

Section-IX B

FOR GROUND IMPROVEMENT USING VIBRO STONE COLUMNS

Revision History

| Revision No. | Date | Clause Ref | Remarks |
|---------------------|-----------------|-------------------|----------------------|
| Rev-0 | Dec-2023 | | First Release |

1. INTRODUCTION

- 1.1 Due to liquefaction condition of soil, ground improvement using vibro stone columns is to be carried out to support the transmission line tower foundations . Ground improvement shall be done up to most significant compressible strata that contribute to the settlement of the foundation/ liquefiable stratum. Ground improvement shall be carried out for transmission line tower foundations with Vibro stone column (using bottom feed method) up to required design depth strictly as per relevant IS codes & standards and as per approved construction drawings.
- 1.2 It is the intent of this specification to describe primary features, materials, and design requirements and to establish minimum standards for the work. The specification is not intended to specify the complete details of various practices of manufactures/ contractor, but to specify the requirements with regard to performance, durability, and satisfactory operation under the specified site conditions.
- 1.3 The work to be done under this specification shall include all labour, plant, equipment, material, and performance of all work necessary for the complete installation and commissioning of the subject work. All apparatus, appliances, material, and labour etc. not specifically mentioned or included, but are necessary to complete the entire work or any portion of the work in compliance with the requirements implied in this specification is deemed to be included in the scope of contractor.
- 1.4 Bidders are advised to visit the transmission line route to acquaint themselves with terrain conditions and associated details.
- 1.5 Before proceeding with the construction work, the contractor shall fully familiarize themselves with the site conditions and general arrangements etc. Though the Employer shall endeavour to provide the information, it shall not be binding for the Employer to provide the same. The contractor shall be fully responsible for providing all equipment, materials, system, and services specified or otherwise which are required to complete the construction and successful installation of stone columns for transmission line tower foundation along transmission line route in all respects.

2. SCOPE OF WORK

The scope of work shall include but not limited to the following.

- a) Submission, and approval of documents like Method statements, Quality documents like field quality plan for Ground improvement, etc. all in complete.
- b) Supply and installation of Ground improvement works using vibro stone columns using bottom feed method as per approved construction drawings.
- c) Excavation of suitable depth and size for laying granular material blanket.
- d) Providing and laying of granular material blanket by using clean medium to coarse sand, over the top of the stone column at cutoff level as per approved drawing.

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- e) The work includes all machineries, materials, tools, plant, labour, transportation, setting up of columns, installations of columns, real time monitoring of depth and compaction effort for every column, preparation of records as per relevant standards, submission, and preparation of as built drawings etc.
- f) Conducting initial single column load tests & initial three column group load tests as per IS 15284 Part1-2003 (Reaffirmed 2018) at the field trial area at the locations specified by POWERGRID and submission of test reports.
- g) Conducting routine single column & group column load tests on the working vibro stone columns as per IS 15284 Part1-2003 (Reaffirmed 2018) and submission of test reports.
- h) Conducting post improvement borehole test at the location specified by POWERGRID upto the treatment depth or refusal whichever is earlier.
- i) Conducting pre and post Electric Cone Penetration test as per approved drawing and layout upto the treatment depth or refusal, whichever is earlier.

3. APPLICABLE CODES AND DOCUMENTS

All works shall be according to specifications, latest relevant codes as specified elsewhere in this tender document.

All applicable documents including standards, codes, rules, laws, regulations of regulatory bodies referred shall be of latest issue or edition and shall be considered as part of this specification, except as may otherwise be stated. The following specifications, standards and codes are referred to in this part:

| | |
|---------------------------------------|---|
| IS: 3764 | Safety code for Excavation Work. |
| IS: 2720 (Relevant parts) | Code of practice for Testing of soil |
| IS: 1892 | Code of practice for Subsurface Investigation for foundations |
| IS: 383: 2016 | Specification for coarse and fine aggregates from Natural Sources. |
| IS 15284 Part1-2003 (Reaffirmed 2018) | Design and construction for ground improvement – Guidelines: - Part 1 Stone Columns |
| IS: 1893 | Criteria for Earthquake Resistant Design of Structures |
| IS: 6403 | Code of Practice for Determination of Bearing capacity of shallow foundations. |
| IS: 8009 | Code of practice for calculation of settlements of foundations |

4. TENTATIVE DESIGN SCHEME

| Sl | Description | Design Scheme |
|----|--------------------------------|---------------------------------------|
| 1 | Diameter of vibro stone column | Minimum finished dia 800mm |
| 2 | Spacing & pattern | 2m c/c equilateral triangular pattern |
| 3 | Depth of treatment | Up to 18m depth from cut-off level) |

| | | |
|---|---------------|---|
| 4 | Cut-off level | Approx. 2m-4m below GL depending on the structure |
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5. GROUND IMPROVEMENT USING VIBRO STONE COLUMNS

5.1 General

The ground improvement techniques should be carried out for liquefaction mitigation, to limit post construction long term settlements and to enhance bearing capacity of the subsoil. The work shall include installation as per the latest codal practice and using soil parameters indicated in the soil investigation report.

Contractor shall also submit detailed construction methodology of installation of ground improvement works for approval of the Employer. Suggestions, if any, made by the Employer on the construction methods shall also be implemented by the Contractor.

5.2 Vibro Stone Columns

Vibro stone columns shall be installed using bottom feed method. The granular fill shall be compacted by suitable means to create a compacted column.

The average consumption of stone backfill should be more than the theoretical volume of the column (calculated based on the column diameter & depth specified) plus additional volume due to compaction effort and losses during installation. The rate of stone consumption shall be assessed by averaging the material used in 9 adjacent columns. The consumption check shall be done by stack measurement. Stone stacking shall be done at demarcated locations prior to the start of works on site and material shall be used from nearby stacks.

Significant variations in the quantity of stone used in forming vibro stone columns of the same length & diameter shall be reported immediately to the Engineer in charge.

A detailed method statement should be submitted by contractor to Employer for its approval prior to the start of works. The ground improvement installation works shall be monitored using automated real time monitoring system.

5.3 Sand blanket

A coarse sand pad of around 0.5 m thick covering entire area of stone columns needs to be provided above the cut-off level of stone columns for proper drainage in tower foundations. The blanket material should be laid after ensuring complete removal of slush deposited during boring/charging operations etc. The granular blanket shall be compacted in each layer of 150mm to 250mm thickness by suitable means such as rolling or tamping to densify the layer.

6. EQUIPMENTS

The contractor shall supply equipment in good condition capable of carrying out the work described in this specification. The deep electrical or hydraulic vibrator used to construct vibro stone columns shall be sufficiently powerful to ensure the depth indicated in the drawings shall

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be reached with adequate compaction of the stones. The vibrator shall not be removed from the ground during column construction in order to maintain stability of the sides and to ensure that the stone reach the required depth. Further, the contractor shall have to deploy the machines adequately for installation of stone columns with bottom feed / dry feed technique as per requirement but not less than two numbers for each package.

Critical control parameters (depth, compaction effort, time, probe details) during the ground improvement works shall be monitored and recorded using computerized automatic (real-time) monitoring systems.

In case if stiff / hard layer is encountered within the design treatment depth, predrilling can be used to penetrate till treatment depth.

Working platform, if required, shall be prepared, and maintained in a manner suitable for the safe movement and working of the machinery without hindrance to other works.

7. TOLERANCES

7.1 Setting out

Contractor should construct and maintain Temporary Benchmarks (TBM) inside the site throughout the construction period as required and as directed by the Engineer in charge. The MSL from the nearby permanent benchmarks should be transferred to the TBM and the levels of the TBM shall be rechecked periodically as directed by the Engineer in charge.

Setting out shall be carried out from reference lines and points shown in the drawings. The Contractor shall provide and maintain benchmarks at the area throughout the duration of works. Immediately before installation, the ground improvement point positions shall be marked with suitable identifiable pegs and markers.

7.2 Depth and spacing

The depth and spacing of the ground improvement points shall be as shown in the approved drawings and neither the depth nor the spacing shall be varied without prior agreement with the Engineer in charge. Any variations in depth of treatment due to site conditions not anticipated in the design shall be reported immediately to the Engineer in charge for information and any further action.

7.3 Position

The column shall be positioned at the designed locations below the foundations for various structures as per the approved layout. The maximum permissible deviation from the centre point shown on the ground treatment layout drawing shall be 150 mm in any direction.

8. MATERIALS

8.1 General

All materials to be used shall conform to the specification as described hereunder and shall be subject to approval of Engineer in charge prior to use. The materials for ground improvement

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works shall be obtained from approved source / quarry. Required wastage for compaction and handling of all materials shall be considered by the contractor.

8.2 Aggregate for Stone Columns works

The vibro stone columns shall be filled with crushed stone aggregates at the designed spacing and up to designed depths. The aggregates and source of aggregates shall be approved by the Engineer in charge.

Aggregate used in the vibro stone columns shall be quarry crushed rock, clean, durable, angular, hard, inert material and resistant to breakage. Materials likely to degrade or significantly weaken when saturated in situ shall be rejected for use in vibro stone column construction. The material shall be suitable for the ground conditions in which vibro stone columns are formed and have no adverse effects on other works on the site. The material selected to form the stone columns shall be able to withstand the impact forces of the vibrating nozzle and retain long term integrity under the applied foundation loads. It shall not excessively crush or break down during compaction or under long term static loads applied in service.

40mm downgraded stones shall be used as a filling material in stone columns as the Gradation Table given in Field Quality Plan. Filling material shall be free from any harmful ingredients (i.e., vegetable matters, clay lumps, cobbles, and boulders)

The materials shall be graded appropriately for compaction to form a dense column fully interlocked with the surrounding ground and in compliance with other requirements such as drainage. The materials shall also be compatible with the plant used for construction and shall flow freely within bottom feed delivery systems without arching which may block these systems.

The gradation of aggregate used in construction of vibro stone column shall conform to size as indicated above or as approved by the Engineer in charge. Prior to the commencement of vibro stone column installation, the Contractor shall submit to the Engineer in charge, test reports of the materials to be used for the work determining gradation, specific gravity, loose and compacted density, aggregate crushing value, aggregate impact value, etc. The same test shall be repeated at regular intervals or whenever there is a change in the source of supply of the material.

Contractor shall at all times maintain at the site of work such quantities of aggregates as are considered by the Engineer in charge to be sufficient to ensure continuity of work.

8.3 Sand blanket

Sand/ fine aggregate of Zone-I, Zone-II and Zone-III as per IS 383 shall be used for sand blanketing.

9. GROUND HEAVE

Contractor shall monitor the existing ground surface for any possible heave during construction of stone columns with suitable reference points. In order to reduce ground heave, excessive treatment in the final stage of the column formation shall be avoided. If ground heave occurs, then the spoil so formed shall be removed from the working area by the Contractor.

10. PERSONNEL

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The Contractor shall only employ personnel experienced in similar type of work for the construction of vibro stone columns. The personnel operating the machine should be experienced enough to be able to quickly identify the situations and able to take corrective action for the smooth operation and maintain safety.

11. WORKMANSHIP

The Contractor shall inform the type and number of rigs to be used for the work and shall satisfy the Engineer in charge regarding the suitability, efficiency, and adequacy of the equipment to be employed. On completion of each area of ground treatment the Contractor shall grade debris and surplus materials arising from the ground treatment to leave a reasonable firm and level working surface at no extra cost.

The Contractor shall inform the Engineer in charge, at regular mutually agreed intervals, of the forward program of ground treatment.

The Contractor shall submit to the Engineer in charge on the first day of each week, or at such longer periods as the Engineer in charge may from time to time direct, a progress report showing the current rate of progress and progress during the previous period on all important items of each section of the works.

On completion of the ground treatment works to the satisfaction of the Engineer in charge, the Contractor shall remove all plants and unwanted material from the site.

12. DETAILS OF TESTING (LOAD TESTS)

12.1 General

The bearing capacity and settlement of the treated ground shall be established by conducting field plate load test according to IS: 15284 (Part 1). The field loading tests to evaluate the behaviour of soil post improvement and load application pattern shall be carried out as indicated in IS: 15284 (Part 1).

Safety precautions during the test shall comply with all safety / statutory requirements.

12.2 Initial Load Tests

The initial load tests should be performed at a trial test site to evaluate the load settlement behaviour of the soil-stone column system. The tests should be conducted on a single and on a group of minimum three columns.

For initial load tests in order to simulate the field conditions of compaction of the intervening soil, a minimum of seven columns for a single column test and twelve columns for three column group tests shall be constructed in a triangular pattern at the location specified by Employer before commencement of main work. The load test shall be conducted for design loading intensity of 15 T/sqm.

The initial and final soil conditions at the trial site should be investigated by drilling at least one borehole and one static cone test pressure meter test/ dynamic cone test prior and subsequent to the installation of columns as per IS:15284 Part-1. Since, borehole test prior to the installation of columns is already conducted by Employer, test reports shall be provided to the successful bidder during detailed engineering. Post-improvement borehole test shall be in Rev -0 (Dec-2023)

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the scope of contractor. All these tests including the standard penetration test and collection of undisturbed/disturbed samples and laboratory testing on the samples should be as per relevant Indian Standards.

12.3 Routine Load Tests

The routine load tests shall be performed on working columns as per IS 15284: Part-1. The test column & testing frequency shall be decided by POWERGRID.

12.4 Testing Equipment

The Contractor shall ensure that when the hydraulic jack and load measuring device are mounted, the whole system will be stable up to the maximum load to be applied during the testing. The hydraulic jack, pump, hoses, pipes, couplings, and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum pressure without leaking.

12.5 Preliminary Tests

The ground treatment for the area for preliminary test loading shall be carried out in a manner similar to that proposed for the working area and using similar equipment and materials.

Full details shall be submitted to the Engineer in charge prior to any work relating to the testing process being carried out at the site.

12.6 Loading System

The equipment used for applying load shall consist of one or more hydraulic rams or jacks. The total capacity of the jacks shall be arranged in conjunction with the reaction system to deliver an axial load to the area. The complete system shall be capable of transferring the maximum load required for the test.

12.7 Measurement of load

The load shall be measured by a load measuring device (e.g., load cell) and by a calibrated pressure gauge included in the hydraulic system. Readings of both the load measuring device and the pressure gauge shall be recorded. Care must be taken to avoid any risk of buckling. Load measuring devices and jacks shall be arranged to ensure that axial load is maintained throughout the test.

The load measuring device shall be calibrated before and after each series of tests, whenever adjustments are made to the device or at maximum intervals of six months. The pressure gauge and hydraulic jack shall be calibrated together. Certificates of calibration shall be supplied to the Engineer in charge before start of the work.

12.8 Settlement Recording

The movement of the plate / slab shall be measured by not less than four deflection gauges positioned symmetrically around the plate / slab. Sensitivity of each gauge shall be less than or equal to 0.02 mm and fixed diametrically opposite ends of the footing and shall be mounted on a reference frame which will not be affected by the movement of the ground due to weather, kentledge, application of test load, movement of site traffic or other such causes.

12.9 Supervision

During the progress of a test the testing equipment and all records of the test shall be available for inspection by the Engineer in charge.

12.10 Acceptance criteria

The load should be accepted only if it meets the settlement criteria as mentioned in IS 15284 Part1-2003 (Reaffirmed 2018)

12.11 Completion of a test

Detailed reports for all tests shall be compiled and submitted to Engineer in charge for information and records.

Excavations to foundation level shall be carefully backfilled and compacted with suitable materials up to the general level of the site.

13. QUALITY CONTROL SYSTEMS

A comprehensive quality control system shall be implemented to ensure a high standard of work. The system shall include schematic online recording of each ground improvement point construction parameters and post construction testing. During the construction essential parameters are monitored using computerized recording systems, online (real time) recording of essential parameters (time, depth, energy, etc) during column formation process.

A site laboratory shall be set up by the contractor for the periodic testing of the following parameters for material.

- i. Grading for stone
- ii. Crushing value
- iii. Flakiness index
- iv. Abrasion value
- v. Impact value, etc
- vi. Organic content & silt content for sand.

14. DOCUMENTATION & RECORD SUBMISSION

The as built drawings and records shall be submitted to Engineer-in-charge in soft and hard copies and shall include the following minimum information but not limited to below documents:

- a) Particular directives which are relevant to subsequent use of the treated ground.
- b) The source, type and quality of materials used for ground improvement works.
- c) Quality control plan and inspection test plan (ITP).
- d) Ground improvement records (includes power consumption, depth of penetration, method of treatment, presence of heave, date-time, obstruction/delays, any unforeseen conditions encountered, etc.)

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- e) Initial & Routine load test reports
- f) Any other document.

15. SCHEDULE OF QUANTITIES

The requirements are indicated in Bid Price Schedules (BPS).

The civil works for which quantities has been given in the BPS shall be payable on unit rate basis. During actual execution, any variation in such quantities shall be paid based on the unit rate under each item incorporated in Letter of Award (LOA). Wherever the quantities of items/works are indicated in EA/Nos./LS, the contractor is required to estimate the quantity required for entire execution and completion of works and incorporate their price in respective Bid price schedules. Further, items such as mobilization of machines/ manpower, preparation of approach (if required) are deemed to be included in the quoted rate and nothing shall be paid on account of these items.

Contractor should include all such items in the bid proposal sheets, which are not specifically mentioned but are essential for the execution of the contract. Item which explicitly may not appear in various schedules and required for successful commissioning of ground improvement works using vibro stone columns shall be included in the bid price and shall be provided at no extra cost to Employer.

- 16. Mode of Measurement for stone columns-**The contractor may carry out the required bores of suitable diameter for stone columns starting from ground level upto termination depth and alternatively from cut-off level to termination depth by carrying out excavation up to cut-off level. In either of the execution methods, payment shall be made corresponding to the length of boring as per measurement from cut-off level to termination depth restricted to the length mentioned in the drawing.