TENDER SPECIFICATIONS

FOR

GEO TECHNICAL INVESTIGATIONS, TOPOGRAPHICAL SURVEY

OF

Upgradation of SRGM Repair Facility - Mumbai Unit

AT
Naval dockyard
MUMBAI

Revisions	Prepared :	Checked :	Approved :	Date :
Refer to record of revisions	AN	PUR	EC	28.02.2026

INDEX

SECTION – I: GENERAL SPECIFICATION

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1.0.0 *INTRODUCTION, LOCATION & FEATURES OF SITE*

1.1 Heavy Power Equipment Plant (HPEP), is executing an EPC contract for Upgradation of SRGM Repair Facility – at Naval dockyard Mumbai.

1.2 The proposed project site is located at Naval dockyard, Mumbai, Maharastra.

1.3 It is proposed to get soil investigation and topographical survey at the proposed site to establish various soil parameters to enable design of technological structure foundation, machine foundations, Tanks foundations, other equipment and structural foundations.

2.0.0 *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, tests for dynamic properties, electrical resistivity tests, Cross hole seismic test, laboratory tests etc. and topographical survey listed in Schedule of Items & Rates/Prices. Indicative field tests location are marked on drawing number PY-DZ-1-M278-2001-01
Trial pits shall be made to locate the extent of the existing foundation and same is to be marked on drawing to true scale.

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, relevant dynamic 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 Within 07 days of receipt of the draft final report, BHEL will provide its comments, if any

2.5.0 Preparation and submission of Final Report incorporating the comments of BHEL/HPEP in the draft report within 07 Days of receipt of BHEL comments. Five (5) copies of the final report along with the soft copy in CD (native and PDF file) of all annexure of the report (borelogs, graphs, tables, charts etc.) shall be submitted.

2.6.0 All field tests and laboratory tests shall be done in accordance with BHEL's soil investigation specifications / relevant IS codes, ND Mumbai /customer requirement if any whichever is more stringent.

3.0.0 ***Commencement of contract & periof of completion***

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. The total contract period for completion of entire work shall be 45 (Forty Five) Days from the start of erection as specified earlier

Time Schedule: The tenderer shall strictly adhere to the time schedule furnished below. Under no circumstances extension of time will be granted.

3.1.0	Commencement of work at site	:	The date of commencement of contract period shall be the mutually agreed date between the bidder and BHEL engineer to start the work
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 **25 days** from the date of commencement .
3.3.0	Completion of balance field work and laboratory tests and submission of draft report.	:	Within 30 days from the date of commencement
3.4.0	Submission of Final Report	:	Within 45 days from the date of commencement.

SECTION II : CONDITIONS OF CONTRACT

1.0.0 ***Water & Power.***
Water and electrical power shall be tapped from the nearest available sources at the ND Mumbai project site. If provision is not available It shall be the Contractor's responsibility to arrange for water and electricity required for the work and to arrange for diesel generators as required at his own cost. The quoted rates shall be inclusive of the same.

2.0.0 ***Cement and Steel***
The Contractor shall make his own arrangement for procuring cement and steel required for the work and his quoted price shall be inclusive of the same.

3.0.0 ***Execution of work***
3.1.0 Only one bench mark and one corner grid point will be furnished to the contractor. The location of bore holes and other tests, their demarcation, alignment, level etc. shall be the responsibility of the contractor and no extra payment shall be made to the contractor by BHEL on such account.

3.2.0 Dewatering the surface as well as subsoil water during execution of the work shall be carried out by the contractor at his own cost.

3.3.0 Surplus excavated earth materials and muck shall be disposed off by the contractor at his own cost and to the places as directed by the Engineer. The site shall be cleared of all bentonite slurry, muck etc. after execution of work as directed by the Engineer/Naval Dockyard. Backfilling wherever specified in the specification shall be watered, rammed and compacted.

3.4.0 The Contractor shall make his own arrangement for accommodating his personnel, equipment and materials at site and his quoted rates shall be inclusive of the same.

3.5.0 Approval & permit required from municipal authority for disposal of debris if any.
3.6.0 The bidder shall be responsible for obtaining all gate passes, permits, and necessary clearances required for material delivery and execution at the project site

4.0.0 ***Interstate permits:-***
Contractor shall be responsible for arranging all required interstate lorry permits.

5.0.0 Statutory Regulations:-
5.1.0 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.

5.0.0 NOT USED

SECTION III: TECHNICAL SPECIFICATION

1. SOIL INVESTIGATION

1.0.0 *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, structures/machines and methods of deep excavation.

2.0.0 *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 possion'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 D4428/D 4428M : Standard Test Methods for Crosshole Seismic Testing

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

3.0.0 ***FIELD INVESTIGATION***

3.1.0 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. Minimum depth of bore hole shall be 20.0 m.

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. Hammer used for driving the sampler rod shall be 65 Kg and a drop of 750 mm shall be maintained. SPT at any depth shall be terminated when the number of blows exceed 75 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.

3.2.0 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.

3.2.1 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.

3.2.2 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.

3.3.0 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.

3.4.0 STATIC CONE PENETRATION TEST:

Static cone penetration test shall be conducted to know the soil stratification and to estimate the various physical and engineering properties of soil. The cone penetrometer shall be advanced by pushing and the static force required for unit penetration shall be determined. The test shall be conducted using a 200kN capacity mechanically operated equipment upto the specified depth or refusal whichever is earlier. For this test, 'refusal' means meeting very hard strata which cannot be penetrated at the rate of at least 0.3cm/sec even when the equipment is loaded to its full capacity. The specification for the equipment and accessories required for performing the test, test procedure, field observation and reporting of results shall conform to IS : 4968, Part-III. At the ground level, preboring upto 0.5m depth shall be permitted if the overlying strata is very hard. No extra payment shall be made on account of this preboring. Continuous record of the penetration resistance shall be maintained.

3.5.0 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.

3.6.0 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.

3.7.0 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.

3.8.0 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.

3.9.0 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 15 m if weathered rock or hard rock is encountered in lower depth. 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.

3.10.0 TESTS FOR DYNAMIC PROPERTIES:

For evaluation of in situ dynamic and damping properties of soils, block vibration test/ Cross hole survey and cyclic plate load 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 indicated in drawings and/or at such location as directed by the Engineer.

The tests shall be carried out as described in IS:5249 and/or IS:1888. 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 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 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 embedments of foundation bolts etc. and back filling after the test.

3.10.1 BLOCK VIBRATION TEST:

Test pits of size 4.50m X 2.75m at the bottom and depth 2.50m shall have to be made. Then at the bottom of the pit a plain cement concrete block of grade M-20 and of size
1.50 X 0.75m X 0.70m shall be constructed. Suitable foundation bolts shall be embedded in the concrete block during casting for fixing the oscillator assembly. The concrete block shall be cured for a minimum of fifteen (15) days and then the following block forced/free vibration tests shall be carried out as per the recommendations of IS: 5249.

a. Vertical Vibration Test
b. Horizontal Vibration Test

3.10.2 CYCLIC PLATE LOAD TEST:

The test shall be carried out in a manner as to give a dependable assessment of load-deformation characteristics within the soil mass.

The provisions of IS:1888 shall be followed for conducting the test. The testing procedure shall be as per IS:5249. The application of load may be by gravity or by reaction as detailed out in the above standard. The test shall be conducted at a depth of 2.50m below existing ground level.

The Contractor must get the dial gauges and pressure gauges calibrated by an approved testing laboratory before commencing the test at site and produce the certificates 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.

The Contractor shall provide a layer of cement-sand mortar (1:1 mix) below the bearing plate to level-off any uneven parts and interstices on the rock surfaces. Also to achieve a uniform distribution of pressure over the loaded surface, the Contractor shall provide a flexible layer in the form of rubber pad over the loaded surface.

For conducting the load test, the Contractor shall apply cyclic loading and unloading, with five to six cycles, increasing in successive increments of 16% to 20% of full load. While releasing the loads the rebounds to be observed in a similar manner as the settlement observations. The range of cyclic loading shall be decided only after the static net bearing capacity is established by conventional plate load tests.

3.10.3 CROSS HOLE SEISMIC TEST:

Cross Hole Seismic test should be performed following the procedures and guidelines outlined in IS13372/ASTM D4428 M-84. In general, this test is carried out using three boreholes to measure wave propagation velocities along horizontal paths. One hole contains an impulse energy source called Source borehole and other two holes are Receiver holes. Generally, all the three boreholes should be aligned with 3.0 m spacing center-to-center on the ground surface. If S wave velocities exceed 450 m/s (often in alluvial materials), borehole spacing may be extended to 4.5 m. A borehole deviation survey must be performed to determine the horizontal distances between borings accurately. The holes must be drilled down to a depth of 25m at all borehole locations. The boreholes shall preferably be uncased. The receivers shall be in perfect contact with the side wall of the hole. Uncased holes should be kept filled with water or drilling mud in order to ensure perfect contact between the borehole wall and the geophone. In case of cased hole preferably a low velocity material such as a high impact PVC should be used for casing and it is essential that it should be well grouted behind in order to make an intimate contact with the soil. The charge shall be installed within the depth as specified and the waves shall be picked up from the geophones installed at required depths in receiver boreholes. Knowing the travel time from shot hole to receiver hole and corresponding distance, the velocity of the waves is determined which enables to estimate dynamic elastic modulus, shear modulus and Poisson's ratio. These values are to be recorded at 2m, 4m, 6m, 8, 10m, 12m, 15m depth. However, at least one reading shall be taken in each stratum.

The report should include Comparison and co-relation of the plots of P and S wave velocity vs depth; dynamic shear modulus vs depth; young's modulus vs depth and bulk modulus vs depth.

4.0.0 ***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.

4.1.0 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.

4.2.0 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.

4.3.0 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.

4.4.0 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 back up pressure applied shall be indicated in the report.

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

4.5.0 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.

4.6.0 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 & %
d.

4.7.0 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.

4.8.0 CYCLIC TRIAXIAL TEST:

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

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

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

h. 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.

i. 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.

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

k. Evaluation of dynamic parameters of soil based on Cross hole seismic test for design analysis based on tests for dynamic properties of soil like amplitude Vs, frequency curves, coefficient of elastic uniform compression (Cz), coefficient of elastic uniform shear of soil (Cφ), coefficient of elastic non-uniform compression (Cɵ), coefficient of elastic non-uniform shear (Cψ), value of damping coefficient (c), dynamic elastic and shear modules of soil and poisson's ratio of soils.

l. 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.

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

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

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

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

q. 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.

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

s. Founding depths for various foundations 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 III: TECHNICAL SPECIFICATION

2. TOPOGRAPHICAL SURVEY

TOPOGRAPHY SURVEY

CONTRACTOR shall carry out Topographical / Contour survey for proposed area. CONTRACTOR shall clear the site from all the debris lying on the site to facilitate topo survey. During bidding stage, CONTRACTOR shall visit the site and study the existing site conditions & existing structure / pit if any.

SECTION III: TECHNICAL SPECIFICATION

4. GENERAL NOTES

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.

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.

9. On completion of work, all the temporary buildings, structures, pipe lines, cables etc. shall be dismantled and leveled and debris shall be removed as per instructions of BHEL by the contractor at his cost. In the event of his failure to do so, the expenditure towards clearance of the same will be recovered from the contractor. The decision of BHEL Engineer in this regard is final.

NOTES

1. Details of items shall be read in conjunction with the corresponding specifications, drawings and other tender terms.

2. The tenderer shall quote for finished items and shall provide for all necessary power, fuel, tool and plant, tackle, materials, field and laboratory test equipment, transport of materials labour, supervision and maintenance till handing over, repairs, rectification etc. as per tender terms.

3. Quantities mentioned in the schedule of items depend upon the type of soil actually met with during execution and may vary to any extent. The quantities are indicated merely for the purpose of quoting rates. Payment shall be based on actual work done both in the field and laboratory. The contractor shall carry out all the works up to variation of 30% of the total contract value and all tendered rates shall remained firm within this limit.

4. Every page of schedule of items and rates/ prices, shall be signed by the contractor.

5. Refer Annexure-I for Geotechnical test, Topographical survey & any other test if any Bill of Quantities

RECORD OF REVISIONS

Rev. No.	Date	Revision Details	Revised By	Approved By
Rev 00	28.02.26	First Issue	First Issue	First Issue

Revisions	Prepared :	Checked :	Approved :	Date :
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