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VOLUME - IA

Technical Conditions of Contract (TCC) for Soil Investigation (GEO TECHNICAL INVESTIGATIONS, TOPOGRAPHICAL SURVEY & UNDERGROUND SCANNING SURVEY)

FOR

Demonstration of Methanol Firing in One GT at NTPC Kayamkulam

BHARAT HEAVY ELECTRICALS LIMITED

	Technical Conditions Of Contract (TCC) **PROJECT ENGINEERING & SYSTEMS DIVISION** **HYDERABAD**	Ref No: HY/PE&SD/Projects/TCC/2024-25/Soil Investigation/01 Rev. No. 00

TECHNICAL CONDITIONS OF CONTRACT (TCC)

FOR

SOIL INVESTIGATION
(GEOTECHNICAL INVESTIGATION & TOPOGRAPHICAL SURVEY)

FOR
Demonstration of Methanol Firing in One GT at NTPC Kayamkulam

Revisions: Refer to record of revisions	Prepared By:	Checked By:	Approved By:	Date
				26.07.2024
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Volume IA
Part I
Contract specific details

Chapter I- Project Information

1.0 Project Details			
1	Customer	:	NTPC, Kayamkulam, Kerala
2	Project Information	:	Demonstration of Methanol Firing in One GT at NTPC Kayamkulam
3	Location	:	Kayam kulam, Kerala
4	Address Detail	:	Choolatheruvu, Haripad in Alappuzha district, Kerala, India
5	Nearest Railway Station	:	Cheppad halt RS, Harippad RS
6	Road Approach	:	38KM towards South from District Head quarters
7	Nearest Air Port	:	Trivandrum International airport (Approx. 110.0 Km), Kochi International Airport (Approx. 99.0 Km)
11	Ambient Air Temperature (Average)	:	a) Maximum : 30^0 C b) Minimum : 25^0 C
12	Average Relative Humidity	:	73%
13	Climatic Condition	:	Tropical Climate

Bidder is advised to visit the project site and appraise himself about the local conditions and infrastructure available in the area for fulfilling their commitments under the contract. BHEL will not admit any claims whatsoever on account of Contractor's non-familiarization of local conditions.

Chapter II- Scope of Work

The scope broadly covers the following:

2.1.0 Carry out field tests in the form of test boring including drilling through rocks (if required), direct load tests, penetration tests, trial pits, electrical resistivity tests, laboratory tests etc. and topographical survey listed in Schedule of Items & Rates/Prices.

Location of field tests are marked on drawing number PY-DZ-1-M231-1201-01. (Shall be provided after preparation of preliminary plot plan)

2.2.0 Preparation and submission of preliminary report (in duplicate) containing firm recommendation on the type of foundation to be adopted. This report shall include details of borelogs, trial pits, plate load tests, cone penetration tests etc., based on which the recommendations were arrived at.

2.3.0 Preparation and submission of Draft Final Report (in duplicate) covering the entire scope of work and giving the recommendations as per the requirements of Technical Specifications.

2.4.0 Preparation and submission of Final Report incorporating the comments of PE&SD in the draft report. Two (2) copies of the final report along with the soft copy in CD of all annexure to the report (borelogs, graphs, tables, charts etc.,) shall be submitted.

2.5.0 All field tests and laboratory tests shall be done in accordance with NTPC specifications (CS-0011-130A-9_PART-B_SUB_SECTION_D-01_ANNEXURE-A) as given in Annexure II or BHEL's soil investigation specifications / relevant IS codes as mentioned in this document, whichever is more stringent and in case of any mismatch between the specifications, NTPC specifications will take precedence and contractor has to strictly adhere to them.

Chapter III- Facilities in the scope of Contractor/BHEL (scope matrix)

S. No.	Description PART I	Scope / to be taken care by		*Remarks*
		BHEL	**Bidder**	
3.1	**ESTABLISHMENT**			
3.1.1	**FOR CONSTRUCTION PURPOSE**:			
a	Open space for office (as per availability)		Yes	
b	Open space for storage (as per availability)		Yes	
c	Construction of bidder's office, canteen and storage building including supply of materials and other services		Yes	
d	Bidder's all office equipment, office / store / canteen consumables		Yes	
e	Canteen facilities for the bidder's staff, supervisors and engineers etc.		Yes	
f	Firefighting equipment like buckets, extinguishers etc.		Yes	
g	Fencing of storage area, office, canteen etc. of the bidder		Yes	
3.1.2	**FOR LIVING PURPOSES OF THE BIDDER**			
a	Open space for labor colony (as per availability)		Yes	
b	Labor Colony with internal roads, sanitation, complying with statutory requirements		Yes	
3.2.0	**ELECTRICITY**			
3.2.1	Electricity For construction purposes	Yes		Electricity shall be provided by BHEL/end customer NTPC at one point on chargeable basis. Further distribution shall be done by contractor.
3.2.2	Electricity for the office, stores, canteen etc. of the bidder	Yes		
3.2.3	Electricity for living accommodation of the bidder's staff, engineers, supervisors etc.	Yes		
3.3.0	**WATER SUPPLY**			
3.3.1	For construction purposes	**Yes**		Water shall be provided by BHEL/end customer NTPC at one point on chargeable basis.
3.3.2	Water supply for bidder's office, stores, canteen etc.	**Yes**		

S. No.	Description PART I	Scope / to be taken care by		*Remarks*
		BHEL	**Bidder**	
3.3.3	Water supply for Living Purpose	Yes		Further distribution shall be done by contractor.
3.4.0	**LIGHTING**			
a	For construction work (supply of all the necessary materials) 1. At office/storage area 2. At the preassembly area 3. At the construction site /area		Yes	
b	For construction work (execution of the lighting work/ arrangements) 1. At office/storage area 2. At the preassembly area At the construction site /area		Yes	
c	Providing the necessary consumables like bulbs, switches, etc. during the course of project work		Yes	
d	Lighting for the living purposes of the bidder at the colony / quarters		Yes	
3.5.0	**COMMUNICATION FACILITIES FOR SITE OPERATIONS OF THE BIDDER**			
a	Téléphone, fax, internet, intranet, E-mail etc.		Yes	
3.6.0	**COMPRESSED AIR wherever required for the work**		Yes	
3.7.0	**Demobilization of all the above facilities**		Yes	
3.8.0	**TRANSPORTATION**			
a	For site personnel of the bidder		Yes	
b	For bidder's equipment and consumables (T&P, Consumables etc.)		Yes	

Sl. No	Description PART II 3.9.0 CONSTRUCTION FACILITIES	Scope / to be taken care by		*Remarks*
		BHEL	**Bidder**	
3.9.1	**Engineering works for construction:**			
a	Providing the construction drawings for all the works covered under this scope			**Not Applicable**
b	Drawings for construction methods			**Not Applicable**
c	As-built drawings – where ever deviations observed and executed and also based on the decisions taken at site- example – routing of small bore pipes		Yes	In consultation with BHEL
d	Shipping lists etc. for reference and planning the activities		Yes	In consultation with BHEL
e	Preparation of construction (Concreting B/W, etc.) schedules and other input requirements		Yes	In consultation with BHEL
f	Review of performance and revision of site construction schedules in order to achieve the end dates and other commitments	Yes	Yes	In consultation with BHEL
g	Weekly construction schedules based on S. No. e. hard copy to Construction manager, by email to HO.		Yes	In consultation with BHEL
h	Daily construction / work plan based on S. No. g. hard copy to Construction manager, by email to HO.		Yes	In consultation with BHEL
i	Periodic visit of senior official of the bidder to site to review the progress so that works are completed as per schedule. It is suggested this review by the senior official of the bidder should be done once in every two Weeks.		Yes	
j	Arranging the materials required for Work		Yes	
k	Coordination for inspection & checking and getting clearance from customer		Yes	
l	Preparation of formats for completion of activities		Yes	

Chapter IV- Tools & plants to be deployed by Contractor

LIST OF TOOLS AND PLANT:

The contractor shall make available all required Tools, Plants, Testing Apparatus, etc. for completing the job, including all consumables likely to be used at his own cost at the time of mobilization.

Chapter V- Time Schedule

5.1 TIME SCHEDULE

5.1.1
The entire work of Soil investigation survey as detailed elsewhere in the Tender Specification shall be completed within **30 (Thirty) Days** from the date of commencement of work at site.

5.1.2
During the total period of contract, the contractor has to carry out the activities in a phased manner as required by BHEL and the program of milestone events.

5.1.3
The work shall be commenced on the mutually agreed date between the bidder and BHEL engineer. The decision of BHEL in this regard shall be final and binding on the contractor. The scope of work under this contract is deemed to be completed only when so certified by the site Engineer.

5.2 COMMENCEMENT OF CONTRACT PERIOD

The date of commencement of contract period shall be the mutually agreed date between the bidder and BHEL engineer to start the work. In case of discrepancy, the decision of BHEL engineer will be final.

5.3 MOBILISATION

5.3.1
The activities for Soil survey, survey report reparation, survey report submission and approval from BHEL shall be started as per directions of Construction Manager of BHEL.
5.3.2
The contractor should mobilize man power in order to complete the work in **30 (Thirty) Days**.
5.3.3
Requisite Material, men and machinery should be arranged in order to complete the project within stipulated time.
5.3.4
The contractor has to augment his resources in such a manner that following major milestones of the project are achieved on specified schedules:

In order to meet above schedule in general, and any other intermediate targets set, to meet project, contractor shall arrange & augment all necessary resources from time to time on the instructions of BHEL.

5.4 CONTRACT PERIOD

For the purpose of contract, the period shall be taken as 30 (Thirty) Days. Completion of the work shall be as per BHEL Bar Charts revised from time to time. In order to expedite the work, the contractor has to deploy manpower as per site requirement without any extra cost to BHEL.

5.5 TENTATIVE SCHEDULE

The tenderer shall strictly adhere to the time schedule furnished below.

3.1.0	Commencement of work at site `	:	Within 10 days from the date of issue of LOI. (Tentatively first week of September,2024)
3.2.0	Completion of bore holes, static cone Penetration Test, Plate load test and necessary laboratory tests and submission of preliminary report covering the recommendation of type of foundations to be adopted.	:	Within 15 days from the date of commencement of work
3.3.0	Completion of balance field work and laboratory tests and submission of draft report.	:	Within 20 days from the date of commencement.
3.4.0	Submission of Final Report	:	Within 5 days from the date of receipt of comments of BHEL by the Contractor.

5.5 GUARANTEE PERIOD

The guarantee period of twelve months shall commence from the date of completion of all works as certified by the BHEL site engineer.

5.6 PROTECTION OF WORK

The contractor shall have total responsibility for protecting his works until it is taken over by the Employer. No claim will be entertained by the Employer or the representative of the Employer for any damage or loss to the Contractor's works and the Contractor shall be responsible for complete restoration of the damaged works to original conditions to comply with the specification and drawings. Should any such damage to the Contractor's Works occur because of other party not being under his supervision or control, the Contractor shall make his claim directly with the party concerned.

If disagreement, conflict, or dispute develops between the Contractor and the other party or parties concerned regarding the responsibility for damage to the Contractor's Works the same shall be rectified. The Contractor shall not cause any delay in the repair of such damaged Works because of any delay in the resolution of such disputes. The Contractor shall proceed to repair the Work immediately and no cause thereof will be assigned pending resolution of such disputes.

5.7 COMPLETION OF WORK AND MEASUREMENT

5.7.1 **Total works including complete soil report and topographical survey report shall be furnished within 30 days from the date of issue of LOA or handing over of site / work order for all activities put together, whichever is later.** Contractor shall also furnish the preliminary soil report after completion of 40% of field tests, lab tests & topographical surveys.

5.7.2 All work shall be carried out and measured according to scope of work mentioned in bill of quantity

5.7.3 On completion of the work, the Contractor must submit to BHEL the test reports, topographical drawing etc. as per bill of quantity/ scope of work.

5.7.4 The Final Report after incorporation of all BHEL comments, required revisions and modifications in Report shall be submitted within one week of specific instructions by BHEL for the same

Chapter VI- Statutory Regulations

6.1 For All types of works

The contractor shall pay all (save the specific exclusions as enumerated in this contract) taxes, fees, license charges, deposits, duties, tools, royalty, commissions or other charges which may be levied on the input goods & services consumed and output goods & services delivered in course of his operations in executing the contract. In case BHEL is forced to pay any of such taxes, BHEL shall have the right to recover the same from his bills or otherwise as deemed fit.

6.2 New Taxes/Levies

In case the Government imposes any new levy/tax on the output service/ goods/work after award of the contract, the same shall be reimbursed by BHEL at actual.

In case any new tax/levy/duty etc. becomes applicable after the date of Bidder's offer, the Bidder/Contractor must convey its impact on his price duly substantiated by documentary evidence in support of the same before opening of Price Bid. Claim for any such impact after opening the Price Bid will not be considered by BHEL for reimbursement of tax or reassessment of offer.

No reimbursement/recovery because of increase/reduction in the rate of taxes, levies, duties etc. on input goods/services/work shall be made. Such impact shall be taken care of by the Price Variation/Adjustment Clause (PVC) if any. In case PVC is not applicable for the contract, Bidder has to make his own assessment of the impact of future variation if any, in rates of taxes/duties/ levies etc. in his price bid.

6.3 GST: For All types of works excepting works covered under sl no 6.2

6.4 BUILDING & OTHER CONSTRUCTION WORKERS (REGULATION OF EMPLOYMENT AND CONDITIONS OF SERVICE) ACT, 1996 (BOCW Act) AND RULES OF 1998 READ WITH BUILDING & OTHER CONSTRUCTION WORKERS CESS Act, 1996 & CESS RULES, 1998 and

INTER-STATE MIGRANT WORKMEN ACT, 1979 (IN CASE BIDDER ENGAGE MANPOWER FROM OTHER STATE)

In case any portion of work involves execution through building or construction workers and/or inter-state migrant workers, then compliance to the above titled Acts as applicable shall be ensured by the contractor and contractor shall obtain license and deposit the cess under the Act. In the circumstances, it may be ensured as under: -

It shall be the sole responsibility of the contractor in the capacity of employer to forthwith (within a period of 15 days from the award of work) apply for a license to the Competent Authority under the

BOCW Act and/or ISMW Act as applicable and obtain proper certificate thereof by specifying the scope of its work. It shall also be responsibility of the contractor to furnish a copy of such certificate of license / permission to BHEL within a period of one month from the date of award of contract.

It shall be the sole responsibility of the contractor as employer to ensure compliance of all the statutory obligations under these acts and rules including that of payment / deposit of cess as per the applicability under above referred Acts within a period of one month from the receipt of payment.

It shall be the responsibility of the sub-contractor to furnish the receipts / challans towards deposit of the cess together with the number, name and other details of beneficiaries (building/Inter-state Migrant workmen) engaged by the sub-contractor during the preceding month.

It shall be the absolute responsibility of the sub-contractor to make payment of all statutory payments & compensations to its workers including that is provided under the Workmen's Compensation Act, 1923.

6.5 For entry and permission for working at site for contractor's men & materials, there is mandatory procedure specified by the end customer, M/s NTPC, which is elaborated in CLIMS (Attached as Annexure-II). The bidder has to strictly comply the requirements of this document.

Volume IA
Part II
Technical Specifications

SECTION – I: GENERAL SPECIFICATIONS

1.0.0 INTRODUCTION, LOCATION & FEATURES OF SITE

1.1 Project Engineering & Systems Division (PE&SD), received a contract to set up a Methanol tank with Dyke wall for Methanol firing in Gas turbine for NTPC Kayamkulam CCPP, Kerala, India.

1.2 The proposed project site is located at NTPC Kayamkulam, Kerala.

1.3 It is proposed to get soil investigations and topographical survey done at Tank farm area of the combined cycle power plant to establish various soil parameters to enable design of tank foundation, dyke wall foundations, and misc. foundations.

2.0.0 SCOPE OF WORK

This specification covers the complete soil exploration work including carrying out field tests and laboratory tests to evaluate static parameters of soil/rock and preparation of detailed report including the recommendations regarding founding level, structures/machines and methods of deep excavation

3.0.0 ***CODES AND STANDARDS***

The following is the general list of IS codes to be used for the geo-technical investigation work and preparation of report. In all cases latest revision along with Amendments, if any, shall be referred to.

IS: 1498 Classification and identification of soils for general engineering purposes

IS: 1888 Method of load tests on soils

IS: 1892 Subsurface investigation for foundation

IS: 1904 Structural safety of buildings: shallow foundations

IS: 2131 Methods of standard penetration tests for soils

IS: 2132	Code of practice for thin walled tube sampling of soils
IS: 2720	Methods of tests for soils
IS: 2809	Glossary of terms and symbols relating to soil engineering
IS: 2810	Glossary of terms relating to soil dynamics
IS: 2911	Code of practice for design and construction of pile foundations
IS: 3025	Methods of sampling and testing (phy. and chem.) for water used in Industry
IS: 3043	Code of practice for earthing
IS: 4078	Indexing and storage of drill cores
IS: 4434	Code of practice for in-situ vane shear test for soils
IS: 4453	Code of practice for exploration by pits, trenches, drifts and shafts
IS: 4464	Presentation of drilling information and core description in foundation investigation
IS: 4968	Method of subsurface sounding of soils (Part II & Part III)
IS: 5249	Method of test for determination of dynamic properties of soil

IS: 5313	Guide for core drilling observations
IS: 5529	Code of practice for in-situ permeability test (Part-I & II)
IS: 6065	Recommendation for the preparation of geological and geotechnical maps for river valley project
IS: 6403	Determination of allowable bearing pressure on shallow foundations
IS: 6926	Diamond core drilling for site investigation for river valley projects
IS: 6935	Method of determination of water level in a bore hole
IS: 7422	Symbols and abbreviations for use in geological maps, sections and subsurface exploratory logs
IS: 7746	In situ shear test on rock
IS: 8009 (Part I & II)	Code of practice for Calculation of settlement of foundations subjected to symmetrical static vertical loads-Shallow foundations; Deep foundations.
IS: 8763	Guide for undisturbed sampling of sand
IS: 8764	Method for determination of point load strength index of rocks
IS: 9143	Method for the determination of unconfined compressive strength of rock materials

IS: 9179 Method for preparation of rock specimen for laboratory testing

IS: 9198 Compaction rammer for soil testing

IS: 9214 Method of determination of modulus of sub grade reaction (k-value) of soils in field

IS: 9221 Method of determination of modulus of elasticity and poission's ratio of rock materials in uniaxial compression

IS: 9259 Liquid limit apparatus for soils

IS: 9640 Specifications for split spoon sampler

IS: 9669 Specifications for CBR mould and its accessories

IS: 10060 Code of practice for subsurface investigation for power house sites

IS: 10074 Specification for compaction mould assembly for light and heavy compaction

IS: 10108 Sampling of soils by thin wall samples with stationary piston

IS: 10589 Equipment for determination of subsurface sounding of soils

IS: 10837 Specifications of moulds for determination of relative density and its

accessories

IS: 11229 Specifications for shear box testing of soils

IS: 11315 Description of discontinuities in rock mass - Core recovery and rock quality (Part-II)

IS: 12070 Code of practice for design and construction of shallow foundations on rocks

IS: 13372 Code of practice for seismic testing of rock mass

IS: 14593 Design and construction of bored cast-in-situ piles founded on rocks

ASTM D5311-92 : Standard Test Method for Load Controlled Cyclic Triaxial Strength of Soil

4.0.0 ***FIELD INVESTIGATION***

4.1.0 TEST BORING:

Test boring through different layers of soil shall be carried out by the Contractor at the locations marked in the drawings and/or at such other locations as directed by the engineer in a manner described below.

Various methods of boring as described in IS:1892 may be adopted depending on the site conditions. Auger boring shall be resorted for above water table, whereas below the water table the bore holes shall be advanced by shell and auger unless the deposit is so

hard that it becomes mandatory to adopt other methods of boring. Minimum diameter of bore hole shall be 150 mm.

As bored cast-in-situ piles are recommended by M/s NTPC. Termination criteria for borehole is 3 consecutive SPT of N value 100 else up to 30M to 35M depth. If very hard strata is met within the borehole at depths shallower than specified in tender documents, the borehole shall be advanced by chiseling. If in the opinion of the Engineer-in-Charge, the rate of advancement of borehole is still low, boring may be resorted to subsequently. All boreholes shall be terminated in consultation with the Engineer-in-Charge.

The Contractor shall describe in details the equipment and method of boring he proposes to use.

Standard penetration tests and collection of undisturbed soil samples shall be carried out at regular intervals at all bore holes. In addition subsoil water samples are also to be collected from all bore holes.

The size of soil test samples shall preferably be 100 mm dia. X 300 mm high. The Contractor shall maintain a bore log for each soil test boring on an approved proforma.

For obtaining undisturbed samples in its simplest form, an open drive sampler shall be attached to a rod and shall be lowered to the bottom after completely cleaning the bore hole bottom by washing. The sampler shall be forced in one continuous motion, not driven, into the ground below the casing. The sample shall be shipped to laboratory in such a manner as not to cause any disturbance to or loss of moisture from sample. The soil sample shall not be removed from the sample tube and the ends shall be filled with paraffin and sealed with metal / plastic caps and marked with respective test bore number, elevation at which the sample was taken and other relevant informations as per IS:1892.

Ground water level for each bore hole shall be checked during boring operation and shall be recorded in bore log. Subsoil water samples shall also be collected from each bore hole and recorded.

Standard Penetration Tests (SPT) shall be carried out in accordance with IS:2131 at every change in strata or at 1.00 m intervals or as directed by the Engineer. The Contractor shall record the number of blows for each 150 mm of penetration of the split spoon sampler. The first 150 mm of penetration shall not be considered for penetration resistance. Auto trip hammer used for driving the sampler rod shall be 63.5 Kg and a drop of 750 mm shall be maintained. SPT at any depth shall be terminated when the number of blows exceed 100 or if the penetration is less than 25 mm per 50 blows.

Records of driving the sampler, number of blows and penetration shall be maintained in the bore log. IS:2131 shall be followed for additional information. SPT are to be conducted on soils and not on pebbles or weathered rock.

The bore hole shall be cleaned using suitable tools up to the depth of testing or sampling ensuring that there is minimum disturbance of soil at the bottom of the bore hole. The process of jetting through an open tube sampler shall not be permitted. In cohesive soils, the borehole may be cleaned using a bailer with a flap valve. Gentle circulation of drilling fluid shall be done when rotary mud circulation boring is adopted.

The Contractor shall quote all inclusive unit rate for the above work which shall included cost of all materials, labour etc. These bore holes shall be backfilled by the Contractor using sand.

4.2.0 IN-SITU PERMEABILITY TEST:

In-situ permeability test shall be conducted to determine the water percolation capacity of overburden soil. This test shall be performed inside the bore hole/trial pit at specified depths or in each layer or as per the directions of the engineer-in-charge. The type of test shall be either pump-in or pump-out test depending on the subsoil and ground water conditions. Pump-in test shall be conducted whether ground water in borehole exists or not. Pump-out test shall be conducted to obtain data for dewatering purposes when ground water is met in the borehole. The specification for equipments required for the test and the procedure of testing shall be in accordance with IS: 5529, Part-1. When it is required to carry out the permeability test for a particular section of the soil strata above

ground water table, bentonite slurry shall not be used while boring.

4.2.1 PUMP-IN-TEST

Pump-in test shall be conducted in the bore hole/trial pit by allowing water to percolate into the soil. Choice of the method of testing shall depend on the soil permeability and prevailing ground water level. Only clear water shall be used for conducting the test. Before conducting the test, the borehole shall be cleaned as specified in clause 3.1.0. Water shall be allowed to percolate through the test section for sufficient period of time to saturate the soil before starting the observation.

A) CONSTANT HEAD METHOD (IN BORE HOLE)

This test shall be conducted in boreholes where soil has a high permeability. Water shall be allowed into the borehole through a metering system ensuring gravity flow at constant head so as to maintain a steady water level in the borehole. A reference mark shall be made at a convenient level which can be easily seen in the casing pipe to note down the fluctuations of water level. The fluctuations shall be counteracted by varying the quantity of water flowing into the borehole. The elevation of water shall be observed at every 5 minute interval. When three consecutive readings show constant value, the necessary observations such as flow rate, elevation of water surface above test depth, diameter of casing pipe etc shall be made and recorded as per the proforma recommended in IS: 5529, Part-1, Appendix-A.

B) FALLING HEAD METHOD (IN BORE HOLE)

This method shall be adopted for soils of low permeability and which can stand without casing. The test section shall be sealed at the bottom of the borehole and a packer at the top of the test section. If the test has to be conducted at an intermediate section of a pre-bored hole then double packers shall be used. Access to the test section through the packer shall be by means of a pipe which shall extend above the ground level. Water shall

be filled into the pipe upto the level marked just below the top of the pipe and water be allowed to drain into the test section. The water level in the pipe shall be recorded at regular intervals as mentioned in IS: 5529, Part-1, Appendix-B. The test shall be repeated till constant records of water level are achieved.

C) PERCOLATION TEST (IN TRIAL PIT)

Percolation test shall be conducted in trial pit in areas where water/effluent is stored/discharged in ground level tanks. The loss of water due to percolation into the soil shall be estimated by the soil absorption capacity.

4.2.2 PUMP-OUT TEST

This test shall be carried out at site to determine the co-efficient of permeability of soil below water table. This test shall be conducted by continuous pumping out of water from a well so as to maintain a steady water level at the desired depth in the well. The fluctuations in the water level shall be counteracted by varying the quantity of water pumped out of the well. The specification for the equipments & accessories required for performing the test, the procedure of testing, field observations and reporting of results shall conform to IS: 5529, Part-1. The well shall be of 400mm in diameter to be installed with a 250mm diameter perforated GI/MS pipe. Observation pipes of 50mm diameter shall be installed at regular intervals along three radial lines extending from the well at 120 degrees to each other. Length of these pipes shall depend upon the ground level, estimated depth of lowering the ground water and the distance from the well. Sufficient number of observation pipes shall be installed along each of the radial lines so as to assess the zones of influence due to dewatering. Draw down depth in the well shall be as specified in the drawing.

4.3.0 VANE SHEAR TEST:

Field vane shear test shall be performed inside the borehole to determine the shear strength of cohesive soils, especially of soft and sensitive clays which are highly susceptible to sampling disturbance. This test shall be conducted by advancing a four winged vane of suitable size (75mm or 100mm diameter as per the soil condition) into the soil upto desired depth and measuring the torque required to rotate the vane. The specification for equipments & accessories required, the test procedure and field

observations etc shall be as per IS: 4434. This test may also be conducted by direct penetration from the ground surface. If the cuttings at the test depth in the bore hole show any presence of gravel, sand, shells, decomposed wood etc which are likely to influence the test results substantially, the test at that particular depth may be omitted with the permission of the engineer-in-charge. However the test shall be conducted at a depth where these obstructions cease to occur.

4.4.0 DYNAMIC CONE PENETRATION TEST:

Dynamic cone penetration test shall be conducted using bentonite slurry by driving a standard size cone attached to the bottom of a string of drill rods. The test shall be conducted upto the specified depth or refusal whichever is earlier. Refusal shall be considered when the blow count exceeds 150 for 300mm penetration. The specification for the equipment and accessories required for performing the test, test procedure, field observations and reporting of results shall conform to IS:4968, Part-II. The driving system shall comprise of a 65 kg weight having a free fall of 0.75m. The cone shall be of 65mm diameter provided with vents for continuous flow of bentonite slurry through the cone and rods in order to avoid friction between the rods and soil. On completion of the test, the results shall be presented as a continuous record of number of blows required for every 300mm penetration of the cone into the soil in a suitable chart supplemented by a graphical plot.

4.5.0 PLATE LOAD TEST:

The direct load tests on soil shall be carried out in the trial pits of sufficient size as per IS:1888 at locations, specified in drawing and/or at such other locations as directed by the Engineer. This test is to be carried out at 2.50 m below the existing ground level using 600mmX600mm plates as indicated in the drawing/as directed by the Engineer. The test shall be carried out in a manner as to give dependable assessment of bearing capacities of the soils at particular level. The results of the test shall also be used for arriving at the modulus of subgrade reaction and deformation and deformation modulus of soil. The tenderer shall furnish in his tender the complete details of the equipment and method he proposes to follow.

The excavation and side protection during the test and backfilling after the test shall be carried out by the contractor. Backfilling shall be done by suitable excavated earth.

The Contractor shall provide a suitable access to the bottom of the pits.

The Contractor will submit for approval of the Engineer, a detailed arrangement drawing for the tests and satisfy the Engineer about its adequacy in respect of strength and safety and of it being capable of giving accurate data. However, the Contractor shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The Contractor must get the dial gauges and pressure gauges calibrated by an approved testing laboratory before commencing the direct load tests at the site and produce the certificate of the tests to the Engineer. There shall be adequate number of standby gauges available at the site for quick replacement of faulty gauges. The Contractor shall bring not less than two dial gauges and one pressure gauge as standby.

In no case settlement observations by means of level and staff shall be accepted. The test shall be carried out as described in IS: 1888 unless otherwise specifically directed. The application of load may be by gravity or by reaction as detailed out in the above standard.

The test plate shall be preloaded with a load of 700 kg/sq.m retained for a reasonable period and then released to take out all slacks of the arrangement. All settlement observations shall start thereafter. Unless the ultimate bearing capacity can be calculated from the available soil data, the Contractor shall assess the ultimate bearing capacity of the soil under test. Increments of the load shall be of about one tenth of the ultimate bearing capacity or 1kg/sq.cm whichever is less. The increments shall continue to an extent that allows locating the “Yield value of Soil” as defined in IS: 1888 or up to practicable limit of testing.

While releasing the loads, the rebounds are to be observed in a similar manner as the settlement observations.

The observations shall be recorded directly in log books, proforma of which has to be approved by the Engineer, who shall also be present to check the data. The Engineer shall be notified well in advance of the detailed program of the tests and shall also be informed prior to start of releasing the load so that the total settlement can be checked by him.

The water table shall be noted in the nearest bore hole at the time of testing. If water table is within test zone to a depth of 3 times the width of plate, it is advisable to conduct the test at higher level. All expenses in this connection shall be included in his quoted rates.

In addition to carrying out plate load tests, undisturbed/disturbed soil samples shall also be collected at regular intervals during excavation.

The payment shall be lumpsum for each test and shall include all costs including of earthwork in excavation up to 2.50 depth below existing ground level, shoring for side protection, if necessary, and backfilling after the test.

4.6.0 FIELD CALIFORNIA BEARING RATIO TEST:

This test shall be carried out to obtain the properties of soil required for the design of roads. The equipments and accessories required for carrying out the test, test procedure, recording of observations and presentation of results shall conform to IS: 2720 part XXXI. The test locations and depth shall be as specified in the drawings or as directed by the engineer-in-charge.

4.7.0 ELECTRICAL RESISTIVITY TEST:

Resistivity tests shall be conducted at the location shown in the drawing or as instructed by the Engineer, to study the resistivity characteristics of soil at different depths from existing ground level.

The soil resistivity test has to be carried out strictly as per standards i.e IS/IEEE/IEC.

Since the value of electrical resistivity of soil is an important parameter for designing plant earthing system, the soil resistivity test has to be carried out in all ERT locations

keeping the spacing between electrodes necessarily at 1, 2, 3, 4, 5, 10, 15 & 20 Meters, strictly as per IS: 3043.

The payment will be based on the number of locations at which the test is conducted.

4.8.0 ROCK DRILLING:

During boring operation, once the rock strata is encountered, the normal method of boring operation as described under Clause 3.1.0 earlier shall have to be stopped and drilling operation will be resorted to for determining depth and nature of rock strata, in a manner as described below.

Rotary core drilling technique with continuous core recovery should be adopted for drilling through rock. The tenderer shall indicate in his tender the type of coring bit he proposes to use. The behavior of rock mass is governed more significantly by the nature of fractures in the rock than by the type and hardness of the material composing the rock itself. Hence, good drilling technique should be adopted to obtain intact samples truly representative of the in-situ material and for achieving highest percentage of recovery possible.

Variations in the speed of rotation, the downward pressure on the core barrel, the pressure at which the drilling fluid is introduced into the hole and the length of hole drilled (run length) prior to removal of the core are major items which must be controlled by the driller. In general, coring should be initiated with short runs both because the upper-portions of rock masses are commonly highly fractured and also because the elevations of any core losses can be more accurately determined. If conditions indicate that it is possible, the length of the runs may be determined by the length of the core barrel.

In zones which are highly fractured or where the barrel continuously becomes blocked, it

is essential that short runs be used even though this means removal of the entire string of drilling tools every 300 mm or less. Reduced bit pressure should be resorted to when rod vibration or chatter occurs. The pressure under which the drilling fluid should be introduced into the hole will be minimum to be consistent with adequate removal of cuttings from the hole and proper cooling of the bit. To minimize the erosive action of the drilling fluid on the core and thereby to improve core recovery, double tube core barrels should be used. The bore hole shall be advanced by NX coring using diamond bits.

During the drilling operation for each bore hole the Contractor shall record the rate of sinking of drill rods, ground water table elevations, if any, nature, type and sequence of rock drilled. From the recovered cores, the Contractor shall determine nature of fractures and degree of weathering of rock for each bore hole. The contractor shall also note and record any appreciable loss of drilling fluid throughout the entire drilling operations for each bore hole. The contractor shall also determine the percentage recovery ratio and rock quality designation from the recovered cores for each stage of core advance and for all the bore holes. Rock quality designation is defined as the ratio of cumulative lengths of intact pieces for core greater than 100 mm to the length of core advance.

The Contractor shall furnish all the information mentioned above fully verified and signed by the Engineer at site and submit them in triplicate to the Engineer.

Minimum boring depth shall be 20 m if weathered rock or hard rock is encountered in lower depth. If weathered rock or hard rock does not encountered within the depth of 20m, then boring shall be continued till 3m boing in weathered rock or hard rock, as elaborated in Clause no. 3.9.0. However, minimum depth of boring in weathered rock or hard rock shall be 3m.

In addition to the above-mentioned points, the contractor shall also take into consideration the provisions of the latest revisions of the following codes of practice along with Amendments, if any.

a) IS: 6926 Diamond core drilling for site investigation for river valley projects (optional).

b) IS: 4078 Indexing and storing of drill cores.

c) IS: 4464 Presentation of drilling information and core description in foundation investigation.

5.0.0 ***LABORATORY TESTS ON SOIL SAMPLES/ROCK CORES:***

The Contractor shall carry out the tests as listed out in the Schedule of items, and/or as decided by the Engineer, in laboratory. He shall furnish the names of laboratories where he proposes to have the tests carried out and have them approved by the Engineer.

The owner shall have the right of access to Contractor's laboratory and/or any other laboratory where tests have been arranged to be carried out during the progress of this investigation.

Adequate volume of test samples of soil/rock cores shall have to be collected from site, stored, labeled and transported carefully to the approved laboratory for carrying out the tests. The method and procedure of testing to be followed shall be as per the latest revisions of relevant Indian Standard Codes of practice modified to the extent given below. The results of the tests shall be submitted to the Engineer in sextuplicate (6nos.) with one transparency duly signed by the Laboratory-in-charge. In tests for rock cores L/D=1.0 of samples must be obtained.

The rate quoted by the tenderer for each type of laboratory test will be inclusive of transportation of the test samples from field to the laboratory.

5.1.0 GRAIN SIZE DISTRIBUTION:

Wherever applicable both the sieve and hydrometer analysis shall be conducted to indicate complete range of grain sizes in the soil sample tested.

5.2.0 ATTERBERG LIMITS:

Wherever applicable, these tests shall be carried out by the same skilled personnel. The tests result should include liquid limit and plastic limit of the soil sample tests. These tests should be conducted as per IS: 2720 Part-V.

5.3.0 CONSOLIDATION TESTS:

The following loading stages shall be employed:

0, 0.1, 0.25, 0.5, 1.0, 2.0, 4.0 and 8.0 kg/cm2

From e Vs. log p curves, pre-consolidation pressure shall be determined to establish whether the soil is normally consolidated or over consolidated. The point (eo, po) showing initial condition of the soil under test must be specifically marked on the consolidation curves.

Settlement prediction based on field virgin compression curve shall only be acceptable. The procedure adopted in respect of obtaining compression indices from the field curves and that for computing settlements for the type of clay under consideration shall be clearly illustrated in the report.

It is to be noted that deviations from the standard procedure of performing consolidation tests given in IS:2720 are permissible in order to enable computation of settlements based on the above procedure i.e. cycle (s) of loading, unloading and reloading shall be employed wherever required.

The following curves shall be included in the report:

A: e Vs.log p

B: e.Vs.p

C: Compression Vs. log t or compression Vs. Squareroot of t

Where e: void ratio

p: applied pressure

t: time

The choice of a relationship depends upon the shape of the plot which enables a clear determination of Cv, the coefficient of consolidation. All the soil properties necessary for calculation of consolidation settlement of soil (Cc, Cv, mv) shall be given in the report, wherever applicable.

The time period required for 50% and 90% primary consolidation shall be given in the report.

Computations of secondary settlements, if significant, shall also be made and included in the report.

5.4.0 TRIAXIAL TESTS:

These tests shall be done on specimens saturated by the application of back pressure. Only if the water table is at sufficient depth so that chances of its rising to the base of the footing are meagre to nil, the triaxial tests shall be performed on specimens at natural moisture content. The magnitude of the backup pressure applied shall be indicated in the report.

All stress strain diagrams as well as Mohr circle envelope shall be included in the report.

5.5.0 MODULUS OF ELASTICITY:

E-Value shall be determined from the triaxial tests. Relevant corrections applied to the computed E shall be clearly illustrated in the report.

5.6.0 CHEMICAL TESTS:

Chemical tests shall be conducted on soil and water samples to report the following:

a. PH
b. Chlorides in ppm & %
c. Sulphates in ppm & %

5.7.0 SWELLING CHARACTERISTICS:

Wherever black cotton soil is encountered, swelling potential, swelling pressure and shrinkage limit shall be determined as per relevant IS codes. One set of these tests shall be conducted for every 2.0 m thickness of black cotton soil layer. However if the thickness is less than 2.0 m results of at least one such test shall be reported.

5.8.0 CYCLIC TRIAXIAL TEST:

The preparation of the test specimens and test procedures shall be strictly as per ASTM D5311.

6.0.0 *REPORT ON SUB-SOIL INVESTIGATION:*

The Contractor shall make analyses of soil samples and rock cores, as collected in the field and approved by the Engineer-in-charge, as well as field tests and laboratory tests. A comprehensive report shall have to be prepared by contractor, finally incorporating all the data collected in proper tabular forms or otherwise along with analyses. Firm recommendations supported by calculations shall be included in the report. The report shall include but not limited to the following:

a. Geological information of the region.

b. Past observations and historical data, if available for the area or for other area with similar profile or for similar structures in the near by area. The contour map of the area is enclosed with the specifications.

c. A detailed write up on the procedures adopted in all phase of soil investigation.

d. A plan of bore hole & field test locations.

e. Net safe bearing capacity based on both shear and settlement criteria (25, 40 & 75 mm) for different types of foundations (square, rectangular, strip footings and raft) for various widths and depths (for foundation widths 1.0, 2.0, 3.0, 4.0 and 5.0m & φ1.0, φ 2.0, φ 3.0 and φ4.0m for isolated footing and more for rafts, and depth of foundation 1.0, 2.0, 3.0, 4.0, 5.0m) from proposed FGL based on field as well as laboratory test results and firm recommendation on the allowable soil pressure to be adopted for foundation design.

f. Considering the prevailing sub soil conditions in the proposed areas, all major foundations shall be supported on **Bored cast-in-situ pile**. Therefore, pile capacities, length of 500mm dia, 600mm dia and 700mm dia shall be furnished. Pile capacity calculation (vertical and horizontal) for single or group of piles shall also be included in the report. Method to calculate negative skin friction, if required, shall also be included.

g. Recommendations for ground improvement/ stone pile etc for temporary structure foundation i.e. fencing.

h. Recommendation regarding stability of slopes, if any, during excavations, etc.

i. Aggressiveness of percolating water through sub-soil/rock fissures to reinforced concrete foundation/sub-structures and also recommended protective measures, if required.

j. Bore hole and trial pit logs on standard proforma showing the depths, extent of various soil strata, ground level, sampling locations, SPT blow count, laboratory test results, ground water level & pertinent data etc.

k. Modules of subgrade reaction from plate load test for pressure ranging up to 6 kg/sq.cm. The recommended values shall include the effect of size, shape and depth of foundations.

l. Deformation modulus from plate load tests and triaxial tests.

m. Recommendation for the type of cement to be used and any treatment to the underground concrete structures based on the chemical composition of soil and subsoil water.

n. Recommendations for fill material and for grading as per natural availability in the region. Agency may also suggest the source for filling/grading material.

o. Cross section of soil profile in two perpendicular & diagonal directions and all load curves & consolidation test curves.

p. Recommended soil properties such as density, specific gravity, cohesion, angle of internal friction, coefficient of volume compressibility, compression index, modulus of elasticity, shear modulus, sub grade modulus (k) at different levels etc for design.

q. Susceptibility of sub soil strata to liquefaction (as per IS 1893/specialist literature) in the event of earthquake. If so, recommendation for remedial measures.

r. Precautions to be taken for the design of lightly loaded structures when expensive soil is encountered with respect to swelling pressure and free swell index values obtained.

s. The contractor's recommendations shall include specific and definitive information on the following, supported by detailed calculations.

t. Any other recommendation as required as per NTPC Specification CS-0011-130A-9.

Founding depths for various foundations as given below and corresponding safe soil bearing capacities evaluated from both shear and settlement considerations.

Values obtained from field tests and laboratory tests shall be compared and suitable interpretation shall be furnished.

Note: ***Soil Investigation Agency shall submit the borehole data immediately after completion of first two boreholes.***

SECTION II:

2. TECHNICAL SPECIFICATION FOR TOPOGRAPHICAL SURVEY

(Topo survey along with UG Scanning shall be carried out as per item of work mentioned in Schedule of Quantities and customer specification)

SECTION III:

3.General Notes

3. GENERAL NOTES:

1. The item of work in the schedule of quantities describes the work very briefly. Details of items shall be read in conjunction with the corresponding specification, drawings and other tender terms. For each item in the schedule of quantities, the bidder's rate shall include all the activities covered in the description of the items as well as for all necessary operations in detail described in the technical specification.

2. The bidder shall quote for finished items of work and shall provide all necessary power, water, instruments, fuel, tools and plants, tackles, materials, transport, labor, supervision and maintenance till handing over, repairs, rectifications, safety and security of their workmen and equipments including insurance etc.

3. The unit rates quoted shall include minor details which are obviously and fairly intended and which may not have been included in these documents but are essential for the satisfactory completion of the work.

4. Quantities of the various items mentioned in the schedule of quantities are approximate and may vary upto any extent or be deleted altogether and new items may be added. The contractor shall carry out all the works upto a variation of +/- 30% (plus or minus thirty percent) on the tendered value of the contract and all tendered rates shall remain firm within this limit.

5. Rates shall be quoted in both figures and words in clear legible writing. No overwriting is allowed. All scoring and cancellations should be countersigned by the bidder. In case of illegibility, the interpretation of the engineer-in-charge shall be the final and binding on the contractor.

6. Engineer-in-charge's decision regarding clarification of items in the schedule with respect to other sections of the contract shall be final and binding on the contractor.

7. The bidder shall submit a scheme showing the arrangement and equipment proposed to be used for conducting the work along with the rates.

8. Contractor shall make his own arrangement for water, electricity, accommodation, access to site and the cost of all such works shall be considered to be included in his quoted price.

ANNEXURE- I

WEB BASED CONTRACTORS' LABOUR INFORMATION AND MANAGEMENT SYSTEM [CLIMS] IN NTPC.

INTRODUCTION:

NTPC has implemented an in house 'captive private cloud' based solution; **'Contractors' Labour Information Management System (CLIMS)'** to streamline the labour management processes, to ensure physical and social welfare of workers, statutory compliances and to get accurate picture of real time availability of workers. It has also resulted in proper keeping of records in a digitalized format and ensuring that the wages and other benefits of labour deployed at NTPC Plants are disbursed correctly and in time.

The **CLIMS application** also has inbuilt features like bio-metric attendance, medical fitness, safety training/ clearances, ESI registration and other regulatory checks. CLIMS is designed to automate several time-consuming processes in a contract involving labour force, including wage sheet processing for contractor's labour and statutory reporting and archival. The application covers the management of information of contractors and their work contracts including management and control of contractor's labour force; their work timings, wages, welfare, safety and health concerns. While the contractor retains ownership of labour data and enjoys full control over labour attendance, work timing, wages etc., system provides real time information windows to concerned NTPC officers like Engineer-in-charge, HR and safety department etc. for ensuring compliance of labour laws and labour welfare.

Pre-set Workflows have been incorporated in CLIMS wherein labour can enter the plant only after the requisite safety training and medical clearance. It is not only a labour information and attendance system but a system spanning bigger objectives of economic development, social justice and safety & welfare of labour. The administration of CLIMS since its rolling out has proven a game changer by all means. The digital transformation achieved through CLIMS in management of contractors' workers has tremendously benefitted all its stakeholders. It is institutionalized in NTPC and is running successfully at 47 projects ensuring and ascertaining social security, welfare and financial stability to thousands of workers.

SALIENT FEATURES OF CLIMS:

1. **Repository of Contracts' data, Work' data and Workers' data:** CLIMS keeps information of all types of work contracts including the contracts of project construction, regular operation or periodic maintenance. The database keeps record of the contractors, their works or contracts; single or multiple, and the labour registered by the contractors against each contract. The system also keeps record of workers' medical fitness, safety training, skill training, training requirements, safety clearances and several other regulatory checks. A completely digital data repository of workers' data is maintained which includes workers' addresses, qualifications, designation, skills, bank account details, nominees, PF/ESIC numbers etc.

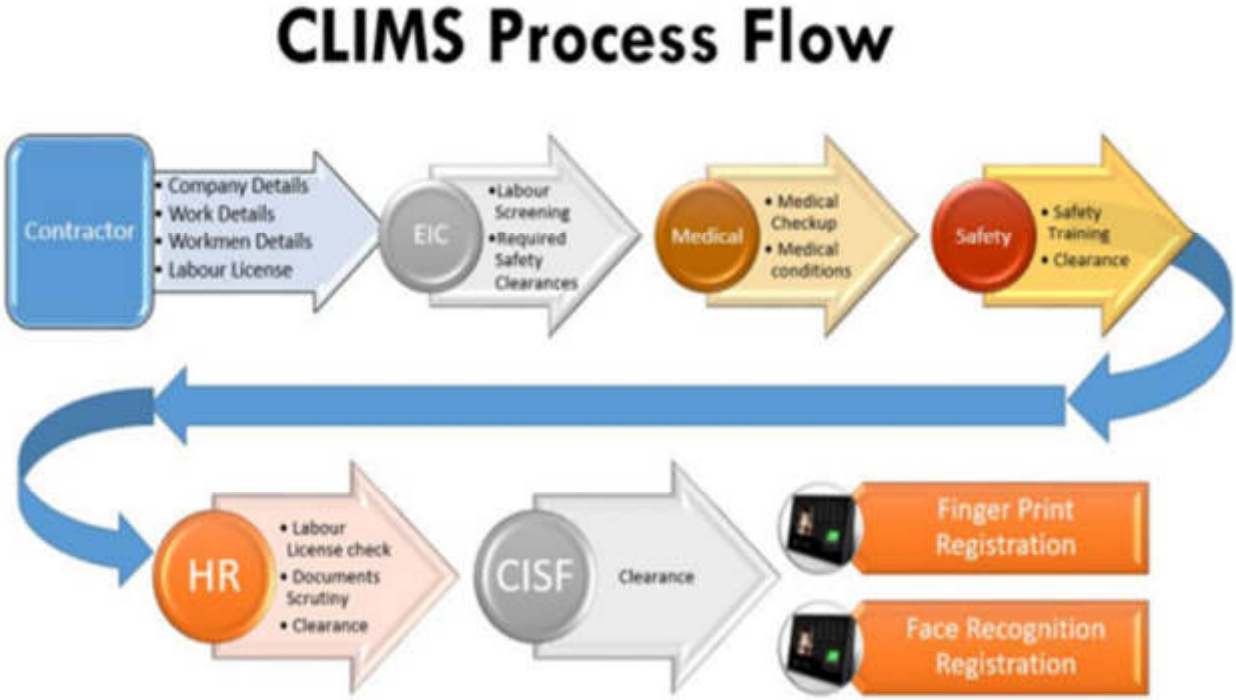
2. **Workers' Biometric data:** Biometric authentication employing face detection or finger print identification ensures that there will be no unlawful entry and each entry and exit will also be immediately recorded. Biometric authentication system at all entry and exit points. This has further helped in strengthening the security of the power plants.

3. Authentication of Workers' for access control and attendance: Labour authentication at plant gates and automated attendance of contractors' labour form an important part of CLIMS. Plant gates are

fitted with biometric face or finger authentication systems. All the contractors' workmen registered in the CLIMS database have a workman ID and their finger prints and face matrix are captured and recorded by the authentication machines. All the authenticating machines at the gates are connected to the central database of CLIMS through Intranet and the in-out timing of labour at all gates is stored in the central database in real time.

4. Wage sheet preparation: Wage sheets of workers are automatically generated by CLIMS application using the attendance data of workers received from biometric machines. This feature makes it possible to handle millions of numbers in a few minutes and prepare accurate wage sheets of workmen without any manual slogging. This also helps in processing of wages as per statutory guidelines and bringing transparency in wages paid to workers based on their actual attendance. Contractors, EIC, Finance and HR personnel can review the attendance and wage sheets of workers using their CLIMS portal login account. This is the most important feature of CLIMS which helps in faster wage sheet generation, statutory compliances, faster HR clearance and helps in ensuring wage payment on the last day of the Month.

5. Data Management: Contractors are primarily responsible for maintaining correct data of their labour force in CLIMS. Each contractor gets its own login and password to work in CLIMS. Contractor details, assigned work and worker details are filled into the CLIMS web application by contractors using their CLIMS login. Complete details of workmen are captured and stored in the system including their permanent address, emergency contacts, education level, designation & skill level, category, insurance details, EPF, UAN, ESI-IP Number, bank account details, PMJJY and PMSBY data etc. Photographs of workers and scanned identity documents are also uploaded. Contractor uploads all the required forms and documents into the CLIMS repository to get clearance of labour entry inside the plant premise



Annexure II

Geotechnical Investigation :

The Contractor shall carry out detailed geotechnical investigation in the areas under his scope for establishing the sub-surface conditions and to decide type of foundations for the structures envisaged, construction methods, any special requirements/treatment called for remedial measures for sub-soil/ foundations etc. in view of soft sub-soils, aggressive sub-soils and water, expansive/swelling soils etc. prior to commencement of detailed design/drawings. The Contractor shall obtain the approval for the field-testing scheme proposed by him from the Owner before undertaking the geotechnical investigation work.

Scheme of geotechnical Investigation :

Field test shall include but not be limited to the following: Boreholes, Standard Penetration Test (SPT), Dynamic Cone Penetration Test (DCPT), collection of disturbed samples (DS) and undisturbed soil samples (UDS), Trial Pits (TP), Plate Load Tests (PLT), Electrical Resistivity Test (ERT), In situ field permeability tests, collection of water samples, etc.

The diameter of borehole shall be minimum 150 mm in soil and 76 mm in rock. The diameter of UDS sampler shall be 100 mm minimum. SPT shall be carried out by driving a standard split spoon sampler in the bore hole by means of a 63.5 kg hammer having a free fall of 0.75 m with auto trip hammer. Core drilling in rock shall be done by using hydraulically feed rotary drill & double tube core barrel with diamond bit.

The minimum tests are indicated in Clause No. 1.12.02. Adequate number of tests shall be conducted up to sufficient depth for complete determination of subsoil conditions. The depth of boreholes shall be as specified in Appendix A. SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery up to 20%, met within a borehole. This test shall be conducted at every 3.0 m interval or at change of strata, up to the final depth. SPT 'N' of 100 and above shall be referred as refusal. UDS shall be collected at every 3.0 m interval or at change of strata up to depth of borehole. UDS may be replaced by additional SPT, if SPT'N' value in the strata is above 50.

Laboratory tests shall be done as per relevant IS codes. The laboratory tests, not be limited to the following shall be conducted on disturbed and undisturbed soil samples, rock samples & water samples collected during field investigations in sufficient numbers.

Laboratory Tests on Soil Samples: Laboratory tests shall be carried out on disturbed and undisturbed soil samples for Grain Size Analysis, Hydrometer Analysis, Atterberg Limits, Triaxial Shear Tests (UU), Natural Moisture Content, Specific Gravity and Bulk Unit Weight, Consolidation Tests, Unconfined Compression Test, Free swell Index, Shrinkage Limit, Swell Pressure Test, Chemical Analysis test on soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, organic matter and any other chemicals harmful to concrete and reinforcement/ steel.

Laboratory Tests on Rock Samples: Moisture content, porosity & density, Specific Gravity, Hardness, Soundness, Slake durability index, Unconfined compression test (Both at saturated and insitu water content), Point load strength index and deformability test (Both at saturated and in-situ water content) shall be carried out on rock samples

Geotechnical investigation (field & laboratory) shall be carried out in accordance with the provisions of relevant Indian Standards. On completion of all field & laboratory work, geotechnical investigation report shall be submitted for Owner's review/approval. The Geotechnical investigation report shall contain geological information of the region, procedure adopted for investigation, field & laboratory observations/ data/ records, analysis of results & recommendations on type of foundation for different type of structures envisaged for all areas of work with supporting calculations. Recommendations on treatment for soil, foundation, based on subsoil characteristics, soft soils, aggressive chemicals, expansive soils, etc. Recommendations on foundation system and the net allowable bearing pressures shall be based on the conservative values of geotechnical investigation data.