

4 TECHNICAL

4.1 Description of the ground improvement technique

Vibro Stone Columns are formed by inserting a vibroprobe into the soils to compact and incorporate granular material into the ground and create vertical inclusions with high stiffness, shear strength and drainage characteristics.

Under uniformly loaded structures such as embankments and slabs-on-grade, Vibro Stone Columns are installed on a regular grid spacing. Treatment by Vibro Stone Columns results in a reduction of the total and differential settlements.

Vibro Stone Columns can also be installed as a group to support isolated loads (shallow pads) or directly under linear loadings such as strip footing or retaining walls. In this case, Vibro Stone Columns increase the bearing capacity of the soil while reducing the magnitude of settlement.

4.2 Method of Execution

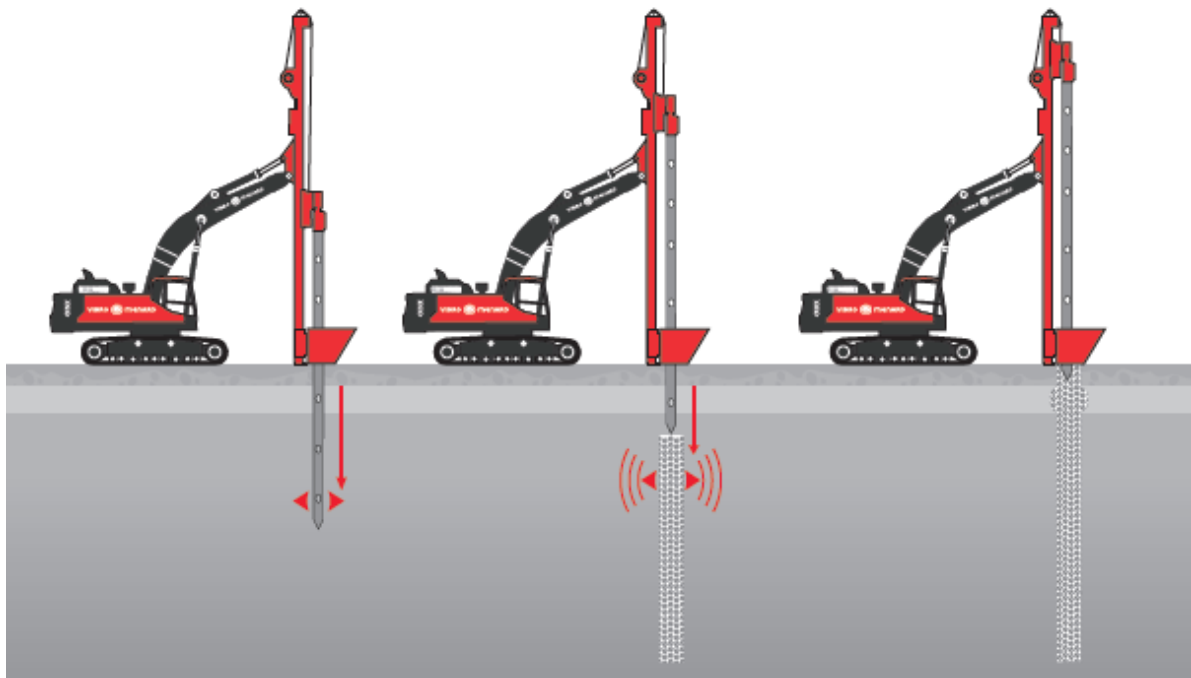


Figure 2 - VSC installation process

The soil is penetrated to the required depth by the combined effects of Vibroprobe weight and vibration (plus jetting action by air if free hanging). The in-situ soil is displaced sideways.

The vibroprobe is then lifted out. Coarse gravel, crushed stone or slag is tipped into the hole in increments of typically 500mm of the column bore. The vibroprobe is re-inserted and the stone infill is compacted under the weight and vibration of the vibroprobe. Radial forces produced by the vibroprobe force the stone infill material horizontally out against the in-situ soil.

When the required degree of compaction has been reached, the vibroprobe is again removed. The filling / compacting cycle is repeated step by step up to the working platform level. Thus, a continuous column of dense granular material interlocking with the surrounding ground is formed through the treatment zone.

The diameter of the vibro stone column constructed is typically between 300-600 mm and is subject to the properties of the surrounding soil: in softer soils, the compaction process results in higher lateral expansion of the columns. Over the length of the entire column, variable diameter could thus be created due to variable layers with different soil conditions.



Figure 3 – VSC rig on site

4.3 Adaptation to the project

4.3.1 Ground improvement principle

The foreseen ground improvement system involves the installation of vertical Vibro Stone Columns beneath the foundations and ground bearing slab in order to create a composite material [Soil+VSC] and therefore increase the bearing capacity of the soil and reduce long term settlements to within acceptable limits.

4.3.2 Characteristics of the Vibro Stone Columns solution

- a) Our tender is based on our **working platform level being approximately equal to 300 mm below the Final Floor Levels, i.e. around +15.2 mAOD. Please advise us of any changes to the levels as this will impact our quotation.**
- b) The anticipated depth of treatment below our working level will vary from 2 to 3 mbgl. Depths may vary according to the ground conditions encountered on site. *It may happen that for shallow VSC, during the excavation of the foundations, the totality of the VSC is as well excavated, in such case the foundation can be installed directly on the soil as the refusal of our equipment means that the bearing capacity of the soil is sufficient.*
- c) Pads and strip footings:
 - The new structures must be supported on reinforced concrete pad and strip footings founded at a minimum of 0.6 m beneath the level from which the ground improvement is undertaken.
 - VSC will be positioned either singly or in groups beneath pads and at a maximum of 2.5 m centres beneath strip footings.
 - The number of VSC will be determined upon reception of shallow foundation drawings indicating the loads. *The current proposal is based on the foundation drawing [5], considering a bearing pressure of 120 kPa as indicated in [8].*
 - An increased SLS bearing capacity of **175 kPa** will be achieved beneath the footings.
- d) Ground Bearing Slabs:
 - VSC will be positioned on a grid of maximum 9 m² per VSC depending on the load.
 - The uniformly distributed load applied on the slab is **50 kPa**, in accordance with the loading plan [7].
 - The ground floor slab must be founded on a layer of well compacted hard-core of at least 300mm in thickness (the working platform could be used for this slab subbase after proper regrading and re-compaction).
- e) Prior to construction of floor slabs or pavement areas the formation must be regraded and mechanically compacted by vibratory roller.
- f) Long term residual settlements under the exploitation loads will be limited to 25 mm with relative differential settlements not exceeding 1/500.
- g) The working area should be prepared to the working levels detailed in 4.3.2 (a), including the working platform. Please advise us as to any change in this assumed level so that we can amend our tender accordingly. The working platform should extend at least 2.0 m horizontally beyond the perimeter of the building and have a slope not greater than 1 in 2.
- h) When treating predominantly granular soils there may be no or only small amounts of our imported backfill evident at depths of over 1.0 m. This results from the loose granular in-situ soil falling down the bore as the Vibroprobe is withdrawn and acting in place of our aggregate. This is not detrimental to the performance of the ground improvement.

5 TESTING

We propose to check the quality of our work by Plate Loading Tests as described below. We have included for **1 plate load test per 150 VSC** on this project.

- The Plate Loading Test comprises a 0.6 m diameter plate which is positioned centrally over a Vibro Stone Column on a layer of sand at a depth of approximately 0.6m below working surface. The load is applied centrally to the plate by a calibrated hydraulic jack.
- The plate is carefully bedded onto the Vibro Stone Column point by means of a small pre-load of 2.0 tonnes which is immediately released. The stage loading will then be applied in 2.0 tonnes increments up to 3 times the particular design bearing pressure calculated over the area of the plate or to a maximum of 11.0 tonnes whichever is the least.
- Deflections of the plate will be measured by dial gauges supported independently and remote from the test area. Unloading is carried out in a single stage and recovery recorded. The total duration of each test will not exceed 1 hour.

As an option, we could also offer to undertake dummy foundation tests as described below.

- Our dummy foundation test consists of a rigid fabricated steel plate whose dimensions of 1.5 m x 0.6 m which will be laid on a thin layer of sand in a carefully prepared trench approximately 600 mm below the level from which treatment was undertaken.
- This plate will be bedded onto the ground by means of small pre-load of 20 kN which is immediately released.
- The loading is applied centrally to the plate by a calibrated hydraulic jack using our rig as Kentledge.
- Reference beams carrying 4 dial gauges will be supported by stakes driven into the ground.
- The loadings will be applied in 5 equal increments at a rate of 2.25 tonnes per 15 minutes to a maximum load of 150 kN/m² calculated over the actual area of the plate (i.e. 135 kN). The final test load is to be held overnight.
- At the end of the test unloading will be carried out in a single stage and the recovery of the plate will be measured.
- The reading on the dial gauges will be recorded at suitable intervals to enable graphs to be drawn giving the results of settlement against load.

In cohesive soils relatively high settlements of the plate may be recorded due to temporary increase in pore water pressure. Also, tests are not usually undertaken between Vibro Stone Columns. The results of tests in clay soils cannot be used as failure criteria for our work.

Dummy footing tests will require some out of hours work to allow the application of increments up to final hold out of productive hours. This can typically require 3 hours outside of the standard hours of work, all necessary attendances to allow us to undertake this should be made.

6 MONITORING AND RECORDING

- A layout drawing showing the location of each Vibro Stone Column will be produced by Vibro Menard Limited. The work done will be recorded by a log of each VSC showing the VSC reference number, penetration length and a note of any unusual circumstances encountered during the compaction. This log will be recorded on our standard Daily Record Sheet. As a matter of record of the chargeable work carried out, we require this form to be attested daily as a true record of work carried out by the Client and Vibro Menard.
- Where requested, 'as-built' records and drawings can be provided. No retention of monies is to be made against the agreed and certified final application for payment.
- All work will be measured and valued in accordance with the agreed Daily Record Sheets at rates given in the Bill of Quantities and/or Schedule of Rates.

7 WORKS PHASING

- a) Removal of topsoil layer and removal of any existing foundation, services and slabs, cut/fill works + testing (*Main Contractor*),
- b) Installation of a granular or part lime stabilised working platform and testing to support our equipment (*Main Contractor*),
- c) Execution of Vibro Stone Columns by *Vibro Menard Ltd*,
- d) Re-grading and re-compaction of the working platform (*Main Contractor*),
- e) Installation of the hard-core layer below the slab (*Main Contractor*),
- f) Construction of the structures (*Main Contractor*).

8 POST TREATMENT WORKS

- Some surface disturbance may result from our treatment and in some cohesive soils there may be surface heave. Others are to make final adjustments to level as may be necessary and remove surplus materials at no cost to us, including any excess infill stone.
- All excavations by others following treatment will be executed in a manner which will not loosen or disturb treated ground below the proposed foundations. Care should be taken whilst laying adjacent services and when excavating below the water table in fine grained cohesionless soils where 'running sand' conditions may exist.
- Where excavations for footings of the new structures expose obstructions such as cellars or old foundations these must be cut down 1.0m below proposed founding level. Excavations so formed shall be made good to formation level with granular material compacted in the trench by the Main Contractor. This avoids the possibility of the new foundations resting on local hard points.

9 OBSTRUCTIONS

- Occasionally an obstruction may prevent or significantly slow down penetration of the vibroprobe causing a “refusal” which has the potential to cause damage to our equipment.
- In these circumstances we will attempt to install a Vibro Stone Column again at a point a short distance away from the intended position introducing additional VSC where necessary to bridge the obstructions.
- Large obstructions which cannot be dealt with in accordance with the preceding paragraph will require excavation and removal and subsequent loose backfilling with suitable granular material and re-compaction at no cost to us.
- Any refusals and additional VSC required under items above will be charged at the rates given in the attached Bill of Quantities.

10 ADJACENT STRUCTURES AND SERVICES

- At the time of the Vibro Stone Column work is carried out there will be no existing structure or underground service within 5.0 m of any of our VSC positions.
- Where our works are required close to an existing building or feature, others are to ensure that the structure is of a good condition and will not be affected by our operations. We are unable to accept any liability for any such damage.