1x80MW COAL BASED THERMAL POWER PLANT

AT RENUSAGAR

FLUE GAS DESULPHURIZATION PROJECT

SPECIFICATION FOR

GEOTECHNICAL INVESTIGATION

DOCUMENT NO. RPD-U5-FGD-C-SPC-01.R1

SPECIFICATION

FOR

GEOTECHNICAL INVESTIGATION

C O N T E N T S

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1.00.00 SCOPE

This specification covers the complete soil exploration work including carrying out field tests and laboratory tests to evaluate static as well as dynamic parameters of soil/rock and preparation of detailed report including the recommendations regarding founding level, type of foundation for different kinds of structures/machines and methods of deep excavation.

2.00.00 GENERAL

The contractor shall perform all work under the purview of this specification along with all incidentals and related work including setting out, staging, approach to test locations, contractor's office, stores and protection of adjacent buildings, structures or services / facilities. No separate payments shall be made on such accounts. The tenderer should therefore take into account all such relevant items while quoting his unit rates against the schedule of items.

2.01.00 Work to be provided for the contractor

The work to be provided by the contractor, unless specified otherwise shall include but not be limited to the following.

a) Furnish necessary plant and equipment, tools and tackles, instruments, necessary power, fuel, water, labour, supervisions by qualified and experienced engineers and supervisors specialized in the type of investigation, transport of materials, men and equipment etc., services, full insurance and all other incidental items as may be necessary for successful completion of the work as per tender terms, drawings, specifications and instruction of the owner / engineer.

b) Locate in the field and in layout drawing all boreholes and other field investigation items.

c) Furnish progressively and periodically field bore logs, investigation observations, test results with relevant data and features in triplicate.

d) Prepare and submit the sub soil investigation report (after incorporating comments, if any) as per specification, schedule of items and instructions of the owner / his engineer.

2.02.00 **Work to be provided by others**

No work under this specification will be provided by any agency other than the contractor unless specifically mentioned elsewhere in the contract.

2.03.00 **Location and Levels**

Location of all boreholes and field test points and levels of the existing ground at such locations shall be established by the contractor at his own cost from two reference grids and one bench mark given by the owner/ his engineer and these shall be subsequently plotted in the layout plan, bore logs and other relevant field test data sheets / tables to be incorporated in the report by the contractor.

Making bench mark pillar (s) and reference line pillars (whatever are required for the work) and maintaining them upto the completion of the work shall be the responsibility of the contractor at no extra cost by the owner.

Tentative location of the boreholes to be explored is marked in drawing number **RPD-U5-BHM/001** for reference and is attached with this specification.

2.04.00 **Codes and Standards**

Indian code of practice shall be used for the soil investigation work and preparation of report in general. In all cases latest revision along with amendments, if any, shall be referred to.

3.00.00 **SOIL EXPLORATION**

3.01.00 **Test Boring**

Test Boring through different layers of soil shall be carried out by the contractor at the locations as marked in the Plot Plan drawing and/or at such other locations as directed by the Engineer in a manner described below.

Various methods of boring as described in the above mentioned codes may be adopted. The tenderer shall furnish in his tender the complete details of the equipment and the method he proposes to follow. Minimum diameter of boring shall be 150 mm.

During the boring operations if rock strata is not encountered, the boring shall be continued upto 20m depth unless required otherwise. Incase rock strata is encountered within the above depths, boring operations shall be discontinued and

drilling operation as enumerated in clause 4.0 below shall be resorted to. If the present formation level is above the natural ground with filled-up soil, the depth of boring mentioned above shall exclude such filled-up soil.

When boring cannot be advanced due to presence of hard material, it should be checked whether there is continuous strata of hard material below before resorting to drilling methods. If only a local boulder is present it should be chopped using suitable chopping bits and the debris removed and normal boring continued.

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

3.02.00 **Stabilization of Boreholes**

Boreholes shall is stabilized, whenever required, against caving of the sides of the drill hole and heaving of the bottom of the hole. especially in cases where the hole is carried below the ground water level , by use of drive pipe or casing or by means of drilling fluids (water or mixtures of water and colloidal, gel forming thixotropic clays such as bentonite) or other suitable methods.

3.03.00 **Open Trial Pits**

The location of open trial pits shall be shown in the Plot Plan drawing. If the present formation level is above the natural ground level with filled-up soil, the depth of trial pits shall be up to a depth of 3.5m below natural ground level or not below the ground water table or as directed by the Engineer. In no case, the depth shall be extended over 5m. The size of pits shall be 3.0m x 3.0m or as directed by the Engineer. Samples of undisturbed soil shall be obtained preferably at every 1.5m or where a change in strata is noticed.

The contractor shall provide a suitable access to the bottom of the pits. Sampling in trial pits shall be done as directed by the engineer.

The contractor shall be paid at contract unit price for each trial pit which will include all costs for earthwork in excavation with necessary side slope and backfilling and shoring/ sheeting for side protection, if required.

After completion of the test, sampling and visual examination, the pit shall be suitably backfilled as directed by the engineer. Unless otherwise specified, excavated soil shall be used for this purpose.

3.04.00 **Boring in River Bed**

For carrying out boring in river bed, the barge / boat should be properly anchored so that there is no movement of the platform due to waves which can cause damage to the drill rods and casing.

3.05.00 **Rock Drilling**

During boring operation, once rock strata is encountered, the normal method of boring operation as described under clause 3.01.00 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 behaviour of rock mass is governed more significantly by the nature of fractures in the rock then by the type and hardness of the material composing the rock itself. Hence, good drilling technique should be adopted to obtain an intact sample truly representative of the in-situ material and for achieving highest percentage of recovery possible. 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 at which core losses occur 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.

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.

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.

The drilling operation shall be terminated when more than 75% of the core recovery is possible. If core recovery is lower and the nature of rock is weathered, drilling must be continued upto 30m for two bore holes and 20m for the remaining boreholes below the natural ground level.

3.06.00 **Sampling**

Bored spoil shall be collected continuously during boring to note any change of strata. Samples of undisturbed soil shall be obtained preferably at every 1.5 m where a change in strata is indicated by the slurry flowing out. In no case shall the depth between successive sampling be more than 3.0 m and a sample shall be obtained on the average for every 2.0 m depth of boring, since it is intended to

ascertain the characteristics of the soil at various depths. If, however, there is fair uniformity in the characteristics of the soil for certain depths the engineer may limit the number of samples stipulated above.

3.06.01 **Tube Sampling**

For obtaining undisturbed samples in its simplest from, an open drive thin wall tube sampler shall be attached to a rod and shall be lowered to the bottom after completely cleaning the borehole bottom by washing. The samplers to be used should have area ratio less than 13 percent and preferably less than 10 percent. The head should have check valve and ports to permit easy escape of drilling fluid or air from the sample tube as the sample enters it.

Sampling will be accomplished by jacking or driving the tube depending on the type of soil to be sampled. Upon completion of the sampling operation the sampler shall be withdrawn from the borehole and the sample of soil carefully taken out. Approximately on inch length of soil is to be removed from each end for identification. If there is any surface water on the sample, this shall be wiped off with soaking paper, all sludge of cuttings from advancement of borehole removed and the sample immediately packed in an airtight, close fitting container marked with respective test bore numbers, elevation at which the sample was taken. The size of soil test samples shall preferably be 65 mm dia x 200 mm high, but not less than 50 mm dia. x 150 mm high.

Representative / disturbed samples shall also be taken in different strata for visual classification, water content, grain size analysis, Atterberg limits, determination of specific gravity and compaction tests.

3.06.02 **Chunk Samples**

In cohesive soils, undisturbed samples of regular shapes shall be collected. The samples shall be cut and trimmed to a suitable size (0.3 x 0.3 x 0.3 m). A square area (0.35 x 0.35 m) shall be marked at the centre of the levelled surface at the bottom of the pit. Without disturbing the soil inside the marked area, the soil around this marking shall be carefully removed upto a depth of 0.35 m. The four vertical faces of the soil block protruding at the centre shall be trimmed slowly so that its size reduced to 0.3 x 0.3 m. Wax paper cut to suitable size shall be wrapped uniformly and covered with two layers of thin cloth over all the 5 exposed surfaces of the soil block and sealed properly using molten wax. A firmly constructed wooden box of size 0.35m x 0.35m (internal dimensions) with the top and bottom open shall be placed around the soil block and held in such a manner that its top edge protrudes just above the surface of the block. The space between the soil block and the box shall be filled uniformly and tightly with moist saw dust. The top surface shall also be covered with saw dust before nailing the wooden lid to cover the box firmly taking care that the soil block is not disturbed. The area of contact between the bottom portion of the block and the ground shall be reduced slowly by removing soil in small quantities using small rods, so that the block can be

separated from the ground slowly without disturbance. After inverting the wooden box along with the soil block, the bottom portion shall be trimmed and covered with wax paper, cloth and sealed with molten wax. A wooden lid shall be nailed to the box after providing proper saw dust cushion below it. An arrow mark shall be made on the vertical face of the wooden box to indicate the top surface along with the coordinates and depth of sampling.

3.06.03 **Sampling in rock**

Sampling in rock shall be accomplished during the drilling process by employing double tube core barrels for continuous core recovery. The drilling procedure to be followed should be the one which brings about the highest percent recovery and the exact procedure must be determined in the field.

3.07.00 **Record of Boring**

Detailed chronological record of drilling and sampling operations shall be maintained in the field log and should be submitted to the owner after completion of boring work at site. The final log showing pertinent subsurface information and results of field and laboratory testing should be submitted with the soil report.

The final log shall be a condensation of the field log refined on the basis of field and laboratory tests. The final log should present a clear, concise and accurate picture of subsurface conditions to be utilized by the engineer.

4.00.00 **PENETRATION TESTS**

Penetration tests using various types of equipment as specified shall be conducted to measure the resistance of soil to penetration.

4.01.00 **Standard Penetration Test**

Standard penetration test (SPT) shall be carried out in accordance with Indian Codes or any other acceptable code of practice at every change in strata or at 1.5 m intervals or as directed by the engineer. The contractor shall record the number of blows for each 150 mm penetration of the standard split spoon sampler over a depth of 450 mm. The number of blows for the first 150 mm of penetration shall not be considered in evaluating the penetration resistance. Records of the test including depth at which driving is initiated and the number of blows for each 150 mm penetration shall be shown in the field log, the final log shall indicate the actual SPT value (sum of number of blows for last 300 mm of penetration) at appropriate depths.

4.02.00 **Static Cone Penetration Test**

The test shall be carried out in accordance with Indian Codes or any other acceptable code of practice at locations as directed by the Engineer. The test shall be carried out upto a depth of 20 m or upto the top of rock layer whichever is earlier. Cone resistance and frictional resistance shall be separately provided in the report together with a borehole log.

4.03.00 **Dynamic Cone Penetration Test**

Dynamic cone penetration test shall be conducted to predict stratification, density, bearing capacity etc. of soils. The test shall be conducted 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 terminated earlier if the number of blows exceeds 35 for 100 mm penetration when the cone is driven dry and 20 for 100 mm penetration when the cone is penetrated by circulating bentonite, in order to avoid damage to the equipment.

The specification for the equipment and accessories for performing this test, test procedure, field observations and reporting or results shall conform to Indian Codes or any other acceptable code of practice. On completion of the test, the results shall be presented as a continuous record of the number of blows required for every 300 mm penetration of the cone into the soil in a suitable chart supplemented by a graphical plot of blow count for 300 mm penetration vs. depth.

5.00.00 **GROUND WATER INVESTIGATION**

Groundwater investigation shall comprise determination of groundwater levels and pressures and permeability of subsurface materials. The effect of tidal variations (if applicable for the site) on ground water level shall also be observed by noting the water level in boreholes during high and low tide periods.

5.01.00 **Ground water level observation**

The contractor shall make necessary arrangements to prepare the boreholes for ground water observation. Completed boreholes should be capped and a G.I. pipe inserted in order to preserve them for future ground water observation. These observations will be taken by the contractor during the period of investigation. At the end of the site investigation work, these boreholes shall be handed over to the owner in such a condition that further observations can be taken by the owner for a period of at least a year.

Piezometers will have to be installed in boreholes as directed by the owner. A piezometer consisting of either a simple standpipe of PVC tubing with a slotted end and surrounded by granular filter of plastic fabrics shall be used for granular soils or permeable rocks. In impermeable soils, hydraulic piezometer consisting of a

porous element connected by twin small-bore plastic tubing to a remote reading station will be used.

5.02.00 **In-Situ Permeability Test**

In-situ permeability test shall be performed in the 2 boreholes specified in drawing and/or at such other locations at specified depths as directed by the Engineer for determination of the permeability co-efficient of the soil. The type of test shall be either pump-in or pump-out test depending on the sub-soil and ground water conditions. Pump- in test shall be conducted whether ground water in the borehole exists or not. Pump-out test with piezometer installations shall be conducted to obtain data for dewatering purposes when ground water is met in the borehole.

The specification for the equipment required for the test and the procedure of testing shall be in accordance with Indian Codes or any other acceptable code of practice. The contractor shall provide all necessary equipment (diesel operated). When it is required to carry out the permeability test for a particular section of the soil strata above the ground water table, bentonite slurry shall not be used while boring.

6.00.00 **FIELD TESTS**

In situ tests shall be performed as desired by the engineer to measure properties of soil during the field investigation work.

6.01.00 **Menard Pressuremeter test**

This test shall be carried out as per Indian Codes or any other acceptable code of practice in the bore holes specified in drawing and/or at such other locations as directed by the Engineer to the full depth of bore holes, to assess the co-efficient of earth pressure at rest and the stress-strain modulus of soil. The tests shall be carried out at every 3.0 m intervals.

6.02.00 **Direct Load Tests on Soils**

The direct load tests on soil shall be carried out in the trial pits specified in Tender drawing and/or at such other locations as directed by the Engineer. This test is to be carried out at 2.5m/3.5m below the natural ground level as indicated in the above drawing/as directed by the Engineer. The plate sizes to be used shall depend on the nature of the soil, a 45 cm square plate will be used in clayey soil and in sandy soils, three plates of size varying between 30 cm to 75 cm will be used. 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 modulus of soil.

The excavation and side protection during the test and back-filling after the test shall be carried out by the contractor. If ground water table is at a depth higher than the specified test depth, the ground water table shall be lowered and maintained at the test depth for the entire duration of the test. The cost of dewatering shall be borne by the contractor.

The tests shall be carried out in accordance with Indian Codes or any other acceptable code of practice. The application of load may be by gravity or by reaction as detailed out in the above standard.

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 programme of the test and shall also be informed prior to start of releasing the load so that the total settlement can be checked by him.

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 lump sum for each test and shall include all costs inclusive of earthwork in excavation upto 3.5m depth below natural ground level, shoring for side protection, if necessary, and back filling after the test. For the depths over 3.5m extra payments shall be made only for earthwork and shoring, if any. If water table is required to be lowered during the test, necessary diesel operated pumping arrangement will have to be provided by the contractor himself. All expenses in this connection shall be included in his quoted rates.

6.03.00 **Vane Shear Tests**

Vane shear test shall be conducted for measuring the strength of soft clay in-situ at all depths from the surface to at least 20m and at locations as specified. The test shall be conducted by pushing into the clay a small four-bladed vane of suitable size (75mm or 100 mm diameter depending upon the soil condition), attached to the end of a rod and then measuring the maximum torque necessary to cause rotation. This torque is a measure of the moment developed by the shear strength of the clay acting over the surface of the cylinder.

The test can be performed at desired depths either inside boreholes or by direct penetration from ground surface. If 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, the test at that particular depth may be omitted with the permission of the engineer.

The specification for the equipment and accessories required for performing this test procedure, field observations and reporting of results shall be in accordance with Indian Codes or any other acceptable code of practice.

6.04.00 **Determination of Dry-Density of Soils**

In place dry density of soil is required for assessment of bearing capacity of soils analysis for stability of natural slopes and in settlement calculations for estimating overburden pressure at different depths. Methods depending on the scope of application in different types of soils shall be adopted conforming to the relevant codes for determination of in-place dry density of soils.

6.05.00 **In-situ Block Shear / Wedge Shear Test**

The test shall be carried out in a manner as to give a dependable assessment of shear resistance of rock, when at a shallow depth, rock is encountered.

The test shall be carried out in the trial pits and/or at such other locations as directed by the Engineer. The interpretation of test data and report shall be in accordance with Indian Codes or any other acceptable code of practice. The set up without an arrangement for direct application of normal load as detailed in the above standard shall be followed.

The payment terms as indicated for clause 3.03.00 above shall hold good for this test.

6.06.00 **Test for Measurement of soil Resistivity**

For designing the earthing system for the project it is necessary to find out the electric resistivity of the soil at some representative locations of the project site.

Soil resistivity is determined in Ohmmeter by using "WENNER's FOUR ELECTRODE METHOD". The principle of the above method is generally as under:

Four electrodes are driven into the earth along a straight line at equal intervals of 'S'. This distance 'S' can be varied and different readings taken for electrode spacing S = 5, 10, 15, 20 metres etc. to detect the vertical variations of resistivity at a certain location. A current I is passed through the two outer electrodes and the earth. The voltage difference, V, between the two inner electrodes is measured. The current I flowing into the earth produces an electric field proportional to its density and to the resistivity of the soil. The voltage V measured between the inner electrodes is, therefore, proportional to this field. Consequently, the resistivity will be proportional to the ratio of voltage to current.

If the depth of burial of electrodes in the ground is negligible compared to the spacing between the electrodes then the soil resistivity.

= 2 X 3.14 X S.V / I

Where, Resistivity of soil in Ohm-meter

S = Spacing between electrodes in metre

V = Voltage difference between two inner electrodes in volts.

= Current flowing through two outer electrodes in amp.

Earth testers normally used for the above purpose comprise the current source and meters in a single instrument and directly read the resistance. Such an instrument is known as four terminal meggar. Using such meggar for measurement, above formula becomes

= 2 X 3.14 X S.R.

Where, R is meggar reading in Ohms.

Depth of burial of electrodes shall not be more than 1/20 or the spacing between the electrodes.

Correction of the test results should be done, if necessary, using the method outlined in the relevant codes.

The location and number of the test points are shown in the plant layout. The number shall be increased if the test results obtained in different locations show a significant difference.

7.00.00**T** ESTS FOR DYNAMIC PROPERTIES

For evaluation of in-situ dynamic and damping properties of soils, Block Vibration Test, Cyclic Plate Load Test and Wave Propagation Test shall be conducted. The triaxial test method using repeated static loading should also be carried out for arriving at the value of the Young's Modulus.

The Tenderer shall furnish in his tender the complete details of the equipment and method of testing he proposes to follow.

The locations at which such tests are to be carried out are as directed by the Engineer. If the present formation level is above the natural ground level with filled-up soil, the depth of trial pits shall exclude such filled-up soil.

The tests shall be carried out in accordance with Indian Codes or any other acceptable code of practice.

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 programme of the test and shall also be informed prior to the start of releasing the load so that the total settlement can be checked by him.

The payment shall be lump sum for each test and shall include all costs inclusive of earthwork in excavation, shoring for side protection (if necessary) construction/curing of plain concrete test block, supply and embedment of foundation bolts etc. and backfilling after the test.

8.00.00 FIELD DETERMINATION OF CALIFORNIA BEARING RATIO

The test shall be carried out at locations as shown on the drawing or at locations as directed by the Engineer. The test shall be carried out at a depth of 500 mm below the finished ground level.

The surface area to be tested shall be exposed, cleaned of all loose and dried material, levelled and then soaked till saturation with a surcharge weight of 15 kg. After soaking is complete, the test surface shall be drained of all free water and allowed to stand for at least 15 minutes before starting further operations.

The test shall be carried out strictly in accordance with the provisions as laid down in Indian Codes or any other acceptable code of practice. Surcharge weights of 15 kg including that of the annular weight of 5 kg shall be applied before application of load on the penetration piston. Load shall be applied on the penetration piston such that the penetration is approximately 1.25 mm/min. The load readings shall be recorded at penetrations of 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5 mm. The maximum load and penetration shall be recorded if it occurs for a penetration of less than 12.5 mm.

After completion of the test, a sample of soil shall be taken from the point of penetration for moisture content determination. In place density shall also be determined.

From the plot of load penetration curve, after necessary correction, the bearing ratios shall be calculated for penetrations of 2.5 mm and 5 mm. If the bearing ratio at 2.5 mm penetration is greater than that at 5 mm penetration the former shall be taken as the bearing ratio. If bearing ratio at 2.5 mm penetration is less than that at 5 mm penetration, the test shall be repeated and if the ratio at 5 mm penetration is consistently greater than that at 2.5 mm penetration, the ratio at 5 mm penetration shall be taken.

9.00.00 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 name/s 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 and stored, labelled and transported carefully to the approved laboratory for carrying out the tests. The method and procedure of testing to be followed shall be in accordance with Indian Codes or any other acceptable code of practice. The results of the tests shall be submitted to the Engineer duly signed by the laboratory-in-charge. In tests for rock cores, L/D = 1.0 of samples must be maintained.

10.00.00 REPORT ON SUB-SOIL INVESTIGATION

10.01.00 General

a) On completion of all the field and laboratory work, the contractor shall submit a formal report containing geological information of the region, procedure adopted for investigation, field observations, summarized test data, conclusion and recommendations. The report shall include detailed bore logs, subsoil sections, field test results, laboratory observations and test results both in tabular as well as graphical form, practical and theoretical considerations for the interpretation of test results, the supporting calculation for the conclusions drawn etc. Initially, the contractor shall submit two (2) copies of the report in draft form for the owner's review.

b) The contractor's qualified geotechnical engineer shall visit the owner's corporate office for a detailed discussion on the owner's comments on his draft report. During the discussions, it shall be decided as to the modifications that need to be done in the draft report. Thereafter, the contractor shall incorporate in his report the agreed modifications and after getting the amended draft report approved, four (4) copies of the detailed final report shall be submitted.

c) The detailed final report based on field observations, in-situ and laboratory tests shall encompass theoretical as well as practical considerations for foundations for different type of structures envisaged in the area under investigations. The contractor shall acquaint himself about the type of

structures, foundations loads and other information required from the Engineer.

10.02.00 **Data to be furnished**

The report shall include the enlisted items but not be limited to them.

a) Purpose and scope of investigation.

b) Authorization enabling the contractor to carry out the work at the site.

c) Project description including proposed facilities.

d) Description of the site which shall include the followings.

   i) Location of the site and existing facilities.

   ii) Topography of the site

   iii) Drainage Characteristics

e) A plot plan showing the locations and reduced levels of all field tests e.g., boreholes, trial pits, static cone penetration tests, dynamic cone penetration tests, plate load tests etc., properly drawn to scale and dimensioned with reference to the established grid lines.

f) A true cross section of all individual bore holes and trial pits with reduced levels and coordinates showing the classification and thickness of individual stratum, position of ground water table, various in-situ tests conducted and samples collected at different depths and the rock stratum, if met with.

g) A set of longitudinal and transverse profiles connecting various boreholes shall be presented in order to give a clear picture of the site, how soil/rock strata is varying vertically and horizontally.

h) Geological information

   i) Regional geology - geologic province, topographic position of site, processes of formation of subsurface materials at site.

   ii) Description of overburden and bedrock at the site (if applicable for the site)

   iii) Comments on texture and structure of rock joints, bedding planes, fissures, weathering condition etc. (if applicable for the site)

   iv) Effect of geologic features on design.

i) Borehole & trial pit logs on standard proforma showing the depths, extent of various soil strata etc.

j) Plot of SPT (N) value (both uncorrected and corrected) with depth.

k) Procedure of investigations employed - field tests and laboratory investigation.

l) Results of all laboratory tests summarized (i) for each sample as well as (ii) for each layer along with all the relevant charts, tables, graphs, figures, supporting calculations, conclusions and photographs of representative rock cores.

m) For all triaxial shear tests stress vs. strain diagrams as well as Mohr's circle envelopes shall be furnished. If back pressure is applied for saturation, the magnitude of the same shall be indicated. The value of modulus of elasticity E shall be furnished for all tests along with relevant calculations.

n) For all consolidation tests, the following curves shall be furnished:

e vs log p
e vs p and
compression vs. log t or

Compression vs. square root of t (depending upon the shape of the plot for proper determination of co-efficient of consolidation).

The point showing the initial conditions (e, P) of the soil shall be marked on the curves.

o) The procedure adopted for calculating the compression index from the field curve and settlement of soil strata shall be clearly specified. The time required for 50% and 90% primary consolidation along with secondary settlements, if significant, shall also be calculated.

p) For pressure meter tests, the following curves shall be furnished:

Field pressure meter, creep and air calibration curves indicating Po, Pf and P1.

Corrected pressure meter and creep curves indicating P'o, P'f & P'1.

q) From the pressure meter test results the value of cohesion, angle of internal friction, pressure meter modulus, shear modulus and coefficient of subgrade reaction shall be furnished along with sample calculation. Calculation for allowable bearing pressures and corresponding total settlements, for shallow foundations mentioned below and capacity calculation of piles in various modes shall also be included.

10.03.00 **Recommendations**

Recommendations shall be given area wise duly considering the type of soil, structure and foundation in the area. The recommendations shall include but not be limited to the following:

a) Type of foundations to be adopted for various structures, duly considering the sub soil characteristics, water table, total settlements permissible for structures and equipment. Minimum depth and width of foundation shall also be recommended. The provision in relevant standards/codes as indicated in clause 2.04.00 of this document shall be considered.

b) For shallow foundations, the following shall be indicated with comprehensive supporting calculations:

   i) Net safe allowable bearing pressure for isolated square and rectangular and continuous strip footings of different sizes at different founding depths below ground level considering both shear failure and settlement criteria, giving reasons for type of shear failure adopted in the calculation.

   ii) Net safe allowable bearing pressure for mat foundations at different founding depths below ground level considering both shear failure and settlement criteria.

   iii) Rate and magnitude of settlement expected of the structure.

   iv) Modulus of subgrade reaction, modulus of elasticity (E), shear modulus (G), coefficient of elastic uniform compression (Cu) and coefficient of elastic uniform shear (Ct).

c) If piling is envisaged, the following shall be indicated with comprehensive supporting calculations:

   i) Type of pile and reasons for recommending the same considering soil characteristics.

   ii) Suitable founding strata for pile.

   iii) Estimated length and diameter of pile for various values of pile capacities. End bearing and frictional resistance shall be indicated separately.

   iv) Magnitude of negative skin friction, if any, to be considered in pile design.

d) Recommendations on foundations for special structures like tanks, transformers, sub-station structures, conveyor trestles, silo/stack like structures, etc.

e) Recommendations regarding bases of roads and pavements.

10.04.00 **Additional Recommendations**

a) Co-efficient of permeability of various sub soil and rock strata based on in-situ permeability tests.

b) Cone resistance, frictional resistance, total resistance, relation between cone resistance and SPT (N) value and settlement analysis for different footing sizes based on CPT/SPT.

c) Electricity resistivity of sub-soil based on electrical resistivity tests including electrode spacing vs. cumulative resistivity curve.

d) Evaluation of design parameters for design and analysis based on dynamic parameters of soil like Amplitude vs. Frequency curves, co-efficient of elastic uniform compression and elastic uniform shear of soil, co-efficient of elastic non-uniform compression, co-efficient of elastic non-uniform shear, value of damping co-efficient, elastic and shear modulus of soil and Poisson's ratio of soils.

e) Values of co-efficient of permeability shall be included in the report.

f) Recommendations regarding method and slope of deep excavations.

g) Recommendations regarding stability of slopes, during excavations, etc.

h) If expansive soil is met with recommendation on removal or retainment of the same under the structures/roads etc. shall be given. In the latter case detailed specification of any special treatment required including specification for materials to be used, construction method, equipment to be deployed etc. shall be furnished.

i) Information of special significance like dewatering schemes etc. which may have a bearing on design and construction.

j) 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 sub-soil water.

k) Recommendation for additional investigation beyond the scope of the present work if the contractor considers it necessary.

ITEM NO.	DESCRIPTION	APPROX. QTY.	UNITS	Rate in Rupees & paise	Amount in figure to nearest whole rupee
				(In figures) (In words)	
1.	Mobilisation of boring plant, other in-situ test equipment, etc. and personnel at site and demobilisation on completion and removal from site.	1	L.S.		
2.	Making 150 mm dia. test bores in any type of soil and weathered rock including taking out undisturbed and disturbed soil samples maintaining necessary driving records of standard penetration tests at various depths in soil and weathered rock, test bores through rock requring drilling including taking out rock cores as specified, maintaining necessary drilling records and furnishing the necessary report and data in the Bore Log form in sextuplicate to the Engineer.				
	a) Upto 6.0 m depth from natural ground level in any type of soil and weathered rock	36	RM		
	b) Beyond 6.0 m upto 13.0 m depth from natural ground level in any type of soil, weathered rock and rock requiring drilling	42	RM		
	c) Beyond 13.0 m upto 20.0 m depth from natural ground level in any type of soil, weathered rock and rock requiring drilling	42	RM		

ITEM NO.	DESCRIPTION	APPROX. QTY.	UNITS	Rate in Rupees & paise	Amount in figure to nearest whole rupee
				(In figures) (In words)	
3.	Backfilling of boreholes, as directed by the Engineer using sand as filling material.	120	RM		
4.	Making open trial pits of size 3.0 m x 3.0 m upto 3.5 m depth below natural ground level and taking undisturbed / disturbed soil samples as per specification, including backfilling with excavated earth.	3	Each		
5.	Recovering water samples from sub-soil and their subsequent despatching to laboratory including providing all necessary labour, tools and tackles, all complete whatsoever required for the entire process.	3	Each		
6.	Carrying out in-situ field permeability test in bore holes and establishment of permeability coefficient by Pump Out method including installation of piezometer as per specification and direction of the Engineer.	2	Each		
7.	Carrying out Plate Load tests as per specification at a depth of 2.5 m / 3.5 m below natural ground level, extra to item no. 4 above.	3	Each		
8.	Carrying out field Vane Shear test in boreholes, taking necessary observations and furnishing reports and data as per specification	2	Each		

ITEM NO.	DESCRIPTION	APPROX. QTY.	UNITS	Rate in Rupees & paise	Amount in figure to nearest whole rupee
				(In figures) (In words)	
9.	Carrying out Static Cone Penetration tests, taking necessary observations, furnishing reports and data as per specification.	2	Each		
10.	Carrying out Dynamic Cone Penetration tests, taking necessary observations, furnishing reports and data as per specification.	2	Each		
11.	Carrying out Electrical Resistivity tests, taking necessary observations, furnishing reports and data as per specification.	3	Each		
12.	Carrying out field tests for Dynamic Properties, taking necessary observations, furnishing reports and data as per specification.	1	Each		
13.	Carrying out field tests for Determination of California Bearing Ratio, taking necessary observations, furnishing reports and data as per specification.	2	Each		
14.	Soil / Rock Sample Tests in approved laboratory				
	a) Natural moisture content	15	Each		
	b) Particle size analysis				
	i) Sieve analysis	15	Each		
	ii) Mechanical analysis (Hydrometer)	15	Each		

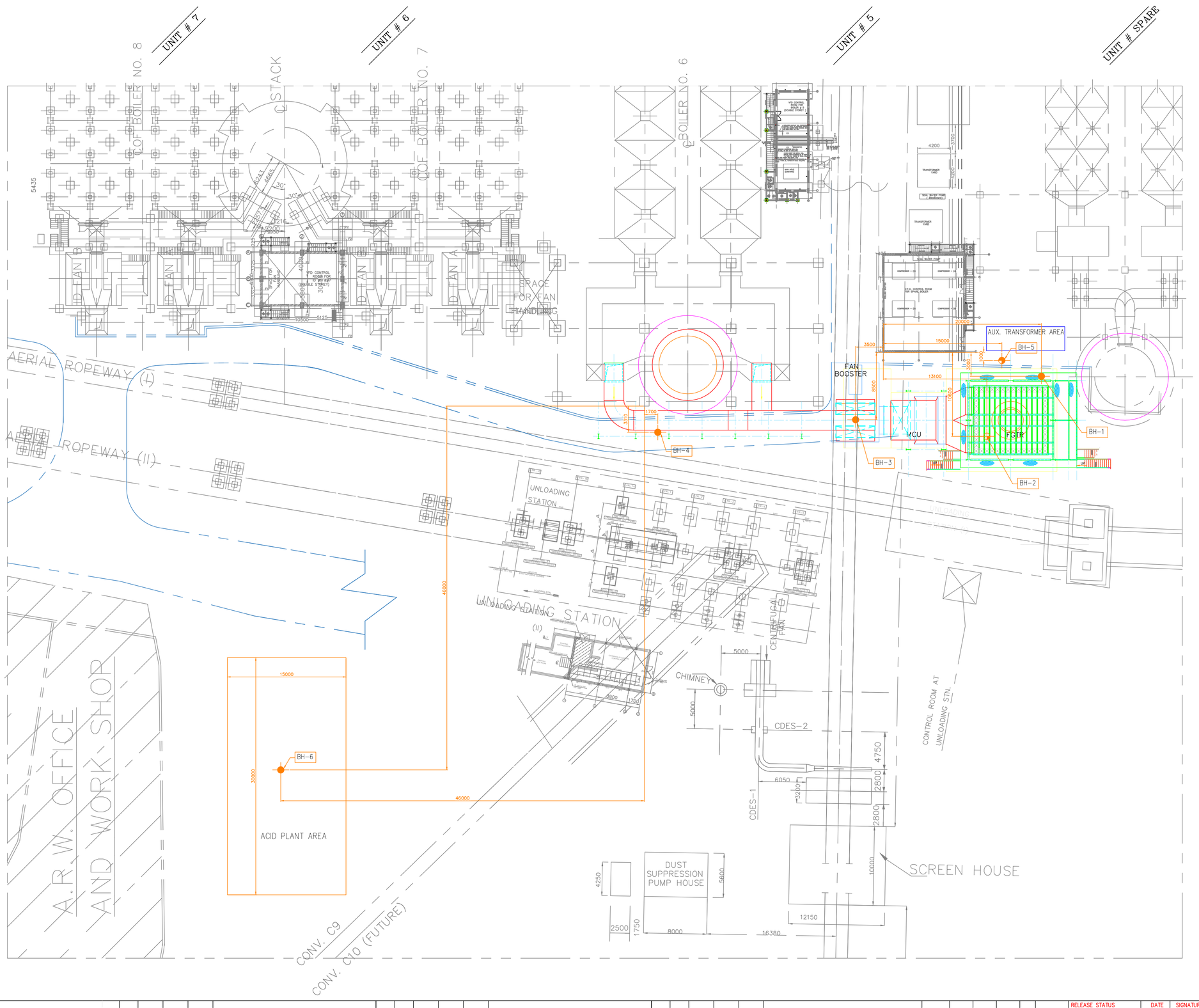
ITEM NO.	DESCRIPTION	APPROX. QTY.	UNITS	Rate in Rupees & paise	Amount in figure to nearest whole rupee
				(In figures) (In words)	
14.	Soil / Rock Sample Tests in approved laboratory (contd.)				
	c) Index properties (liquid and plastic limits, shrinkage and plasticity index)	15	Each		
	d) Bulk and dry density	15	Each		
	e) Unconfined compression test	10	Each		
	f) Shear test by Triaxial compression (if reqd.)	10	Each		
	g) Direct shear test	10	Each		
	h) Consolidation test (if required)	10	Each		
	i) Specific gravity of soil / rock	5	Each		
	j) Chemical analysis for :				
	i) Soil	3	Each		
	ii) Sub-soil water	3	Each		

ITEM NO.	DESCRIPTION	APPROX. QTY.	UNITS	Rate in Rupees & paise	Amount in figure to nearest whole rupee
				(In figures) (In words)	
15.	Preparation and submission of Detail Soil Report (preliminary and final) including recommendations, as per specification and instruction of the Engineer.	1	L.S.		

TOTAL Rs. : .....

(TOTAL RUPEES ..... AND PAISE ....ONLY)

.....
SIGNATURE OF THE TENDERER



NOTE:

1. DIMENSIONS ARE IN 'MM'
2. LEVELS ARE IN 'M'
3. EXISTING EQUIPMENT ARE SHOWN CHAIN DOTED LINE
4. FGTR SIZE CONSIDERING GMCS MODULE DIMENSION LxWxH=683x633x332

PROJECT	1x80MW COAL BASED THERMAL POWER PROJECT AT RENUSAGAR
OWNER	RENUSAGAR POWER, HINDALCO
EPC CONTRACTOR & TECHNOLOGY OWNER	W.L GORE & Associates Inc.
MANAGEMENT CONSULTANT	SalesCom Corporation
ENGINEERING & PROCUREMENT	SMARTLüth SMARTLüTH SOLUTION AND SERVICE LLP / ASTHA ENERGY SERVICES PVT. LTD. KOLKATA, WEST BENGAL- INDIA
TITLE	FLUE GAS TREATMENT SYSTEM BORE HOLES MARKING
SCALE: – 1:150	DRAWING NO.– RPD–U5/BHM/001
APPD./DT.	
CHD/DT.	
DRN./DT.	SHEET NO. REV. 2

REVISION	REV.	ZONE	BY/DT	CHD/DT	APPD/DT	DESCRIPTION
	2					ACID PLANT AREA SHOWN & BH–6 MARKED

RELEASE STATUS	DATE	SIGNATURE
PRELIMINARY		
FOR TENDER ONLY		
FOR CONSTRUCTION	****	**
REVIEWED: ARCHITECTURAL	***	**
REVIEWED: CIVIL & STRUCTURAL	***	**
REVIEWED: ELECTRICAL	***	**
REVIEWED: INSTRUMENTATION	***	**
REVIEWED: MECHANICAL	***	**

DESIGNED | DRAWN | CHECKED | APPROV. | REV. 2 | DATE 15.11.2021