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METHODS AND APPROACHES FOR SLOPE STRENGTHENING

Slope strengthening is carried out to protect inclined areas of terrain from landslides and soil erosion caused by natural factors such as wind, precipitation, and temperature fluctuations.

The main idea of strengthening is to increase the stability of the upper soil layer by strengthening it with various technological means [1,3].

The specific method is chosen taking into account the terrain relief, slope steepness, climatic conditions, and loads [2].

Main methods of slope strengthening:

1. Slope strengthening with a geogrid

Advantages:

- High soil strengthening efficiency.
- Flexible structure adaptable to terrain irregularities.
- Quick installation, suitable for both manual and mechanized placement.
- Possibility of landscaping and combination with biological strengthening methods.
- Lightweight material, convenient for transportation and installation.

Disadvantages:

- Limited applicability by slope height and steepness (most effective on slopes up to 45°).
- Requires thorough base preparation (soil compaction and removal of unstable layers).
- Not suitable for mobile or highly water-saturated soils without additional drainage.
- Limited resistance to mechanical damage during operation.
- Efficiency depends on the quality of installation and the type of filler material.

2. Slope strengthening with geomats

Advantages:

- Effective prevention of surface soil layer erosion.
- Lightweight and flexible material that allows installation on uneven slopes.
- Quick and simple installation without the need for complex equipment.
- Reduces soil washout during heavy rainfall.

Disadvantages:

- Effective mainly on gentle and moderate slopes (not suitable for steep slopes without additional measures).
- Require surface preparation and removal of large irregularities.
- Performance depends on the quality of installation and soil compaction.
- May suffer mechanical damage during operation, for example, from machinery or strong water flows.

3. Slope strengthening with gabions

Advantages:

- High strength and reliability of the structure, even on steep slopes.
- Drainage properties - water easily passes through the stone fill, reducing the risk of excessive soil moisture.
- Ability to adapt to uneven terrain.
- Easier installation compared to massive concrete structures.
- Ability of the structure to adjust independently to soil movements without damage.

Disadvantages:

- High material cost and transportation expenses.
- Requires a strong foundation to prevent settlement on weak soils.
- Heavy structure complicates installation in hard-to-reach areas.
- Not always effective on very unstable soils without additional strengthening (piles, anchors).

4. Slope strengthening with vegetation

Advantages:

- Natural soil strengthening through plant root systems.
- Environmentally friendly, with no harmful impact on the surrounding ecosystem.
- Reduces erosion and surface water runoff.
- Can be combined with other strengthening methods (geomats, geogrids).
- Relatively low costs for materials and installation.

Disadvantages:

- Effective only on gentle to moderate slopes; steep slopes require additional measures.
- Requires time for the root system to fully establish and provide stability.
- Performance depends on climatic conditions and proper plant care.
- May require supplemental irrigation or protection from pests during the initial stage.

The choice of a specific slope strengthening method depends on the soil type, slope steepness and length, climatic conditions, land use, and economic considerations. In many cases, combining different methods is advisable.

Overall, a proper approach to slope strengthening helps preserve infrastructure, protect the environment, and enhance the safety of the area, which is especially important for roads, railways, residential, and industrial facilities.

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