What is soil nailing technique?

Soil nailing technique used to reinforce soil to make it more stable. Added to that, it is used for slopes, excavations, retaining walls etc. to make it more stable. This article will shed light on soil nailing technique, its types and applications.

Soil nailing technique process

In this technique, soil is reinforced with slender elements such as reinforcing bars which are called as nails as illustrated in Fig.1. These reinforcing bars are installed into pre-drilled holes and then grouted. Moreover, these nails are installed at an inclination of 10 to 20 degrees with vertical.

Soil nailing is a ground stabilisation technique that can be used on either natural or excavated slopes. It involves drilling holes for steel bars to be inserted into a slope face which are then grouted in place. Mesh is attached to the bar ends to hold the slope face in position.

They are commonly used as a remedial measure to stabilise embankments, levees, and so on. Other applications for soil nailing include:

- Temporary excavation shoring.
- Tunnel portals.
- Roadway cuts.
- Under bridge abutments.
- Repair and reconstruction of existing retaining structures.

The main considerations for deciding whether soil nailing will be appropriate include; the ground conditions, the suitability of other systems, such as ground anchors, geosynthetic materials, and so on and cost.

Although soil nails are versatile and can be used for a variety of soil types and conditions, it is preferable that the soil should be capable of standing – without supports – to a height of 1-2 m for no less than 2 days when cut vertical or near-vertical.

Soils which are particularly suited to soil nailing include clays, clayey silts, silty clays, sandy clays, glacial soils, sandy silts, sand, gravels. Soil nailing can be used on weathered rock as long as the weathering is even (i.e. without any weakness planes) throughout the rock.

Soils which are not well-suited to soil nailing include those with a high groundwater table, cohesion-less soils, soft fine-grained soils, highly-corrosive soils, loess, loose granular soils, and ground exposed to repeated freeze-thaw action.

Design considerations that will inform the design include:

- Strength limit: The limit state at which potential failure or collapse occurs.
- Service limit: The limit state at which loss of service function occurs resulting from excessive wall deformation.
- Height and length.

- Vertical and horizontal spacing of the soil nails.
- Inclination of the soil nails.
- Ground properties.
- Nail length, diameter and maximum force.
- Drainage, frost penetration, external loads due to wind and hydrostatic forces.

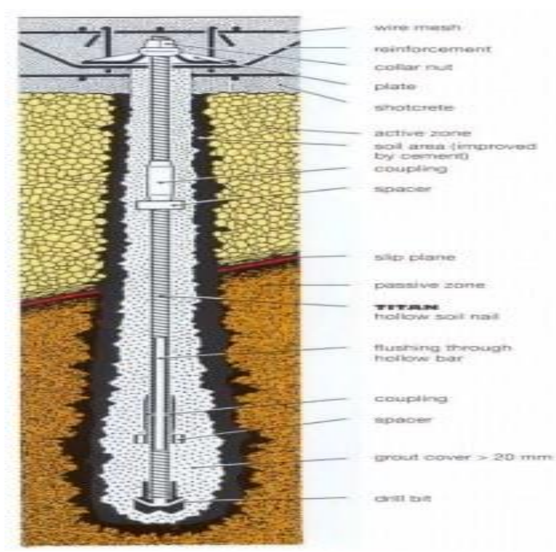
A drainage system may be inserted once all the nails are in place. This involves a synthetic drainage mat placed vertically between the nail heads, which extends to the wall base and is connected to a footing drain.

Some of the advantages of using soil nailing include:

- They are good for confined spaces with restricted access.
- There is less environmental impact.
- They are relatively quick and easy to install.
- They use less materials and shoring.
- They are flexible enough to be used on new constructions, temporary structures or on remodelling processes.
- The height is not restricted.

Limitations of using soil nailing include:

- They are not suitable for areas with a high water table.
- In soils of low shear strength, very high soil nail density may be required.
- They are not suitable for permanent use in sensitive and expansive soils.
- Specialist contractors are required.
- Extensive 3D modelling may be required.



As the excavation proceeds, the shotcrete, concrete or other grouting materials are applied on the excavation face to grout the reinforcing steel or nails. Fig.2 to Fig.5 illustrate typical soil nailing process.

Applications of soil nailing

- Stabilization of existing retaining wall
- Excavating retaining structures in urban areas for high rise buildings and underground facilities.
- Landslide redemption
- Stabilization of highway and roadway embankments and cut slopes
- Tunnel portals in unstable and steep stratified slopes
- Construction and retrofitting bridge abutments
- Steep cutting stabilizations
- Stabilizing of over steep existing embankments
- Provide long term stability to existing concrete structures without demolition and rebuilding costs
- Lastly, temporary excavation shoring

A reinforced earth wall is designed and constructed to resist the lateral pressure of the soil and supports the soil laterally so that it can be maintained at different levels on both sides. The lateral pressure could be also due to earth filling, liquid pressure, sand, and granular materials. The walls are used to bound soils between two different elevations often in areas of terrain possessing undesirable slopes. These walls are an economical way to meet every-day earth retention needs for highway and bridge grade separations, railroads and mass transit systems. They are also used in response to difficult design conditions such as very high structures, restricted space, where obstructions within the soil mass are present.

Applications Reinforced Earth Wall

Reinforced earth wall is compatible with a variety of facing systems, including large-sized discrete concrete panels, segmental panels, small-sized modular concrete blocks, vegetative facing with wrap around or with stones filled gabion, etc. It is also compatible with a wide range of fill materials, ranging from non-cohesive frictional fills locally available at site to fly ash and other similar non-cohesive, non-plastic fills. The marginal cohesive fill material can also be used with reinforced earth walls by providing adequate design. The benefits of these structures are especially evident on projects with challenging design conditions such as large structural loads, extreme height, restricted space, obstructions within the soil mass, poor foundation soils, high or variable water level and seismic loading. Its application area includes;

- Highway and roads
- Bridges
- Railway
- Waterways and dams
- Protective structures and Comercial & public facilities

Geommebrane is the low permeability liner made of high grade polyethylene raw material, adding carbon black, antioxidant, anti-aging and UV-resistance component which features excellent chemical resistance, outstanding stress crack capacity, lowest permeability and excellent UV resistance. BPM brand geomembrane is widely used for waste containment, water containment, aquaculture, energy, mining, industrial and civil engineering applications.

Geomembranes have been used in the following environmental, geotechnical, hydraulic, transportation, and private development applications:

- As liners for potable water
- As liners for reserve water (e.g., safe shutdown of nuclear facilities)
- As liners for waste liquids (e.g., sewage sludge)
- Liners for radioactive or hazardous waste liquid
- As liners for secondary containment of underground storage tanks
- As liners for solar ponds
- As liners for brine solutions
- As liners for the agriculture industry
- As liners for the aquiculture industry, such as fish/shrimp pond
- As liners for golf course water holes and sand bunkers
- As liners for all types of decorative and architectural ponds
- As liners for water conveyance canals
- As liners for various waste conveyance canals
- As liners for primary, secondary, and/or tertiary solid-waste landfills and waste piles
- As liners for heap leach pads
- As covers (caps) for solid-waste landfills
- As covers for aerobic and anaerobic manure digesters in the agriculture industry
- As covers for power plant coal ash
- As liners for vertical walls: single or double with leak detection
- As cutoffs within zoned earth dams for seepage control
- As linings for emergency spillways
- As waterproofing liners within tunnels and pipelines
- As waterproof facing of earth and rockfill dams
- As waterproof facing for roller compacted concrete dams
- As waterproof facing for masonry and concrete dams
- Within cofferdams for seepage control
- As floating reservoirs for seepage control
- As floating reservoir covers for preventing pollution
- To contain and transport liquids in trucks
- To contain and transport potable water and other liquids in the ocean
- As a barrier to odors from landfills
- As a barrier to vapors (radon, hydrocarbons, etc.) beneath buildings
- To control expansive soils
- To control frost-susceptible soils
- To shield sinkhole-susceptible areas from flowing water
- To prevent infiltration of water in sensitive areas
- To form barrier tubes as dams

- To face structural supports as temporary cofferdams
- To conduct water flow into preferred paths
- Beneath highways to prevent pollution from deicing salts
- Beneath and adjacent to highways to capture hazardous liquid spills
- As containment structures for temporary surcharges
- To aid in establishing uniformity of subsurface compressibility and subsidence
- Beneath asphalt overlays as a waterproofing layer
- To contain seepage losses in existing above-ground tanks
- As flexible forms where loss of material cannot be allowed.

Geogrid is a polymeric material made up of many polymers like polyethylene, polyvinyl alcohol polypropylene etc. It is one of the most important inventions in geosynthesis which is used as a reinforcing material. They formed by joining intersecting ribs. They have large open spaces in between the ribs known as "apertures".

The manufacturing of geogrids commercially is carried out by three ways which is explained below,

- By Extrusion: In this method a flat polymeric sheet of material is made into a geogrid by extrusion and holes of desired dimensions are punched in the flat sheet to form the apertures. Then stretching is done to impart the tensile strength.
- By Weaving or Knitting: As the name signifies the geogrids are manufactured by weaving fibrous yarns and apertures are formed in between the flexible joints. These types of geogrids have high tenacity.
- By Welding and Extrusion: This method is similar to that of extrusion, only difference is that the extrusion of ribs is carried out by passing it through rollers, then they are sent to the welding section to form apertures. This method makes use of automated machines

Geogrids can be classified into two types based on the stress transfer or direction of stretching during manufacture as

1 Type of geogrid based on pattern

1.uniaxial geogrid 2.biaxial geogrid 3. Triaxial geogrid

Types of Geogrid based on Manufacturing

Geogrids also have another classification based on the method of manufacturing, they are

- Extruded geogrid
- Woven geogrid
- Bonded geogrid

Working of Geogrid

Geogrids work by interlocking with the granular or fine material placed over them. The apertures allow for strike-through of the cover soil material which then interlocks with the ribs (flat straps/bars) providing confinement of the overlaying granular/soil material due to the stiffness and strength of the ribs.

Advantages of Geogrids:

- The use of geogrids results in a more economical construction.

- It is environmental friendly.
- Imparting geogrids makes the members more durable since it resists environmental attacks.
- It prevents the soil from erosion.
- Geogrids ensure ease of construction as the placement techniques are simple.

  Thus by the above mentioned applications and benefits, it is seen that the use of geogrids will result in a sustainable development in the construction industry.

Soil nailing is **an economical technique used to stabilize existing slopes and to construct retaining walls from the top down**. This soil reinforcement process uses steel tendons which are drilled and grouted into the soil to create a composite mass similar to a gravity wall.

Grouting is a process of injecting materials into cavities or cracks in concrete,masonry structure,soil,rock –mass to increase the soil’s load bearing capacity refers to grouting and the material used for this objective is Grout

The following are **methods of soil stabilization** used.

1. Mechanical Stabilization
2. Lime Stabilization
3. Cement Stabilization
4. Chemical Stabilization
5. Fly ash Stabilization
6. Rice Husk ash Stabilization
7. Bituminous Stabilization
8. Thermal Stabilization
9. Electrical Stabilization
10. Stabilization by Geotextile and Fabrics
11. Recycled and Waste Products etc.

Lime-Soil stabilization is the process of adding lime to the soil to improve its properties like density, bearing capacity etc. Various factors affecting lime-soil stabilization are soil type, lime type, lime content used, compaction, curing period and additives