

Study on the Behavior of Slope using Soil Nailing and Shotcreting

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Abstract - Climatic pattern changes have affected the reliability on hilly roadways due to unexpected landslides. Such landslides being sudden and huge, may result in heavy loss of material and human lives. Hence, stabilization of such slopes for the safety of people and property is an immediate need. Soil nailing is an emerging soil stabilization technique, which is nothing but reinforcing the soil mass to restrain its displacements. This paper is an effort to minimize the risk of landslides by reinforcing the slope with steel bars. Shotcreting will be provided on the slope surface to improve the stability of the nails in the slope. Behaviour of un-nailed and nailed slopes of less cohesive soil are compared in this paper.

Key words - Soil stabilization, Nailing, Shotcreting

1. INTRODUCTION

Slope stabilization is a topic of serious concern to the geologists all over the world, as the slope instability and erosion of soil by water and wind are major environmental hazards. Although they are the result of natural geomorphic processes, they have the consequences for human activity, often incurring economic and social damage and have resulted in considerable loss of life. Any ground surface that stands at an angle to the horizontal is termed an unrestrained slope and can be of natural origin or man-made. Both natural and man-made slopes can be stable or unstable and several methods of analyses of their stability as well as the stabilization techniques have evolved from simple to more sophisticated ones.

Soil nailing is an advanced technique among the other soil stabilization techniques. In this technique, the existing soil slopes and excavations are passively reinforced by insertion of relatively slender elements normally steel bars (nails). The grout is provided to prevent corrosion of steel bars as well as to transfer the load efficiently. Wire meshed shotcrete is provided over the slip surface, which support the face between the nails and also acts as the bearing surface for nail plates.

2. CONCEPT OF SOIL NAILING AND SHOTCRETING

The main objective of soil nailing technique is to strengthen or stabilize the existing steep slopes and excavations for longer period of time. In this technique the huge soil mass is reinforced with steel bars to restrict the movement of soil during any natural

disasters. The nails are installed into pre-drilled holes and then grouted to prevent corrosion of the steel bars (nails). They are usually installed at an angle of 10 to 20 degrees with horizontal and are primarily subjected to tensile stress. This process will proceed from top to down.

The soil nail system can be divided into active and passive regions. During the slope failure, active region tends to deform, which results in the axial displacement along soil nails which are placed across the failure plane. This will result in the development of tensile forces in the soil nails located in passive region, which will resist the deformation of active zone. Slope surface or slip surface is then covered with wire mesh and shotcreted so as to provide support for the nail heads. Shotcrete is both method and material made up of cement and sand commonly known as mortar. The mortar is then applied by pneumatic pressure through special hose. There are 2 types of shotcrete, according to their mixing processes which are dry and wet mix processes. Here we adopt wet mix process, as the other one needs skilled persons to operate the nozzle processes.

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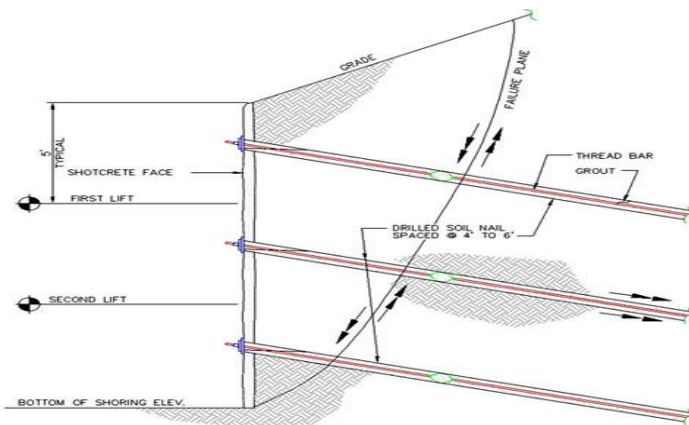


Figure1: Typical soil nailing



Figure 2: Wire mesh covered on a slope

2.1 Various methods of soil nailing

- Drilled and grouted soil nailing – Holes are drilled in walls or slope faces. Then, nails are inserted into the pre-drilled holes. After that, hole is filled with grouting materials such as concrete, shotcrete etc.
- Driven soil nailing – This method is considerably fast and will be used for temporary stabilization of soil slopes. In this method, nails are driven in slope face during excavation. But it doesn't provide corrosion protection.
- Self-drilling soil nailing – Hollow bars are drilled into the slope surface, grout also injected simultaneously during the drilling process. It provides more corrosion resistance to the nails than driven nails.
- Jet grouted soil nailing – In this method, jets are used for creating holes on the slope surface. And then, steel bars are installed in the holes and grouted with concrete. This method provides good corrosion protection for the steel bars.
- Launched soil nailing – In this method, the nails are forced into the soil with a single

shot using compressed air mechanism. And so, installation of soil nails is fast, but penetration of over length bars is difficult.

2.2 Applications of soil nailing

- Stabilization of railroad and highway cut slopes.
- Excavation retaining structures in urban areas for high-rise building and underground facilities.
- Tunnel portals in steep and unstable stratified slopes.
- Stabilization of existing over steep embankments.

Soil nailing through existing concrete or masonry structures such as failing retaining walls and bridge abutments to provide long term stability without demolition and rebuild costs.



Figure 3: Collected Materials

3. TESTING THE PROPERTIES OF SOIL

The soil sample is subjected to various tests recommended as per Indian standards, IS: 1498-1970, IS:2720 (Part 5) -1985 and IS:2720 (Part 10) – 1991, to identify the type of soil.

3.1 Unified Soil Classification System as per IS 1498

Soil is classified into coarse grained soils, fine grained soils, highly organic soils and other miscellaneous soils. The soil sample is tested as per the codal provisions, and found that it is fine grained silt clayey soil.

3.2 Atterberg limits as per IS: 2720(Part 5)

Plastic limit: Plastic limit is the moisture content of the soil at which changes from semi-solid to plastic state. In other words, the water content at which soil

begin to crumble when rolled into a thread approximately 1/8 inches in diameter. It is the maximum water content in semi solid state and minimum water content in plastic state.

Liquid limit : Liquid limit is the water content at which the soil changes from plastic to liquid state. It is the maximum water content in plastic state and minimum water content in liquid state.

Test procedures are followed as per the IS recommendations and their results are,

Liquid limit – 50.05

Plastic limit – 43.73

Plasticity index - 6.72

Flow index – 34.5

Toughness index – 0.18

Concluded that, the soil sample is fine grained silt clayey soil.

3.3 Unconfined compressive strength as per IS: 2720 (Part 10)

Unconfined compressive strength is the load per unit area at which the cylindrical specimen of a cohesive soil falls in compression. The un-drained shear strength of soil is equal to the one half of the unconfined compressive strength. Test procedures are followed as per IS recommendations, and shear strength of the soil was found.

4. EXPERIMENTAL RESULTS

The experimental work has been carried out in laboratory by using 10 mm diameter steel bars as nail on less cohesive soil in tank of size 50x 40x40 cm. As per IRC: 36-2010, Embankment's Slope was chosen as 2H:1V. Maximum ultimate load has been found out by applying the load up to the failure of slope.

The main aim of this study is to evaluate, the behavior of un-nailed and nailed embankments at different inclinations (10° and 20°). The vertical spacing and horizontal spacing is 10cm.

4.1 Embankment without nails

A model embankment of slope 2:1 is created and tested for maximum load it can withstand by applying load gradually. Finally, it is found that the embankment fails at 6.7 kN.

4.2 Embankment with nails

Same model embankment is built and this time they are reinforced with 10mm steel bars at both horizontal and vertical directions. The nails are inserted at 20° inclination, covered with a wire mesh at the slope surface and shotcrete is applied over it.

After that, load is applied gradually and maximum load it can withstand was found to be 11.2 kN.

Same procedure is followed for 10° inclination of nails and tested by gradual application of load. The embankment fails at 20.22kN. So, compared to others embankment with nails inclined at 10° withstands higher load.

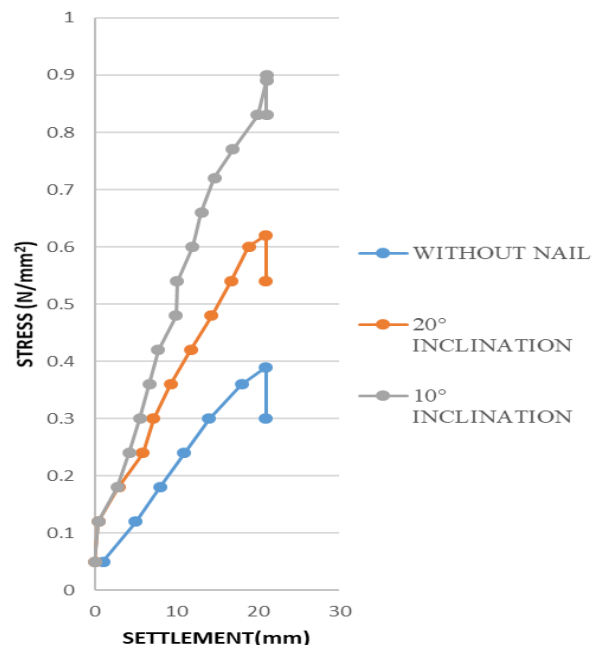


Chart 1: comparison of results

5. CONCLUSION

From the above results, it is concluded that soil slope reinforced with nails can offer higher strength and stability to the slope than normal slope without nails. So the reinforcing the nails in the slopes could prevent the landslides and failure of less cohesive soil effectively. This method of slope stabilization is economical as well as time saving when compared to other soil stabilization techniques. Reinforcing the soil mass will increase the shear strength of the soil. As the shear strength gets increased, the slope will provide more resistance to the failure. Shotcreting the slope surface should prevent the failure due to shear.

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