Case Study: Ground Improvement Using Stone Columns and PVD

Eldho, C.A.  
U.G Student  
e-mail: eldhoca1990@gmail.com

Jose, Ansel  
U.G Student  
e-mail: anseljosep@gmail.com

Balamurugan, V.  
U.G Student  
e-mail: enviru_bala46@yahoo.in

Parackal, Paul James  
U.G Student  
e-mail: jpppaul90@gmail.com

Priya, K.L.  
Assistant Professor

Civil Department, Karunya University, Coimbatore

ABSTRACT

An International Container Transhipment Terminal is being developed at Vallarpadam Island by the Cochin Port. This terminal has to be connected to the main land (NH-47 & 17) by constructing several bridges, across the backwaters connecting various islands. Major portion of this connection is to be made over the land which is reclaimed from the backwaters. The soil in this area is a mixed deposit of silt, clay and sand. This soil need to be improved using advanced techniques like Stone Columns and Prefabricated Vertical Drains (PVD). The stone column technique introduces a coarse grained material consisting of gravel or crushed stone aggregate as the load bearing medium. The ground improvement technique using PVD is highly suitable for saturated soft clay prone to excessive settlement. The work involving stone columns and PVD is subcontracted to Keller GMBH of Germany who are doing this work for the first time in Kerala. The paper presents the details of the ground improvement techniques used at the site.

1. INTRODUCTION

The length of the proposed NH connectivity is 17.2 km (fig.1). This starts from Appolo Junction, Kalamassery and ends in the proposed container terminal. A contract is made between National Highways Authority of India (NHAI) and SUNCON–SOMA JV for the completion of the project.Net value of the project is around 600 crores. The work includes 4-lane road (NH) of 17.2km, service roads of 8.85 km, 23 numbers of bridges and 6000m$^2$ of reinforced earth walls. Half of the proposed NH connectivity is passing through land area which is reclaimed from back waters. Mixed deposits of silts/clays/sands are present in this 9.84km of the proposed connectivity. It is decided to adopt modern techniques such as stone columns and PVD for the ground improvement.
2. METHODOLOGY

Stone Column Installation
In wet method of stone column installation, high-pressure water jets existing at the tip of the vibrator assist penetration of the vibrator into the soil.

To form a vibro-replacement point the vibrator with its follower tubes is placed over the selected points by means of a suitable supporting rig (crane). After starting the motor the vibrator is lowered into the ground. The oscillating vibrator with its extension tubes sinks rapidly into the soil under its own weight. When the designed depth is reached, a series of up and down motion where by the vibrator is then retracted to the ground surface and penetrated to the indented depth, to wash out an annular space. Aggregates are then transported in using a loader, deposited around the probe point and allowed to fall into the annular space. A constant water flow is maintained to ensure that the stone backfill is washed to the tip of the vibrator and the soft in-situ soils are flushed out. The vibrator is slowly withdrawn in steps of 0.7 to 1.0 meter and the stone falls to the tip of the vibrator. The vibrator is then lowered back into the hole between 0.7 to 0.8 m, thereby creating a 0.2 to 0.3m length of stone column. The action of the vibrator compresses stone radially into the surrounding soil and also compacts the stone in the annular space, resulting in a stone column of diameter which is dependent upon the relative stiffness of the in-situ soil: the softer the soil, the larger the diameter of the stone column.

The constructed column diameter can be determined by gauging the stone consumption during installation. This compaction procedure continues until the full length of the stone column has been constructed. The procedure is depicted in figure 2.

As water is used throughout the process, water sources within close distance to the working area and adequate areas must be made available for constructing sedimentation ponds and to control the flow of water.

To ensure an adequate supply of stone for the building process, wheel loaders are used to continually feed the material from stockpiles on the site.

Upon completion of the installation process, a compacted column of stone is left in the ground, surrounded by a soil/stone matrix of increased density.
Case Study: Ground Improvement Using Stone Columns and PVD

- Stone column reference number
- Date of installation
- Period required for installation
- Maximum depth
- Compaction effort during penetration and compaction process.

These print outs are the main quality control tools during the installation process.

A typical print out for the wet method is shown in figures 3.

**PVD Installation**

Pre-Vertical Drains is one of the most suitable methods to overcome the problem of excessive settlement in clay. The purpose of vertical drain system is to shorten the drainage path of the pore water from a low permeable layer to free water surface or to pre-installed drainage layer, thereby accelerating the rate of primary consolidation for the process of settlement. Application of prefabricated Vertical Drains (PVD) coupled with surcharge or preloading can significantly shorten the period of primary settlement. PVD with surcharge as pre-loading method has been successfully applied in various projects. PVDs are typically used as ground improvement system in-

- Construction of road, railway, embankment, airport and ports
- Industrial projects
- Land reclamation projects

PVDs are installed to a depth of 20 m. Aggregate blanket is provided over this layer for the proper drainage. Impermeable geo textile membrane sheet is placed over the blanket layer to prevent the percolation of water to the PVDs. Periodic settlement of the embankment is noted down.

Time settlement curve of soft clay showing significant time reduction achieved by applying PVD with surcharge loading. PVDs are installed to a depth of 20 m. Aggregate blanket is provided over this layer for the proper drainage. Impermeable geo textile membrane sheet is placed over the blanket layer to prevent the percolation of water to the PVDs. Periodic settlement of the embankment is noted down.

3. RESULTS AND DISCUSSION

- Stone column and PVD are the most modern techniques used for ground improvement.
- Stone column introduces a coarse grained material as load bearing elements consisting of crushed stones.
- Installation of stone columns considerably improves the bearing capacity of the weak soils
- Stone columns are found to be an effective method of ground improvement, the time requirement is considerably less as compared to other methods.
- Crushed stones act as a draining medium in stone columns.
- Application of ground improvement method using prefabricated vertical drains can significantly shorten the period of primary settlement.
- Purpose of vertical drain system is to shorten the drainage path of the pore water.
- PVD installation requires much time as compared to stone column, the cost of installation is high for stone column.

ACKNOWLEDGEMENT

Heartfelt thanks to Mr. M. B Suresh, project manager of SOMA enterprise LTD for allowing us to visit their sites.

REFERENCES

Experimental and theoretical analysis of stone column in soft clay. A.P. Ambly and Gandhi S.R
Geo synthetic encased stone column. Murugesan S and Rajagopal K.
Precast densified stone columns for soft soil ground improvement. Katti R.K. Padmavathy S.V and Dewaikar D.M

Recent developments of ground improvement with pvd on soft Bangkok clay. D.T Bergado and M.A.B Patawaran.

PVD improvement of soft Bangkok clay with combined vacuum and reduced sand embankment pre loading. D.T Bergado, J.C Chai, N.Miura and A.S Balasubramaniam.