- ~~Minimum size of any habitable room — 9 sqm with minimum dimension not less than 3.0m.~~
- ~~Minimum height of any habitable room — 3m which may be reduced to 2.75m for air-conditioned areas.~~
- ~~Maximum height of habitable rooms — 3.6m~~
- ~~Scale of accommodation for — @14cu.m.per occupant. workspaces.~~

~~Minimum clear height of such workspaces shall be 2.5m.~~

A.3.2.2 LIGHTING

Established level of illumination shall be maintained for all parts of the buildings by means of windows, ventilators etc. Provision of referenced publications like NBC part-VIII; Section-1; IS-2440-1975; IS-3646 (part II-1996); IS-7662 (part I-1974), Factory rule or other relevant rules etc. shall be adhered to in this regard. Openings shall be provided with shading devices to avoid glare. For the purpose of illumination, day lighting shall also be supplemented by artificial illumination particularly at fire-exit.

A.3.2.3 VENTILATION

A.3.2.3.1 Natural Ventilation

Established level of ventilation in terms of air changes per hour shall be maintained for all spaces as per the provision of referenced publications like State Factory rules, NBC part-VIII Section-1, IS:3101-1975 (Industrial building), IS:3362-1975 (Residential buildings), IS-:7662 (Part I-1974) or other relevant code/ rules. Natural ventilation shall also be supplemented by mechanical or electrical means of ventilation in all human occupied areas. Sufficient no. of Glazed/Louvered windows/Ventilators shall be provided and supplemented by exhaust fans.

A.3.2.3.2 Mechanical ventilation

In addition to natural ventilation, if required Mechanical or electrical ventilation shall be provided depending on the type of building and its use. Refer Design Basis of Packaged Equipment for its requirement and applications.

A.3.2.4 ACOUSTICS

Specified acceptable noise level and reverberation time shall be maintained inside a building/shed. Following references shall be referred to for the purpose.

- National Building Code of India
- State Factory Act

Required noise level in any space shall be maintained by means of

- Segregating noise sources by buffer zones
- Dampening of noise levels by damping devices
- Providing Acoustic treatment with acoustic material (on walls, ceilings, floors, as required).

A.3.2.5 SAFETY REQUIREMENTS

Safety from fire and like emergencies shall be taken into account in building design as per NBC-Part IV; State Factory Rules and other relevant code/ rules. The buildings shall be provided with exits sufficient to permit safe escape of occupants in case of emergency. The exits shall be in terms of doorway, corridors, etc. to internal/ external staircase or to areas having access to the outside.

A.3.2.6 SITE PLANNING & LANDSCAPING

Site planning of building shall take into account aspects like inter-relationship of the buildings with the whole system, movement pattern, traffic and road net-work, safety regulations, service network,

fire safety, climatic and environmental aspects, site conditions like site dimension, contour, drainage, noise level, view, future expansion, visual aspects, Natural Light and Ventilation etc.

Main and service/ maintenance entrances of buildings shall be provided with vehicular access. All exit points shall also be provided with footpath/ vehicular access. Truck movement space in accordance with traffic pattern shall be provided for the building as per the location of hoisting bay/loading, unloading platform. Road network and open space around the buildings shall be designed considering movement and functioning of Fire tenders and cranes etc.

Climatic factors like wind direction, solar geometry shall be taken into account in orienting the building depending on type of climate. Orientation of Building shall also consider noise and smell propagation, views and visual effect from various directions.

Sufficient open space shall be provided for planned expansion of buildings. Sufficient open space shall also be provided around the buildings for lighting and ventilation in accordance with Factory Acts & National Building Code.

Suitable Landscaping treatment shall also be done around the important buildings. Such treatment shall generally consist of lawns, road side plantation and beautification of building entrance areas. Standard landscape elements such as earth contours, pavings, flower beds, hedges, shrubs, ground cover and ornamental trees shall be incorporated in landscape treatment. Necessary water supply/sprinklers shall also be provided.

A.3.3 BUILDING SERVICES

Following services shall be provided for all buildings as essential services.

A.3.3.1 Water Supply, Distribution and Drainage, Sanitary Services

This service is essential for all human occupied buildings. The building shall have toilet and drinking water facility and accordingly water supply, distribution and drainage, sanitary services as per NBC-Part-IX: Section 1&2, Factory rules and or referenced publication. Drinking water provisions shall be provided within an enclosure separated from the toilets. Space for janitor shall be provided in the toilets. All service pipes showing on the external wall shall be suitably concealed or shall be provided within a shaft.

A.3.3.2 Electrical Services

This service shall be provided as essential service for all the buildings. Electrical services for building shall consist of electrical supply, and distributions, electrical lighting installations, telephone network, fans, exhaust fans, lighting protection system etc., all accessories, cabling etc. including Emergency power supply, all as defined under Engineering Design Basis of Electrical.

A.3.3.3 Air Conditioning and Heating

Some designated rooms (as per Electrical requirement) in the Sub Station Buildings or in other buildings like canteen; scale room etc. may be required to be air-conditioned. For this suitable window/ split/ package type units may be provided as per requirement w.r.t the Design Basis of Packaged Equipment.

A.3.4 AESTHETICS

Apart from the fulfillment of functional & safety requirement, aesthetic requirement of the building shall be taken care of in the design. Preliminary drawings indicating Architectural scheme shall be submitted for Owner's approval.
Architectural scheme shall be based on general principles of Aesthetics. Building facades shall reflect such principles like symmetry, balance, proportion, rhythm, light and shade etc.

Building Elements like canopies, overhangs & shading devices, gutters, roof projections, parapets, door; window/ ventilator composition, External wall/ facade shall be considered as contributory elements to aesthetics. Local Climatic conditions shall be considered while designing the buildings.

Architectural scheme including design of above mentioned elements shall be subjected to Owner/ PMC approval.

Sl. No	COMPLIANCE STATEMENT / QUERY	BIDDER'S CONFIRMATION / ANSWER
1.	Confirm that the scope of work shall be complied in all respects as specified in the bid document and all the equipments, materials and work not explicitly mentioned but nevertheless required to fulfill the functional requirements shall be deemed to be included in the scope of bidder with no additional cost and time implication to the owner.	
2.	A detailed list of drawings / documents {including design calculations, design drawings, bar bending schedules (for RCC works) and fabrication drawings (for structural steel works)} & structure wise quantity statement (showing anticipated, released and balance quantities of concrete, structural steel and piles) shall be submitted to Owner/ Owner's representative for review. The drawing list and quantity statement shall be updated every month and submitted to Owner/ Owner's representative.	
3.	Confirm that all deliverables (document index /documents, drawings/ specifications/ drawings for statutory approval, as-built drawings, list of sub vendors/authorized applicators for specialized items / Monthly/Weekly report showing status of submitted documents/ schedule of submission, category of submitted documents, etc.) as elaborated in scope of work & supply shall be submitted by the contractor.	
4.	The design and drawings for each independent buildings / structures shall be submitted by contractor in one lot so as to facilitate an overall systematic review.	
5.	The bulk MTO for Cement, Reinforcement bars (diameter wise) and structural steel (section wise) shall be submitted to Owner/Owner's representative within 45 days from the date of release of TOI/ LOI. It shall also be updated at 50% and 90% stages of engineering progress and submitted to Owner/ Owner's representative for information.	
6.	Structural design and drawings for any structure/ building/ equipment foundation shall be submitted only after the reference architectural drawings/ general arrangement drawings, equipment data sheets, equipment layout vendor drawings, etc. (on the basis of which structural design & drawings are prepared) have been reviewed at least in Code–2 by the concerned specialist of Owner/ Owner's representative. Copies of these reviewed reference documents shall also be submitted along with structural design and drawings while submitting them to Owner/ Owner's representative for review.	
7.	Internationally accepted commercial software viz. STAADPRO, COSMOS, GT STRUDL, NISA or equivalent are permitted for analysis and design. In case software packages (commercially available or in-house developed) other than listed above are intended to be used for analysis and design, the same shall be informed in writing to Owner/Owner's representative. A validation report consisting of calculations and relevant computer files containing input and detailed output shall be submitted by the Contractor. Only after getting written approval from Owner/ Owner's representative, to this effect, such intended software be put to use for detailed analysis and design.	

Sl. No	COMPLIANCE STATEMENT / QUERY	BIDDER'S CONFIRMATION / ANSWER
8.	General philosophy of designs of all the structures and equipment foundations along with explanatory sketches and basis of design / analysis shall be submitted and got reviewed by Owner/ Owner's representative before the contractor proceeds with the final design and construction drawings.	
9.	Any deviation from the stipulations of the contract document, if necessary, shall be sought in the specified format.	
10.	Bidder to categorically confirm complete compliance for Architectural works (without any exception/ deviation) to the scope of work & supply, job specification, design basis, various technical specifications, drawings and documents, in the Bid Package and its amendments.	
11.	Please confirm that the area has been physically surveyed by bidder and well acquainted with the area and collected relevant site information.	
12.	Please confirm that all approaches (from main road) for construction, erection, maintenance, emergency evacuation, firefighting etc. are in bidder's scope of work.	
13.	Please note and confirm that all statutory approvals within scope are in bidder's scope of work. Any modifications, alterations/ additions required to meet statutory regulations are in bidder's scope of work and no extra amount shall be paid on this account.	
14	Note that area for system package is reasonably graded. Micro grading, pavement after completion of works to the final desired levels is in bidder's scope of work. Please note and confirm that required earth for filling and micro-grading shall be arranged by the bidder. Bidder shall also dispose surplus earth/ debris/ unserviceable material etc. at disposal areas. Borrow & disposal areas to be arranged by Bidder.	
15	Please note and confirm that entire fire hydrant system including hydrant ring main/ hydrants on ring main around and within scope shall be in bidder's scope of work.	
16	All firefighting equipments & extinguishers shall be BIS or equivalent acceptable to TAC. Confirm compliance.	
17	Bidder shall provide all structure, approach roads etc. required for erection of equipments.	
18	Please note and confirm that all temporary chain link fencing required during construction activities shall be provided by the Bidder	
19	General: a. Confirm that the entire work shall be executed as per contract document. No deviation is acceptable. b. Confirm that deviations/ implied deviations has been brought out in the specified format for statement of exceptions and deviations. c. Confirm that the scope of supply and work considered in the Bid proposal is in total compliance to the Bid specification requirement with respect to all civil works. d. Any deviations/ deletions/ corrections brought out by the Bidder elsewhere in the body of the offer (on equipment data sheet, design note, design basis, assumptions, considerations	

Sl. No	COMPLIANCE STATEMENT / QUERY	BIDDER'S CONFIRMATION / ANSWER
	etc.) will not be taken cognizance of and all such deviations shall be deemed to have been withdrawn by the bidder. The deviation if any shall be furnished in the specified format as stipulated by the bid.	

Notes: -

1. The Bidder shall indicate his reply in the space provided in the Technical confirmation. In case space provided is not adequate, the reply may be furnished separately under suitably numbered annexure/ attachments duly referred against the comment / query.
2. The confirmation statements/ Queries are required to be categorically confirmed/answered by the bidder and the completely filled in Technical questionnaire shall be submitted together with the Bid.

S. NO.	DESCRIPTION	WITH BID	POST ORDER			REMARKS
			FOR REVIEW	FOR RECORD	WITH DATA BOOK (FINAL)	
1.	Engineering design basis/design philosophy		✓		✓	
2.	Design calculation document & structural drawings of substructure of storage silos.		✓		✓	*Documents/ drawings to be submitted only after approval of Geotechnical recommendations & GA drawings in Code-2(min). StaadPro input & output also to be included with these documents.*
3.	Design calculation document & structural drawings of substructure and superstructure of silos(shipping, pre-storage etc).			✓	✓	*drawings to be submitted only after approval of Geotechnical recommendations & GA drawings in Code-2(min). StaadPro input & output also to be included with these documents.*
4.	Design calculation document & structural drawings for substructure and superstructure of Bucket Elevator Structures.			✓	✓	*Documents/ drawings to be submitted only after approval of Geotechnical recommendations in Code-2 (min). StaadPro input & output also to be included with these documents.Only one typical bucket elevator foundation & superstructure will be reviewed.*
5.	Design calculation document & structural drawings of substructure and superstructure for Conveyor supporting trestles & Conveyor supporting Girders			✓	✓	*Documents/ drawings to be submitted only after approval of Geotechnical recommendations & GA drawings of Conveyor layout in Code-2(min). StaadPro input & output also to be included with these documents.*
6.	Design calculation document & structural drawings of substructure and superstructure for Process Tower.			✓	✓	*Documents/ drawings to be submitted only after approval of Geotechnical recommendations & mechanical GA drawings of Process Tower in Code-2 (min). StaadPro input & output also to be included with these documents.*
7.	Design calculation document & structural drawings for tunnel for conveyor.			✓	✓	*Documents/ drawings to be submitted only after approval of Geotechnical recommendations & Mechanical GA drawings of in Code-2 (min).Only one typical conveyor tunnel will be reviewed.*

360

S. NO.	DESCRIPTION	WITH BID	POST ORDER			REMARKS
			FOR REVIEW	FOR RECORD	WITH DATA BOOK (FINAL)	
8.	Design calculation document & structural drawings of substructure and superstructure for truck loading system.			✓	✓	*Documents/ drawings to be submitted only after approval of Geotechnical recommendations & mechanical GA drawings of Truck loading system in Code-2 (min). StaadPro input & output also to be included with these documents.*
9.	Design calculation document & structural drawings of substructure and superstructure rail loading system.		✓		✓	*Documents/ drawings to be submitted only after approval of Geotechnical recommendations & mechanical GA drawings of Rail loading system in Code-2 (min). StaadPro input & output also to be included with these documents.*
10.	Design calculation document & structural drawings for foundations of equipments such as inline rail weigh bridge, road weigh bridge.			✓	✓	*Documents/ drawings to be submitted only after approval of Geotechnical recommendations & GA drawings in Code-2(min).*
11.	Design calculation document & structural drawings for substructure and superstructure of substation, operators cabins, Laboratory, office, reception, canteen, DG Shed, Storage shed etc.			✓	✓	*Documents/ drawings to be submitted only after approval of Geotechnical recommendations & Architectural drawings in Code-2 (min). StaadPro input & output also to be included with these documents.*
12.	Design calculation document & structural drawings of substructure and superstructure for truck unloading system.			✓	✓	*Documents/ drawings to be submitted only after approval of Geotechnical recommendations & mechanical GA drawings of Truck loading system in Code-2 (min). StaadPro input & output also to be included with these documents.*
13.	Design calculation document & structural drawings for all other works including balance equipment foundations/ structures, cable rack/supports, pipe supports/ sleepers, operating/ maintenance platforms, platforms & ladders for equipments/structures, walkways, crossovers , skids, monorails, trenches/channels, u/g pits/sump(including lining & cover), sewerage tank,skid/package equipment foundations,pump foundations,drains(precast RCC covers) etc.			✓	✓	
14.	Design calculation & structural drawings for any other structure.			✓	✓	

S. NO.	DESCRIPTION	WITH BID	POST ORDER			REMARKS
			FOR REVIEW	FOR RECORD	WITH DATA BOOK (FINAL)	
15.	Fabrication Drawings for typical Conveyor supporting trestle & process tower.			✓	✓	
16.	Design calculation document & drawings of Structural steel connection details.			✓	✓	
17.	Monthly updated status of BOQ s of major items (i.e. Concrete, Rebar, Structural steel).			✓	✓	
18.	As-built drawings.			✓	✓	
19.	Vendor drawing/ documents submission schedule .		✓		✓	
20.	GA & equipment lay-out of buildings/ sheds indicating sizing of internal spaces.			✓	✓	
21.	Architectural Design/ drawings of Floor, wall & ceiling finishes of Console Room, Entrance lobby, Corridor, passages, exits, Offices, discussion/ meeting/ conference rooms etc.which have decorative features. These drawings shall include 3-D rendered perspective Construction drawings of all the Buildings/ Sheds.		✓		✓	
22.	Construction Drawings shall contain the followings. These drawings shall be prepared incorporating comments etc. on the preliminary Dwgs. 1. Plan of all levels, Terrace Plan, Key Plan. 2. Sections as required for complete understanding of the Design & Construction 3. Elevations of all sides. 4. Schedule of Architectural Finishes 5. Any other Dwg as required for complete understanding of the Design & Construction.		✓		✓	
23.	Construction Drawings shall contain the followings. These drawings shall be prepared incorporating comments etc. on the preliminary Dwgs. 1. Door/Window details. 2. False ceiling/ flooring details & layouts			✓	✓	
24.	Documents/ Drawings for Statutory Approval in accordance with the statutory requirement			✓	✓	
25.	List of all Sub- vendors/ authorized applicators to be engaged for execution of various specialized items (like Aluminium Doors and Windows, Waterproofing/ Insulation, False ceiling/ Flooring, Partitioning etc.			✓	✓	
26.	Hydraulic calculations of drinking water system using PIPENET or equivalent approved software		✓		✓	
27.	Drinking water system including P&IDs		✓		✓	
28.	Drinking water system calculations		✓		✓	
29.	Sanitary drainage system calculations		✓		✓	

S. NO.	DESCRIPTION	WITH BID	POST ORDER			REMARKS
			FOR REVIEW	FOR RECORD	WITH DATA BOOK (FINAL)	
30.	Civil General Arrangement Drawings including ug piping, storm water drains, ERC/IRC, sleepers, pavement, roads, other civil facilities etc.			✓	✓	
31.	Storm water drain system		✓		✓	
32.	Tunnel drainage sump & pumping system		✓		✓	
33.	Fire water layout			✓	✓	
34.	PR's / Vendor drawings for hydrants, monitors, landing valves, portable extinguishers, personal protective equipment, hose boxes and hose reels, RO, other fire fighting equipment,etc.			✓	✓	
35.	Surface drainage, RCC pavement		✓		✓	
36.	Cross-section of road		✓		✓	
37.	Sanitary sewer and plumbing system			✓	✓	
38.	Layout of first aid fire fighting equipment			✓	✓	
39.	GA- drinking water sump		✓		✓	
40.	Bore well/ Tube well system			✓	✓	
41.	Catalogues, brochures, performance data of equipment etc			✓	✓	
42.	Approvals			✓	✓	
43.	Pump data sheet (Drinking Water)		✓		✓	

Notes :

1. "TICK" denotes applicability.
2. Post order, drawing / document review shall commence only after approval of Document Control Index (DCI).
3. All post order documents shall be submitted / approved through EIL eDMS portal.
4. Final documentation shall be submitted in hard copy (Six prints) and soft (two CDs/DVDs) in addition to submission through EIL eDMS.
5. Refer - 6-78-0001: Specification for quality management system from Bidders.
6. Refer - 6-78-0002: Specification for documentation requirements from Contractors.
7. Refer - 6-78-0003: Specification for documentation requirement from Suppliers.
8. All drawings & documents shall be submitted in A4 or A3 paper sizes. Documents in higher paper size shall be submitted in exceptional circumstances or as indicated in the MR/Tender.
9. Post order- The schedule of drawing / data submission shall be mutually agreed between EIL & the bidder / contractor / supplier during finalization of Document Control Index (DCI).
10. "@" indicates submission of documents to Inspection Agency.
11. Bill of Material shall form part of the respective drawing.
12. Also refer other department's VDR :-
13. Electrical
14. Instrumentation

15. Packaged Equipment

16. Native files of all design calculation namely STAAD files, excel sheets or any other formats used to design various structures shall be submitted along with submission of respective document submitted for approval.

Geo Technical Investigation for Construction of 50000 MTC Silos at Base Depot- Nabha (Pb.)

GEOTECHNICAL INVESTIGATIONS

1. INTRODUCTION

1.1 General

This soil investigation work was done at the instance of

The Executive Engineer, Central Ware Housing Corporation,

Construction Cell, Delhi.

Was carried out during the **November Month - 2016** at the proposed site ,

10 bore holes, 25.0 meter deep each, were executed at the proposed site. Besides Boring, Standard Penetration Tests at specified intervals were also performed as per B.I.S. specifications and in addition to the above Test , undisturbed as well as auger samples were collected from the bore-holes for classification of soil, shear strength tests and determination of mechanical properties of the soil in the laboratory & all other relevant tests .

1.2. Object :

The objective of the report is restricted to the factual information to be collected during the investigation period along with laboratory tests results and so as to obtain sequence & extent of soil so as to arrive at design parameters for the foundations from the recommended safe bearing capacity of foundation soil.

1.3 Test point Locations

1.) Bore hole Locations

As desired 10 bore holes each were carried out up to a depth of 25.0 m keeping in view of soil strata so as to carry out the desired investigations at the proposed site.

Total	Bore Hole	=	10 No's

1.4 Planning And Soil Exploration :

On the basis of nature of work it was decided to carry out soil exploration in order to :

b) Obtain soil samples, both representative disturb and undisturbed wherever necessary for classification and other laboratory tests for determining engineering properties of soil strata.

c) Obtain soundings of penetration resistance by standard penetration test in the bore holes.

1.5 Design criteria For Footings :

i) Footing must be safe against shear failure of supporting soil.
ii) Footing must not settle more than permissible limit.

Net safe bearing capacity 'qns' is obtained by using the physical characteristics of foundation & the relevant shear parameters of soil. Factor of safety of 2.5 is applied on ultimate bearing capacity as recommended by B.I.S. Net loading intensity 'qns' is obtained by using physical characteristics of foundation & relevant compressibility characteristics of the underlying soil. The settlement so obtained shall be with in permissible limits as per BIS recommendations.

The lesser of these computed values i.e. **'qns'** or qn is adopted as the allowable bearing capacity for designing the foundations of structures.

1.6 Sub soil water level encounter in

Various bore holes as shown in layout plan is below 25.0 mtrs depth.

2.0 NOTATIONS: -

AS PER SHOWN IN THE APPENDIX ATTACHED:

3.0 DETAILS OF FIELD WORK

3.1 Boring operation & Sampling :

150 mm dia hole was advanced at the location using shell and auger method. 150 mm nominal dia flush steel casing was advanced with the boring and the full length of the bore hole was encased at each location.

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 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 a hoisting equipments, a drive weight (Hammer) of 63.5 Kg, and a guide to ensure a 75 cm free fall of hammer on an anvil. The number of hammer blows that were required to penetrate the sampler through three runs of 150 mm each were recorded. Initial driving of 150 mm was disregarded and the number of blows required to drive the sampler through the remaining 300 mm 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 30 cm for 50 blows, it is considered as refusal and the actual penetration was recorded.

Correction of 'N' value :

In case of Sandy soil & Non plastic silts, the observed SPT values, designated as 'N', are to be corrected to account for the following two effects.

(i) Correct to account for the effect of overburden pressure.

Nn = Cn x N

'Cn' is overburden pressure correction and is calculated from the figure No. 1 given on page No. 8 in IS : 2131-1981.

(ii) Correction due to submergence Correction.

Nc = 15 + (Nn-15)/2 provided Nn is >15 where 'Nc' is the final corrected value where ever both the overburden and submergence corrections are necessary the overburden correction is applied first correction of N values of Bore Hole.

3.4 STATIC CONE PENETRARTION TEST

Static Cone Penetration Test is performed to determine cone resistance and friction of soil at various depths below ground surface by Static Cone Method as per IS : 4968 (Part-III) - 2011.

Static Cone Penetration Test Procedure consists of pushing the cone alone through the soil strata to be tested, then the cone and the friction jacket, and finally the entire assembly in sequence and nothing the respective resistance in the first two cases. The cone is pushed through a distance in accordance with the design of the equipment and the need for the sub- strata and the cone resistance noted. Thereafter, the cone and the friction jacket are pushed together for a distance depending upon the design of the cone and friction jack assembly and the combined value of and friction resistance noted. Procedure is repeated at predetermined intervals. The equipment is securely anchored to the ground at the test point for obtaining the required reaction.

Static Cone Penetration Test was performed at Site at 10 different locations. This test was performed with the help of 20 ton machine.

This test was conducted upto depth of 25.0 meters maximum where the capacity of the machine got exhausted.

Cone resistance and Friction of Soil results were compared with the tests conducted by Standard Penetration Tests (SPT) Tests.

Static Cone Penetration Test IS: 4968 (Part-III)- 2011

Depth (mtrs)	Total Resistance kN/m² (kgf/cm²) x	Cone Resistance (Unit Corrected)kN/m² (kgf/cm²) y	Total Resistance Minus Cone Resistance kN/m² (kgf/cm²) (x-y)	Frictional Resistance (x-y)b = z a	Corrected Frictional Resistance
1.0	2100	670	1430	95.3	96.3
1.5	2250	690	1560	104.0	105.0
2.0	2450	740	1710	114.0	115.0
3.0	2780	770	2010	134.0	135.0
4.5	2870	790	2080	138.7	139.7

Scope of work

The scope of work of drill holes investigation is to :-

- Carry out 10 numbers drive boreholes each upto 25.0 m depth approximately from the existing surface level (ESL), logging of borehole's
  Strata, preservation of selected samples of strata for laboratory tests.
- Carrying out Standard Penetration Tests (SPTs) in boreholes at 1.5 m interval as per IS - 2131 -1981.
- Carrying out Static Cone Penetration Tests (SCPTs) in boreholes at 1.5 m interval as per IS - 4963- III - 2011.
- Collecting disturbed and undisturbed samples from boreholes as per IS-2132-1972 from each type of strata, as application.
- Recording of sub soil water level (SSWL).
- Carrying out laboratory tests for grain size analysis and soil classification and index properties as per IS- 1498- 1970 and other codes.
- Evaluating silt factor for each type of strata , as applicable for sandy soils.
- Evaluating Triaxial shear parameter and consolidation parameters for the cohesive soils and direct shear parameters for non- cohesive soil.
- Determination of unconfined compressive strength (qu) of undisturbed samples.
- Evaluating safe bearing capacity/allowable bearing pressure and submission of report.

4.0 LABORATORY TESTS :

4.10 Index Properties [As per SP 36 (Part-I)-1987] :

All the relevant classification on the samples obtained from the all the bore holes were carried out in the laboratory. The index properties obtained from such classification tests at different depths in the bore holes are reported in the bore hole log sheets, referred to Figs.

4.11 UNDISTURBED SOIL SAMPLES:

Undisturbed soil sample collected in field have been tested in laboratory and preparation of sample for the under mentioned tests have been done in accordance with I.S.2720-(Part-I)-1983.

1. Sieve analysis test as per I.S. Specification No. 2720 --(Part-IV).
2. Atterburg limit test (L.L. & P.I.) as per I.S. Specification No. 2720 --(Part-II).
3. Natural moisture content as per I.S.Specification No.2720 – (Part-IV).
4. Particle size analysis test as per I.S.Specification No. 2720-(Part-VI).
5. Wet density test as per I.S.Specification No 2720- (Part-VI).
6. Dry density test as per I.S.Specification No. 2720- (Part-VI)
7. Specific Gravity test as per I.S.Specification No-2720-(Part-III)-Sec.2.
8. Triaxial compression test and determination of shear parameter (C & Ø as per I.S. XII) & I.S. 2720 – (part – XIII).
9. Consolidation test conducted as per I.S Specification No. 2720-(Part-XV).

4.12 DISTURBED SOIL SAMPLES:

Disturbed Soil samples have been prepared in accordance with I.S. Specification No. 2720- (Part-I)- 1983 and tested as follows:-

1. Sieve analysis test as per I.S.Specification No. 2720- (Part- IV).
2. Atterburg limit test (L.L.. & P.I..) as per I.S.Specification No. 2720 --(Part-II).
3. Particle size analysis test as per I.S.Specification No. 2720-(Part-VI).

Calculation of bearing capacity is governed generally by I.S. Specification No . 8009-) Part-I) - 1976, I.S.No.2720- (Part – II)- 1980, I.S. No 6403-1981, I.S. 1904-1978 and I.S. 1080-1985 and other relevant I.S. Codes as well as based on assessment and latest developments.

4.13 SOIL CLASSIFICATION & GENERAL NATURE OF THE SOIL STRATA:

The soil classification has been done with the help of soil properties obtained by laboratory tests of soil as per I.S. Code 1498-1978" Method of classification and identification of soil for general engineering purposes.

The general nature of the soil strata met with during boring in each bore hole has been indicated on the bore hole charts and on the laboratory test result

DELETERIOUS CHEMICALS:

The nature of strata was fairly identical through the site therefore one representative soil sample was prepared & tested for deleterious chemicals witch may effective the concrete & reinforcement the results are given below :

S.No.	Parameters	Results
1.	PH Value	7.25
2.	Chlorides (as Cl)	Nil
3.	Sulphate (as SO4)	0.004
4.	Reaction to acid	Nil

Above results show that the strata is quite safe for concrete & reinforcement.

375

Corrected N (SPT) Values:

The N SPT value were observed in all the ten (10) number bore holes at an interval of 1.5 m as per IS -2131 – 1981. The refusal is deemed to have been met if for 50 blows (last two runs of 15 cm each of the split spoon sampler)the penetration achieved is less than 30 cm. This value has been stipulated so as to avoid wear and tear of the equipments and bending of drill rods. These values are recorded as under:

N = 50 (R) where R stands for penetration being less than 30 cm i.e refusal.

5.0 SUB SOIL PROFILE :

Nature of strata met at different depths in the bore hole is described as under:

LOCATION – 1

Depth Range (m)		Nature of Strata.
NSL to 4.75	CL	Stiff Clay Strata
4.75 to 10.25	SM	Compact Sand
10.25 to 15.5	CL	Stiff Clay Strata
15.5 to 18.8	SM	Compact Sand
18.8 to 25.0	SM-SP	Compact Sand

LOCATION – 2

Depth Range (m)		Nature of Strata.
NSL to 4.60	CL	Stiff Clay Strata
4.60 to 10.0	SM	Compact Sand
10.0 to 15.2	CL	Stiff Clay Strata
15.2 to 18.5	SM	Compact Sand
18.5 to 25.0	SM-SP	Compact Sand

5.0 SUB SOIL PROFILE :

Nature of strata met at different depths in the bore hole is described as under:

LOCATION – 3

Depth Range (m)		Nature of Strata.
NSL to 4.85	CL	Stiff Clay Strata
4.85 to 10.40	SM	Compact Sand
10.40 to 15.0	CL	Stiff Clay Strata
15.0 to 19.0	SM	Compact Sand
19.0 to 25.0	SM-SP	Compact Sand

LOCATION – 4

Depth Range (m)		Nature of Strata.
NSL to 4.65	CL	Stiff Clay Strata
4.65 to 10.0	SM	Compact Sand
10.0 to 15.2	CL	Stiff Clay Strata
15.2 to 18.4	SM	Compact Sand
18.4 to 25.0	SM-SP	Compact Sand

5.0 SUB SOIL PROFILE :

Nature of strata met at different depths in the bore hole is described as under:

LOCATION – 5

Depth Range (m)		Nature of Strata.
NSL to 4.70	CL	Stiff Clay Strata
4.70 to 10.3	SM	Compact Sand
10.3 to 15.5	CL	Stiff Clay Strata
15.5 to 18.2	SM	Compact Sand
18.2 to 25.0	SM-SP	Compact Sand

LOCATION – 6

Depth Range (m)		Nature of Strata.
NSL to 4.85	CL	Stiff Clay Strata
4.85 to 10.8	SM	Compact Sand
10.8 to 15.8	CL	Stiff Clay Strata
15.8 to 19.0	SM	Compact Sand
19.0 to 25.0	SM-SP	Compact Sand

5.0 SUB SOIL PROFILE :

Nature of strata met at different depths in the bore hole is described as under:

LOCATION – 7

Depth Range (m)		Nature of Strata.
NSL to 4.60	CL	Stiff Clay Strata
4.60 to 10.6	SM	Compact Sand
10.6 to 15.5	CL	Stiff Clay Strata
15.5 to 18.8	SM	Compact Sand
18.8 to 25.0	SM-SP	Compact Sand

LOCATION – 8

Depth Range (m)		Nature of Strata.
NSL to 4.70	CL	Stiff Clay Strata
4.70 to 11.0	SM	Compact Sand
11.0 to 16.0	CL	Stiff Clay Strata
16.0 to 19.0	SM	Compact Sand
19.0 to 25.0	SM-SP	Compact Sand

5.0 SUB SOIL PROFILE :

Nature of strata met at different depths in the bore hole is described as under:

LOCATION – 9

Depth Range (m)		Nature of Strata.
NSL to 4.65	CL	Stiff Clay Strata
4.65 to 10.8	SM	Compact Sand
10.8 to 15.7	CL	Stiff Clay Strata
15.7 to 18.8	SM	Compact Sand
18.8 to 25.0	SM-SP	Compact Sand

LOCATION – 10

Depth Range (m)		Nature of Strata.
NSL to 4.75	CL	Stiff Clay Strata
4.75 to 10.6	SM	Compact Sand
10.6 to 15.5	CL	Stiff Clay Strata
15.5 to 18.5	SM	Compact Sand
18.5 to 25.0	SM-SP	Compact Sand

Electrical Resistivity Test

The electrical Resistively test is based on the measurement and recording of changes in the mean Resistively or apparent specific resistance of the various soils. The Resistively (Ohms- cms) is usually defined as the resistance (Ohms) between opposite faces of a unit cube (centimeter cube) of the material.

Each soil has its own Resistivity depending upon water content, Compaction and composition; e.g, low for saturated silt and high for loose dry or solid rock.

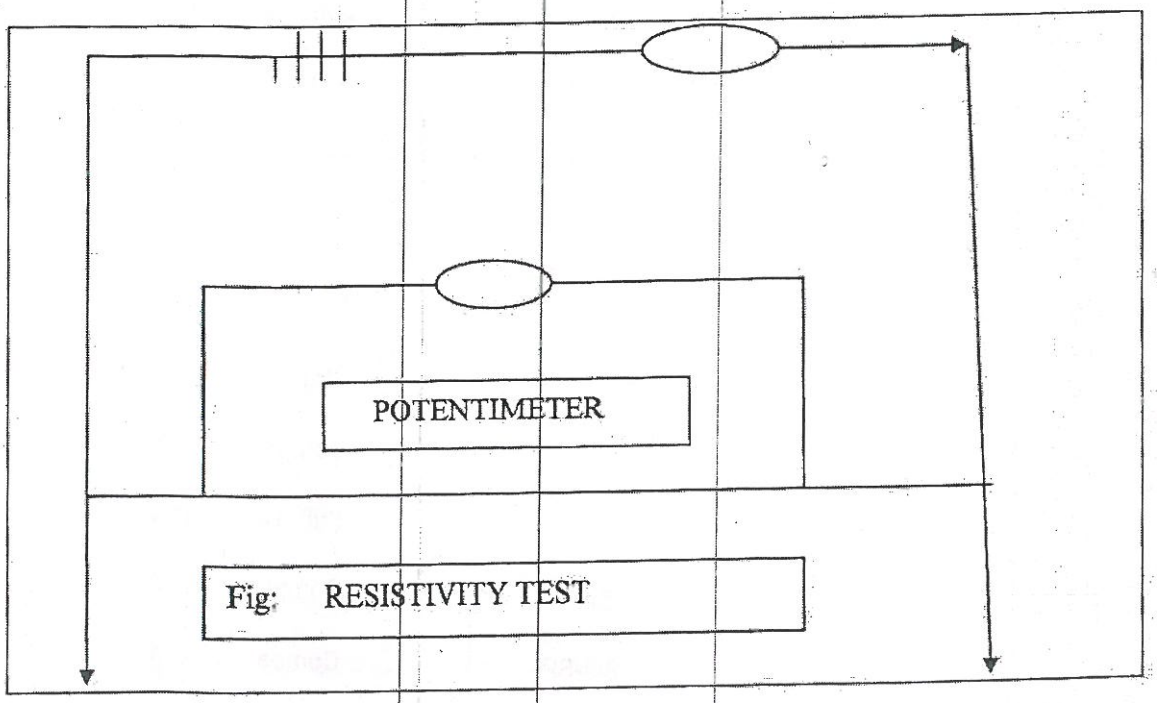

Fig: RESISTIVITY TEST

RESISTIVITY TEST

I.S. - 3043

The test is conducted by driving four spikes to serve as electrodes (Fig.) into the ground along a straight line at equal distance. A direct voltage is imposed the two outer potentiometer electrodes and the potential drop is measured between the inner electrodes. The mean receptivity is given by the following formula:

$$P=2^{nd}\ e/12rdR$$

Where:
P=Mean Resistively (Ohm-cm)
D=Distance between electrodes (Cm)
E=Potential drop between outer electrodes (Volts)
L=Current flowing between outer electrodes (Amperes)
R=Resistance (Ohms)

To correctly interpret the Resistivity data for knowing the nature and distribution of soil formations, it is necessary to make preliminary trial or calibration tests on known formations.

The depth of exploration is roughly proportional to the electrode spacing. For knowing the horizontal changes in the sub-soil, the electrodes, kept at a constant spacing, are moved as a group along the line of test. This method is known as Resistivity mapping. For studying the vertical changes,

The electrode system is expanded, about a fixed central point, by increasing the spacing gradually from an initial small value to a distance roughly equal to the depth of exploration desired. The method is known as Resistivity sounding.

Soil Resistivity Test Results

S.No	Description/Location	Test Result Ohm-Mtrs
1.	Sample/ Location -1	18.5 Ohm-Mtrs
2.	Sample/ Location -2	16.5 Ohm-Mtrs

6.0 TENTATIVE DIMENSION OF THE PROPOSED FOUNDATIONS:

The proposed site is a for Building, Hence the following dimensions of the proposed foundations shall be used in bearing capacity computations as per norms :

1.	**FOR COLUMN FOOTING**	
	Depth of Foundation Df :	1.2, 1.5, 2.0, 3.0, Meter
	Size of footings (B x B) =	2.0 m - 3.0m
2.	**FOR WALL FOOTING**	
	Depth of Foundation Df :	1.5, Metre
	Size of footings (B x B) =	1.5 m

6.0 TENTATIVE DIMENSION OF THE PROPOSED FOUNDATIONS:

The proposed site is a for Building, Hence the following dimensions of the proposed foundations shall be used in bearing capacity computations as per norms:

1.	**FOR COLUMN FOOTING**	
	Depth of Foundation Df :	1.2, 1.5, 2.0, 3.0, Meter
	Size of footings (B x B) =	2.0 m - 3.0m
2.	**FOR WALL FOOTING**	
	Depth of Foundation Df :	1.5 , Metre
	Size of footings (B x B) =	1.5 m

8.0 Shear Failure analysis (IS: 6403)

COMPUTATION OF ALLOWABLE BEARING CAPACITY VALUES

The sub- soil water level was below the depth of 25.0 m at the proposed site. Due to change in climatic conditions or due to same eventuality during the life span of the proposed structures, the subsoil water level can rise and fluctuate within the significant depths of proposed footings. As such as a conservative approach all parameters used in the bearing capacity analysis pertain to submerged/and saturated conditions;-

The value of q_{ns} is governed by the shear strength characteristics of the supporting strata. Borehole wise, the nature of supporting strata and the corresponding governing shear strength parameters are given here under:

Borehole	Nature of Strata	Governing Shear strength parameters (Least Value)
		Depth
		1.5 M
	C_U Kg / cm² & Ø	3.0 T / m² & 13 ^{0}

BEARING CAPACITY BY MEANS OF
SHEAR FAILURE CONSIDERATION TEST :-

Depth = 1.5 metre. **Size = 1.5 x 1.5 mtrs**

The Ultimate bearing capacity is calculated by the following formula :-

$qd = 2/3\ CN\ C'\ scdcic + q\ (N'q - 1)\ sqdqiq + 1/2\ By\ N'r\ sydyiy\ W'$
(IS :- 6403-1981)

Depth = 1.5 Metre

Size = 2.0 Metre

C = 3.0 T/M²

Ø = 13.0

Y = 1.90 T/M³

=0=0=0=0=0=0=0=0=0=0=0=0=0=0=0

$Ø' = \tan^{-1}(0.67 \tan Ø)$

$= \tan^{-1}(0.67 \tan 13)$

$= \tan^{-1}(0.1546)$

$= 8.8^0$

WHERE AS
SHAPE FACTOR (FOR COLUMN FOOTING)

Sc = 1.3 Sq = 1.2 Sy = 0.80

DEPTH FACTOR

Dc = 1.16
Dq = Dy = 1

For Ø' = 8.8^0

N'c = 7.9

N'q = 2.25

N'y = 1.03

Depth = 1.5 Metre

FOR COLUMN FOOTING :-

qd = 2/3 CN C' scdcic + q (N' q -1) sqdqiq + 1 / 2 By N' r sydyiy W'
(IS :- 6403-1981)

qd = q (N' q -1) sqdqiq + 1 / 2 By N' r sydyiy W'

= 2/3 x 2.5 x 7.9 x 1.3 x 1.0 x 1.0 +
1.90 x 1.50 (2.25 -1) x 1.0 x 1.2 +
0.5 x 1.90 x 2.0 x 1.0 x 1.03 x 0.8 X 0.5

= 20.5 + 4.3 + 1.0

= 25.77 / 2.5

= **10.3 *T/M²***

==========

Depth = 1.5 Metre

FOR WALL FOOTING :-

qd = 2/3 CN C' scdcic + q (N' q -1) sqdqiq + 1 / 2 By N' r sydyiy W'
(IS :- 6403-1981)

qd = q (N' q -1) sqdqiq + 1 / 2 By N' r sydyiy W'

= 2/3 x 2.5 x 7.9 x 1.0 x 1.0 x 1.0 +
1.90 x 1.50 (2.25 -1) x 1.0 x 1.2 +
0.5 x 1.90 x 2.0 x 1.0 x 1.03 x 0.8 X 0.5

= 15.76 + 4.3 + 1.0

= 25.77 / 2.5

= 8.5 ***T/M²***

==========

Depth = 2.0 Metre

FOR COLUMN FOOTING :-

qd = 2/3 CN C' scdcic + q (N q -1) sqdqiq + 1 / 2 By N' r sydyiy W'
(IS :- 6403-1981)

qd = q (N' q -1) sqdqiq + 1 / 2 By N' r sydyiy W'

= 2/3 x 3.0 x 7.9 x 1.3 x 1.0 x 1.0 +
1.90 x 2.0 (2.25 -1) x 1.0 x 1.2 +
0.5 x 1.90 x 2.0 x 1.0 x 1.03 x 0.8 X 0.5

= 24.6 + 5.73 + 1.0

= 31.33 / 2.5

= **12.5 T/M^2**

==========

Depth = 3.0 Metre

FOR COLUMN FOOTING :-

qd = 2/3 CN C' scdcic + q (N' q -1) sqdqiq + 1 / 2 By N' r sydyiy W'
(IS :- 6403-1981)

qd = q (N' q -1) sqdqiq + 1 / 2 By N' r sydyiy W'

= 2/3 x 3.0 x 7.9 x 1.3 x 1.0 x 1.0 +
1.90 x 3.0 (2.25 -1) x 1.0 x 1.2 +
0.5 x 1.90 x 2.0 x 1.0 x 1.03 x 1.0 X 0.5

= 24.6 + 8.6 + 1.0

= 34.2/ 2.5

= **13.6 T/M^2**

==========

Depth = 1.5 **Size = 1.5 x 1.5 mtrs**

8.1 SHEAR FAILURE ANALYSIS :-

The value of 'qns is governed by the average value of undrained shear strength of the compressible strata lying within the zone of shear failure of the footings. This zone below footings can be taken as equal to width of footings This governing parameter works out to be as under :

Now,

qnf = Cu Nc Sc dc

Cu = Least value of undrained shear strength of supporting strata

= 0.35 Kg / cm^2

Nc = 5.14 (Undrained condition)

FOR COLUMNS :-

Sc = 1.3 (Square Footing)

$dc = 1 + 0.2 \times \frac{D}{B}$

$dc = 1 + 0.2 \times \frac{1.5}{2.5} = 1.1$

Df = 1.5 M

B = 2.5 x 2.5 M

qnf = 3.5 x 5.14 x 1.3 x 1.1

= 25.72 T/M^2

Using FOS = 2.5

qnf = 10.3 T/M^2

Depth = 1.5 **Size =** 1.5 x 1.5 mtrs

8.1 SHEAR FAILURE ANALYSIS :-

The value of 'qns is governed by the average value of undrained shear strength of the compressible strata lying within the zone of shear failure of the footings. This zone below footings can be taken as equal to width of footings This governing parameter works out to be as under :

Now,

qnf = Cu Nc Sc dc

Cu = Least value of undrained shear strength of supporting strata

= 0.35 Kg / cm^2

Nc = 5.14 (Undrained condition)

FOR WALLS :-

Sc = 1.0 (Strip Footing)

dc = $1 + 0.2 \times \frac{D}{B}$

Df = 1.5 M

qnf = 3.5 x 5.14 x 1.2 x 1.0

= 21.6 T/M^2

Using FOS = 2.5

qnf = 8.6 T/M^2

Depth = 2.0 Size = 1.5 x 1.5 mtrs

8.1 SHEAR FAILURE ANALYSIS :-

The value of 'qns is governed by the average value of undrained shear strength of the compressible strata lying within the zone of shear failure of the footings. This zone below footings can be taken as equal to width of footings This governing parameter works out to be as under :

Now,

qnf = Cu Nc Sc dc

Cu = Least value of undrained shear strength of supporting strata

= 0.40 Kg / cm^2

Nc = 5.14 (Undrained condition)

FOR COLUMNS :-

Sc = 1.3 (Square Footing)

$$dc = 1 + 0.2 \times \frac{D}{B}$$

$$dc = 1 + 0.2 \times \frac{2.0}{3.0} = 1.13$$

Df = 2.0 M

B = 3.0 M

qnf = 4.0 x 5.14 x 1.3 x 1.1

= 29.4 T/M^2

Using FOS = 2.5

qnf = 11.76 T/M^2

Depth = 4.50 Size = 1.5 x 1.5 mtrs

8.1 SHEAR FAILURE ANALYSIS :-

The value of 'qns is governed by the average value of undrained shear strength of the compressible strata lying within the zone of shear failure of the footings. This zone below footings can be taken as equal to width of footings This governing parameter works out to be as under :

Now,

qnf = Cu Nc Sc dc

Cu = Least value of undrained shear strength of supporting strata

= 0.50 Kg / cm^2

Nc = 5.14 (Undrained condition)

FOR COLUMNS :-

Sc = 1.3 (Square Footing)

$dc = 1 + 0.2 \times \frac{D}{B}$

$dc = 1 + 0.2 \times \frac{2.0}{3.0} = 1.13$

Df = 2.0 M

B = 3.0 M

qnf = 5.0 x 5.14 x 1.3 x 1.1

= 36.75 T/M^2

Using FOS = 2.5

qnf = 14.7 T/M^2

Settlement Analysis (IS: 8009 part - 1976)

The value of `qn` is governed by physical and compressibility Characteristics of strata falling within the significant depth of proposed Footing. Combining the data of the boreholes , figures 1 to 10 present the critical foundation soil system for settlement analysis . The results of consolidation tests are given in the Appendix attached .
Total settlement for footing in clayee soil is 75 mm maximum.

The following expression is used to compute settlement.

SETTLEMENT CALCULATIONS:

Consolidation settlement will be calculated with the Following formula:-

$$\frac{Cc \times Hc}{1 + eo} \quad \frac{\text{Log } 10\,(po + p)}{po} \quad Lyf \times Df$$

WHERE AS

S	=	Settlement due to consolidation.
Cc	=	Compression Index as determined from consolidation test.
Eo	=	Void Ratio of the soil in place.
Po	=	Weight of soil above mid height of the consolidating Layer.
P	=	Net addition pressure.

COLUMN FOOTING

Depth = 1.5Mtr. **Size = 3.0 x 3.0M**

P = 10.0 Tons/m2
From elastic analysis p works out to be = 4.6 Tons/M²
Po = 1.90 (1.5 + 2.25) = 7.12 Tons/M²

Hc = 450 cm
Eo = 0.605
Cc = 0.12

S_1 = < 50 mm O.K

Settlement Analysis (IS: 8009 part - 1976)

The value of `qn` is governed by physical and compressibility Characteristics of strata falling within the significant depth of proposed Footing. Combining the data of the boreholes , figures 1 to 10 present the critical foundation soil system for settlement analysis . The results of consolidation tests are given in the Appendix attached.
Total settlement for footing in clayee soil is 75 mm maximum.

The following expression is used to compute settlement.

SETTLEMENT CALCULATIONS:

Consolidation settlement will be calculated with the Following formula:-

$$\frac{Cc \times Hc}{1 + eo} \quad \frac{\text{Log } 10\,(po + p)}{po} \quad Lyf \times Df$$

WHERE AS

S = Settlement due to consolidation.
Cc = Compression Index as determined from consolidation test.
Eo = Void Ratio of the soil in place.
Po = Weight of soil above mid height of the consolidating Layer.
P = Net addition pressure.

WALL FOOTING

Depth = 1.50 mtr **Size = 1.5 M**

P = 8.5 Tons/m2
From elastic analysis p works out to be = 5.78 Tons/M²
Po = 1.90 (1.5 + 1.12) = 3.62 Tons/M²

Hc = 225 cm
Eo = 0.605
Cc = 0.12
S_1 = < 50 mm O.K

Recommendation

The following observation are made on the basis of field test Data & Field Laboratory Test results and our experience In soil testing jobs.

Wall Footing

Sr. No.	Depth in Mtr.	Size in Mtr.	Net SBC in T/ M^2
1.	1.5	1.5	8.5 t/m^2

Column Footing

Sr. No.	Depth in Mtr.	Size in Mtr.	Net SBC in T/ M^2
1.	1.5	1.5 x 1.5	10.0 t / m^2
2.	2.0	1.5 x 1.5	11.5 t / m^2
3.	3.0	2.0 x 2.0	13.0 t / m^2
4.	4.5	3.0 x 3.0	14.5 t / m^2

From design point of view the following average value may be adopted.
At a depth of 1.5 mtrs

(qa) Net = 10.0 T/ M^2

1. Water table was below the depth of 25.0 mtr depth from existing level.
2. It is also suggested that the backfilling of the foundation soil should be well Compacted inlayer at optimum moisture content to active at least 95% of Proctor density, followed by suitable plinth protection & effective drainage System.
3. The results of deleterious chemicals show that the strata is quite safe for Concrete & reinforcement.

Recommendation

The following observation are made on the basis of field test Data & Field Laboratory Test results and our experience In soil testing jobs.

Raft Footing

Sr. No.	Depth in Mtr.	Size in Mtr.	Net SBC in T/ M^2
1.	1.2	6.0mtrs /more	8.3 t / m^2
2.	2.0	6.0mtrs /more	10.0 t / m^2
3.	3.0	6.0mtrs /more	12.5 t / m^2
4.	4.5	6.0mtrs /more	14.5 t / m^2

From design point of view the following average value may be adopted.
At a depth of 2.0 mtrs

(qa) Net = 10.0 T/m^2

SETTLEMENT CONSIDERATION :

(Non-cohesive)

For Raft Footing :-

Depth = 1.2 Mtrs Size = 6.0 /or more mtrs

Settlement / Unit pressure for corrected N' = 12 corresponding to foundation depth of 1.2 mtr & foundation width of **6.0 or more mtr** calculated according to para 9.5 of I.S.8009-(Part-I)-1976 and read from fig :9 p.p. 17 of the I.S. Code comes to 30.0 mm. Settlement corrected for water table

$= \frac{30}{0.5} =$ 60.0 mm.

Allowable settlement being 50mm.,

allowable bearing capacity = $\frac{50}{60}$ = 0.833 Kg/cm^2

= 8.3 t /m^2