

Part—II

Requirements

Section VI
Employer's Requirements

Section 6 - Employer's Requirements

This Section contains the Specifications, the Drawings, and supplementary information that describe the Works to be procured, Personnel Requirements and Equipment Requirements.

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1.0 Preamble

Shillong, located in the East Khasi Hills district, is the capital of Meghalaya, popularly referred as "The Scotland of the East". Shillong functioned, during the British regime, as the administrative capital of the erstwhile Assam province apart from being the only major tourist destination in the region. Situated at 25° 31' 26" -- 25° 39' 56" N Latitude and 91° 47' 20" -- 92° 0' 39" E Longitude, the altitude of the city varies between 1400 and 1800 M above mean sea level (MSL). The National Highway NH40 links Shillong with Guwahati and rest of the country. There is a minor airport at Umroi, 35 KM from Shillong. Guwahati, the largest urban centre of the region, located 100KM from Shillong, is the nearest railhead and National airport.

It is one of the few Hill stations with motorable roads all around the city. Shillong has its own charm, different from other Hill stations and presents a natural scenic beauty with waterfalls, brooks, pine groves and gardens. The place, the people, the flora and fauna and the climate all combine to make Shillong an ideal resort throughout the year.

The Shillong city is located in seismic zone V. The slopes within the city are not very steep and ranges from 5% to 10%. Shillong experiences a humid subtropical climate and is characterized by moderate warm wet summers and cool dry winters. The growth trend in the city indicates a physical growth of the city towards the north-eastern direction, where the new Shillong Township is proposed.

The existing Landfill site at Municipal Trenching Ground at Marten, Mawiong which has been operational and used for disposal purposes since 1938. The site already houses an intermittently operating compost facility.

The collected wastes throughout the city are disposed at Mawiong Disposal Site at a distance of about 8KM from the city. The proposed compost plant is of 170 TPD capacity. There are no sensitive receptors occurring within 500M of the site. Umiam Lake is approximately 3KM from the proposed disposal site. The existing and the proposed Compost Plants of are a part of Riathkwan Reserve Forest.

2.0 Scope of Work

- The Scope of the works involve the following works,
- Dismantling of Existing Compost plant and Site clearance
- Construction of Compost Pad and Tipping Area (Concrete floor)
- Construction of Concrete floor for Curing Shed, Screen Area -2, Control Room, Packing and Finished goods Godown Area
- Construction of Leachate Holding Tank and leachate drains
- Construction/ erection of Monsoon Shed for Compost Pad and Tipping Area, Curing Shed, Screen Area -2, Control Room, Packing and Finished goods Go-down Area
- Construction of Storm water drain
- Providing and Laying Water Supply arrangement
- Supply, Installation, Commissioning and trial run (for 3 months) of Compost Screening Machinery
- Supply and installation of 250kVA Diesel Generator Set
- The brief description of the aforesaid scope of works is given below,
- Dismantling of Existing Compost plant and Site clearance

This work shall consist of removing, as hereinafter set forth, existing buildings, roofs, ceiling, flooring and paving, concrete and brick roofs and suspended floors, walls and columns, reinforced concrete and brick work, partitions, wood work, steel and iron work, doors and windows, pipes and sewer lines, posts or struts, fencing wire mesh, glazing, culverts, bridges, pavements, Kerbs and other structures like guard-rails, utility services, catch basins, inlets, etc., which are in place but interfere with the new construction or are not suitable to remain in place, and of salvaging and disposing of the resulting materials and back filling the resulting trenches and pits.

Existing culverts, bridges, pavements and other structures which are within the highway and which are designated for removal, shall be removed upto the limits and extent specified in the Drawings or as indicated by the Engineer.

Dismantling and removal operations shall be carried out with such equipment and in such a manner as to leave undisturbed, adjacent pavement, structures and any other work to be left in place.

All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

About 1700 Cum of Cement Concrete structure and 1500 quintals of steel from the existing compost plant shall be dismantled demolished completely as per BoQ and directions of the Engineer in charge complete in all respects.

Excavation and grading to proper levels shall be done to dress the site for intended use as per directions of the Engineer in charge complete in all respects.

2.1 Compost Pad and Tipping Area (Concrete floor) –:

- The Concrete floor shall be of M20 mix and 100mm thick as per BoQ and directions of the Engineer in charge complete in all respects
- For Composting pad, concrete floor of 97.5m x 60m shall be constructed
- For tipping area, concrete floor of 44m x 16m shall be constructed
- The details are shown in drawing No. MMD-260652-C-DR-00-SWM-1005, 1007 & 1008

2.2 Concrete floor for Curing Shed, Screen Area -2, Control Room, Packing and Finished goods Godown Area

- The Concrete floor shall be of M20 mix and 100mm thick as per BoQ and directions of the Engineer in charge complete in all respects
- For Curing Shed, Screen Area -2 and Control Room, concrete floor of 37.5m x 36m shall be constructed
- For Packing and Finished goods Godown Area, concrete floor of 22.5m x 18m shall be constructed
- The details are shown in drawing No. MMD-260652-C-DR-00-SWM-1004, 1009 & 1010

2.3 Construction of Leachate Holding Tank

- Leachate holding tank size – 2.5m x 3.0m x 2.0m as per BoQ and directions of the Engineer in charge complete in all respects.
- The details are shown in drawing No. MMD-260652-C-DR-00-SWM-1005.

2.4 Leachate drain:

- Leachate generated from the composting pad, tipping area and curing shed shall be collected and discharged to the Leachate collection tank through 122 m x 0.5m x 0.5m drain.
- The details are shown in drawing No. MMD-260652-C-DR-00-SWM-1005.

2.5 Monsoon Shed for Compost Pad and Tipping Area:

- 186 Nos of Steel box type Columns (2 ISMC 250) shall be erected to support the truss of the monsoon shed. .
- 0.63 mm thick sheet roofing of 6460 square meters area shall be laid on the steel truss with necessary works as per BoQ and directions of the Engineer in charge complete in all respects.
- The details are shown in drawing No. MMD-260652-C-DR-00-SWM-1007, 1008, 1011 & 1012.

2.6 Monsoon Shed for Curing Shed, Screen Area -2,Control Room, Packing and Finished goods Godown Area:

- 42 Nos of Steel box type Columns (2 ISMC 300) shall be erected to support the truss of the monsoon shed. .

- 0.63 mm thick sheet roofing of 6460 square meters area shall be laid on the steel truss with necessary works as per BoQ and directions of the Engineer in charge complete in all respects.
- The details are shown in drawing No. MMD-260652-C-DR-00-SWM-1009, 1010 & 1013.

2.7 Storm water drain:

- Storm water (46 cum/day) from the roof is collected and conveyed outside to the nearest stream through 184 m x 0.5 m x 0.5m drain as per BoQ and directions of the Engineer in charge complete in all respects.

2.8 Providing and Laying Water Supply arrangement

- The details are as per BoQ

2.9 Supply, Installation, Commissioning and trial run of Compost Screening Machinery

The bio-degradable waste from the city is received by Tippers and unloaded on the composting Pad. At this point, minor contraries are segregated manually. The segregated organic material is fed into the receiving feed Conveyor of the Pre-Sorting Section by a Front-end Wheel Loader. It is then passed through a 100mm trommel to facilitate removal of non-biodegradable material if any such as metal, paper, glass, bricks, stones, etc in the pre-sorting section. The segregated organic waste is formed into windrow on the composting pad by a wheel loading shovel.

The decomposed organic matter (after 4 turnings) will be placed on the curing bed for two weeks and covered with PVC sheets after it passes through intermediate screens of Preparatory Section. Water will be sprinkled on a regular basis. This process is done to remove any odour and the microbes present in the compost.

The compost is then passed through a trommel (rotary sieve) of the Finishing Section, to get the compost of desired size (-4 mm). After the mechanical separation, grading and sieving, fully matured and stabilized humus like organic fertilizer/soil enriched is recovered for use in crop production.

The Three sets of Compost refining machineries/equipment (specifications given below) shall be appropriately placed as shown in drawing number MMD-260652-C-DR-SWM-00-1004 to facilitate their intended use. The scope of work involves Supply, Installation, Testing, Commissioning and Trail run for 3 months.

2.9.1 Technical Specifications of Screen for Pre-Sorting Section**(15 TPH Capacity Suitable for 170 TPD Compost Plant)**

Sr.No	EQUIPMENT DESCRIPTION	SIZES	QTY.
1	Feeding Conveyor	1 Mtr Wide x 13 Mtr. Length	01 No.
2	Trommel 100 mm	Dia 2 mtr x 7 mtr Length	01 No
3	Rejects Conveyor	0.8 Mtr Wide x 6 Mtr Length	01 No
4	Accept Conveyor	0.8 Mtr Wide x 15 Mtr Length	01 No
5	Electrical Control Panel	Provided separately for this section	01 No
6	Connected Load	40 HP, 3 phase, 440V	

2.9.2 Technical Specifications of Screen for Preparatory Section**(7.5 TPH Capacity Suitable for 170 TPD Compost Plant)**

Sr.No	EQUIPMENT DESCRIPTION	SIZES	QTY.
1	Feeding Conveyor	0.8 Mtr Wide x 13 Mtr. Length	01 No.
2	Trommel 35 mm	Dia 1.8 mtr x 6 mtr Length	01 No
3	Rejects Conveyor of Trommel-35	0.65 Mtr Wide x 6 Mtr Length	01 No.
4	Accept Conveyor to Trommel-16mm	0.65 Mtr Wide x 17 Mtr Length	01 No.
5	Trommel-16mm	Dia 1.8 Mtr x 6 Mtr Length	01 No.
6	Rejects Conveyor of Trommel-16	0.65 Mtr Wide x 6 Mtr Length	01 No.
7	Accept Conveyor of Trommel - 16mm	0.65 Mtr Wide x 14 Mtr Length	01 No.
8	Electrical Control Panel	Provided separately for this section	01 No.
9	Connected Load	50 HP, 3 phase, 440V	

2.9.3 Technical Specifications of Screen for Finishing Section**(3.75 TPH Capacity suitable for 170 TPD Compost Plant)**

Sr.No	EQUIPMENT DESCRIPTION	SIZES	QTY.
1	Feeding Conveyor	0.6 Mtr Wide x 13 Mtr. Length	01 No.
2	Static Magnetic Separator	600mm wide	01 No
3	Trommel 4mm	Dia 1.4 Mtr x 5.5 Mtr Length	01 No.
4	Rejects Conveyor	0.6 Mtr Wide x 6 Mtr Length	01 No.
5	Accept Conveyor	0.6 Mtr Wide x 18 Mtr Length	01 No.
6	De-Stoner	-	01 No.

Sr.No	EQUIPMENT DESCRIPTION	SIZES	QTY.
7	Dust Collection Unit	-	01 No.
8	Stone Transfer Conveyor	0.5 Mtr Wide x 5 Mtr Length	01 No.
9	Electrical Control Panel	Provided separately for this section	01 No.
10	Connected Load	40 HP, 3 phase, 440V	

The typical drawing number MMD-260652-C-DR-SWM-00-1017, 1018 & 1019 are attached for reference with the tender document. The above are the general minimum requirements and the bidder shall give specifications and other technical details of the equipment proposed at the time of submission of offer.

Successful bidder shall submit the technical data and all the other relevant documents for approval of Employer, before procurement/fabrication.

2.10 Supply and installation of 250kVA Diesel Generator Set (Confirming to CPCB Norms)

A) Diesel Engine: -

Diesel Generating Set, liquid cooled, turbocharged with after cooler @ 1500 RPM. Inline engine, electric start, compression ignition, 4 stroke engine designed to run continuously at 1500 RPM confirming to IS 10002, ISO-3046, BS 5514 standard with an overload capacity of 10 % for one hour in every 12 hrs operation. Diesel Engine conforms to present CPCB-II norms. The diesel engine will comprise of following: -

- Radiator with Fan
- Fuel pump with Electronic Governor
- Dry type air cleaner
- Exhaust Silencer
- Lub Oil filter (Spin On Type or equivalent)
- Fuel Oil filter (Spin On Type or equivalent)
- 24V Electric starting system
- Battery charging alternator
- Stop solenoid
- Lub Oil pressure gauge
- Water temp. Gauge
- Lub oil temperature gauge
- Ammeter battery charging
- Coolant
- First Fill of Lube oil

B) Alternator:-

Alternator, suitable for continuous operation rated at 1500 rpm 415 V, 0.8 PF, 50Hz, 3Ph. in SPDP enclosure, self- excited & self- regulated, Brush less, floor mounted with Ball or Bearings on end shields. The alternator conforms to IS: 4722, BS EN 60034-1 & will be suitable for tropical condition.

C) Base Frame: -

Suitable to couple above Engine & Alternator made from steel sheet metal.

D) Fuel Tank: -

8 Hrs Capacity, with Inlet & Outlet arrangement, air vent & drain plug arrangement.

E) Batteries: -

2 Nos.12 V batteries or equivalent with Leads and Battery Cable

F) Genset Controller Unit With Control Panel

Genset controller unit 'with totally enclosed, steel construction control panel suitable for indoor floor / wall mounting installation having following safeties and display parameters:

Gen-set Display Parameters	Engine Display parameters	Electrical Safeties (along with Display)	Mechanical Safeties (along with Display)
1) Phase Voltage	1) Oil Pressure	1) Genset Under/Over voltage	1) Under/Over speed
2) Line current	2) Engine Temperature	2) Under/Over Battery voltage	2) Low Lube oil pressure
3) Frequency	3) Fuel Status	3) Under/Over frequency	3) High Lube oil Temperature
4) Average Voltage	4) Engine speed	4) Phase Failure	4) High engine coolant temperature
5) Average Current	5) Battery Voltage, Minimum Battery Voltage	5) Phase sequence reverse	5) Low Coolant temperature
6) Phase kW & Total Kw	6) Oil Temperature	6) Over Current	6) Low coolant level
7) kWH	7) Canopy Temperature	7) Over kW	7) Low fuel level
8) kVA	8) Engine Hours	8) High Earth Current	8) High canopy temperature
9) kVAR	9) Total starts		9) Start/Stop fail
10) PF			10) Charge Alternator fail
11) Earth Leakage Current			

G) Technical Specification - Acoustic Enclosure Construction

Following are some technical features of Acoustic Enclosure:-

1. The enclosure is modular in construction
2. Base frame is made of Sheet metal.
3. Durable industrial locking system is provided on doors.
4. Doors are gasketed with high quality EDPN gasket.

H) Corrosion Resistance:-

To make the enclosure weather proof: -

1. All sheet metal parts/components are hot dipped in seven tanks process, pre-treated and passivated.
2. Sheet metal components are painted with P.P base power.
3. Base frame is epoxy coated.
4. Zinc passivated hardware is used to avoid rusting

I) Acoustic Insulation:

1. Sound proofing of the enclosure done with quality Foam confirming to IS: 8183.
2. Acoustic form shall be fire retarded and fire resistant.
3. Attenuates are provided to control sound at entry and exit to and from the container.
4. Specially designed Residential Silencer is provided.

J) Ventilation and Air Circulation:

Exhaust pipe is thoroughly insulated by covering it with glass wool and further cladded in Enclosure.

K) Electrical:

Neutral Body earthing points at the sides of enclosure are isolated through Dough Moulded compound.

L) Safeties:

Emergency push button to stop the DG set from outside, Lub oil level, Lub oil pressure, Fuel level indicator, coolant level, Canopy temperature, High engine temperature

R&D:

Our R & D department is constantly engaged in the modification of the product keeping pace with world's latest technology to give customers value for money in form of improvements. The canopies being offered are for output of < 75 dbA at a distance of 1-meter average around the set.

The above are the general minimum requirements and the bidder shall give his own design, specifications and other technical details at the time of submission of offer.

Successful bidder shall submit the technical data and all the other relevant documents for approval of Employer, before procurement/fabrication.

3.0 Operation and Maintenance Manual

The supplier before commissioning of procured goods under this contract shall submit 6 (six) copies of the operation and maintenance manual of each good supplied under the contract in English language, containing descriptions, illustrations, sketches, drawings, sectional drawings, sectional arrangement view and manufacturers' parts numbers to enable the connections, functions, operation and maintenance of all components of the equipment to be easily followed and for all parts to be easily identified to facilitate ordering of the replacement parts. Exploded views where appropriate shall be used for clarity.

The operation manual shall also include the following:

- Technical data of each good and their performance.
- Instructions for servicing and overhauling.
- Particulars of lubricating oil and grease to be used, also alternative indigenous commercial lubricating oils suitable for use.
- List of tools mounted on wall panels.
- List of spares.
- List of the photographs of the equipment as fabricated by the manufacturer.

4.0 Guarantee

The Supplier shall guarantee all goods supplied under the Contract to be suitable for the application for which it is designed, and against defects due to manufacture or poor workmanship for a period of minimum 12 months from the date of commissioning. The Supplier shall be responsible to rectify and replace free of cost the whole equipment or parts thereof which may be found defective during this period, and to ensure the proper working of the equipment during the guarantee period in accordance with Clause 28 of General Conditions of Contract and clarification in Special Conditions of Contract.

5.0 Quality assurance system to be followed at manufacturer's works

Successful Bidder shall furnish detailed Quality Assurance Programme and Quality Plan for all materials and accessories to be supplied and installed under the scope of work. The Quality Plans shall include all tasks /checks as per the relevant Standards and the requirements of this specification. The Supplier shall ensure that the manufacturer must have a proper setup and independent procedure in quality control with adequate equipment, facilities and personnel for this purpose to ensure quality control from procurement of materials and selection of sub-suppliers to incoming inspection, stage inspection and final inspection.

The Supplier shall further ensure that the equipment ordered are subject to check at any time by purchaser's representative or by representative of inspecting authority deputed by the purchaser. Proper written record of quality assurance system must, therefore, be kept by the manufacturer which would be subject to checking.

6.0 Manufacturer's Test Certificate:

Manufacturer's test certificate including Material test certificates should be submitted by the Supplier to the Employer.

7.0 Testing by Third Party Agency

Any agency among the agencies appointed or authorized by the Employer may undertake independent third party inspections and testing during the manufacture or assembly of the equipment as may be applicable. Prior to commencement of the works the Engineer, in consultation with the Employer, shall inform the supplier of the name of the firm(s) who will be authorized to conduct independent Third Party inspections on the employer's behalf. The Contractor shall be wholly responsible to make his own arrangements with the approved third party inspection agencies for carrying out the required tests. The Contractor shall be responsible to obtain permission for and provide all facilities to such agency for carrying out such inspections or testing as may be required. The Third Party Inspection charges of the agency only will be paid by the employer and all the other costs for such independent inspection and testing shall be borne by the contractor.

A quality assurance plan will be developed which provides for inspection and certification by the third party inspection agency at specified times during the manufacture and fabrication of such items. Third party inspection agency's charges will initially be paid by the contractor which shall be reimbursed by the Employer. Bidder shall make necessary arrangements for third party inspections at manufacturers site and cost (other than inspection agency's fees) towards such arrangements shall be borne by the bidder and will not be reimbursed by the employer.

8.0 Rejection

The Employer or Employer's representative reserves the right to reject any good under this contract if the same does not meet the specifications, requirements, subject to tolerances. The rejected good under this contract shall be replaced by good under this contract complying with the requirements of the specification at the bidder's cost. If the commissioning of the project is likely to be delayed by the rejection good, the Employer's Representative reserves the right to accept the rejected good under this contract until the replacement good under this contract is made available. Transporting the rejected and replacement of good as well as installation and commissioning of both the good shall be at the bidder's cost.

9.0 Trial Run & Maintenance of the Equipment & Training Employer's Personnel

After testing and commissioning of each good supplied under this contract at site, the bidder shall run the equipment for at least 8 hours at full load to demonstrate satisfactory performance to the Engineer in charge prior to taking over by the employer and train the employer's personnel for running independently in the future. The cost towards bidder's engineer and other operating personnel during the said period of trial run, along with cost of fuel, lubrication, tools and spare parts which are required for operation of the equipment during the trial run period, shall be borne by the bidder. In the event that the good supplied under this contract does not satisfactorily achieve the required performance standards during this period, the trial run period shall be extended until such time as the bidder has rectified any deficiencies as may be necessary to satisfy the performance requirements. No additional compensation will be paid to the bidder for such extension.

The contractor has to carry out routine and preventive maintenance as per manufacturer's standards for a period of 12 months from the date of handing over. However, all consumables (fuel / lube oil etc.) and spare parts including filters will be supplied by the department.

10.0 Approval of Drawing

The supplier will prepare and submit the GA and fabrication drawings of all the goods to be supplied under this contract before commencement of fabrication and procurement. The drawings will be reviewed and commented/ approved by the employer. Supplier will fabricate as per approved drawings.

All the technical data specifications of all the goods to be supplied under this contract shall be submitted by the successful Bidder for approval prior to procurement.

Specification Document (Vol III)

Issued separately as Volume III

11.0 Particular Specifications

- The works would be quoted for all lead and lift unless otherwise specified particularly in the document.
- The Employer does not undertake to construct or make available any approach road to the proposed worksite if not mentioned in the Bill of Quantities and the bidder shall get acquainted with available means of approaches to the proposed site and quote for various items. The Employer shall not be liable for any claim raised later on the plea of non availability or non access to the site.
- The Contractor is advised to visit the site and acquaint himself of the prevailing local conditions at site, labour, water and other material requirements etc; required for the successful completion of the works

11.1 General

All the materials incorporated in the works shall be the most suitable for the duty concerned and shall be new and of first class commercial quality, free from imperfections and selected for long life and minimum maintenance. It shall be tested according to relevant IS Specifications in qualified labs and certificates produced to the satisfaction of the Project Manager.

If the specification for a particular item is not given, relevant IS Specifications, the Standard Specifications of Meghalaya PWD or MSPHED or CPWD shall be followed.

The objective of the specifications given in this section is to specify the details pertaining to the design, drawing, and selection of equipment or product. The equipment or product supplied shall be of high standard of quality and best engineering practices and shall comply with all currently applicable standards, regulations and codes.

Except as otherwise specified in this technical specification, the Indian/International Standards and Codes of Practice in their latest version shall be adhered to for the design, manufacturing, inspection, calibration, installation, field testing, packing, handling and transportation of product.

Should any product be offered conforming to other standards, the equipment or products shall be equal to or superior to those specified and the documentary confirmation shall be submitted for the prior approval of the Employer. In case of any discrepancy in interpretation of the code/ clause the decision of the Project Manager shall be final and binding on the Contractor.

The successful contractor shall construct a Landfill facility at Marten as per the MSW Rules 2000 and requirements furnished below.

11.2 Topographical Survey & Geotechnical investigations

The indicative layout plan for proposed works is enclosed along with Tender Drawings for reference. The Contractor shall provide the Total station along with the surveyor for total project period. The report on geotechnical investigations are also appended herewith for reference. The Contractor shall carryout the confirmatory topographical survey and geotechnical investigations of his own and get satisfied before proceeding with the works. No extra cost shall be allowed by the Employer for such survey and investigations to the Contractor. The Contractor shall submit two hard and soft copies of the details of confirmatory topographical and Geotechnical surveys conducted for approval of client.

11.3 Site grading

Before taking up the site grading works the Contractor shall fix the base grid and lines along with bench mark stones and proceed with the grading works without disturbing the grid markings and bench marks fixed for the purpose. The Contractor shall clear the site of all the shrubs and muck if any before starting the excavation.

The excavation shall be done using hydraulic excavators & tippers with disposal upto 5 km for site grading. For road work grading, hydraulic excavator of required power and capacity shall be used along with tippers and earth shall be conveyed to the place shown by the Project Manager and disposed as per the direction of the direction of Project Manager. The bidder shall ascertain the soil quantity and nature of work for grading required through site visit before quoting for the tender. The Contractor shall submit the excavation plan and shall carry out accordingly duly as per the approved drawing and maintain the required slopes of the bund. The bunds shall be trimmed manually to the required grade as shown in the drawings. The required site grading vehicles and equipments shall be organized by the successful bidder before starting of the works.

12.0 Drawings (Vol II)

Drawings have been provided separately as Volume II

12.1 Employer's Drawings:-

The drawings listed in the Tender document are Employer's drawings and are provided by the Employer as a guideline of the specifications and work. All data and information furnished in the drawings by the Employer is given in good faith but the Employer does not accept the responsibility for the completeness and accuracy thereof. The same shall be verified by the contractor promptly pointing out errors or discrepancies thereof to the Engineer. Drawings are provided as Volume 3 of the bid documents.

12.2 Contractor's Drawings:-

All drawings provided by the Contractor shall be on standard size sheets, prepared on computer with Auto CAD Latest revision and shall show particulars in a title block located in the lower right hand corner, in addition to the name of Contractor and equipment manufacturer, date, scale, drawing, revision number (R0 for drawings submitted initially, R1, R2 etc. for drawings submitted subsequently). A blank space shall be provided for the Engineer's approval stamp and provision shall be made for detail of revisions to be recorded. All drawings submitted by the supplier shall use the English language. All drawings shall be clearly and fully cross-referenced to the other drawings as relevant.

The Contractor's attention is drawn to the Specification Document (Volume III) for more information on the drawing requirement.

13.0 Supplementary Information

13.1 Co-operation:

The Contractor shall establish full co-ordination with the officials of ULBs, SIPMIU and the Programme Consultants and extend co-operation to complete work.

13.2 Records procedures and reports:

A work order book shall be maintained by the contractor at site/workshop for taking instructions from employer or his representative. The Contractor shall maintain records pertaining to the quality of installation / erection work and inspection, testing, compliance with all technical requirements in respect of all this works as described before. The Contractor shall submit such records to the Employer after the completion of any particular work before submitting the bill. The Contractor shall also maintain the cement/ steel consumption / material details etc. The Contractor shall proceed with Concrete works only on approval of the pour card by the Project Manager.

13.3 Personnel:

The contractor shall depute sufficient staff to carry out installation, the maintenance and repair work efficiently and satisfactorily. The Contractor shall undertake to comply with applicable legislation and the code of labour law on matters of health, hygiene and safety, and shall assume responsibility for works required in the event of any change in applicable regulations. The contractor shall provide all necessary superintendence during the execution of works and during maintenance. The Contractor's staff shall include adequate and competent persons with proven suitable, previous experience on similar contracts to supervise the works and sufficient skilled, semi-skilled and unskilled labour to ensure completion of works in time. The Contractor shall not remove any representative or skilled labour from the site without prior approval of the Employer's Representative for the proper fulfilling of the contractors obligations under the contract. The contractor or a competent and authorized agent or representative approved in writing by Employer on the basis of qualification and experience to be furnished by the contractor, which approval may at any time be withdrawn, is to be constantly on the works and shall give his whole time to the superintendence of the work.

13.4 Public Authorities:

The Contractor shall comply with all rules & regulations, bye laws and directives given from time to time by any local or public authority in connection with this work and shall himself pay fees or charges which are leviable on him without any extra cost.

13.5 Safety:

The Contractor will be responsible for safety of the material supplied and kept in joint custody of the employer and the contractor till completion of contract. The Contractor shall at his own expense arrange for the safety of his labour / supervisor staff employed by him directly or indirectly for performing the work, as per statutory requirement. The Contractor shall report any accident or unusual

occurrence with the work at site that take place to employer immediately with the action, which he might have taken.

13.5 Acquaintance with Site and Work Conditions

The Bidder shall study the site and general conditions in respect of approaches, labourers, climate and the data included in the tender documents and get it verified with actual inspections of the site, before submitting the tender. In case of doubt about any item or data included in the tender, the same shall be got clarified in pre-bid meeting. Once the tender is accepted, it shall be concluded that the Contractor has verified and made himself conversant with all the details required for completing the work as stipulated conditions and specifications.

13.6 Store Shed Meter Repairs Shop, Office etc:-

The Contractor shall make necessary arrangement at his own cost for store shed, meter repairs shop/ office, meter test bench etc. The Contractor shall consider all the costs related to required personnel, sheds, establishment of lab and equipments in his quote and no costs /claim will be entertained in this regard.

13.7 Quality Control:

This Section 6 shall be read in conjunction with the Standard Specification provided along with Bid Document (Volume III).

14.0 Personnel Requirements

Using Form PER-1 and PER-2 in Section 4 (Bidding Forms), the Bidder must demonstrate it has personnel that meet the following requirements:

No.	Position	Total Work Experience [years]	Experience In Similar Work [years]
1	Project Manager (Graduate Civil Engineer)- 1 No	10	5
2	Site Engineer- Civil (Graduate)-1 No	5	3
3	Site Supervisor (Diploma Civil Engineer)- 2 No (One with survey experience in Total station instrument use)	5	3
4	Environmental Safety Manager – 1 No Diploma or PG in Environmental/Safety	4	2
5	Geo technical Engineer – 1 No. (Intermittent – as and when required)	10	3
6	Electrical/Mechanical Engineer – 1 No.	5	3
7	Security Guards—3 nos (one per shift)	--	----

15.0 Equipment Requirements

Using Form EQU in Section 4 (Bidding Forms), the Bidder must demonstrate it has the key equipment listed below:

No	Equipment Type and Characteristics	Min. Number Required
1	Excavator cum loader	2 No.
2	Mobile Weigh Batch type concrete mixers	2 Nos.
3	Needle Vibrators	5 Nos.
4	Plate Vibrators	2 Nos.
5	Dewatering Pumps 5 HP and 10 HP	2 Nos.
6	Smooth wheeled, Vibratory Roller	1 No.
7	Auto level set	1 No.
8	Total Station for survey and leveling equipment with level staffs etc.	1 No.
9	Shuttering material	3000 Sqm
10	Trucks / Tippers	6 No.
12	Water tankers with pump & sprinkling arrangements	2
13	Bull Dozer	1
14	Laboratory for testing fineness, consistency, setting time compressive & tensile strength of cement; compressive & flexural strength of Cement concrete and proof stress; elongation, tensile strength, bending & re-bending of reinforcement steel; Cubes for testing, UTM; Soil characteristics testing including permeability test	Either Laboratory to be established or Testing arrangement to be made with accredited laboratory with prior approval of client.

Annexure I:

R E P O R T

O N

**GEOTECHNICAL INVESTIGATIONS IN GREATER
SHILLONG PLANNING AREA FOR ABD TA 4779 -
IND,**

1.0

INTRODUCTION

Sub - Soil Investigation was carried out at Mawiong, Shilong to find out the engineering properties of soil and to determine the depth of foundation and safe bearing capacity.

- 1.01 This report consists of field investigation and laboratory analysis along with the rational interpretation of test results and recommendation regarding the safe bearing capacity
- 1.02 All the field investigations and laboratory analysis were conducted as per relevant I.S. Code of practice for soil testing

2.0

FIELD INVESTIGATION

- 2.01 Field investigation was started on 25.02.2009 and completed on 28.02.2009

Field investigation consists of Auger boring with the help of outer casing and inner boring tube upto a maximum depth of 16.5 m

2.02

STANDARD PENETRATION TEST (S.P.T.)

The S.P.T were conducted by using standard split spoon sampler as per IS: 2131. Number of blows required to drive the sampler for first 15cm is neglected and the blows for the next 30cm is considered and expressed in

2.03

DISTURBED / UNDISTURBED SAMPLES

Disturbed and undisturbed samples were collected during the process of boring and were sealed for testing. The samples were sent to laboratory for testing as immediately as possible to avoid loss of moisture etc.

2.04

GROUND WATER LEVEL

The ground water level has been shown in bore hole log enclosed herewith.

3.0

LABORATORY TEST

Selected soil samples were analysed in the laboratory as per I.S: 2720 and the following tests were conducted and corresponding results of the tests have been furnished in the tabular form.

The following tests were conducted.

- i) Natural Moisture Content

- ii) Specific gravity
- iii) Bulk density and Dry density
- iv) Shear Strength
- v) Grain Size analysis
- vi) Atterberg Limits

4.1 BEARING CAPACITY OF THE FOUNDATION

Based on Standard Penetration Resistance value

$$q_u = ((q (N_q - 1) s_q d_q i_q + 0.5 B \gamma N_\gamma s_\gamma d_\gamma i_\gamma W') / F) \times 10 \text{ t / m}^2$$

Where

N_q, N_γ = Bearing capacity factors

s_q, s_γ = Shape factors

For square footing $s_q = 1.2$ $s_\gamma = 1$

B = Width dia of foundation in cm

$d_q = d_\gamma$ = Depth factors = 1.00 for $\phi < 10^\circ$
 = $1 + 0.1 (D_f / B) \times \text{sqrt}(N_\phi)$ for $\phi > 10^\circ$

ϕ = Angle of shearing resistance of soil in degrees

$N_\phi = \tan^2 (45^\circ + \phi / 2)$

D_f = Depth of foundation in cm

$N_\phi = \tan^2 (45^\circ + \phi / 2) = 1$

i_q = Inclination factors = $(1 - (\alpha / 90))^\phi$

i_γ = Inclination factor = $(1 - (\alpha / \phi))^2$

α = Inclination of the load to the vertical in degrees

q = Effective surcharge at the base level of foundation in kgf / cm^2

γ = Bulk unit weight of foundation soil in kgf / cm^3

W' = Water table correction factor

F = Factor of safety

4.2 FROM C-Ø VALUE :

For bearing capacity of the following formula has been adopted as per I.S: 6403 - 1981.

$$q_s = ((q (N_q - 1) s_q d_q i_q + 0.5 B \gamma N_q s_q d_q i_q W') / F) \times 10 \text{ t} / \text{m}^2 \quad (\text{when } C=0)$$

$$q_s = \{(C 5.14 S_c d_c i_c) / F\} \times 10 \text{ t} / \text{m}^2 \quad (\text{When } \phi = 0)$$

Where

C = Cohesion in Kgf / cm^2

S_c = Shape factor

For square $S_c = 1.3$

d_c = Depth Factor = $1 + 0.2 (D/B) \times \text{sqrt. } (N_q)$

$i_c = i_q$ = Inclination Factors = $\{1 - (\alpha / 90)\}^2$

Calculation of Bearing capacityBased on Standard Penetration Resistance valueFor BH.NO - 1

$$\text{At depth } D_f = 150 \text{ cm}$$

$$\text{Average N -value} = (48 + 78 + 100) / 3 = 75.33 \quad \text{Say } N=75$$

$$\text{For } N = 75.00 \quad \phi = 45.83^\circ \quad \phi_{cor} = 45.83^\circ \quad \text{Say } 45^\circ$$

$$\text{For } \phi = 45^\circ \quad N_q = 34.87 \quad N_\gamma = 271.74$$

$$S_q = 1.2 \quad S_\gamma = 0.80$$

$$d_q = d_\gamma = 1 + 0.1 (150 / 200) \times \tan (45 + 45 / 2) = 1.18$$

$$\alpha = 0^\circ \quad i_\gamma = i_q = 1.00$$

$$\gamma = 0.002 \text{ Kgf/cm}^2$$

$$\gamma' = 0.001 \text{ Kgf/cm}^2$$

$$q = 0.001 \times 150 = 0.15 \text{ kgf/cm}^2$$

$$W = 0.5$$

$$F = 2.5$$

$$q_u = \frac{\{ (0.15 \times (34.87 - 1) \times 1.20 \times 1.18 \times 1.00 + 0.50 \times 200 \times 0.002 \times 271.74 \times 0.8 \times 1.18 \times 1.00 \times 0.50) / 2.5 \}}{10}$$

$$= 216.34 \text{ t/m}^2$$

Calculation of Bearing capacityFrom Shear Test ResultsFor BH.NO - 1

$$\phi = 40^{\circ} \quad \phi_{cor} = 40^{\circ}$$

$$\text{For } \phi = 40^{\circ} \quad N_q = 64.20 \quad N_{\gamma} = 109.42$$

$$S_q = 1.2 \quad S_{\gamma} = 0.80$$

$$d_q = d_{\gamma} = 1 + 0.1 (150 / 200) \times \tan (45 + 40 / 2) = 1.16$$

$$\alpha = 0^{\circ} \quad i_{\gamma} = i_q = 1.00$$

$$\gamma = 0.002 \text{ Kgf/cm}^2$$

$$\gamma' = 0.001 \text{ Kgf /cm}^2$$

$$q = 0.001 \times 150 = 0.15 \text{ kgf/cm}^2$$

$$W = 0.5$$

$$F = 2.5$$

$$q_u = \{ (0.15 \times (64.2 - 1) \times 1.20 \times 1.16 \times 1.00 + 0.50 \times 200 \times 0.002 \times 109.42 \times 0.8 \times 1.16 \times 1.00 \times 0.50) / 2.5 \} \times 10$$

$$= 93.40 \text{ t/m}^2$$

For BH.NO - 6

$$\text{At depth } D_f = 300 \text{ cm } \phi = 0^\circ$$

$$C = 0.29$$

$$d_c = 1 + 0.2 (300/200) \times \tan^2 45^\circ = 1.30$$

$$S_c = 1.30$$

$$q_u = \{ (0.29 \times 5.14 \times 1.30 \times 1.30 \times 1.00) / 2.5 \} \times 10 \text{ t/m}^2$$

$$= 10.08 \text{ t/m}^2$$

NET SAFE BEARING CAPACITY (t/m²) AT VARIOUS DEPTHS

Bore Hole No.	Depth (m)	From N-Value	From C-Ø value
1	1.5	216.34	93.40
	2.0	267.18	115.78
	2.5	321.88	140.78
	3.0	380.43	229.50
2	1.5	260.74	93.40
	2.0	321.13	115.78
	2.5	386.06	140.78
	3.0	455.53	195.04
3	1.5	216.34	93.40
	2.0	267.18	115.78
	2.5	321.88	140.78
	3.0	380.43	229.50

NET SAFE BEARING CAPACITY (t/m^2) AT VARIOUS DEPTHS

Bore Hole No.	Depth (m)	From N-Value	From C- ϕ value
4	1.5	181.94	109.22
	2.0	225.21	136.22
	2.5	269.68	164.02
	3.0	319.26	195.04
5	1.5	181.94	80.14
	2.0	225.21	99.56
	2.5	269.68	120.30
	3.0	319.26	166.35
6	1.5	-	-
	2.0	-	-
	2.5	-	-
	3.0	14.76	10.08

RECOMMENDATION

From field and laboratory investigations, the following recommendations have been made for the purpose of design of foundation at the site.

A. For bore hole locations 1,2,3,4 & 5

1. Type of foundation : R.C.C Shallow foundation
2. Recommended Net safe bearing capacity: $15.00 t/m^2$ (considering jointed Rock)
3. Depth of Foundation : 150 cm

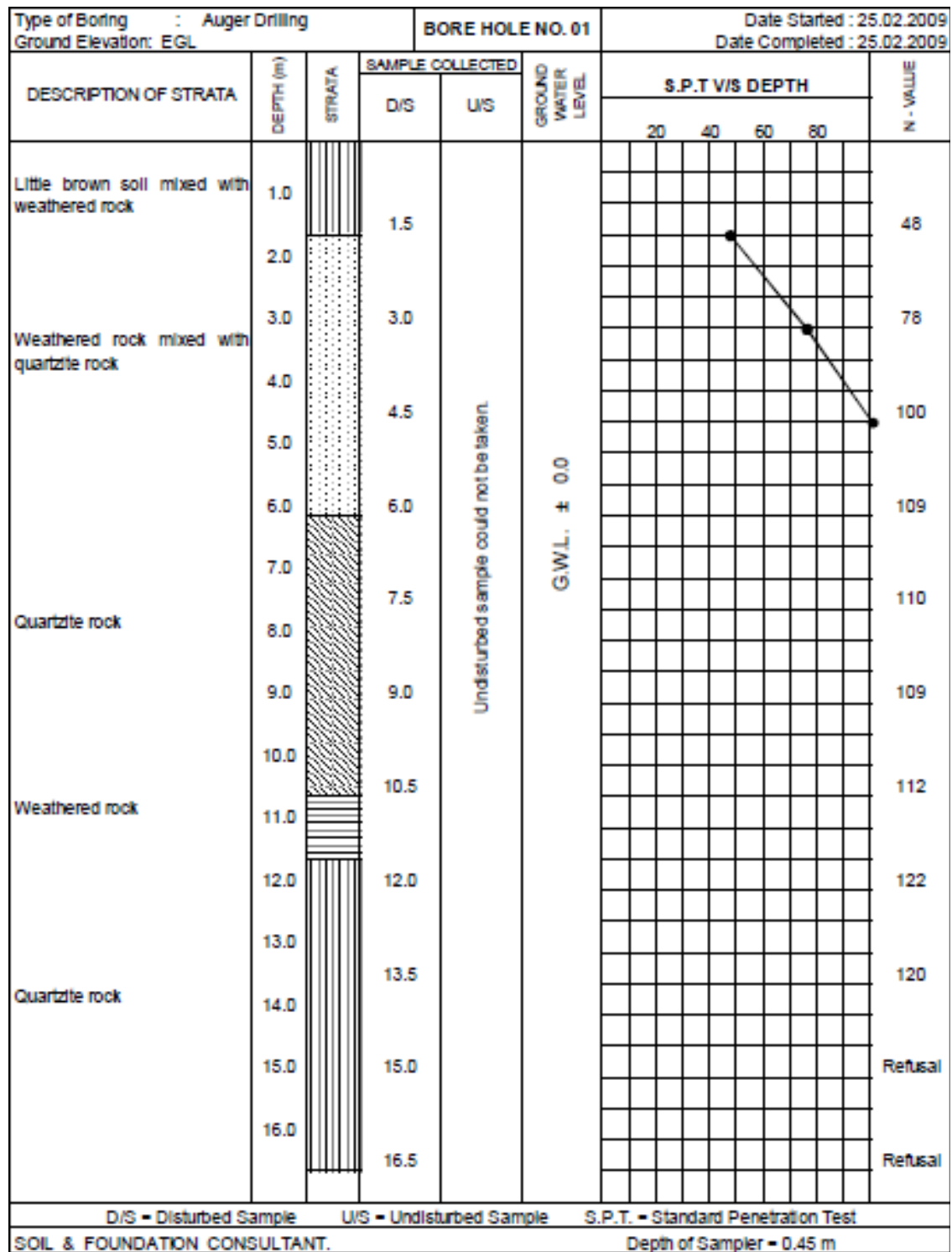
B. For bore hole location 6














1. Type of foundation : R.C.C Shallow foundation
2. Net safe bearing capacity: $10.0 t/m^2$
3. Depth of Foundation : 300 cm

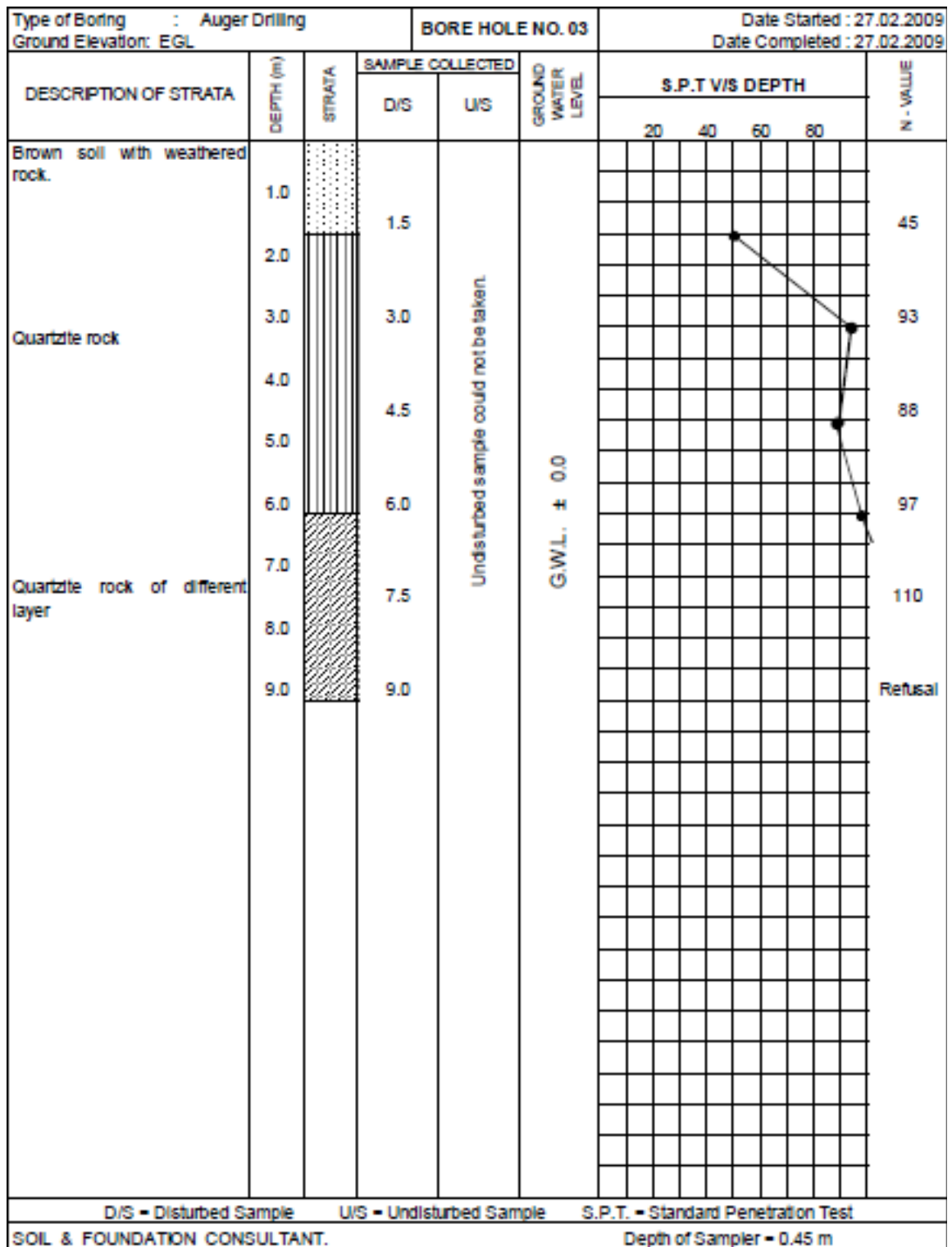
N - VALUE CORRECTION

Depth (m)	Bore Hole No.1		Bore Hole No.2		Bore Hole No. 3	
	Observed N - value	Corrected N - value	Observed N - value	Corrected N - value	Observed N - value	Corrected N - value
1.5	48	45	55	50	45	42
3.0	78	60	88	67	93	70
4.5	100	69	100	69	88	62
6.0	109	70	109	70	97	63
7.5	110	67	108	66	110	67
9.0	109	64	120	69	Refusal	69
10.5	112	63	121	67	-	-
12.0	122	65	129	69	-	-
13.5	120	62	Refusal	69	-	-
15.0	Refusal	60	-	-	-	-
16.5	Refusal	59	-	-	-	-

Depth (m)	Bore Hole No.4		Bore Hole No. 5		Bore Hole No. 6	
	Observed N - value	Corrected N - value	Observed N - value	Corrected N - value	Observed N - value	Corrected N - value
1.5	53	49	50	46	-	-
3.0	82	63	75	58	-	-
4.5	70	51	97	67	8	8
6.0	83	56	115	74	67	46
7.5	92	57	128	77	103	63
9.0	130	74	Refusal	74	-	-
10.5	110	62	-	-	-	-
12.0	Refusal	65	-	-	-	-
13.5	Refusal	67	-	-	-	-



Type of Boring : Auger Drilling		BORE HOLE NO. 02		Date Started : 25.02.2009						
Ground Elevation: EGL				Date Completed : 26.02.2009						
DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED		GROUND WATER LEVEL	S.P.T V/S DEPTH				N - VALUE
			D/S	U/S						
						20	40	60	80	
Soil mixed with quartzite rock	1.0									
Weathered stone	2.0		1.5							55
Quartzite stone mixed with little lime stone.	3.0		3.0							88
Quartzite stone	4.0		4.5							100
	5.0									
Weathered rock mixed with quartzite rock	6.0		6.0							109
	7.0		7.5							108
Quartzite rock	8.0									
	9.0		9.0							120
	10.0		10.5							121
	11.0									
	12.0		12.0							129
	13.0		13.5							Refusal



[illegible]

[illegible]

PROJECT : Geotechnical Investigations in Greater Shillong Planning Area for ADB TA 4773-IND										
Type of Boring : Auger Drilling				BORE HOLE NO. 06		Date Started : 28.02.2009				
Ground Elevation: EGL						Date Completed : 28.02.2009				
DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED		GROUND WATER LEVEL	S.P.T V/S DEPTH				N - VALUE
			D/S	U/S						
						20	40	60	80	
Garbage (Debris)	1.0		1.5		G.W.L. ± 0.0					-
	2.0									
Silty clay grey in colour	3.0		3.0							7
	4.0			3.5						
	5.0		4.5							8
	6.0		6.0							67
weathered rock	7.0									
	8.0		7.5							103

PHYSICAL PROPERTIES

Bore Hole No.	Depth (m)	Moisture Content (%)	Specific gravity	Bulk Density (gm/cc)	Dry Density (gm/cc)	Void Ratio
1	1.5	15.16	2.67	-	-	-
	3.0	24.20	2.69	-	-	-
	4.5	10.67	2.66	-	-	-
	6.0	5.97	2.66	-	-	-
	7.5	7.12	2.67	-	-	-
	9.0	9.07	2.68	-	-	-
	10.5	7.91	2.66	-	-	-
	12.0	3.56	2.67	-	-	-
	13.5	6.33	2.68	-	-	-
	15.0	7.13	2.68	-	-	-
	16.5	8.01	2.68	-	-	-
2	1.5	15.44	2.67	-	-	-
	3.0	5.56	2.69	-	-	-
	4.5	4.19	2.66	-	-	-
	6.0	5.43	2.66	-	-	-
	7.5	9.35	2.67	-	-	-
	9.0	5.01	2.68	-	-	-
	10.5	6.55	2.66	-	-	-
	12.0	4.21	2.67	-	-	-
	13.5	6.52	2.68	-	-	-
3	1.5	14.63	2.67	-	-	-
	3.0	23.94	2.69	-	-	-
	4.5	9.03	2.66	-	-	-
	6.0	7.16	2.66	-	-	-
	7.5	6.65	2.67	-	-	-
	9.0	6.71	2.68	-	-	-

PHYSICAL PROPERTIES

Bore Hole No.	Depth (m)	Moisture Content (%)	Specific gravity	Bulk Density (gm/cc)	Dry Density (gm/cc)	Void Ratio
4	1.5	15.46	2.67	-	-	-
	3.0	6.88	2.69	-	-	-
	4.5	4.45	2.66	-	-	-
	6.0	5.47	2.66	-	-	-
	7.5	9.17	2.67	-	-	-
	9.0	9.18	2.68	-	-	-
	10.5	8.54	2.66	-	-	-
	12.0	4.25	2.67	-	-	-
	13.5	8.14	2.68	-	-	-
5	1.5	17.43	2.67	-	-	-
	3.0	23.59	2.69	-	-	-
	4.5	8.72	2.66	-	-	-
	6.0	7.75	2.66	-	-	-
	7.5	6.36	2.67	-	-	-
	9.0	7.40	2.68	-	-	-
6	1.5	15.18	2.67	-	-	-
	3.0	12.77	2.69	-	-	-
	3.5	13.65	2.69	1.80	1.58	0.70
	4.5	5.38	2.66	-	-	-
	6.0	5.58	2.66	-	-	-
	7.5	10.60	2.67	-	-	-

*N.B.: The Bulk Density, Dry Density & Void Ratio can not be worked out due to undisturbed samples are not available.

CHEMICAL ANALYSIS
at G.L - 0.50m

Sample No	pH	Sulphate (mg/l)	Chlorides (mg/l)
1	6.6	72	87
2	6.7	76	84
3	6.9	79	85
4	6.8	77	88
5	6.8	79	87
6	6.9	78	86

SHEAR TEST RESULTS

BoreHole No.	Depth (m)	Unconfined		Direct shear test	
		C (kgf/cm ²)	ϕ°	C (kgf/cm ²)	ϕ°
1	1.5	-	-	-	40 ^o
	3.0	-	-	-	42 ^o
	4.5	-	-	-	44 ^o
	6.0	-	-	-	42 ^o
	9.0	-	-	-	41 ^o
	10.5	-	-	-	43 ^o
	12.0	-	-	-	44 ^o
	15.0	-	-	-	44 ^o
2	1.5	-	-	-	40 ^o
	3.0	-	-	-	41 ^o
	4.5	-	-	-	42 ^o
	6.0	-	-	-	44 ^o
	7.5	-	-	-	44 ^o
	10.5	-	-	-	44 ^o
	12.0	-	-	-	44 ^o
3	1.5	-	-	-	40 ^o
	3.0	-	-	-	42 ^o
	4.5	-	-	-	43 ^o
	6.0	-	-	-	44 ^o
	7.5	-	-	-	44 ^o

SHEAR TEST RESULTS

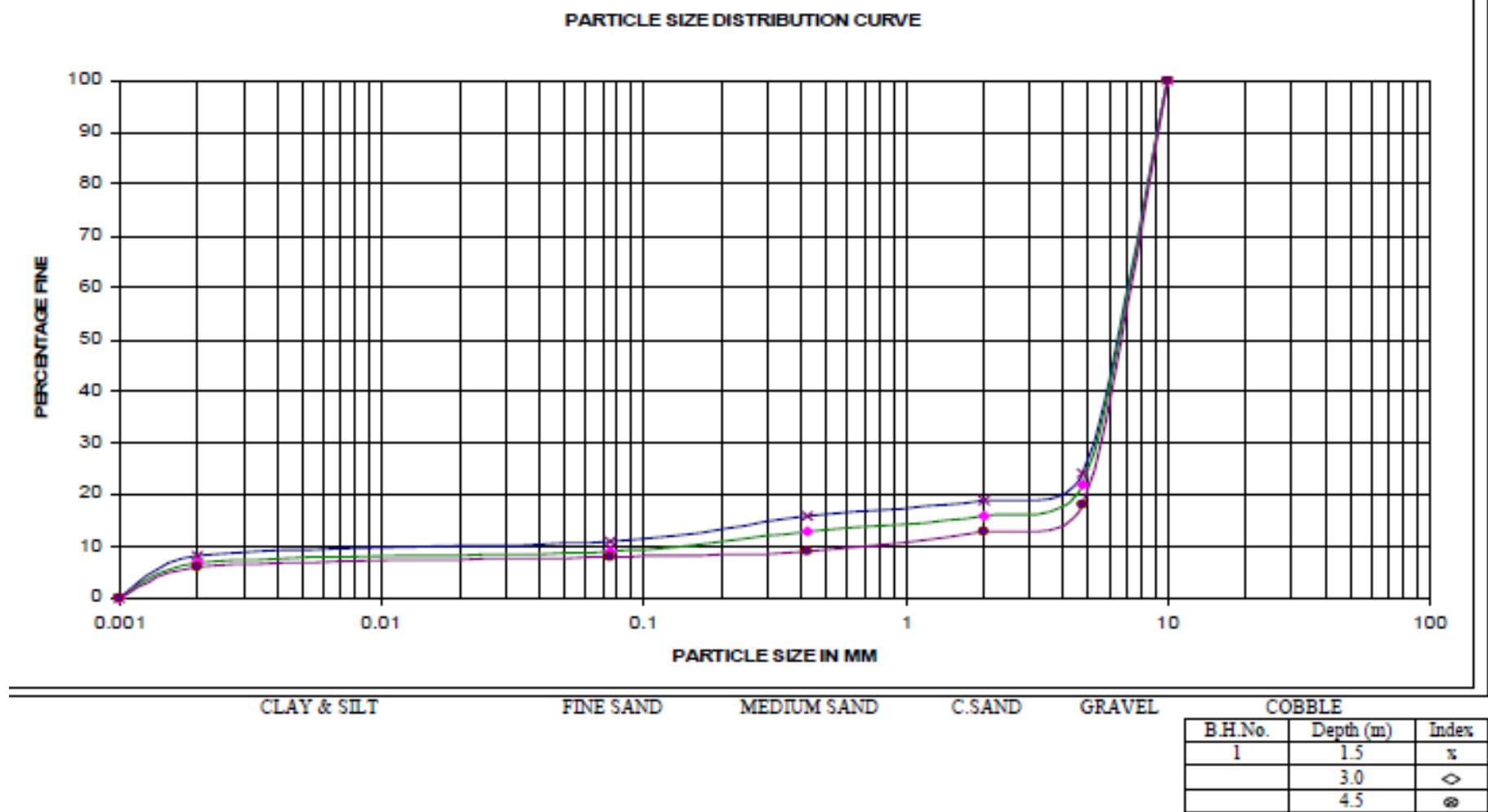
BoreHole No.	Depth (m)	Unconfined		Direct shear test	
		C (kgf/cm ²)	ϕ°	C (kgf/cm ²)	ϕ°
4	1.5	-	-	-	41 ^o
	3.0	-	-	-	41 ^o
	4.5	-	-	-	43 ^o
	7.5	-	-	-	43 ^o
	10.5	-	-	-	44 ^o
	12.0	-	-	-	43 ^o
5	1.5	-	-	-	39 ^o
	3.0	-	-	-	40 ^o
	6.0	-	-	-	42 ^o
	7.5	-	-	-	42 ^o
	9.0	-	-	-	44 ^o
6	3.5	0.29	-	-	-
	4.5	-	-	-	42 ^o
	7.5	-	-	-	43 ^o

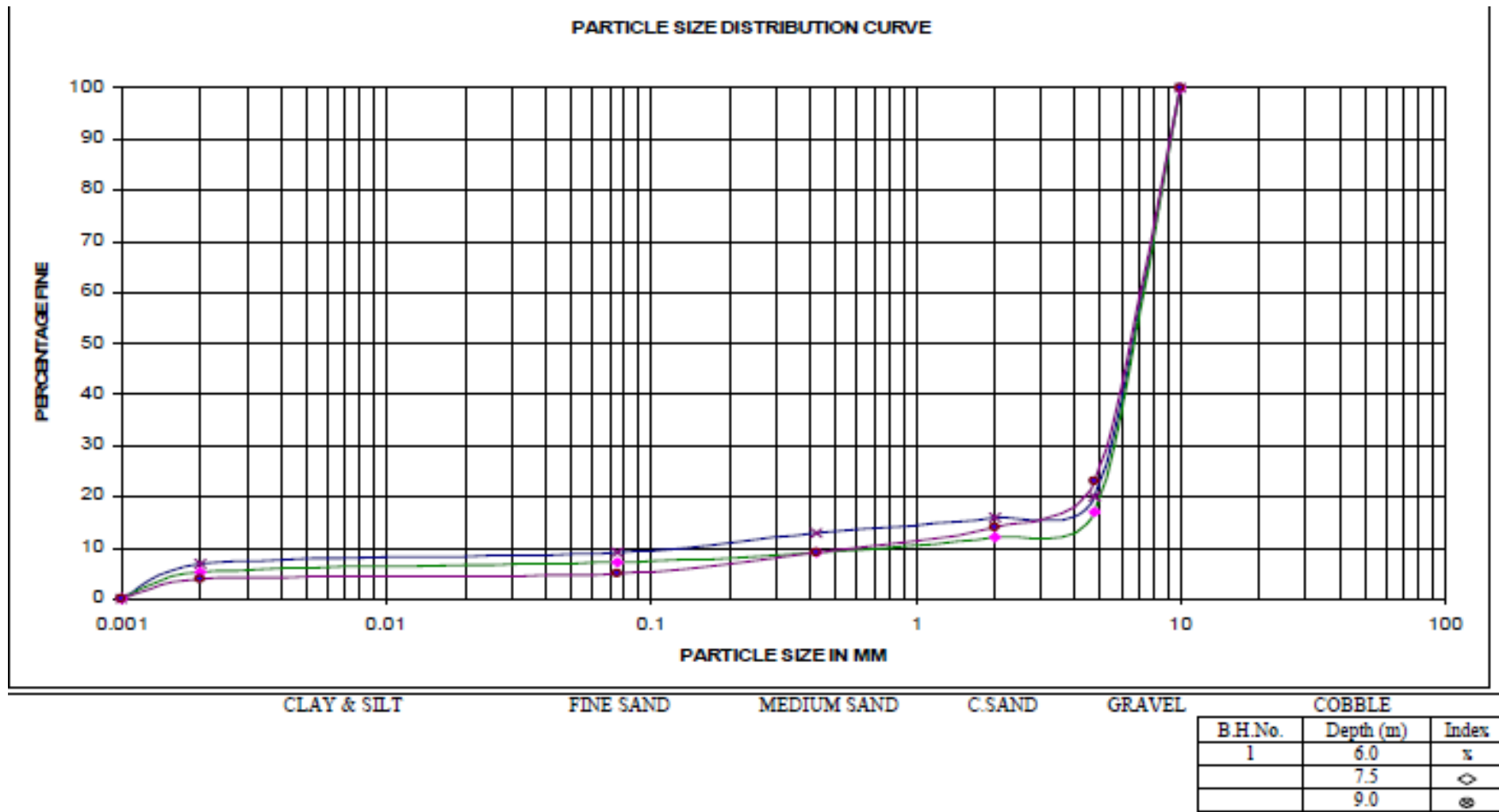
GRAIN SIZE ANALYSIS

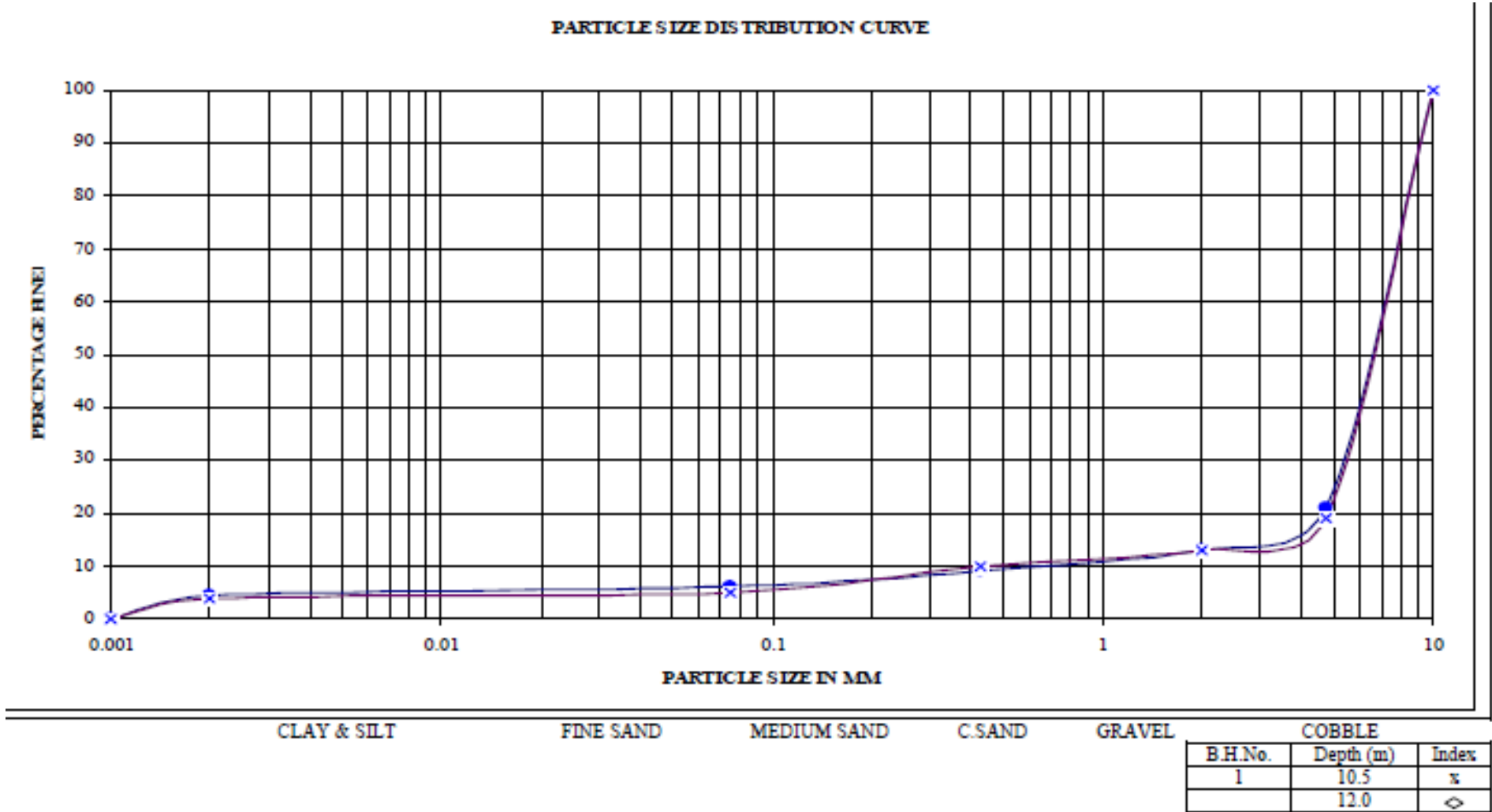
Bore Hole No.	Depth (m)	Silt & Clay (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Gravel (%)
1	1.5	11.00	5.00	3.00	5.0	76.0
	3.0	9.00	4.00	3.00	6.0	78.0
	4.5	8.00	1.00	4.00	5.0	82.0
	6.0	9.00	4.00	3.00	4.0	80.0
	7.5	7.00	2.00	3.00	5.0	83.0
	9.0	5.00	4.00	5.00	9.0	77.0
	10.5	6.00	3.00	4.00	8.0	79.0
	12.0	5.00	5.00	3.00	6.0	81.0
	13.5	4.00	6.00	4.00	7.0	79.0
	15.0	3.00	4.00	6.00	5.0	82.0
	16.5	1.00	2.00	3.00	5.0	89.0
2	1.5	9.00	3.00	4.00	5.0	79.0
	3.0	8.00	4.00	3.00	4.0	81.0
	4.5	5.00	4.00	5.00	9.0	77.0
	6.0	6.00	3.00	4.00	8.0	79.0
	7.5	5.00	2.00	3.00	5.0	85.0
	9.0	3.00	2.00	5.00	8.0	82.0
	10.5	3.00	4.00	2.00	4.0	87.0
	12.0	4.00	3.00	3.00	6.0	84.0
	13.5	2.00	1.00	2.00	5.0	90.0
3	1.5	11.00	3.00	4.00	5.0	77.0
	3.0	4.00	3.00	3.00	6.0	84.0
	4.5	4.00	2.00	5.00	7.0	82.0
	6.0	3.00	4.00	2.00	4.0	87.0
	7.5	5.00	2.00	3.00	5.0	85.0
	9.0	2.00	1.00	2.00	5.0	90.0

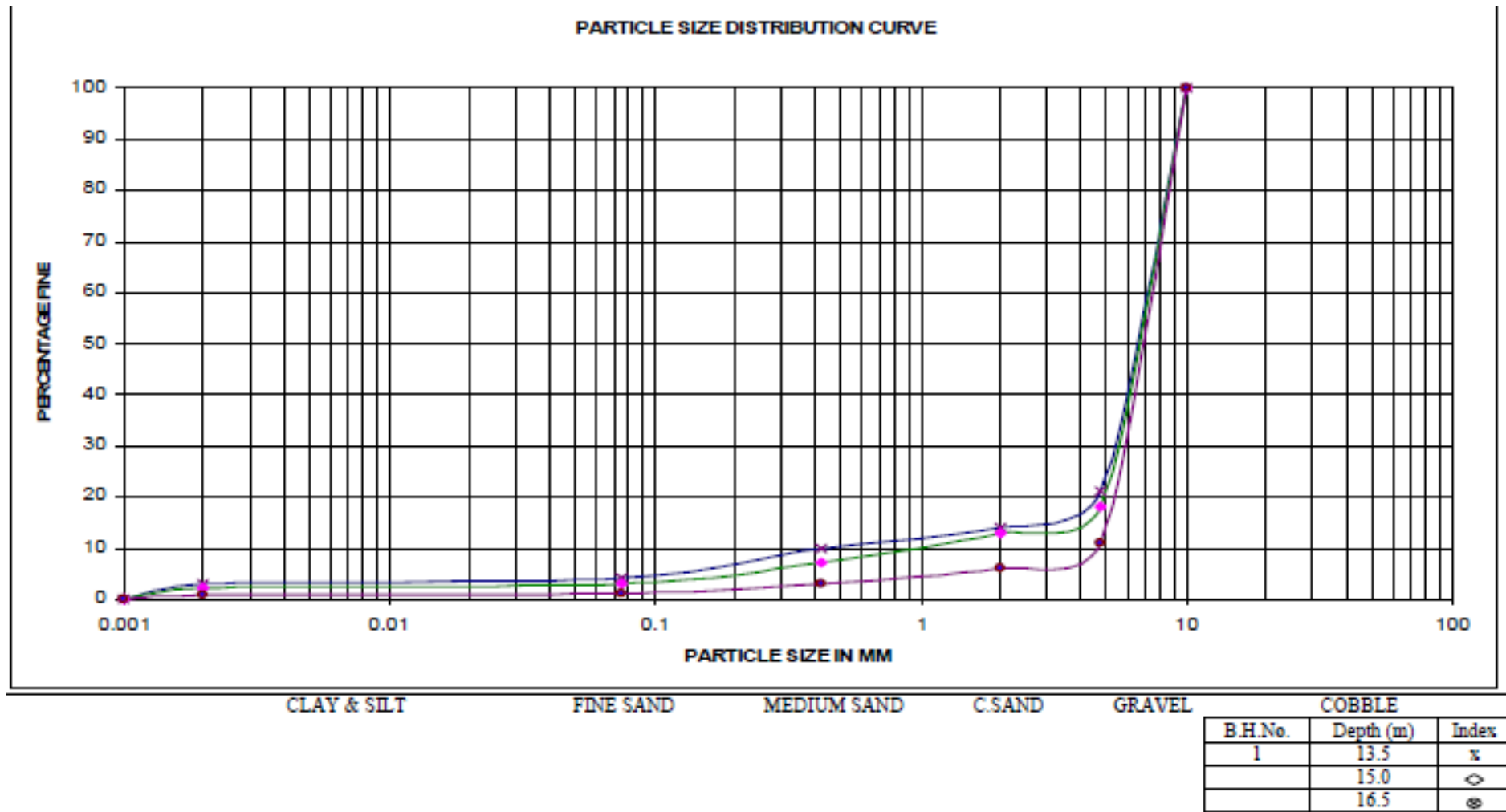
GRAIN SIZE ANALYSIS

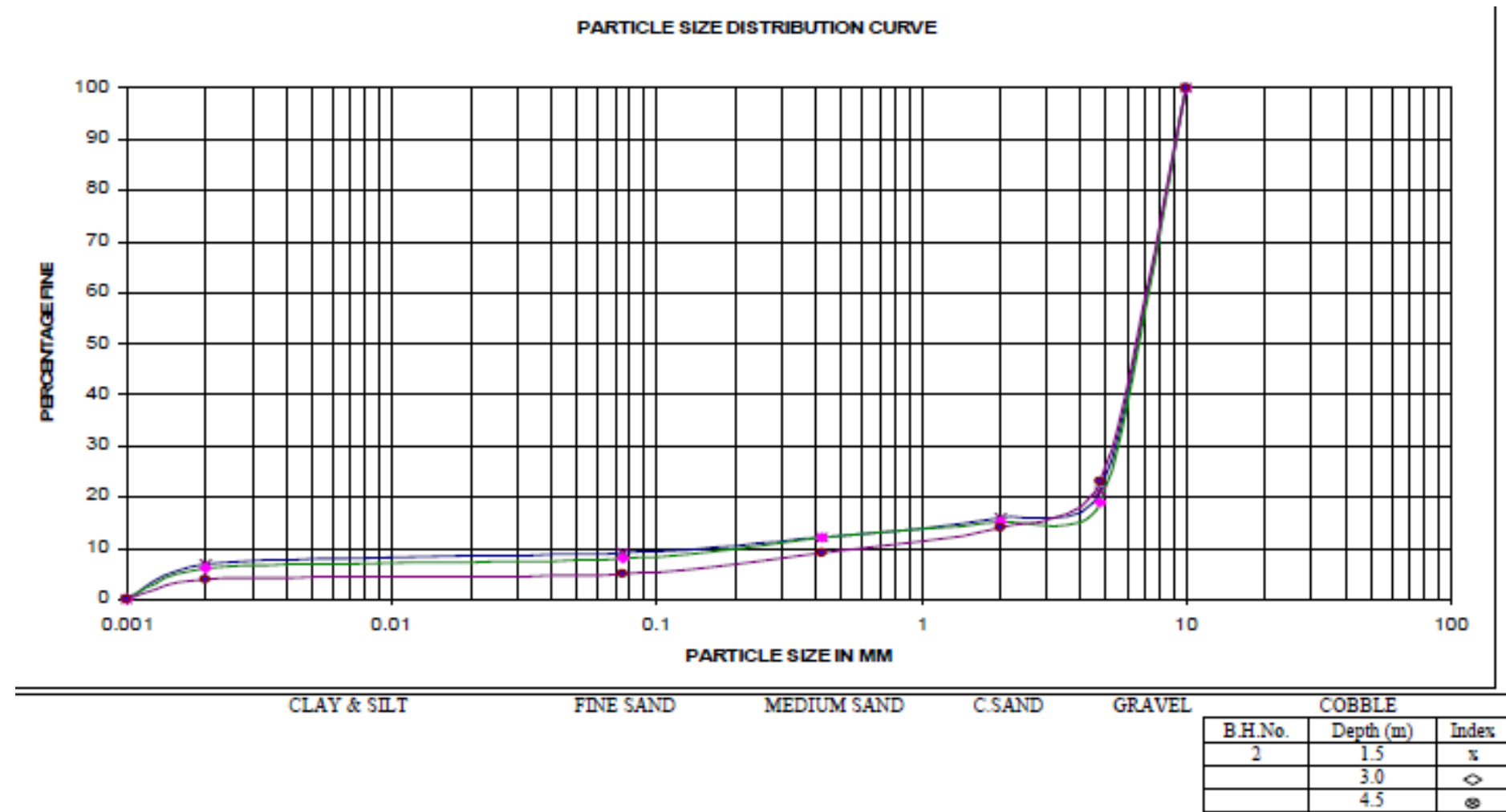
Bore Hole No.	Depth (m)	Silt & Clay (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Gravel (%)
4	1.5	12.00	2.00	3.00	5.0	78.0
	3.0	4.00	3.00	2.00	4.0	83.0
	4.5	3.00	3.00	5.00	4.0	85.0
	6.0	4.00	1.00	4.00	5.0	86.0
	7.5	2.00	1.00	3.00	4.0	90.0
	9.0	3.00	2.00	4.00	2.0	89.0
	10.5	2.00	1.00	2.00	4.0	91.0
	12.0	4.00	1.00	3.00	3.0	89.0
	13.5	2.00	2.00	2.00	4.0	90.0
5	1.5	9.00	3.00	4.00	12.0	72.0
	3.0	4.00	1.00	4.00	5.0	86.0
	4.5	4.00	2.00	5.00	7.0	82.0
	6.0	2.00	1.00	2.00	4.0	91.0
	7.5	3.00	4.00	2.00	4.0	87.0
	9.0	2.00	1.00	2.00	3.0	92.0
6	1.5	-	-	-	-	-
	3.0	62.00	9.00	4.00	15.0	10.0
	4.5	4.00	2.00	5.00	7.0	82.0
	6.0	3.00	4.00	2.00	4.0	87.0
	7.5	2.00	1.00	2.00	3.0	92.0

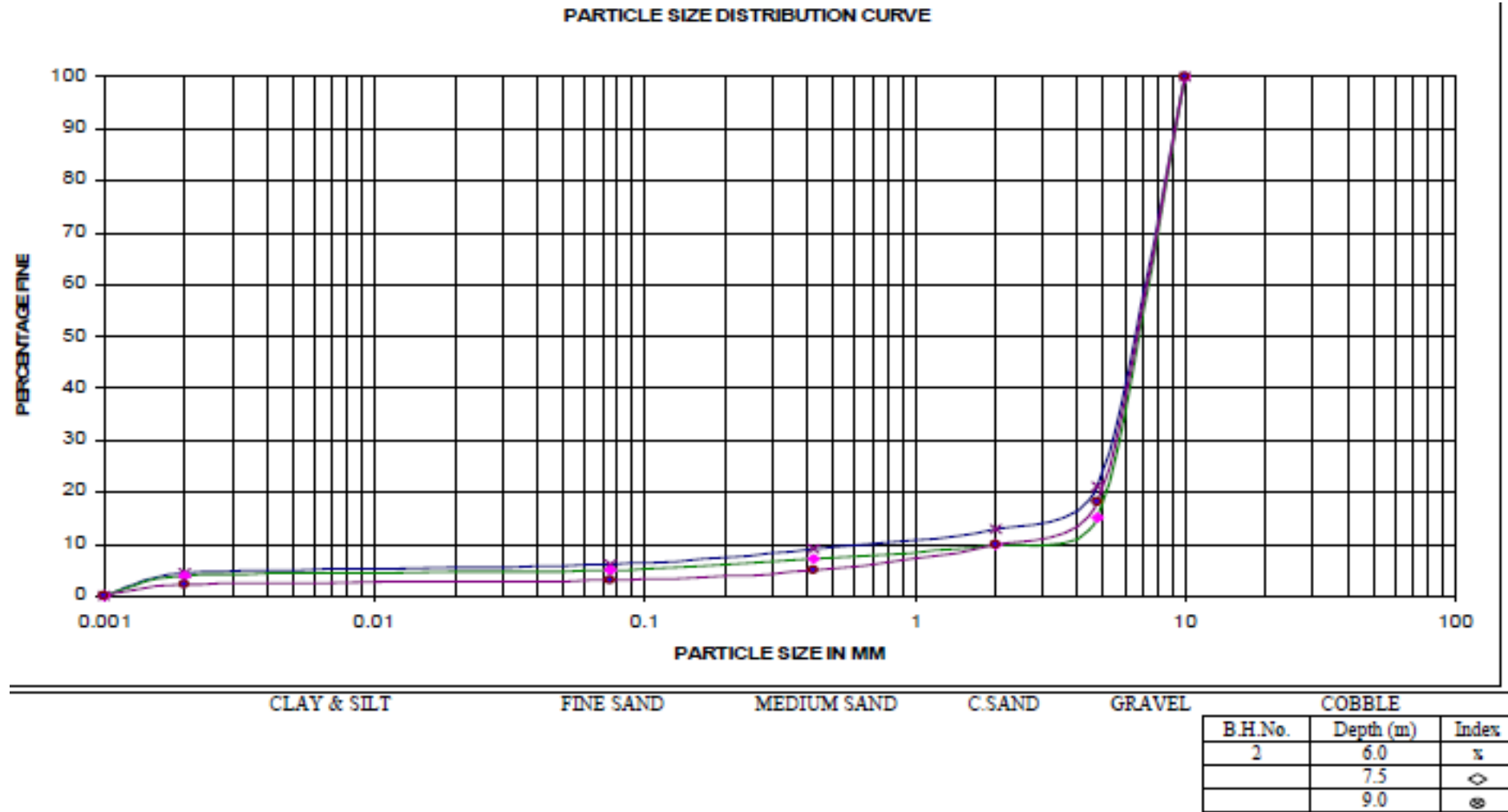


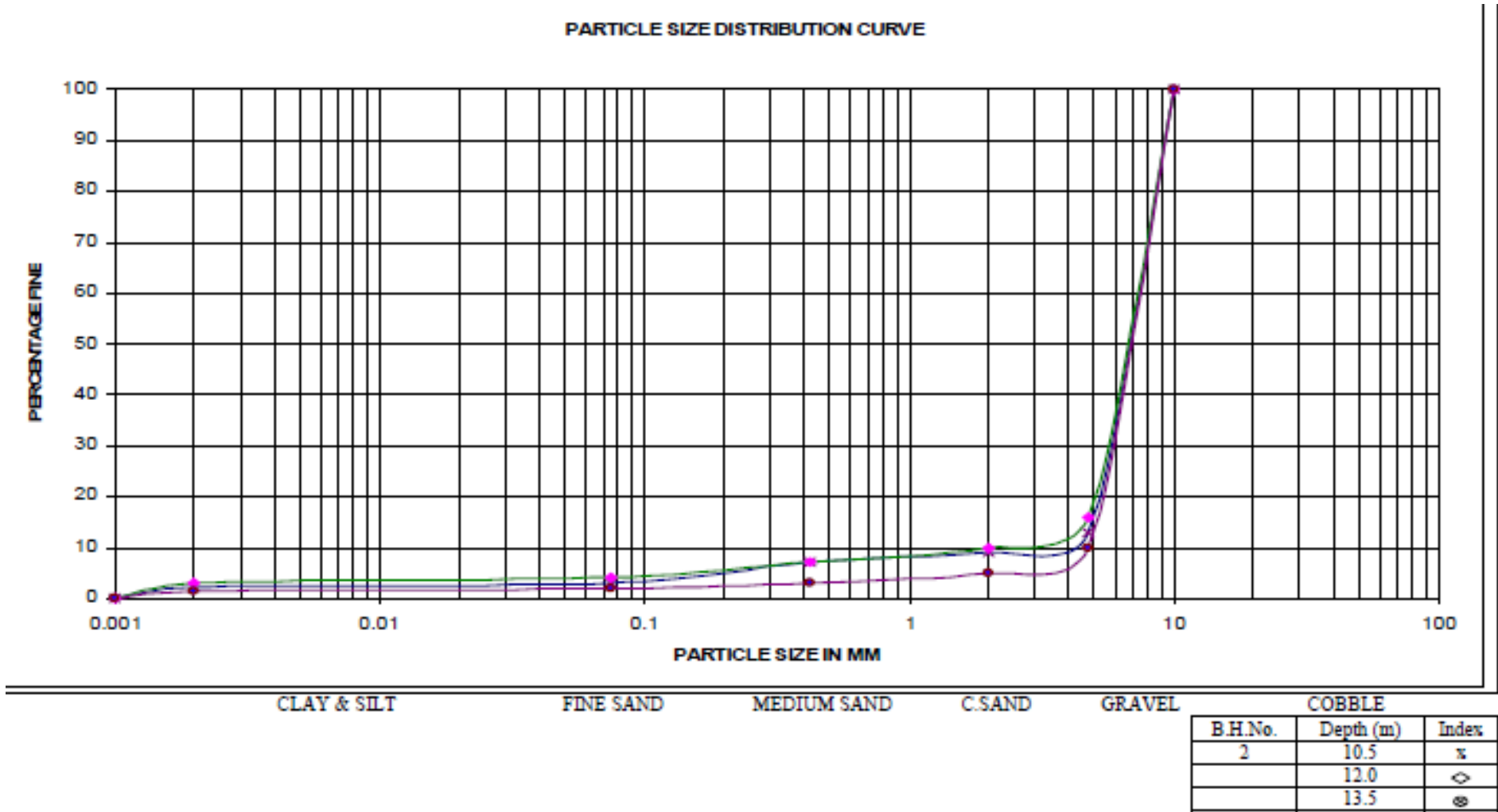


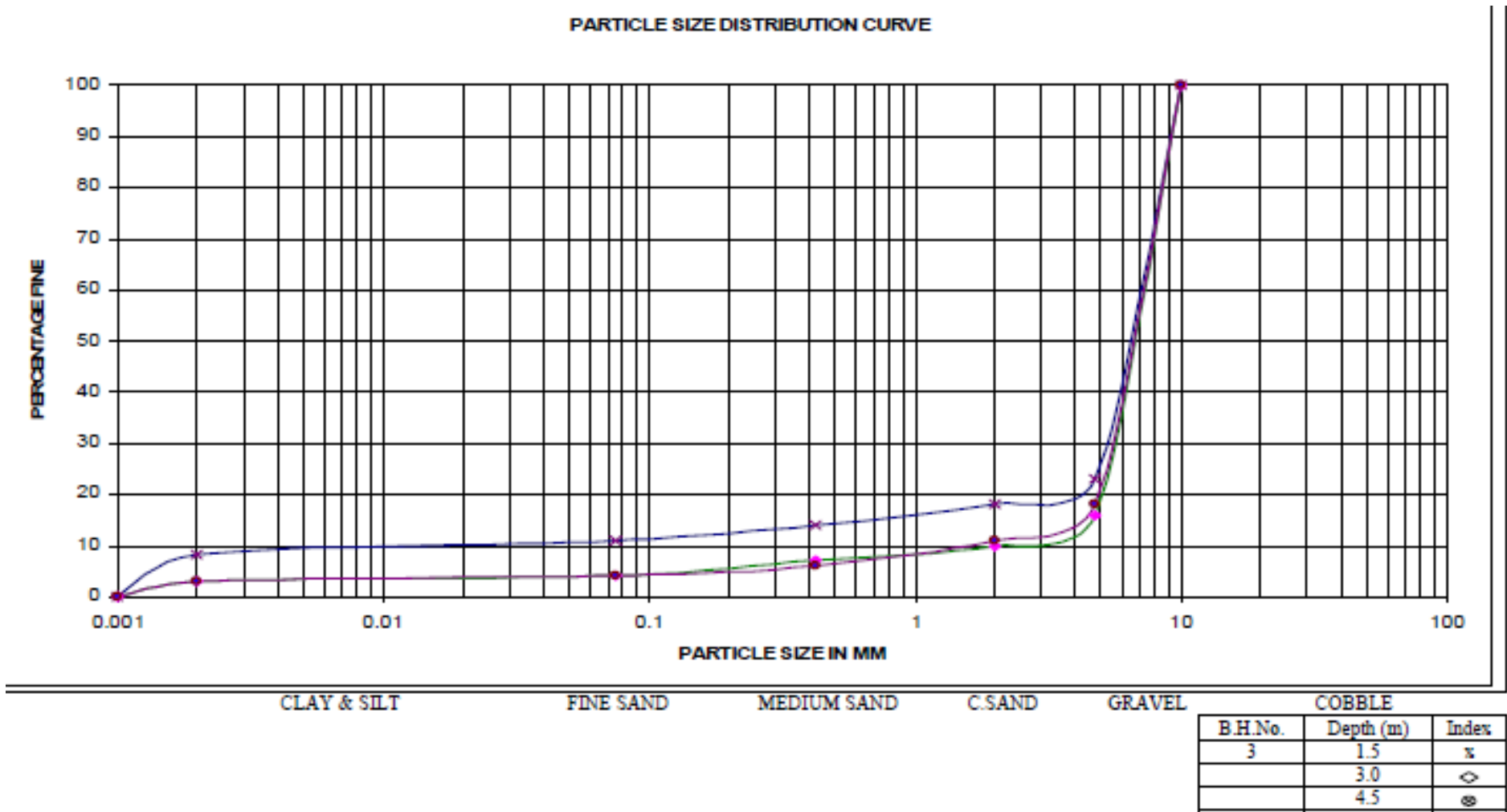


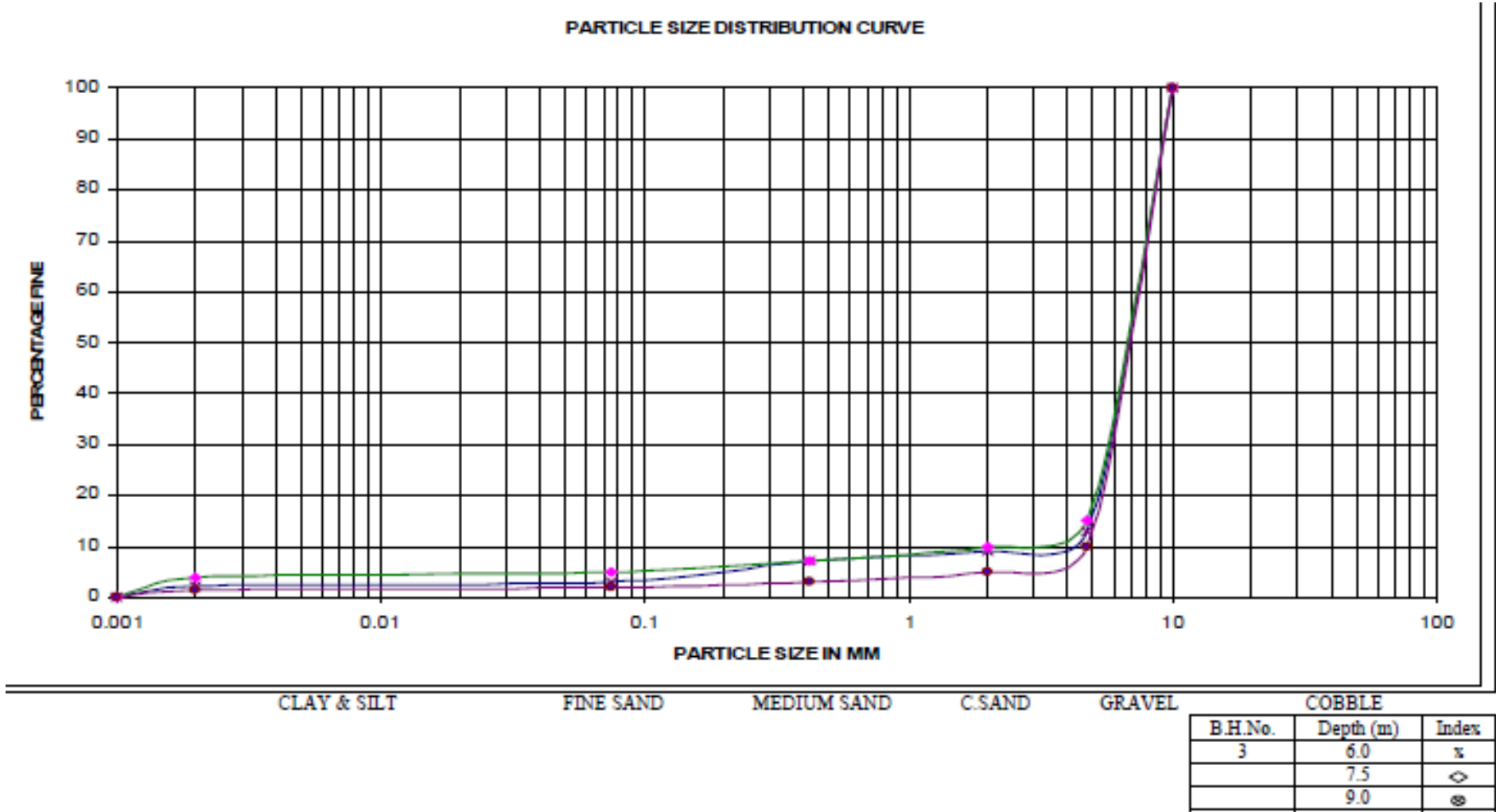


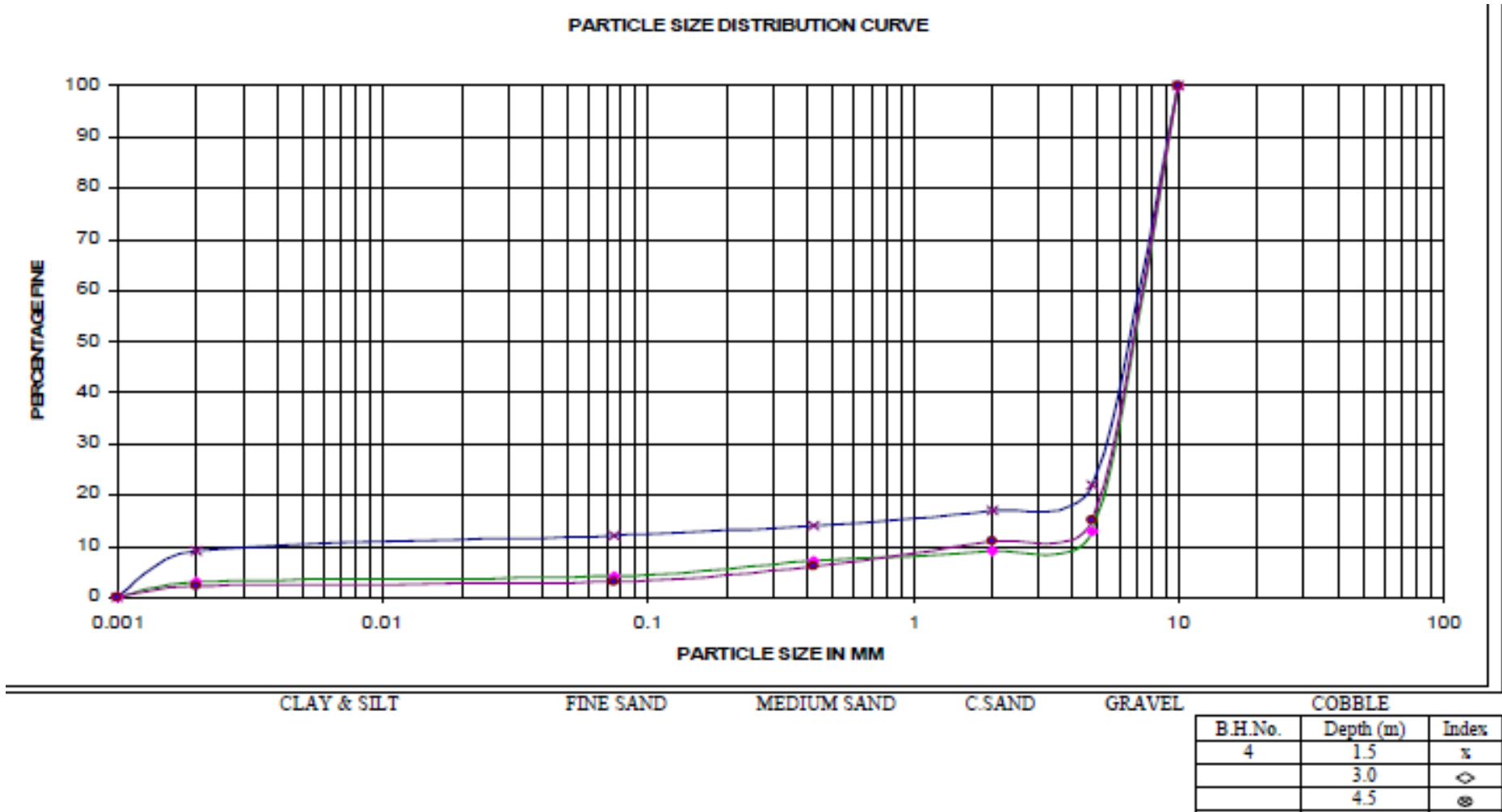


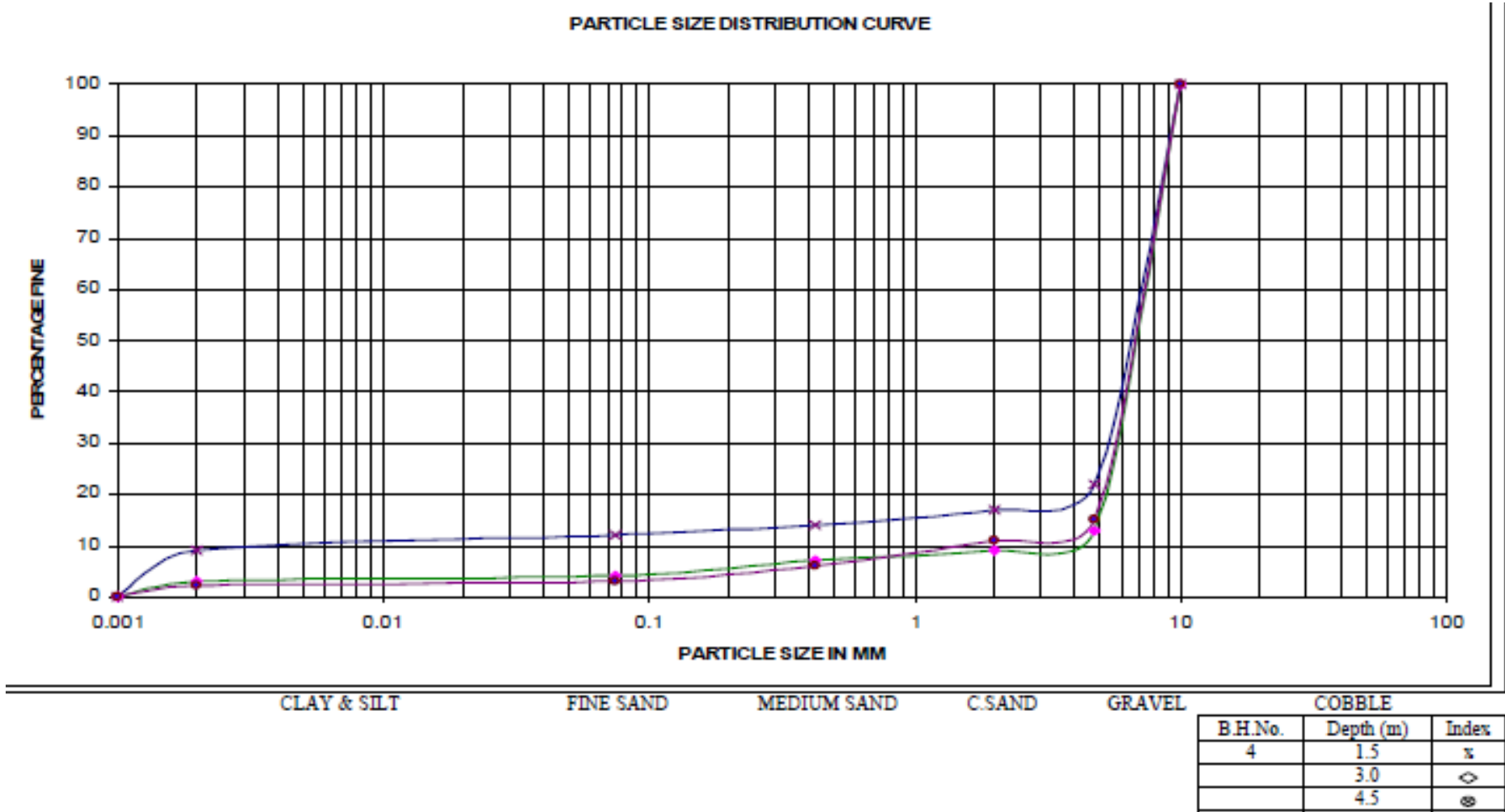


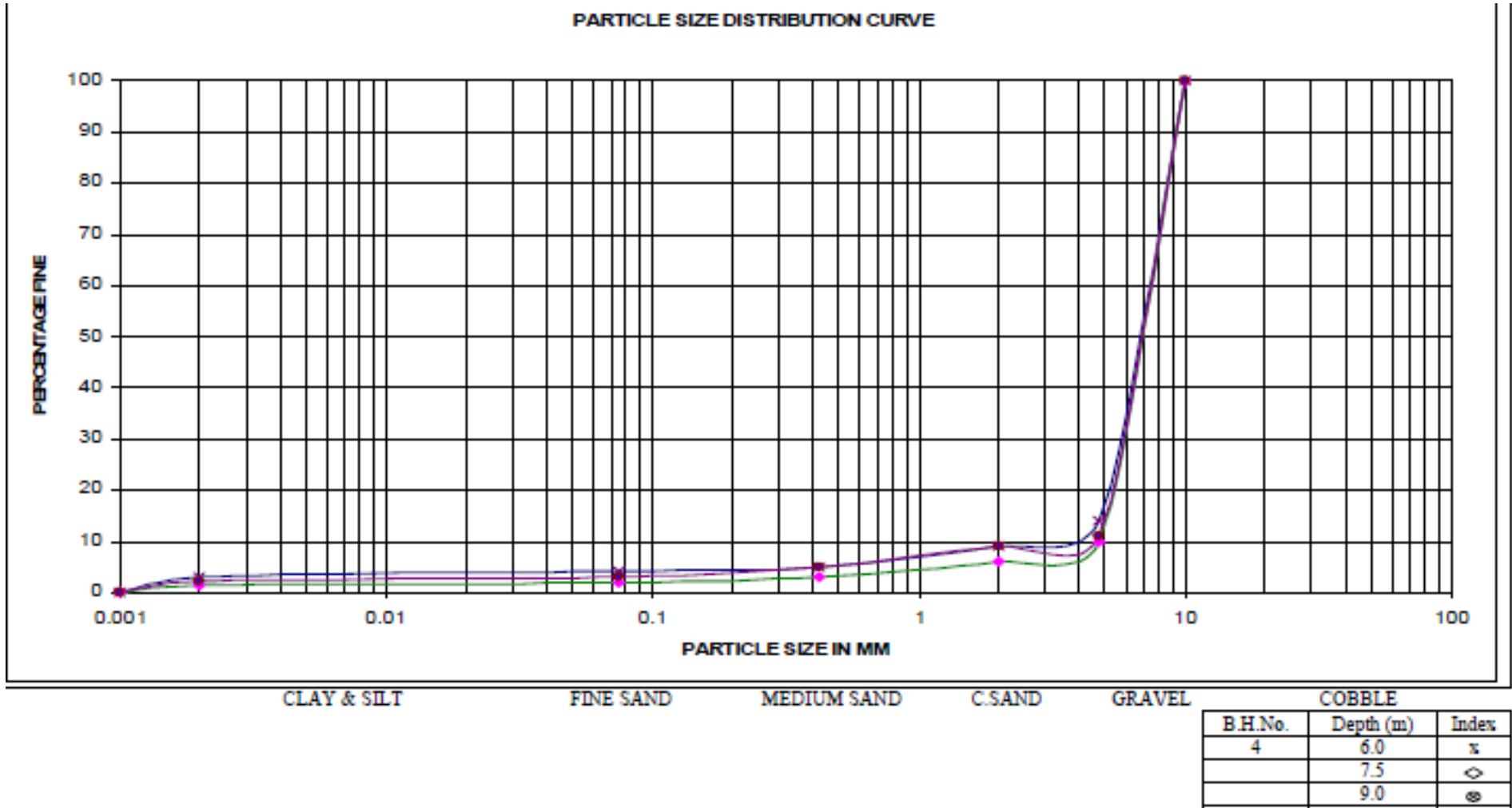


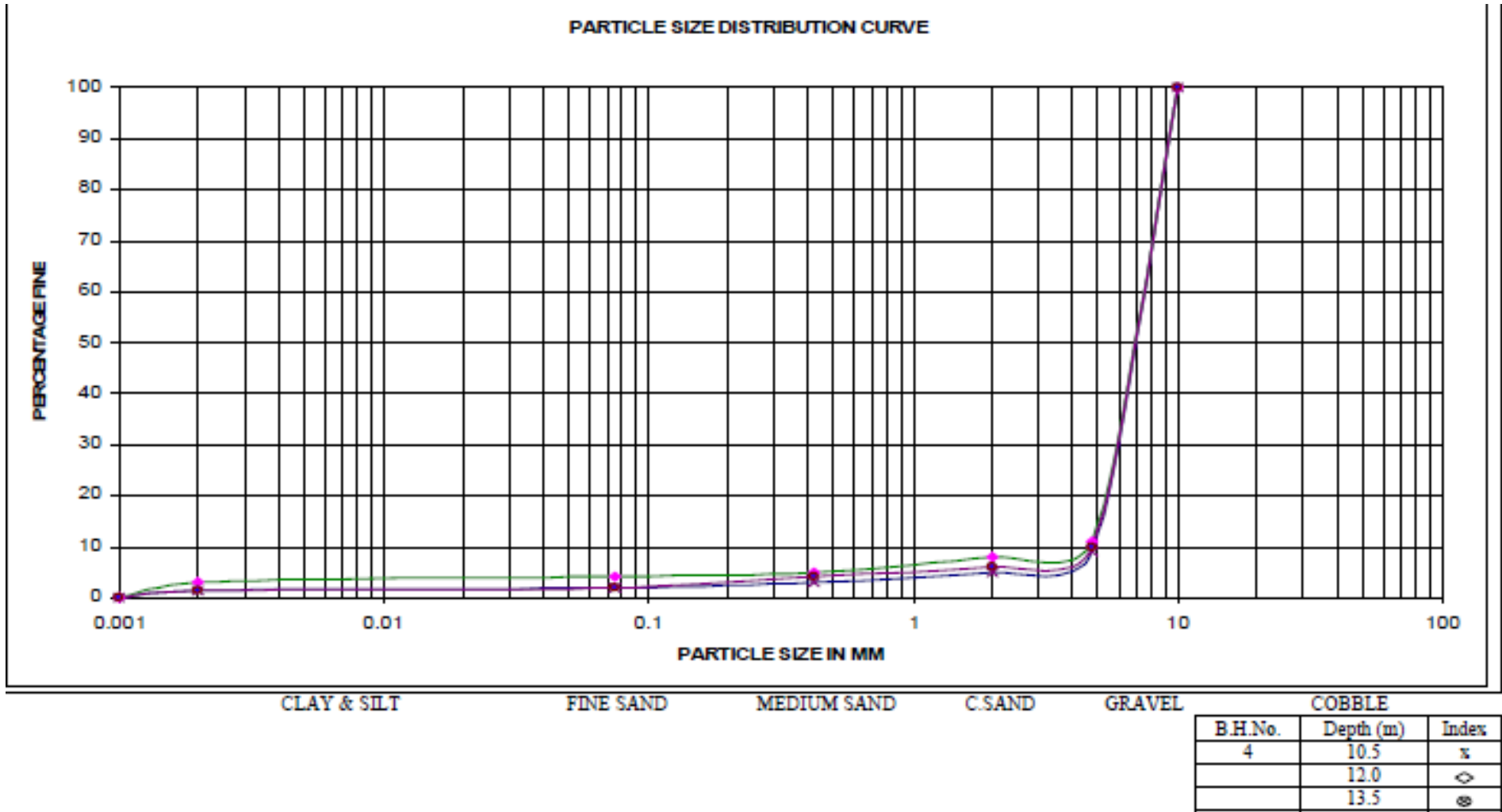


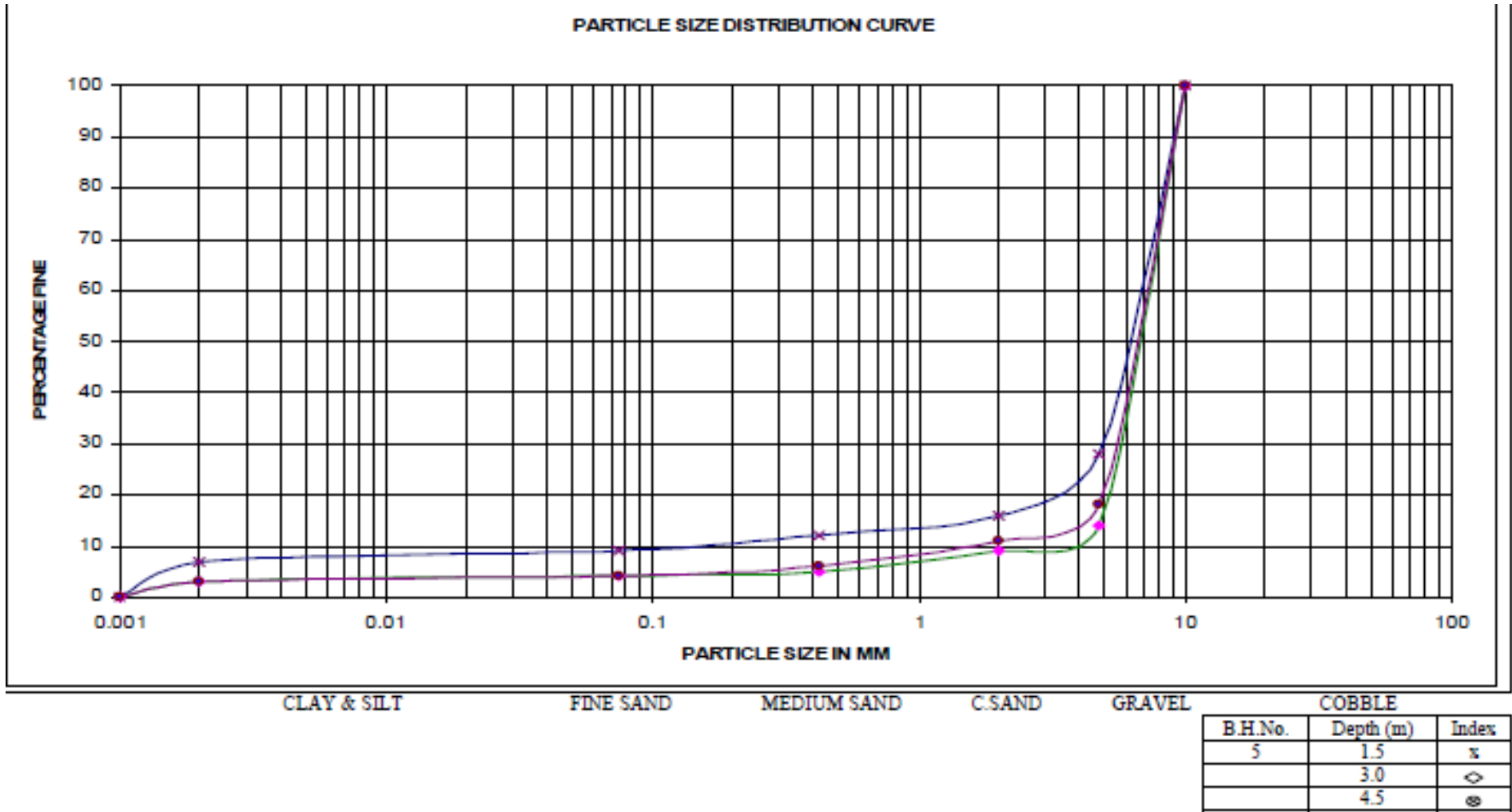


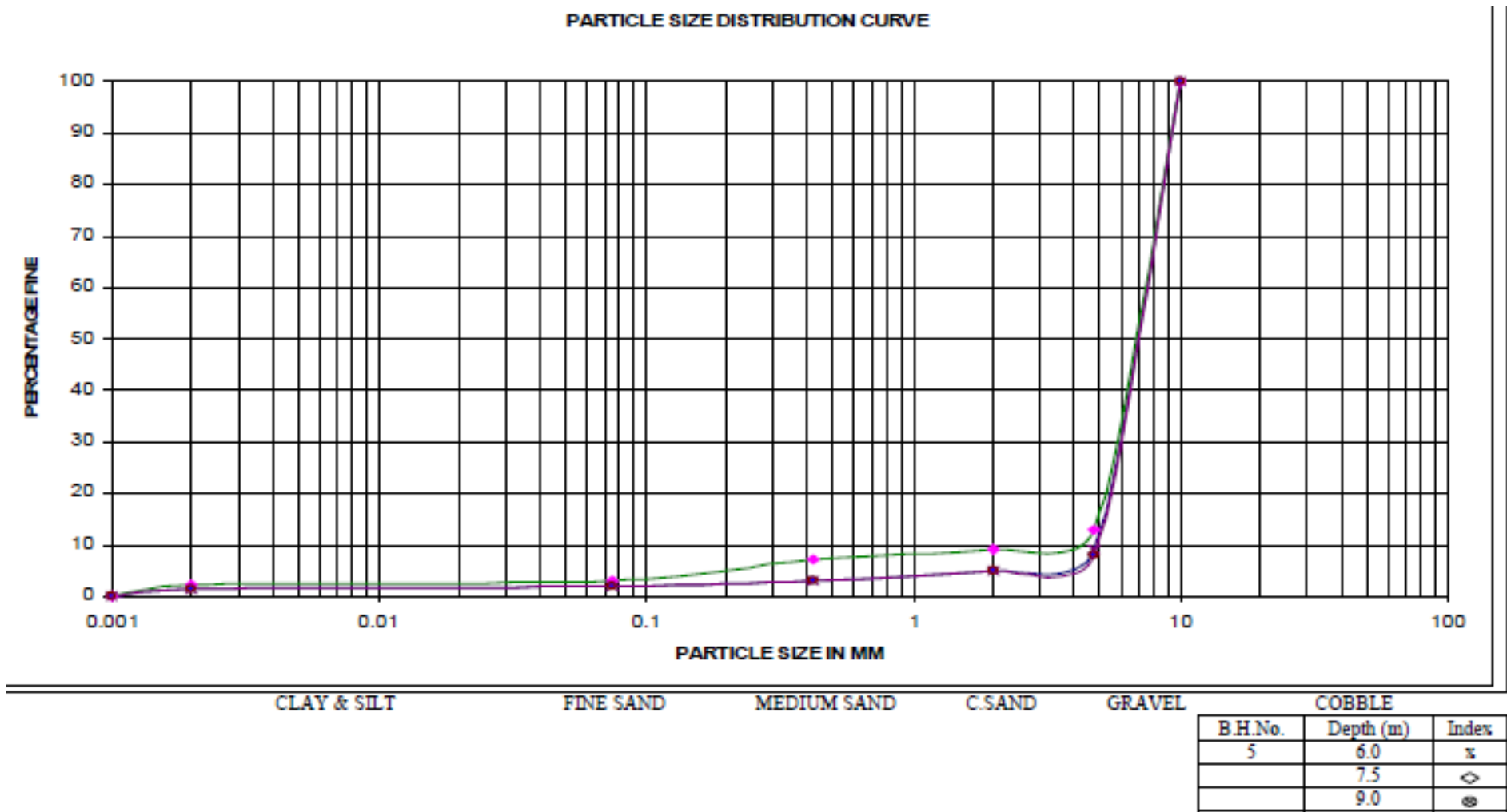


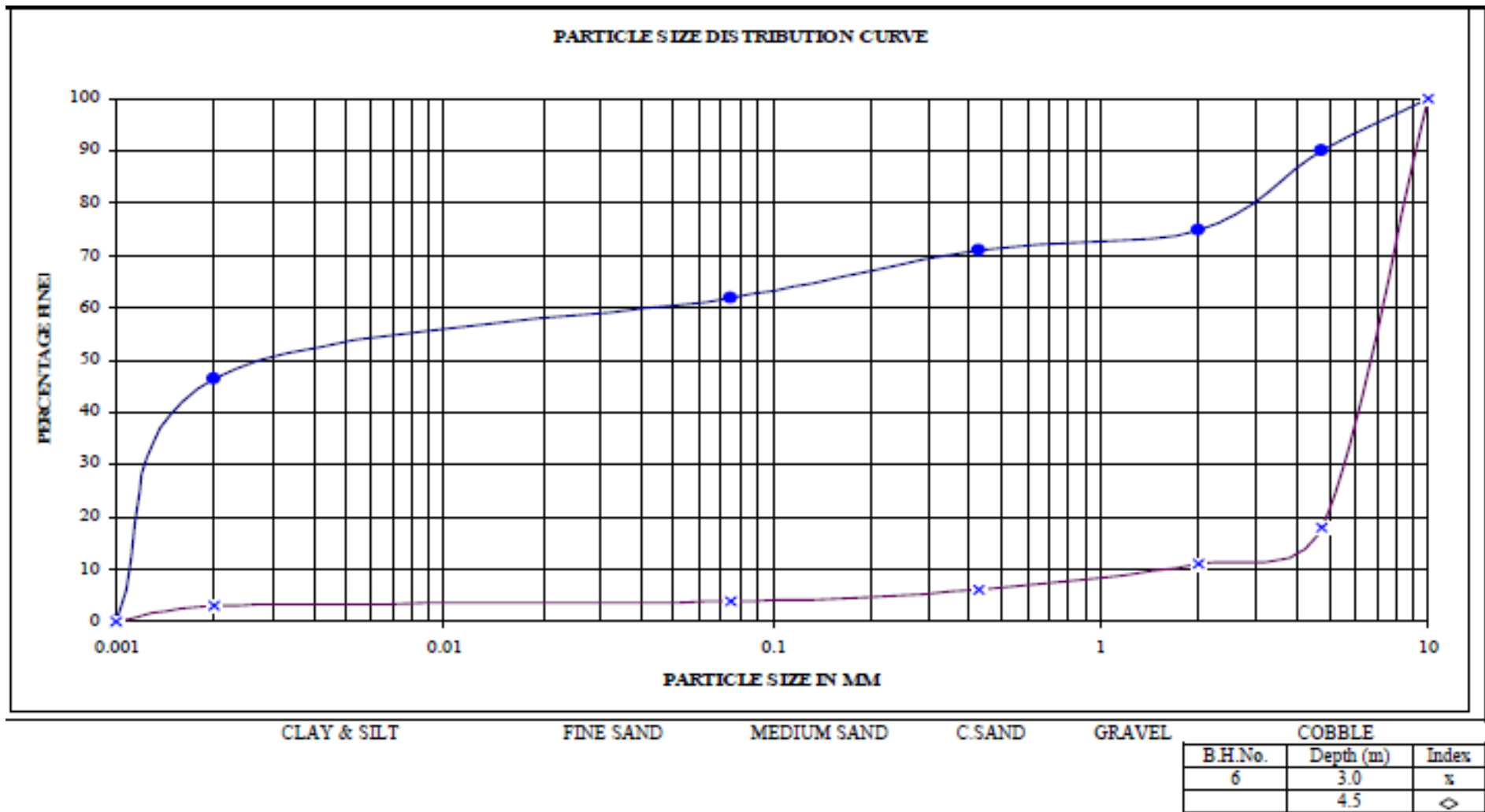


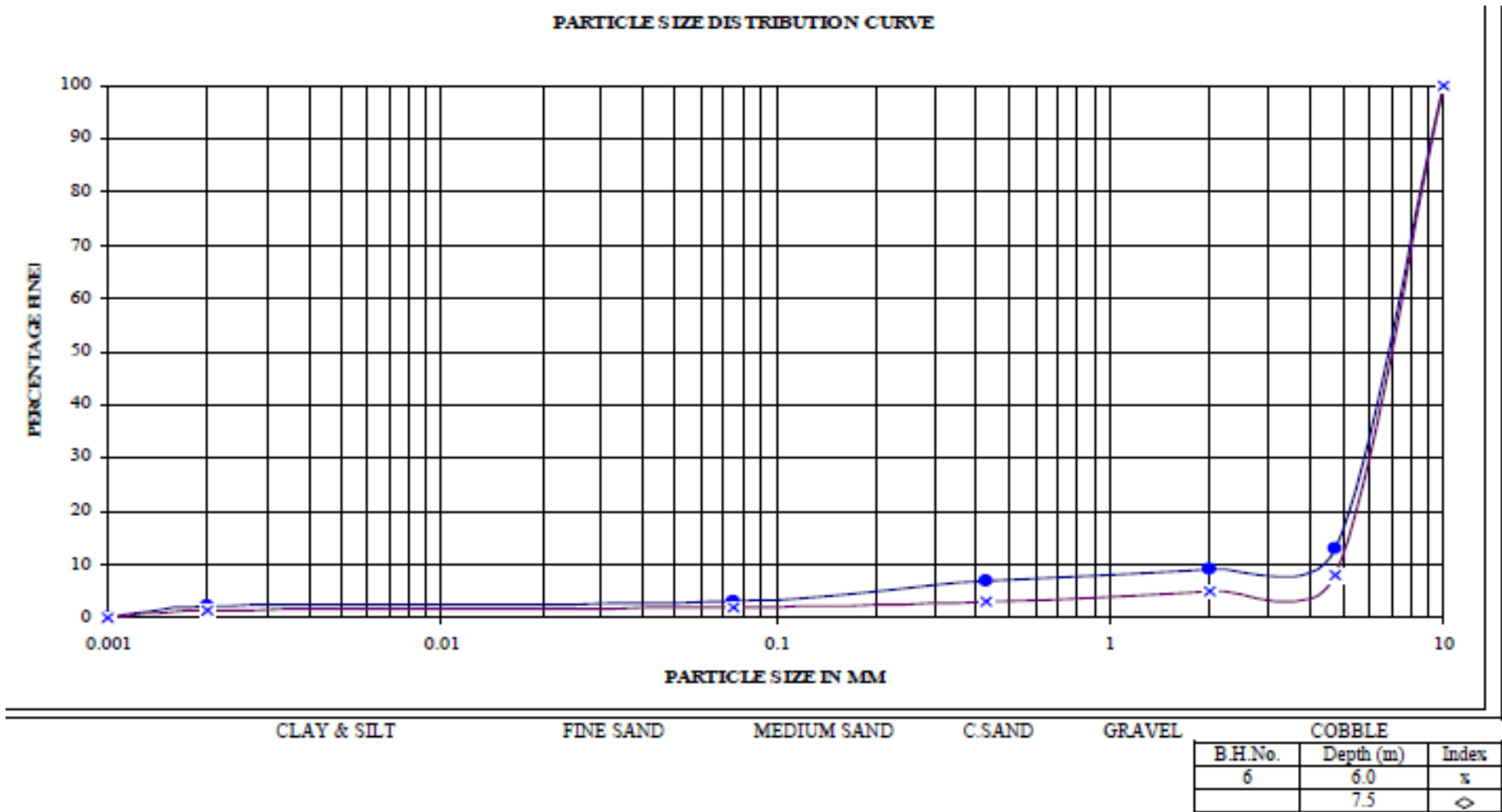












Annexure II:

Annexure 2 :Tests on Soil & Bentonite Mixing

SOIL ANALYSIS FOR THE PROJECT OF SOLID WASTE MANAGEMENT (CONSTRUCTION OF SANITARY LANDFILL SITE AT MAWIONG)

1. The sanitary landfill site of Mawiong area consist mainly of feldspathic quartzite. It is the Shillong Group of metamorphic rocks of Precambrian age. The rocks are highly jointed. The mineral content of the rocks are mostly quartz, feldspar and very less amount of mica. The rocks are also partially weathered. The rocks are permeable in nature due to the presence of joints, fractures and weathering effect. During rainy season water may percolate from the SWM site through joints and fractures and may pollute the soil, nearby streams, lakes and ground water of this area. The soil cover of the area is very thin and silty clay in nature. But in nearby areas of the SWM site thick beds of lateritic clayey soil is available at a distance of 3 km towards Barapani.

2. To make the SWM site into an impervious one we have to add 10 % of Bentonite alongwith the silty clay to laminate the area. For this purpose the following three soil samples had been collected from three different locations of Shillong area for Laboratory analysis.

1. Lateritic soil sample from Mawiong which is only 3.5 km away from SWM site.
2. Soil sample from SWM site of Mawiong.
3. Soil sample from Smit area which is about 25 km away from the SWM site.

3. The following laboratory tests were conducted on the above mentioned samples.

They are –

- 1) Gradation test,
- 2) Liquid limit and Plastic limit,
- 3) Standard proctor test
- 4) Permeability test

4. The summary of the results of laboratory analysis are given below:

Summary of results

Sample No	Test No	Name of test	Result
1	i	Proctor test	
	a	Virgin soil	MDD= 1.69gm/cc OMC = 21%
	b	with 10% Bentonite by weight	MDD= 1.70gm/cc OMC = 23.4%
	ii	Gradation	% silt and clay (Passing .075mm sieve) =80%
	iii	Plasticity	LL=58% PL=35% PI= 23%
	iv	Permeability (Coeff of Permeability) K=	
	a	Virgin soil	K=9.20x10 ⁻⁸ cm/sec
	b	with 10% Bentonite by weight	K=2.85x10 ⁻⁸ cm/sec

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2	i	Proctor test	
	a	Virgin soil	MDD= 1.66gm/cc OMC =13.5%
	b	with 10% Bentonite by weight	MDD= 1.67gm/cc OMC = 15.8%
	ii	Gradation	% silt and clay (Passing .075mm sieve) =18%
	iii	Plasticity	LL=Non Plastic PL=Non Plastic
	iv	Permeability (Coeff of Permeability) K=	
	a	Virgin soil	K=1.80x10 ⁻⁴ cm/sec
	b	with 10% Bentonite by weight	K=2.07x10 ⁻⁶ cm/sec
3	i	Proctor test	
	a	Virgin soil	MDD= 1.66gm/cc OMC = 16%
	b	with 10% Bentonite by weight	MDD= 1.70gm/cc OMC =17%
	ii	Gradation	% silt and clay (Passing .075mm sieve) =35%
	iii	Plasticity	LL=Non Plastic PL=Non Plastic
	iv	Permeability (Coeff of Permeability) K=	
	a	Virgin soil	K=1.30x10 ⁻⁵ cm/sec
	b	with 10% Bentonite by weight	K=9.41x10 ⁻⁸ cm/sec

5. From the study of the laboratory analysis of the above mentioned samples it appears that the sample No.1 which is collected from Mawiong area (3.5 km away) site is suitable for laminating the SWM site. The lateritic silty clay soil after amended with 10 % Bentonite the coefficient of permeability result is $K = 2.85 \times 10^{-8}$ cm/Sec. which will be suitable for SWM site as an impervious layer.

6. The basic requirement of the compacted clay liner is that it should have permeability below prespecified limit (10^{-7} cm/sec.) and that this should be maintained during the design life of landfill. For this purpose sample No.1 is recommended which is available nearby areas with admix of 10 % Bentonite.

The detailed results of laboratory analysis are given as under:-

Sample1 Reddish silty clay (virgin soil)
Name of test : 1. Determination of MDD & OMC (Standard Proctor test)

Proctor test result (IS:2720-VII)

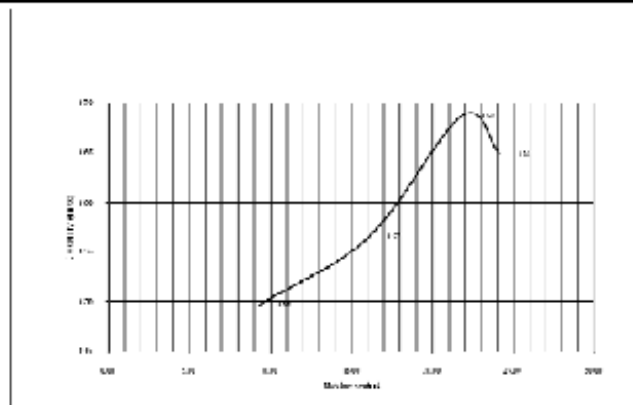
- 1 Size of mould = 10 cm dia x 12.73 cm height
- 2 Capacity of mould = 1000 cc
- 3 Rammer = 2.6 Kg x 310mm
- 4 No of layer = 3
- 5 Blows per layer = 25

(a) Density determination

		Test No	1	2	3	4
1	Mass of mould + soil	(gm)	3830	3810	4050	4040
2	Mass of empty mould	(gm)	1993	1993	1993	1993
3	Mass of compacted soil	(gm)	1837	1817	2057	2047
4	Bulk density	(gm/cc)	1.84	1.82	2.06	2.05
5	Dry density	(gm/cc)	1.50	1.57	1.69	1.65

(b) Moisture content determination

	Container No		A2	A7	N1	N6
1	Container No					
2	Mass of cont + wet soil	gm	48.87	51.64	56.62	60.45
3	Mass of cont + dry soil	gm	45.92	46.2	48.44	51.23
4	Mass of water present	gm	2.95	5.44	8.18	9.22
5	Mass of empty container	gm	14.19	12.36	11.04	13.07
6	Mass of dry soil	gm	31.73	33.84	37.4	38.16
7	Moisture content	%	9.30	16.08	21.87	24.16



Maximum dry density (MDD) = 1.69gm/cc

Optimum moisture content (OMC) = 21.0 %

- 2 Gradation test
Silt and Clay = 80%
- 3 Liquid limit = 58%
Plastic limit = 35%

Sample1 **Reddish silty clay (with 10% Bentonite by weight)**
Name of test : **1. Determination of MDD & OMC (Standard Proctor test)**

Proctor test result (IS:2720-VII)

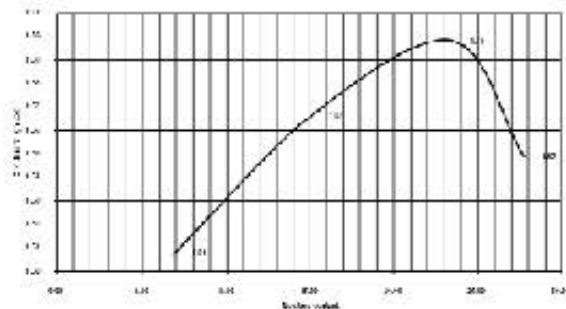
1	Size of mould	=	10 cm dia x 12.73 cm height
2	Capacity of mould	=	1000cc
3	Rammer	=	2.6 Kg x 310mm
4	No of layer	=	3
5	Blows per layer	=	25

(a) Density determination

		Test No	1	2	3	4
1	Mass of mould + soil	(gm)	3710	3910	4090	4100
2	Mass of empty mould	(gm)	1993	1993	1993	1993
3	Mass of compacted soil	(gm)	1717	1917	2097	2107
4	Bulk density	(gm/cc)	1.72	1.92	2.10	2.11
5	Dry density	(gm/cc)	1.61	1.67	1.70	1.65

(b)Moisture content determination

	Container No		N5	N6	N1	N6
1	Container No					
2	Mass of cont + wet soil	gm	41.35	42.8	50.12	53.89
3	Mass of cont + dry soil	gm	39.54	38.81	43.1	45.3
4	Mass of water present	gm	1.81	3.99	7.02	8.59
5	Mass of empty container	gm	12.97	12.1	13.2	14.36
6	Mass of dry soil	gm	26.57	26.51	29.9	30.94
7	Moisture content	%	6.81	15.05	23.48	27.76



Maximum dry density (MDD) = 1.70gm/cc
Optimum moisture content (OMC) = 23.4 %

4 Name of test : Falling head Permeability test

Sample1. (Virgin soil)		
Length of soil sample L=	12.73	cm
Diameter of soil sample =	10	cm
Area of soil sample,A =	78.5	sqcm
Area of stand pipe, a =	0.44	sqcm
Initial head h1 =	100	cm
Final head h2 =	85	cm
Time =	35 hrs	126000 sec
Coefficient of permeability , $K=(2.303aL/At) \log h_1/h_2$		
K= 9.20×10^{-8} cm/sec		

Sample1. (with 10% Bentonite by weight)		
Length of soil sample L=	12.73	cm
Diameter of soil sample =	10	cm
Area of soil sample,A =	78.5	sqcm
Area of stand pipe, a =	0.44	sqcm
Initial head h1 =	90	cm
Final head h2 =	84	cm
Time =	48 hrs	172800 sec
Coefficient of permeability , $K=(2.303aL/At) \log h_1/h_2$		
K= 2.85×10^{-8} cm/sec		

Sample2 (virgin soil)
Name of test : **1. Determination of MDD & OMC (Standard Proctor)**

Proctor test result (IS:2720-VII)

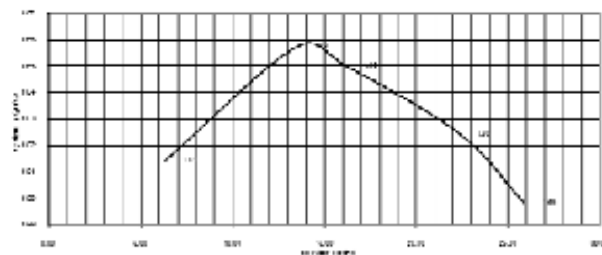
- 1 Size of mould = 10 cm dia x 12.73 cm height
- 2 Capacity of mould = 1000cc
- 3 Rammer= 2.6 Kg x 310mm
- 4 No of layer = 3
- 5 Blows per layer 25

(a) Density determination

		Test No	1	2	3	4	5
1	Mass of mould + soil		3710	3874	3910	3980	4005
2	Mass of empty mould	(gm)	1993	1993	1993	1993	1993
3	Mass of compacted soil	(gm)	1717	1881	1917	1987	2012
4	Bulk density	(gm/cc)	1.72	1.88	1.92	1.99	2.01
5	Dry density	(gm/cc)	1.61	1.88	1.65	1.62	1.60

(b) Moisture content determination

	Container No		5	4	8	9	10
1	Mass of cont + wet soil	gm	64.17	58.2	64.43	61.56	75.03
2	Mass of cont + dry soil	gm	61.25	51.15	57.36	52.23	62.84
3	Mass of water present	gm	2.92	5.05	7.07	9.33	12.19
4	Mass of empty container	gm	15.29	13.73	13.63	10.43	15.75
5	Mass of dry soil	gm	45.96	37.42	43.73	41.8	47.09
6	Moisture content	%	6.35	13.50	16.17	22.32	25.89



Maximum dry density (MDD) = 1.66 gm/cc
Optimum moisture content (OMC) = 13.50%

- 2 Gradation
Silt and clay = 18%
- 3 Liquid limit = Non Plastic
Plastic limit = Non Plastic

Sample2 (with 10% Bentonite by weight)
Name of test : **1. Determination of MDD & OMC (Standard Proctor)**

Proctor test result (IS:2720-VII)

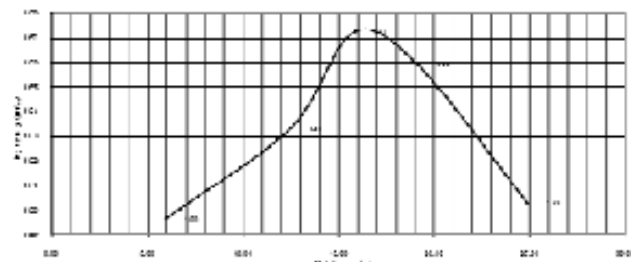
- 1 Size of mould = 10 cm dia x 12.73 cm height
- 2 Capacity of mould = 1000cc
- 3 Rammer= 2.6 Kg x 310mm
- 4 No of layer= 3
- 5 Blows per layer= 25

(a) Density determination

	Test No	1	2	3	4	5
1	Mass of mould + soil	3684	3830	3930	3970	3995
2	Mass of empty mould (gm)	1993	1993	1993	1993	1993
3	Mass of compacted soil (gm)	1691	1837	1937	1977	2002
4	Bulk density (gm/cc)	1.69	1.84	1.94	1.98	2.00
5	Dry density (gm/cc)	1.60	1.63	1.67	1.66	1.60

(b) Moisture content determination

	Container No	B2	B7	B3	B11	B13
2	Mass of cont + wet soil gm	54.23	43.02	51.88	45.19	37.3
3	Mass of cont + dry soil gm	51.98	39.65	47.1	40.36	32.54
4	Mass of water present gm	2.25	3.37	4.78	4.83	4.76
5	Mass of empty container gm	14.06	12.63	16.89	15.19	13.43
6	Mass of dry soil gm	37.92	27.02	30.21	25.17	19.11
7	Moisture content %	5.93	12.47	15.82	19.19	24.91



Maximum dry density (MDD) = 1.67 gm/cc

Optimum moisture content (OMC) = 15.80%

- 2 Gradation
Silt and clay = 18%
- 3 Liquid limit = Non Plastic
Plastic limit = Non Plastic

4 Name of test : Falling head Permeability test

Sample2. (Virgin soil)		
Length of soil sample L= .	12.73	cm
Diameter of soil sample =	10	cm
Area of soil sample,A =	78.5	sqcm
Area of stand pipe, a =	0.44	sqcm
Initial head h1 =	100	cm
Final head h2 =	10	cm
Time =	0.25 hrs= 15 min	900 sec
Coefficient of permeability , $K=(2.303aL/At) \log h_1/h_2$		
K=	1.8×10^{-4}	cm/sec

Sample2. (with 10% Bentonite by weight)		
Length of soil sample L= .	12.73	cm
Diameter of soil sample =	10	cm
Area of soil sample,A =	78.5	sqcm
Area of stand pipe, a =	0.44	sqcm
Initial head h1 =	85	cm
Final head h2 =	69	cm
Time =	2 hrs	7200 sec
Coefficient of permeability , $K=(2.303aL/At) \log h_1/h_2$		
K=	2.07×10^{-6}	cm/sec

Sample3 (virgin soil)
Name of test : 1 Determination of MDD & OMC (Standard Proctor)

Proctor test result (IS:2720-VII)

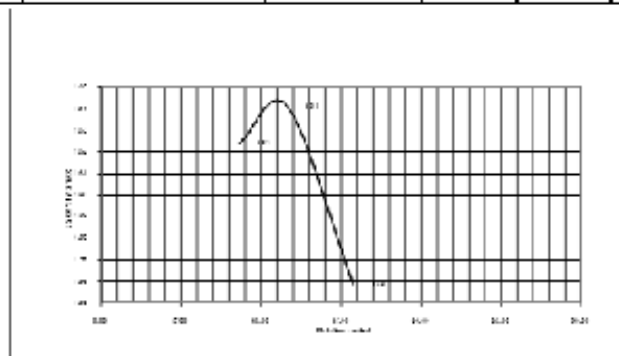
1	Size of mould =	10 cm dia x 12.73 cm height
2	Capacity of mould=	1000 cc
3	Rammer=	2.6 Kg x 310mm
4	No of layer=	3
5	Blows per layer=	25

(a) **Density determination**

		Test No	1	2	3
1	Mass of mould + soil	(gm)	3757	3825	3798
2	Mass of empty mould	(gm)	1993	1993	1993
3	Mass of compacted soil	(gm)	1764	1832	1805
4	Bulk density	(gm/cc)	1.76	1.83	1.81
5	Dry density	(gm/cc)	1.62	1.64	1.58

(b) **Moisture content determination**

	Container No		4	2	8
1	Container No				
2	Mass of cont + wet soil	gm	66	73.71	67.44
3	Mass of cont + dry soil	gm	61.74	67.3	59.78
4	Mass of water present	gm	4.26	6.41	7.66
5	Mass of empty container	gm	12.36	12.27	11.35
6	Mass of dry soil	gm	49.38	55.03	48.43
7	Moisture content	%	8.63	11.65	15.82



Maximum dry density (MDD) = 1.66 gm/cc

Optimum moisture content (OMC) = 16.0 %

- 2 Gradation
Silt and clay = 35%
- 3 Liquid limit = Non Plastic
Plastic limit = Non Plastic

Sample3 : (with 10% Bentonite by weight)

Name of test :

1 Determination of MDD & OMC (Standard Proctor)

Proctor test result (IS:2720-VII)

1 Size of mould = 10 cm dia x 12.73 cm height

2 Capacity of mould = 1000 cc

3 Rammer= 2.6 Kg x 310mm

4 No of layer= 3

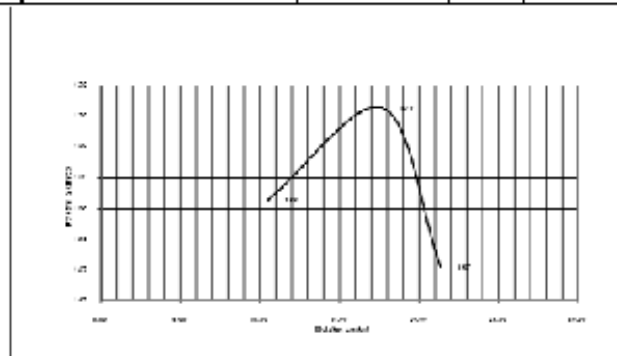
5 Blows per layer= 25

(a) **Density determination**

		Test No	1	2	3
1	Mass of mould + soil	(gm)	3850	3990	4020
2	Mass of empty mould	(gm)	1993	1993	1993
3	Mass of compacted soil	(gm)	1857	1997	2027
4	Bulk density	(gm/cc)	1.86	2.00	2.03
5	Dry density	(gm/cc)	1.68	1.70	1.67

(b) **Moisture content determination**

1	Container No		C1	C5	C3
2	Mass of cont + wet soil	gm	35.3	40.39	37.85
3	Mass of cont + dry soil	gm	33.2	36.23	33.56
4	Mass of water present	gm	2.1	4.16	4.29
5	Mass of empty container	gm	13.1	12.76	13.46
6	Mass of dry soil	gm	20.1	23.47	20.1
7	Moisture content	%	10.45	17.72	21.34



Maximum dry density (MDD) = 1.70 gm/cc
Optimum moisture content (OMC) = 17.0 %

4. Name of test : Falling head Permeability test

Sample3. (Virgin soil)		
Length of soil sample L=	12.73	cm
Diameter of soil sample =	10	cm
Area of soil sample,A =	78.5	sqcm
Area of stand pipe, a =	0.44	sqcm
Initial head h1 =	91	cm
Final head h2 =	47	cm
Time =	1 hrs	3600 sec
Coefficient of permeability , $K=(2.303aL/At) \log h_1/h_2$		
K= 1.30×10^{-5} cm/sec		

Sample3. (with 10% Bentonite by weight)		
Length of soil sample L=	12.73	cm
Diameter of soil sample =	10	cm
Area of soil sample,A =	78.5	sqcm
Area of stand pipe, a =	0.44	sqcm
Initial head h1 =	83	cm
Final head h2 =	68	cm
Time =	42 hrs	151200 sec
Coefficient of permeability , $K=(2.303aL/At) \log h_1/h_2$		
K= 9.41×10^{-8} cm/sec		

