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Micro Piling and Soil Nailing For Ground Improvement

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Abstract: Ground improvement is the most imaginative field of geotechnical engineering. It is a field in which the engineer forces the ground to adopt the project's requirements, by altering the natural state of the soil, instead of alter the design in response to the ground's natural limitations. The results usually include saving in construction cost and reduction of implementation time. In the present decade, techniques related to ground improvement has advanced to a much huge level. There are number of techniques available for improving the mechanical and engineering properties of the soil. However, each technique has some limitations and suitability's to get maximum improvement in the soil conditions with minimum effort. Micro piling and Soil nailing are the most important ground improvement techniques which are discussed in this paper. Micro piles have been used effectively in many applications of ground improvement to increase the bearing capacity and reduce the settlements particularly in strengthening the existing foundations. Frictional resistance between the surface of the pile and soil and the associated group/network effects of micro piles are considered as the possible mechanism for improvement. Micro piles are small diameter drilled and grouted friction piles. Each pile includes steel elements that are bonded into the bearing soil or rock – usually with cement grout. The bearing stratum is logged during installation drilling to assure that bearing capacity is adequate. Micro piles do not rely on end-bearing capacity, so there is no need to establish the competency of rock beyond bond-depth. They can be installed quickly in virtually every type of ground using highly adaptable mobile drilling equipment. These steel piles have working capacities up to 250 tons. Soil nailing is a construction technique that can be used as a remedial measure to treat unstable natural soil slopes or as a construction technique that allows the safe over-steepening of new or existing soil slopes. The technique involves the insertion of relatively slender reinforcing elements into the slope although solid or hollow-system bars. Solid bars are usually installed into pre-drilled holes and then grouted into place using a separate grout line, whereas hollow bars may be drilled and grouted simultaneously by the use of a sacrificial drill bit and by pumping grout down the hollow bar as drilling progresses.

I. INTRODUCTION

Ground improvement systems used in the ground or some modification of it to transfer or support loads. Ground improvement can increase soil strength and stiffness and reduce permeability. In many situations, ground improvement can be used to support new foundations or increase the capacity of existing foundations in place of bypass systems, such as piling, caissons, or remove and replace. In doing so, the ground improvement system reduces the overall foundation cost by allowing the new structure to be built on spread footings with a slab on grade rather than pile caps and a structural slab.

In choosing a ground improvement system it is first necessary to accurately characterize soil conditions at the site. Stratigraphy and groundwater conditions must be determined above, below and in the treatment zone. Typical properties of importance in the treatment zone include gradation, plasticity, moisture content, organic content, strength and consolidation properties. Properties of the proposed structure including column loads, slab loads and tolerable total and differential settlements are also required in the analysis.

Pile foundations have been used in construction for thousands of years as an economical means of transmitting the loads from superstructures to the underlying soil or rock strata. In pile design, piles must be able to sustain axial loads

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from the superstructure without failing in bearing capacity or settling so much that structural damage occurs or serviceability of the superstructure is jeopardized.

In general, settlement controls the design in most cases because, by the time a pile has failed in terms of bearing capacity, it is very likely that serviceability will have already been compromised. Therefore, realistic estimation of settlement for the given load is very important in design of axially loaded piles. This notwithstanding, pile design has relied on calculations of ultimate resistances reduced by factors of safety that would indirectly prevent settlement-based limit states. This is in part due to the lack of accessible realistic analysis tools for estimation of settlement, especially for piles installed in layered soil.

II. Proposed Work

There are several types of ground improvements whose applications are based on the site in which ground improvement is to be done. Some common methods are listed below:

- Micro piling
- Soil Nailing
- Blasting
- Pre-compression
- Stone column
- Vibrofloatation
- Grouting
- Electro osmosis
- Thermal treatment
- Compaction pile

Among these techniques for ground improvement, our paper focuses on micro piles and soil nailing.

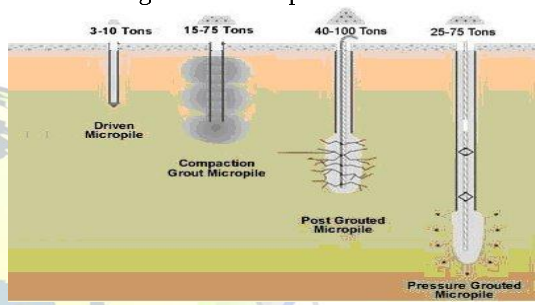
MICROPILES:

Micro piles are small-diameter piles that are sometimes called mini piles, root piles, pin piles or needle piles. The conceptual idea behind this important technological development was to create a type of pile that would be able to carry large loads while causing minimal vibration or disturbance to in situ materials at the time of installation. The rigs required to install them are often relatively small. Because of these important advantages, micro piles have been widely used in seismic retrofitting, in the rehabilitation of foundations of structures that are very sensitive, low headroom. Furthermore, micro piles have been increasingly used, not only as underpinning foundation elements, but also as foundations for new structures.

DIFFERENT TYES OF MICROPILES:

There are different types of micro piles based on the mode of erection and its applications. They are:

- Driven micropile
- Compaction grouted micropile
- Post grouted micropile
- Pressure grouted micropile



A. Driven Micropile

In this method a mini hydraulic hammer is used to install piles using percussion method. The length of each pile section can be custom fabricated up to a maximum length of 3 meters. Hammer ranging in weight from 1.1 ton to 2.8 ton are available for various situation and application with a safe working load of 15 ton to 30 ton. The system provides a cost effective solution to satisfy the increasingly stringent limits placed on noise and vibration while at the same time offering superior construction to the conventional R.C. Pile and Bored Micro piles.

B. Compaction Grouted Micropiles

In this method the micro piles are used with a diameter of 76 mm and length of 3.05 m were tested. The micro piles were constructed by incrementally applying dynamic compaction energy from the SPT hammer of a conventional drill rig to the concrete grout as the hole was filled. The results of the tension tests showed that in comparison with a micro pile constructed using gravity free- fall placement of the concrete, the pullout capacity of the micro piles was significantly increased when compaction energy was used. This increase is primarily due to the increase in lateral stress produced by the compaction.

C. Post Grouted Micro Piles

Post-grouted micro-piles were used for the seismic upgrading in International Airport. The micro-piles provided vertical resistance to both uplift and compression loads to

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supplement the existing timber pile foundations ability to resist the earthquake induced forces, and to provide foundation support at locations where the installation of traditional driven piles was difficult. It is used to increase bond and load transfer in cohesive soils.

D. Pressure Grouted Micro Pile:

The High Capacity Steel Micro pile is made using High Tensile Tubular Steel. The steel micro pile is provided with "manchettes". Manchettes, are rubber sleeves installed at regular interval in the active length of high pressure injected tubular steel micro piles and are acting as check valves, allowing cement to flow outwards into the surrounding soil and preventing backflow.

The High Capacity Micro pile is drilled and then fixed into the ground by annular grout. Due to the very small cross section area are generally skin-friction piles. The Pressure Grouting done through the manchettes provided within the micro piles active length creates series of bulges between the annular grouting of the Micro pile and the soil formation surrounding the micro pile. The irregular shapes of the micro piles' bulges have a sizable area which in turn translates to a sizeable increase of the micro pile lateral area, creating an increase of the micropiles' shaft interface with the medium [soil] surrounding the Micro pile. The end result of the process is giving this type of micropile a much higher bearing capacity as compared to non-pressure grouted micropiles .

Micropiles used for underpinning can be precompressed prior to being connected to the pre-existing structures, in this way further settlements are generally avoided, since the piles are made active from inception. Micropile field of application is very wide. Pressure Injected Micropile is an extremely reliable technology. Micropiles are generally designed with high safety factor and are usually tested by static load test using reaction micropiles to provide the necessary loads.

Pressure injected tubular steel micropiles are a versatile technology, because of the small dimension of the equipment needed for micro pile execution, and because the material needed to form the micropile can be split into small loads and can be carried even by hand, practically mountain trails, rice fields, mountainous forested areas [for foundations of electric power transmission lines and telecom transmission towers].

III. IMPLEMENTATION

Step 1: The pile point is determined by a surveyor and position the drill rig on top of the point.
The first drill rod with a drill bit is placed above the drill point. Ensure verticality is achieved before starting drilling works. This is done by checking the verticality of both the first drill rod and the mast using a spirit level.

Step 2: For drilling in both soft and/or hard soils the hole can be drilled with the wash boring method using either a drag bit or roller bit. Wash boring, also known as the reverse circulation system is an assembly of the drill bit - drag bit or roller bit being assembled to the end of a string of drill rods onto a drill rig or drill frame. The drill bit is advanced by adding drill rods when drilling. Water is pumped through the string of drill rods and the outflow water emerging from the borehole is channelled to a holding pit and recycled through a slurry pump back into the drill rig's swivel head – hence the term 'reverse circulation'.

Step 3: If collapsible soil layers is encountered from or anticipated from the soil investigation record, drilling using temporary casing shall be employed. Advance a casing into by either drilling using a casing shoe without the aid of a drill rod or using a drill rod with drag/roller bit together with a casing up to the suspected collapsible layer felt by the driller. The latter method can be done without a casing shoe. Upon reaching the end of the collapsible area cease the advancing of the casing. Continue drilling using drag/roller bit until the depth of the pile is reached.

Step 4: Upon completion of the drilling, the borehole is cleaned by flushing out any soil particles from the inside of the casing with recirculation water or air. Reinforcement Bars installation: - If a mobile crane is to be used for, move the drilling rig back. The pipe / rebar cage shall be lowered segment-by-segment using a mobile crane. Cordon the area for safety reasons.

If the drilling rig winch is to be used, lift the pipes/rebar cage up segment-by-segment using the winch. Cordon the area for safety reasons. The joints of the API Pipe shall be properly screwed together with grease to assist tightening If welding is used, clean the edge of the pipe and conduct a full butt weld on the outside of the pipe. If Reinforcement Bars are used, lap the bar for 40D and join by tie wire or welding.

Step 5: If in Step 4, the mobile crane is used to install the Rebar Cage, the same mobile crane can be used to pull/withdraw the temporary casing. Shall this cannot be

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done due to safety reasons move the drill rig back. Withdraw the casing using the winch tied around the casing. Shall this be unsuccessful, reattach the adaptor and using the reverse circulation method flush water into the casing to loosen it while withdrawing the casing using the rotary unit.

A. Benefits Of Micropiles:

- Can be installed through most ground condition, obstruction and foundation at any incline.
- Ensure minimum vibration or other damage to foundation and subsoil.
- Depending on situation, could actually allow facility operations to be maintained during construction.
- Simple and economical connection to existing and new structures. Can be used in tension and compression.
- High grout pressures can be achieved
- Improved anchoring capacities and reduced settlement
- Minimum grout cover, maximum corrosion protection

B. Limitations Of Micropiles:

- Vertical micropiles may be limited in lateral capacity.
- Cost effectiveness.
- Potential buckling under seismic loading and liquefaction.
- Cannot be used for low head rooms.

C. Applications Of Micropiles:

- Rock Socket ting – where driven piles cannot penetrate.
- Supporting New Loads in Congested Areas
- Seismic Retrofit
- Arresting Structural Settlement
- Resisting Uplift and Dynamic Loads
- Underpinning

D. Soil Nailing:

Soil nailing is a construction technique that can be used as a remedial measure to treat unstable natural soil slopes or as a construction technique that allows the safe over-steepening of new or existing soil slopes. The technique involves the insertion of relatively slender reinforcing elements into the slope – often general purpose reinforcing bars (rebar) although proprietary solid or hollow-system bars are also available. Solid bars are usually installed into pre-drilled holes and then grouted into place using a separate grout line, whereas hollow bars may be drilled and grouted simultaneously by the use of a sacrificial drill bit and by pumping grout down the hollow bar as drilling progresses. Kinetic methods of firing relatively short bars into soil slopes have also been developed. Bars installed using drilling techniques are usually fully grouted and installed at a slight downward inclination with bars installed at regularly spaced points across the slope face.

E. Design:

After a preliminary analysis of the site, initial designs of the soil nail wall can be begin. This begins with a selection of limit states and design approaches. The two most common limit states used in soil nail wall design is strength limit and service limit states. The strength limit state is the limit state that addresses potential failure mechanisms or collapse states of the soil nail wall system. The service limit state is the limit state that addresses loss of service function resulting from excessive wall deformation. The two most common design approaches for soil nail walls are limit state design and service load design.

Initial design considerations include wall layout (wall height and length), soil nail vertical and horizontal spacing, soil nail pattern on wall face, soil nail inclination, soil nail length and distribution, soil nail material and relevant ground properties. After the initial design is completed, final design progresses where the soil nail wall has to be tested for external and internal failure modes, seismic considerations and aesthetic qualities. Drainage, frost penetration and external loads such as wind and hydrostatic forces also have to be determined and included in the final examination of the design.

F. Soil Nail Installation Process:

Soil nail provides a resisting force against slope failures. Its construction process is faster than other similar methods. The construction procedure starts, drilling into the soil, where the nail, steel bar, is going to be placed. After the drilling has been completed, exact depth must be provided by the geotechnical engineer, the nail must be inserted into the drilled hole. Then, it must be grouted into the soil to create a structure similar to a gravity wall. After placing the nail, a shot-Crete layer is usually placed as a facing material, to protect the exposed nail, and then other architectural options are placed over the shot-Crete, creating an aesthetic finish to the project.

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Drainage is a critical aspect of soil nail wall construction. Face drainage is virtually always used with permanent walls, and very commonly used with temporary walls. Face drainage usually consists of synthetic drainage elements placed between the shot-Crete and the retained soil, and may be typically 8 to 12 inches wide synthetic strips or perforated pipes.

The grouted soil nail hole typically has a minimum diameter of 4 inches. Centralizers are placed around the soil nail to maintain an even thickness of grout around the bar. For permanent applications, nails may be epoxy-coated or provided with a protective sheath for corrosion protection.

G. Advantages:

- Allow in-situ strengthening on existing slope surface with minimum excavation and backfilling.
- It is an eco- friendly process.
- Sub-vertical cut surface reducing loss of space.
- It avoids unnecessary temporary works.
- It requires light machinery and equipment.

H. Disadvantages:

- Generally larger lateral soil strain during removal of lateral support and ground surface cracking may appear.
- Tendency of high ground loss due to drilling technique.
- Less suitable for course grained soil and soft clayey soil.

IV. Conclusion

Although there are several techniques for soil improvement, each has its own advantages and limitations. A particular technique which is proved appropriate at a given situation does not be appropriate under some other circumstance. In any case, care should be taken to achieve increased output with less economy.

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