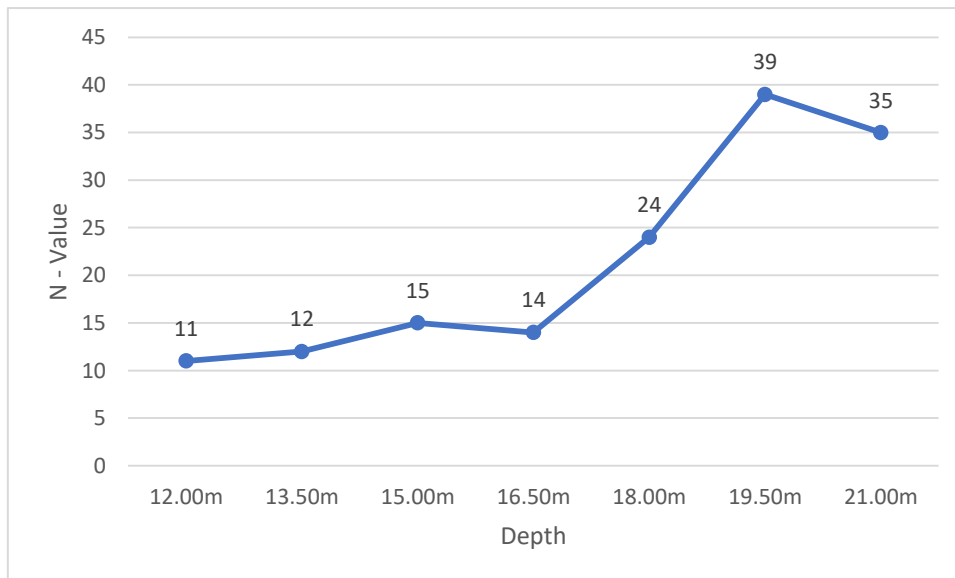


Figure 10 Depth vs N Value for MBH – 2 (12.00m to 21.00m)

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

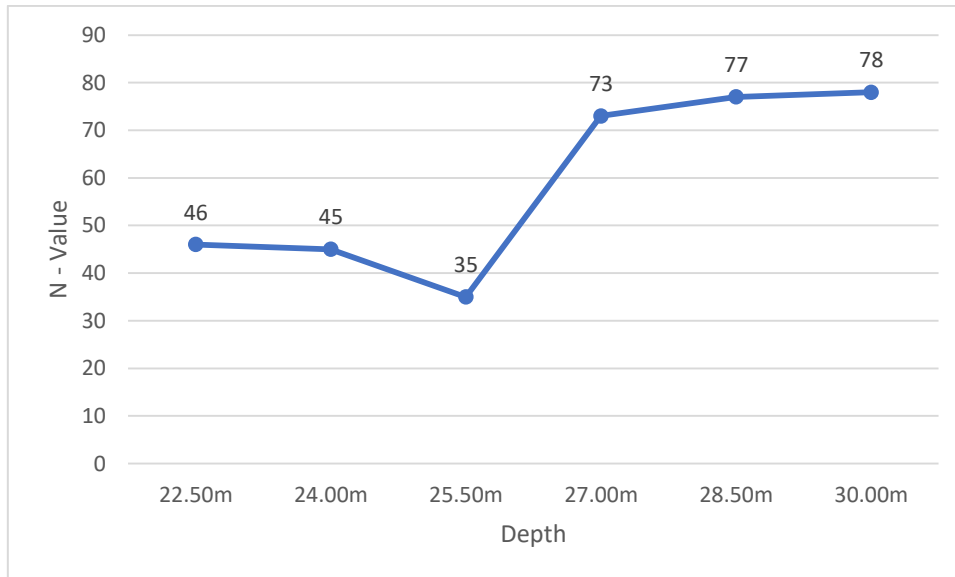


Figure 11 Depth vs N Value for MBH – 2 (22.50m to 30.00m)

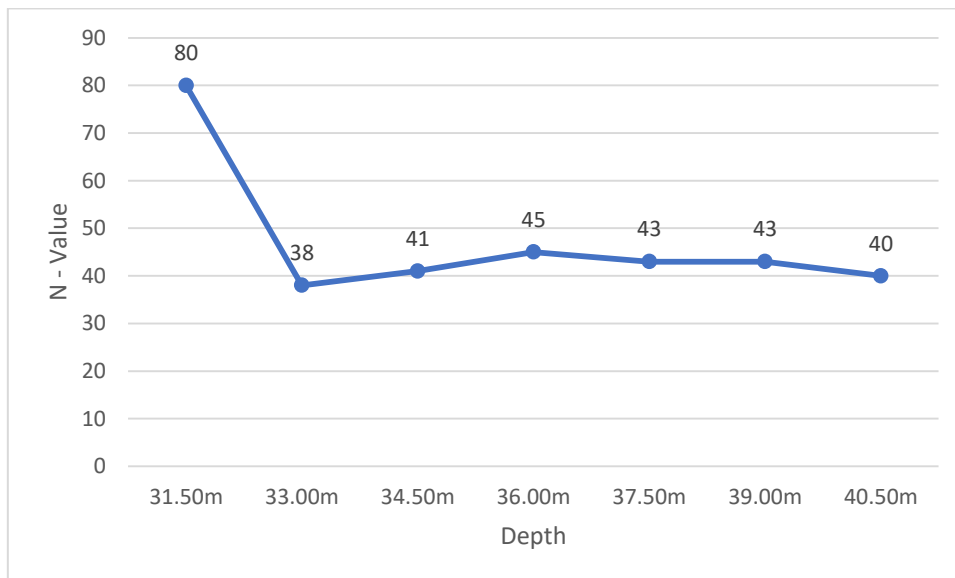


Figure 12 Depth vs N Value for MBH – 2 (31.50m to 40.50m)

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

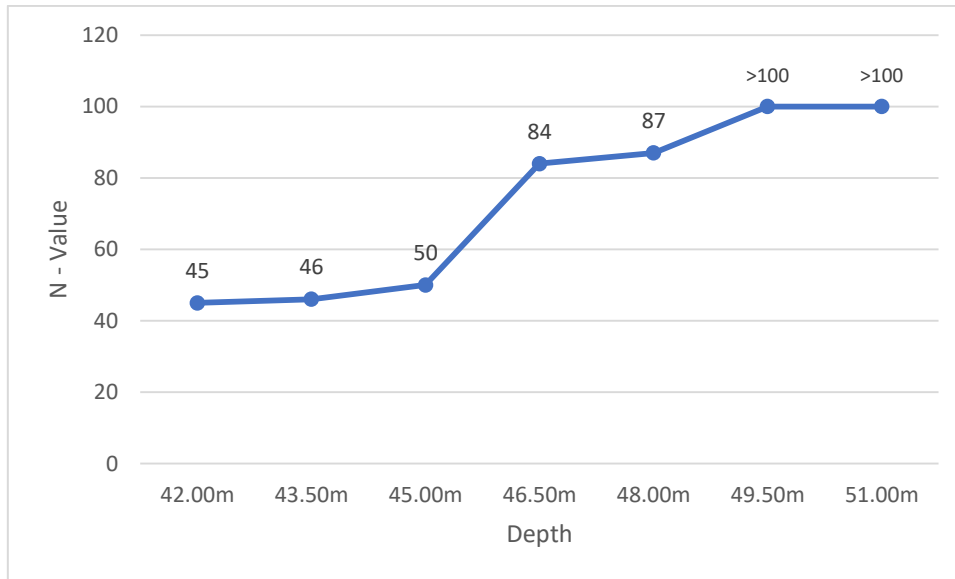


Figure 13 Depth vs N Value for MBH – 2 (42.00m to 51.00m)

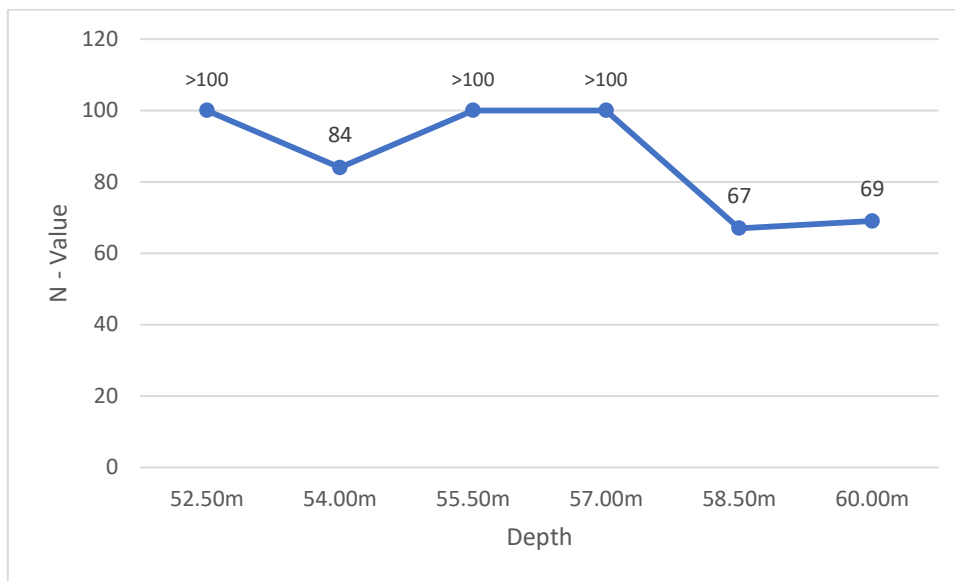


Figure 14 Depth vs N Value for MBH – 2 (52.50m to 60.00m)

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

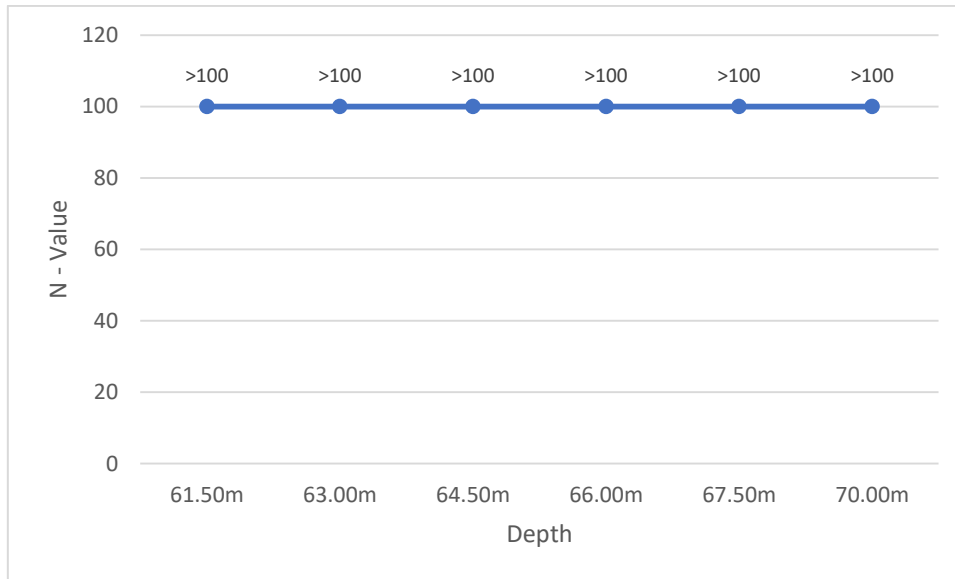
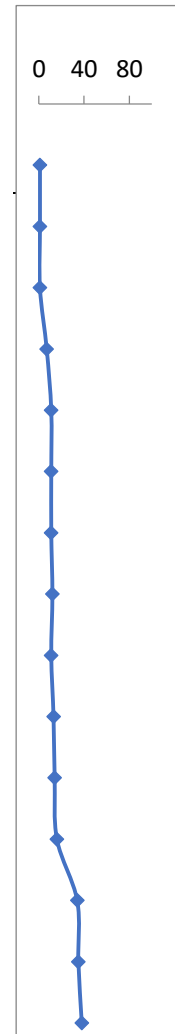


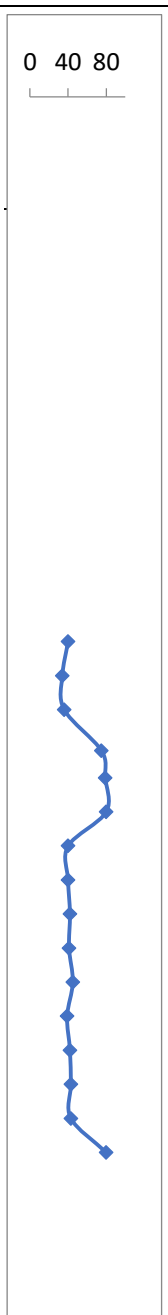
Figure 15 Depth vs N Value for MBH – 2 (61.50m to 70.00m)

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

Table 5 Bore log data of Marine Bore Hole – 3


MARINE SOIL BORE LOG 3							
Drilling method		Rotary Drilling					GWL
Diameter of Bore		150 mm					Top Level
Depth below G.L (m)	Soil Profile	Sample type SPT/UDS	SPT Details			“N” Value	Graphical representation of penetration resistance
			15	30	45		
0m to 1.50m	Very loose silty clay with sea shells	1.50m	1	0	1	1	
1.50m to 3.00m		3.00m	1	0	1	1	
3.00m to 4.50m		4.50m	1	1	0	1	
4.50m to 6.00m		6.00m	1	3	4	7	
6.00m to 7.50m	Blackish silty clay with sea shells	7.50m	2	4	7	11	
7.50m to 9.00m		9.00m	2	4	7	11	
9.00m to 10.50m		10.50m	3	5	6	11	
10.50m to 12.00m		12.00m	3	6	6	12	
12.00m to 13.50m		13.50m	3	5	6	11	
13.50m to 15.00m		15.00m	3	6	7	13	
15.00m to 16.50m		16.50m	4	6	8	14	
16.50m to 18.00m	Greyish silty clay with sea shells	18.00m	5	7	9	16	
18.00m to 19.50m	Greyish silty clay with fine particles of whitish yellow colour	19.50m	8	15	19	34	
19.50m to 21.00m		21.00m	9	15	20	35	
21.00m to 22.50m		22.50m	11	16	22	38	

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

MARINE SOIL BORE LOG 3							
Drilling method		Rotary Drilling					GWL
Dia of Bore		150 mm					Top Level
Depth below G.L (m)	Soil Profile	Sample type SPT/UDS	SPT Details			"N" Value	Graphical representation of penetration resistance
			15	30	45		
22.50m to 24.00m	Grayish silty clay with fine particles of whitish yellow colour	24.00m	14	18	22	40	
24.00m to 25.50m		25.50m	10	15	19	34	
25.50m to 27.00m	Silty clay in whitish grey colour	27.00m	12	16	20	36	
27.00m to 28.50m		28.50m	20	32	43	75	
28.50m to 30.00m	Grayish silty clay with shells and kankar	30.00m	21	34	45	79	
30.00m to 31.50m		31.50m	22	35	45	80	
31.50m to 33.00m		33.00m	15	20	20	40	
33.00m to 34.50m	Silty clay in greenish gray colour	34.50m	15	19	21	40	
34.50m to 36.00m		36.00m	16	20	22	42	
36.00m to 37.50m		37.50m	16	20	21	41	
37.50m to 39.00m	Blackish silty clay with fine particles of whitish colour	39.00m	13	20	25	45	
39.00m to 40.50m		40.50m	12	16	23	39	
40.50m to 42.00m		42.00m	13	17	25	42	
42.00m to 43.50m		43.50m	14	18	25	43	
43.50m to 45.00m		45.00m	15	18	25	43	
45.00m to 46.50m		46.50m	25	35	45	80	

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

MARINE SOIL BORE LOG 3

Drilling method		Rotary Drilling					GWL
Dia of Bore		150 mm					Top Level
Depth below G.L (m)	Soil Profile	Sample type SPT/UDS	SPT Details			"N" Value	Graphical representation of penetration resistance
			15	30	45		
46.50m to 48.00m	Blackish silty clay with fine particles of whitish colour	48.00m	31	36	49	87	
48.00m to 49.50m		49.50m	45	>100	>100	>100	
49.50m to 51.00m		51.00m	48	>100	>100	>100	
51.00m to 52.50m		52.50m	18	31	44	75	
52.50m to 54.00m	Greyish silty clay with mica	54.00m	18	32	45	77	
54.00m to 55.50m		55.50m	35	45	>55 for 13cm	>100	
55.50m to 57.00m		57.00m	38	50	>50 for 12cm	>100	
57.00m to 58.50m		58.50m	15	31	38	69	
58.50m to 60.00m	Blackish sandy silty clay with mica	60.00m	15	32	39	71	
60.00m to 61.50m		61.50m	20	58	>42 for 10cm	>100	
61.50m to 63.00m	Blackish silty clay with decayed coal particles	63.00m	22	60	>40 for 7cm	>100	
63.00m to 64.50m		64.50m	22	61	>39 for 7cm	>100	
64.50m to 66.00m		66.00m	23	62	>38 for 7cm	>100	
66.00m to 67.50m		67.50m	23	64	>36 for 5cm	>100	
67.50m to 70.00m		70.00m	24	65	>35 for 3cm	>100	

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

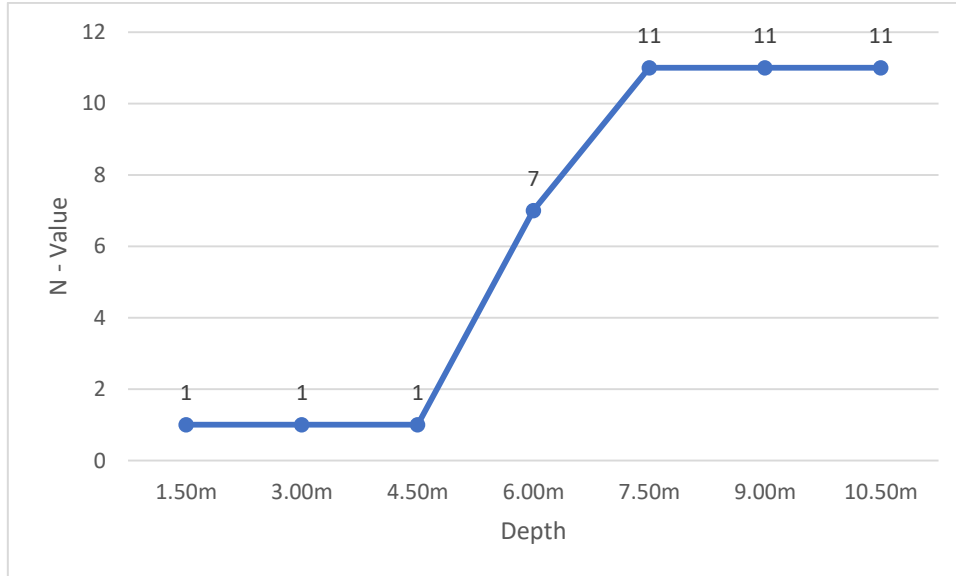


Figure 16 Depth vs N Value for MBH – 3 (0.00m to 10.50m)

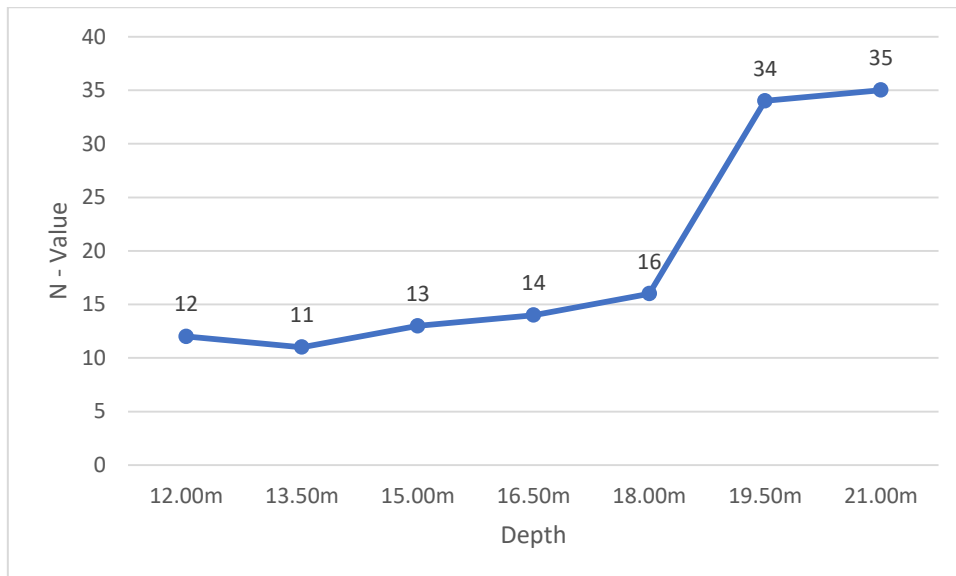


Figure 17 Depth vs N Value for MBH – 3 (12.00m to 21.00m)

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

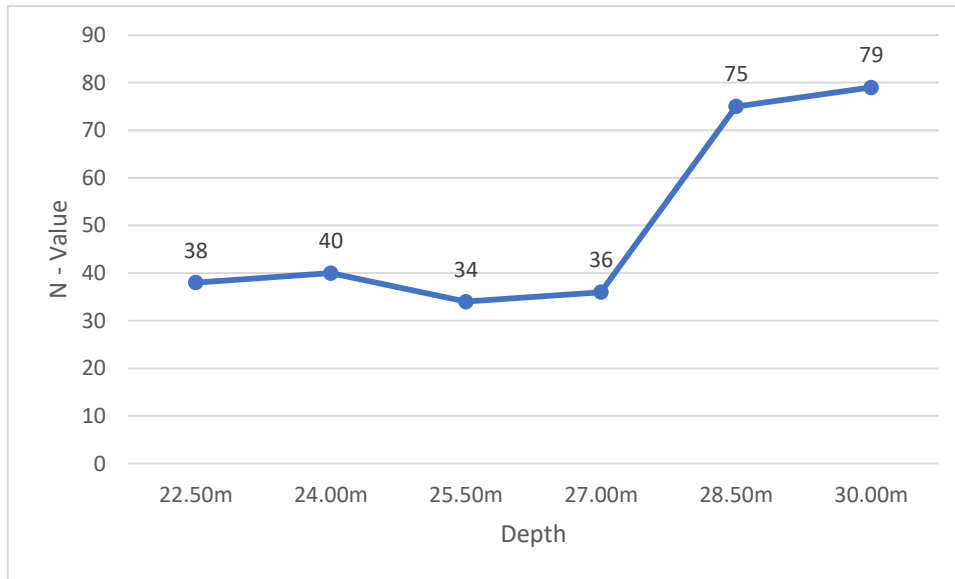


Figure 18 Depth vs N Value for MBH – 3 (22.50m to 30.00m)

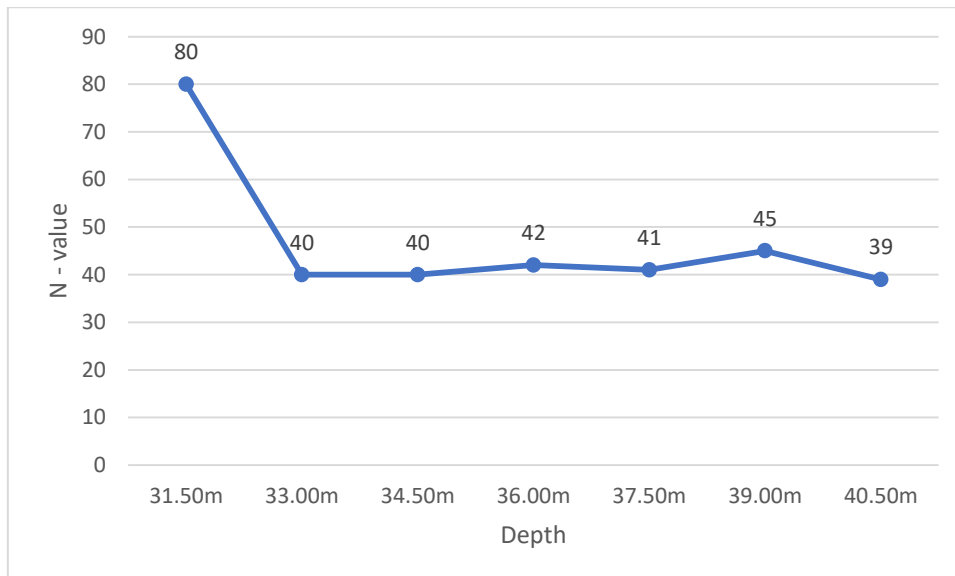


Figure 19 Depth vs N Value for MBH – 3 (31.50m to 40.50m)

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

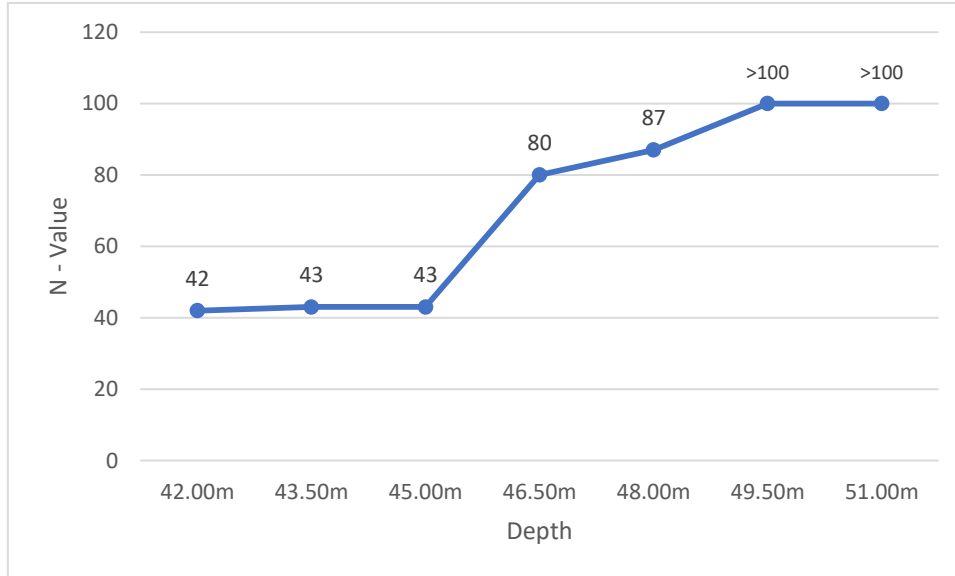


Figure 20 Depth vs N Value for MBH – 3 (42.00m to 51.00m)

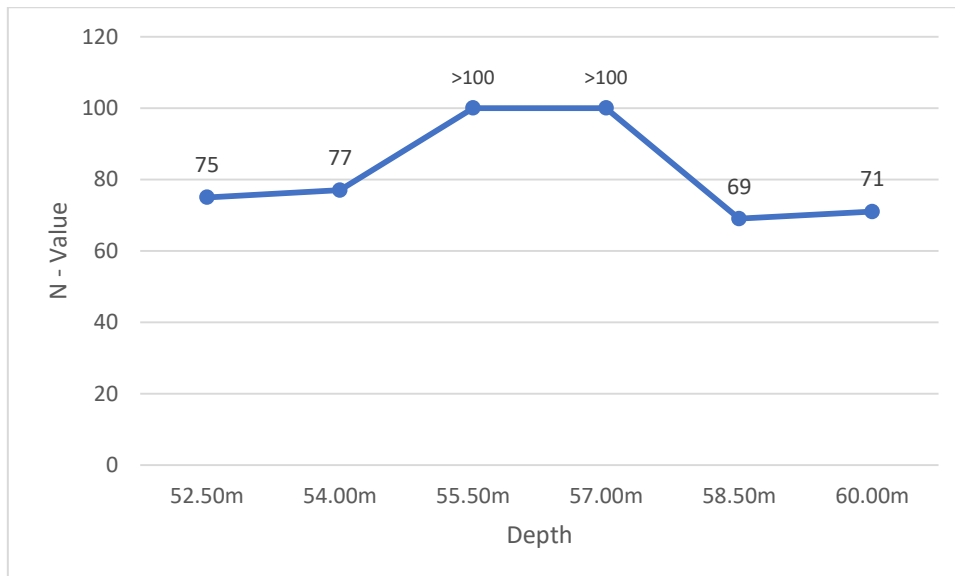


Figure 21 Depth vs N Value for MBH – 3 (52.50m to 60.00m)

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

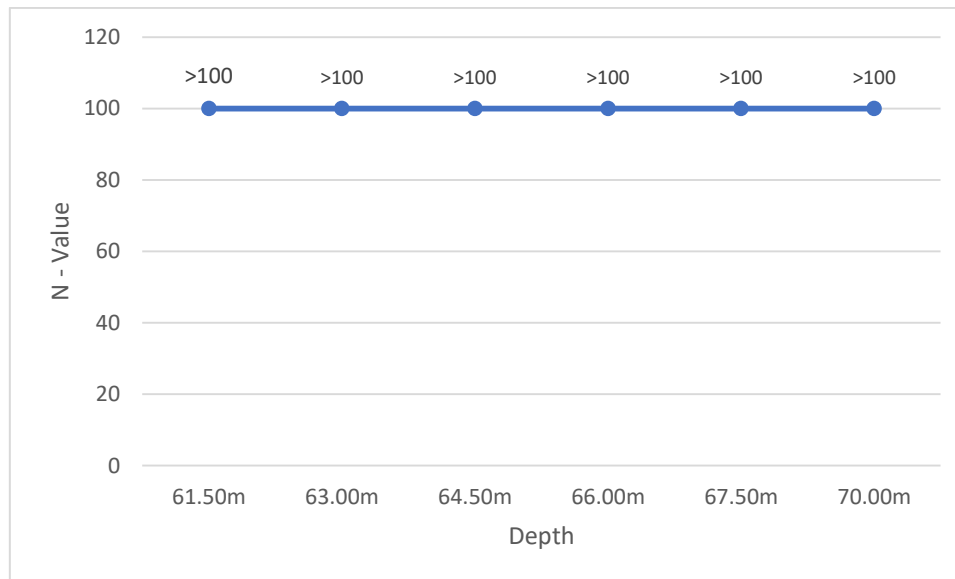


Figure 22 Depth vs N Value for MBH – 3 (52.50m to 60.00m)

Table 6 Chemical analysis of sea sand (%)

Depth (m)	Organic Matter (%)	Soluble Chloride (%)	Ph	Soluble Sulphate (%)
ESBL to 6.0	0.62	0.012	7.02	0.087
6.0 to 16.5	0.68	0.18	6.48	0.082
16.5 to 22.5	0.62	0.025	6.81	0.078
22.5 to 25.5	0.65	0.034	6.55	0.065
25.5 to 28.5	0.61	0.018	6.19	0.071
28.25 to 33.0	0.73	0.032	5.98	0.059
33.0 to 36.0	0.71	0.021	6.31	0.081
36.0 to 45.0	0.58	0.017	6.25	0.062
45.0 to 46.5	0.46	0.006	5.78	0.068
46.5 to 51.0	0.62	0.008	6.13	0.076
51.0 to 58.5	0.52	0.018	6.08	0.084
58.5 to 61.5	0.58	0.022	3.27	0.087

Client	Cochin Port Trust, Cochin	Date	05/08/2020
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Depth (m)	Organic Matter (%)	Soluble Chloride (%)	Ph	Soluble Sulphate (%)
61.5 to 64.5	0.42	0.031	6.15	0.076
64.5 to 70.0	0.54	0.024	5.81	0.062

Table 7 Chemical properties of sea water

Properties	ppm, mg/kg	salinity (%)
Chloride Cl	19362	53.2
Sodium Na	10458	30.68
Sulfate SO ₄	2687	7.25
Magnesium Mg	1284	3.59
Calcium Ca	402	1.14
Potassium K	387	1.12
Bicarbonate HCO ₃	132	0.39
Bromide Br	60	0.17
Borate BO ₃	24	0.06
Strontium Sr	10	0.03
Fluoride F	0.9	0.002

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL

Table 8 Laboratory test results of MBH – 1

Depth (m)		Type of Soil	Grain Size Analysis (%)				Atterberg Limits (%)			Swell Index (%)	NMC (%)	Swell Pressure (kg/cm ²)	Sp.Gr	Shear Parameters		CBR Value (%)	Soil Classification	Poison Ratio
From	To		Coarse Sand (%)	Medium Sand (%)	Fine Silty Sand (%)	Silt & Clay (%)	LL	PL	PI					Frition Angle ϕ	C (kg/cm ²)			
EGL	6.00	Very loose silty clay with sea shells	0.00	0.00	2.60	97.40	72.5	16.2	56.3	76.50	13.50	1.22	2.37	0	0.325	2.31	OH	0.53
6.00	16.50	Blackish silty clay with sea shells	0.00	0.00	4.10	95.90	67.4	19.5	47.9	74.2	16.50	1.20	2.39	0	0.398	2.39	CH	0.51
16.50	22.50	Grayish silty clay with fine particles of whitish yellow colour	0.00	0.00	5.20	94.80	62.4	23.4	39.0	70.10	14.20	1.15	2.38	0	0.514	2.56	OH	0.48
22.50	25.50	Grayish silty clay with fine particles of whitish yellow colour	0.00	0.00	6.50	93.50	54.2	26.5	27.7	65.40	17.50	1.10	2.41	0	0.547	2.75	ML	0.47
25.50	28.50	Silty clay in whitish grey colour	0.00	4.00	8.90	87.10	56.3	22.1	34.2	56.40	13.20	1.00	2.45	0	0.614	3.15	CL	0.45
28.50	33.00	Grayish silty clay with shells and kankar	0.00	6.50	12.50	81.00	50.4	23.6	26.8	50.20	13.60	0.94	2.48	0	0.81	2.95	CL	0.41
33.00	36.00	Silty clay in greenish gray colour	0.00	7.40	14.50	78.10	51.2	21.7	29.5	47.50	16.20	0.91	2.51	0	0.684	2.78	ML	0.45
36.00	45.00	Blackish silty clay	0.00	9.65	18.70	71.65	41.8	19.8	22.0	40.30	11.80	0.83	2.53	0	0.762	3.02	CL	0.48
45.00	46.50	Blackish silty clay with decayed coal particles	0.00	13.50	21.20	65.30	39.5	24.0	15.5	45.20	14.70	0.88	2.48	0	0.87	3.15	OL	0.38
46.50	51.00	Blackish silty clay with decayed coal particles	0.00	17.80	25.40	56.80	47.5	25.0	22.5	43.90	13.80	0.87	2.51	0	1.16	3.28	ML	0.42
51.00	58.50	Grayish silty clay with mica	0.00	23.50	28.60	47.90	54.7	28.1	26.6	38.50	16.20	0.81	2.50	0	1.27	3.12	ML	0.37

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Depth (m)		Type of Soil	Grain Size Analysis (%)				Atterberg Limits (%)			Swell Index (%)	NMC (%)	Swell Pressure (kg/cm ²)	Sp.Gr	Shear Parameters		CBR Value (%)	Soil Classification	Poison Ratio
From	To		Coarse Sand (%)	Medium Sand (%)	Fine Silty Sand (%)	Silt & Clay (%)	LL	PL	PI					Friction Angle ϕ	C (kg/cm ²)			
58.50	61.50	Blackish sandy silty clay with mica	0.00	26.40	32.40	41.20	46.2	25.6	20.6	34.10	15.90	0.76	2.51	0	1.56	3.21	SC	0.43
61.50	64.50	Blackish silty clay with decayed coal particles	0.00	27.90	35.60	36.50	32.5	19.5	13.0	32.12	14.10	0.74	2.54	0	1.87	3.18	SM	0.42
64.50	70.00		0.00	30.50	41.20	28.30	29.8	16.5	13.3	25.80	12.30	0.67	2.55	0	2.1	3.24	SM	0.32

Table 9 Laboratory test results of MBH – 2

Depth (m)		Type of Soil	Grain Size Analysis (%)				Atterberg Limits (%)			Swell Index (%)	NMC (%)	Swell Pressure (kg/cm ²)	Sp.Gr	Shear Parameters, UCC		CBR Value (%)	Soil Classification	Poison Ratio
From	To		Coarse Sand (%)	Medium Sand (%)	Fine Silty Sand (%)	Silt & Clay (%)	LL	PL	PI					Friction Angle ϕ	C (kg/cm ²)			
EGL	6.00	Very loose silty clay with sea shells	0.00	0.00	2.40	97.60	71.2	15.2	56.0	78.50	13.60	1.25	2.38	0	0.31	2.28	OH	0.52
6.00	16.50	Blackish silty clay with sea shells	0.00	0.00	3.50	96.50	66.5	18.5	48.0	75.2	14.50	1.21	2.37	0	0.38	2.31	CH	0.53
16.50	22.50	Grayish silty clay with fine particles of whitish yellow colour	0.00	0.00	4.70	95.30	60.5	20.4	40.1	71.50	13.80	1.17	2.35	0	0.49	2.36	CH	0.47
22.50	25.50	Grayish silty clay with fine particles of whitish yellow colour	0.00	0.00	5.80	94.20	55.4	23.2	32.2	63.50	15.20	1.08	2.42	0	0.58	2.45	ML	0.41.
25.50	28.50	Silty clay in whitish grey colour	0.00	3.65	7.90	88.45	57.1	20.4	36.7	58.00	12.65	1.02	2.42	0	0.612	2.47	ML	0.35

Client	Cochin Port Trust, Cochin	Date	05/08/2020
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Depth (m)		Type of Soil	Grain Size Analysis (%)				Atterberg Limits (%)			Swell Index (%)	NMC (%)	Swell Pressure (kg/cm ²)	Sp.Gr	Shear Parameters, UCC		CBR Value (%)	Soil Classification	Poison Ratio
From	To		Coarse Sand (%)	Medium Sand (%)	Fine Silty Sand (%)	Silt & Clay (%)	LL	PL	PI					Friction Angle ϕ	C (kg/cm ²)			
28.50	33.00	Grayish silty clay with shells and kankar	0.00	4.85	11.30	83.85	52.3	22.1	30.2	54.20	13.20	0.98	2.43	0	0.82	2.65	CL	0.39
33.00	36.00	Silty clay in greenish gray colour	0.00	5.68	13.50	80.82	50.4	25.2	25.2	45.20	11.50	0.88	2.48	0	0.66	2.51	CL	0.41
36.00	45.00	Blackish silty clay	0.00	7.45	19.20	73.35	46.5	24.6	21.9	43.50	12.65	0.86	2.51	0	0.77	2.68	ML	0.38
45.00	46.50	Blackish silty clay with decayed coal particles	0.00	11.25	20.40	68.35	42.1	23.5	18.6	49.50	12.40	0.93	2.50	0	0.86	3.01	OL	0.47
46.50	51.00	Blackish silty clay with decayed coal particles	0.00	16.50	22.40	61.10	48.2	19.2	29.0	42.50	12.60	0.85	2.51	0	0.821	3.18	CL	0.43
51.00	58.50	Grayish silty clay with mica	0.00	21.70	26.50	51.80	43.5	23.2	20.3	34.50	13.50	0.76	2.52	0	0.98	3.24	MH	0.45
58.50	61.50	Blackish sandy silty clay with mica	0.00	25.40	31.50	43.10	41.5	26.3	15.2	36.50	14.05	0.78	2.53	0	0.11	3.15	SC	0.41
61.50	64.50	Blackish silty clay with decayed coal particles	0.00	28.50	34.70	36.80	34.5	22.4	12.1	35.50	13.20	0.77	2.55	0	0.13	3.65	SC	0.38
64.50	70.00		0.00	31.50	40.20	28.30	30.2	20.7	9.5	33.40	12.58	0.75	2.54	0	1.52	3.21	SM	0.39

Client	Cochin Port Trust, Cochin	Date	05/08/2020
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Table 10 Laboratory test results of MBH – 3

Depth (m)		Type of Soil	Grain Size Analysis (%)				Atterberg Limits (%)			Swell Index (%)	NMC (%)	Swell Pressure (kg/cm ²)	Sp.Gr	Shear Parameters, UCC, Cohesion		CBR Value (%)	Soil Classification	Poison Ratio
From	To		Coarse Sand (%)	Medium Sand (%)	Fine Silty Sand (%)	Silt & Clay (%)	LL	PL	PI					Friction Angle ϕ	C (kg/cm ²)			
EGL	6.00	Very loose silty clay with sea shells	0.00	0.00	2.80	97.20	73.6	15.2	58.4	77.10	12.60	1.23	2.39	0	0.32	2.36	OH	0.39
6.00	16.50	Blackish silty clay with sea shells	0.00	0.00	3.20	96.80	65.2	18.5	46.7	70.3	13.50	1.16	2.34	0	0.37	2.31	CH	0.40
16.50	22.50	Grayish silty clay with fine particles of whitish yellow colour	0.00	0.00	3.67	96.33	62.4	20.4	42.0	72.10	16.20	1.18	2.36	0	0.46	2.28	CH	0.43
22.50	25.50	Grayish silty clay with fine particles of whitish yellow colour	0.00	0.00	4.61	95.39	58.4	23.2	35.2	64.80	14.20	1.10	2.41	0	0.37	2.17	ML	0.41
25.50	28.50	Silty clay in whitish grey color	0.00	3.41	6.21	90.38	55.6	20.4	35.2	63.20	15.80	1.08	2.39	0	0.62	2.40	ML	0.42
28.50	33.00	Grayish silty clay with shells and kankar	0.00	4.26	8.45	87.29	56.4	22.1	34.3	55.20	13.20	0.99	2.37	0	0.75	2.31	CL	0.42
33.00	36.00	Silty clay in greenish gray color	0.00	4.51	9.64	85.85	54.2	25.2	29.0	49.50	13.65	0.93	2.41	0	0.67	2.41	CL	0.38
36.00	45.00	Blackish silty clay	0.00	6.35	11.35	82.30	47.6	24.6	23.0	42.50	14.15	0.85	2.43	0	0.72	2.35	ML	0.39
45.00	46.50	Blackish silty clay with decayed coal particles	0.00	8.74	14.50	76.76	45.2	23.5	21.7	48.10	12.57	0.91	2.45	0	0.78	2.84	OL	0.42
46.50	51.00	Blackish silty clay with decayed coal particles	0.00	12.40	16.80	70.80	41.2	19.2	22.0	43.20	11.50	0.86	2.48	0	0.85	2.65	CL	0.37
51.00	58.50	Grayish silty clay with mica	0.00	19.20	19.20	61.60	42.6	23.2	19.4	40.60	12.64	0.83	2.51	0	1.21	2.71	MH	0.46

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Depth (m)		Type of Soil	Grain Size Analysis (%)				Atterberg Limits (%)			Swell Index (%)	NMC (%)	Swell Pressure (kg/cm ²)	Sp.Gr	Shear Parameters, UCC, Cohesion		CBR Value (%)	Soil Classification	Poison Ratio
From	To		Coarse Sand (%)	Medium Sand (%)	Fine Silty Sand (%)	Silt & Clay (%)	LL	PL	PI					Friction Angle Ø	C (kg/cm ²)			
58.50	61.50	Blackish sandy silty clay with mica	0.00	22.62	24.50	52.88	38.5	26.3	12.2	38.10	12.08	0.80	2.52	0	1.46	3.06	SC	0.41
61.50	64.50	Blackish silty clay with decayed coal particles	0.00	27.40	36.50	36.10	33.6	22.4	11.2	36.40	13.50	0.78	2.53	0	1.57	3.14	SC	0.31
64.50	70.00		0.00	30.80	37.40	31.80	32.1	20.7	11.4	32.80	14.17	0.74	2.54	0	1.92	3.58	SM	0.32

Table 11 Calculated Safe Bearing Capacity of MBH – 1 as per IS 6403 - 1981(RA:2002)

Depth of Drilling (D)	m	1.00	6.00	16.50	22.50	25.50	28.50	33.00	36.00	37.50	45.00	46.50	51.00	58.50	61.00	64.50	70.00
Width of Footing (B)	m	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Length of Footing (L)	m	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Bulk density of Soil Sample	kN/m ³	10.35	10.87	11.65	12.35	12.46	13.65	13.54	13.67	13.82	14.15	15.65	16.25	16.25	16.25	16.57	16.02
Observed SPT N Value		1	9	15	42	33	78	38	41	44	100	100	66	66	66	100	100
SPT Corrected N Value		1	8	12	37	30	70	38	41	90	90	60	90	90	90	90	90
Angle of Internal friction		0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	33
Shear Failure criterion		Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local
Bearing capacity factors	N _c	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	35.49	38.64
	N _q	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.18	26.09
	N _r	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.22	35.19



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Shape factor	Sc	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
	Sq	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
	Sr	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Depth factor	Dc	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.86	1.93
	Dq & Dr	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01
Inclination factor		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ultimate Bearing Capacity	kN/m ²	211.3	258.7	334.1	355.6	399.1	529.1	444.6	495.3	566.2	757.3	828.1	1016.0	1216.8	1367.0	2605.1	3901.4
Factor of Safety		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Allowable Safe Bearing Capacity	kN/m ²	84.5	103.5	133.6	142.2	159.6	211.6	177.8	198.1	226.5	302.9	331.2	406.4	486.7	546.8	1042.1	1560.5

Table 12 Calculated Safe Bearing Capacity of MBH – 2 as per IS 6403 - 1981(RA:2002)

Depth of Drilling (D)	m	1.00	6.00	16.50	22.50	25.50	28.50	33.00	36.00	37.50	45.00	46.50	51.00	58.50	61.00	64.50	70.00
Width of Footing (B)	m	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Length of Footing (L)	m	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Bulk density of Soil Sample	kN/m ³	10.52	10.78	11.41	11.85	12.16	12.54	13.05	13.76	14.17	14.48	14.79	15.65	15.82	16.65	16.82	17.32
Observed SPT N Value		1	10	14	46	35	77	38	45	43	50	84	100	67	100	100	100
SPT Corrected N Value		7	8	11	40	32	74	35	42	40	44	75	90	60	90	90	90
Angle of Internal friction		0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	33
Shear Failure criterion		Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local
Bearing capacity factors	N _c	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	38.64	38.64

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	N _q	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.09	26.09
	N _r	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.19	35.19
Shape factor	Sc	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
	Sq	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
	Sr	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Depth factor	Dc	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.86	1.93
	Dq & Dr	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01
Inclination factor		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ultimate Bearing Capacity	kN/m ²	201.5	247.0	318.5	377.0	397.8	535.0	432.3	503.1	560.3	533.7	639.6	739.1	822.3	990.6	2929.1	3863.7	
Factor of Safety		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
Allowable Safe Bearing Capacity	kN/m ²	80.6	98.8	127.4	150.8	159.1	214.0	172.9	201.2	224.1	213.5	255.8	295.6	328.9	396.2	1171.6	1545.5	

Table 13 Calculated Safe Bearing Capacity of MBH – 3 as per IS 6403 - 1981(RA:2002)

Depth of Drilling (D)	m	1.00	6.00	16.50	22.50	25.50	28.50	33.00	36.00	37.50	45.00	46.50	51.00	58.50	61.00	64.50	70.00
Width of Footing (B)	m	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Length of Footing (L)	m	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Dry density of Soil Sample	kN/m ³	10.41	10.72	11.38	11.64	12.28	12.79	13.25	13.54	14.25	15.64	15.83	16.25	16.25	17.25	17.20	17.32
Observed SPT N Value		1	7	14	38	34	75	40	42	41	43	80	75	69	100	100	100
SPT Corrected N Value		1	5	11	35	31	70	38	40	37	90	70	70	60	90	90	90
Angle of Internal friction		0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	33

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Shear Failure criterion		Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	Local	
Bearing capacity factors	N _c	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	38.64	38.64
	N _q	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.09	26.09
	N _r	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.19	35.19
Shape factor	S _c	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
	S _q	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
	S _r	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Depth factor	D _c	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.86	1.93
	D _q & D _r	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01
Inclination factor		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Ultimate Bearing Capacity	kN/m ²	210.6	245.7	300.3	371.2	405.0	489.5	440.7	471.3	510.9	557.1	789.1	951.0	1021.8	1250.6	2908.6	3841.5	
Factor of Safety		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
Allowable Safe Bearing Capacity	kN/m ²	84.2	98.3	120.1	148.5	162.0	195.8	176.3	188.5	204.4	222.8	315.6	380.4	408.7	500.2	1163.4	1536.6	

Depending upon anticipated load requirements, the foundation may be adopted at suitable depth as recommended above. SBC is given based on the Shear factor, Settlement factor and UCC factor considered.

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11.0 SITE PHOTOGRAPHS



Figure 23 A view of Geo Technical Investigation at South Coal Berth

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL



Figure 24 A view of Geo Technical Investigation at South Coal Berth

Client	Cochin Port Trust, Cochin	Date	05/08/2020
Project	Geotechnical Investigation alongside the existing south coal berth at Cochin Port Trust, cochin, Kerala	By	NTCPWC/ WEIPL



Figure 25 A view of Geo Technical Investigation at South Coal Berth

Client	Cochin Port Trust, Cochin	Date	05/08/2020
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Figure 26 A view of sample collection from SPT spoon sampler

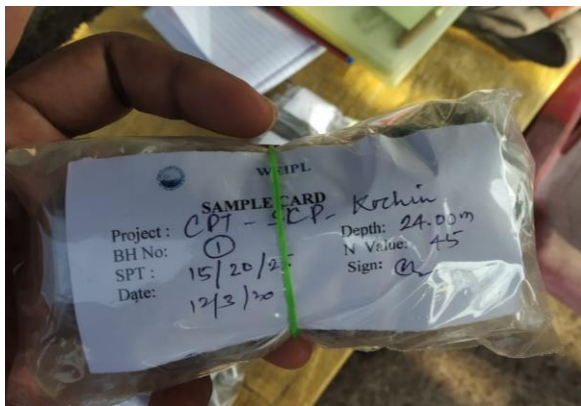


Figure 27 A view of packed samples