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Concept and Design of Vegetation Engineering

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Outline

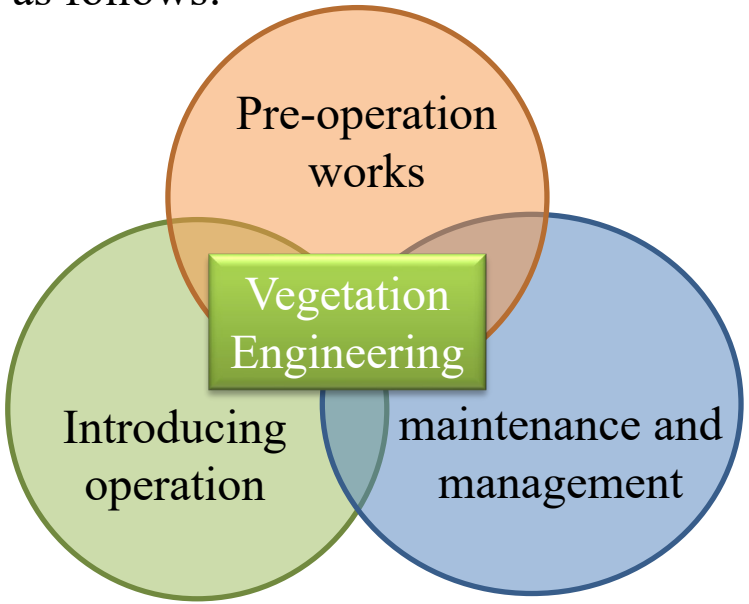
- Key Items of Vegetation Engineering Planning
- Basic Types of Vegetation Engineering Design Objectives
- Site Conditions and Corresponding Strategies of Vegetation Engineering
- Base Site Conditions and Vegetation Engineering Treatment
- Guest Soil

Key Items of Vegetation Engineering Planning

When planning a vegetation engineering, it is necessary to first establish the expected goal of the vegetation engineering, so as to develop a vegetation engineering plan. When studying and developing, it should consider as follows:

1. Vegetation pre-operation works,
2. Vegetation introducing operation,
3. Vegetation maintenance and management.

Core works



Key Items of Vegetation Engineering Planning

1. Vegetation pre-operation works

Define:
Refers to the engineering protection measures done before introducing vegetation in exposed slopes.

Goal:
To aim at reducing soil erosion, stabilizing slope, preventing the expansion of collapse area, enhancing the stability of slope foundation, and creating the environmental conditions helpful to the germination, growth, and succession of plants. When plants are introduced into slope, the premise is that the gradient and erosion control of the base, physicochemical properties of the soil matrix, and the climatic conditions must be suitable for the growth and establishment of the target plant community.

Key Items of Vegetation Engineering Planning

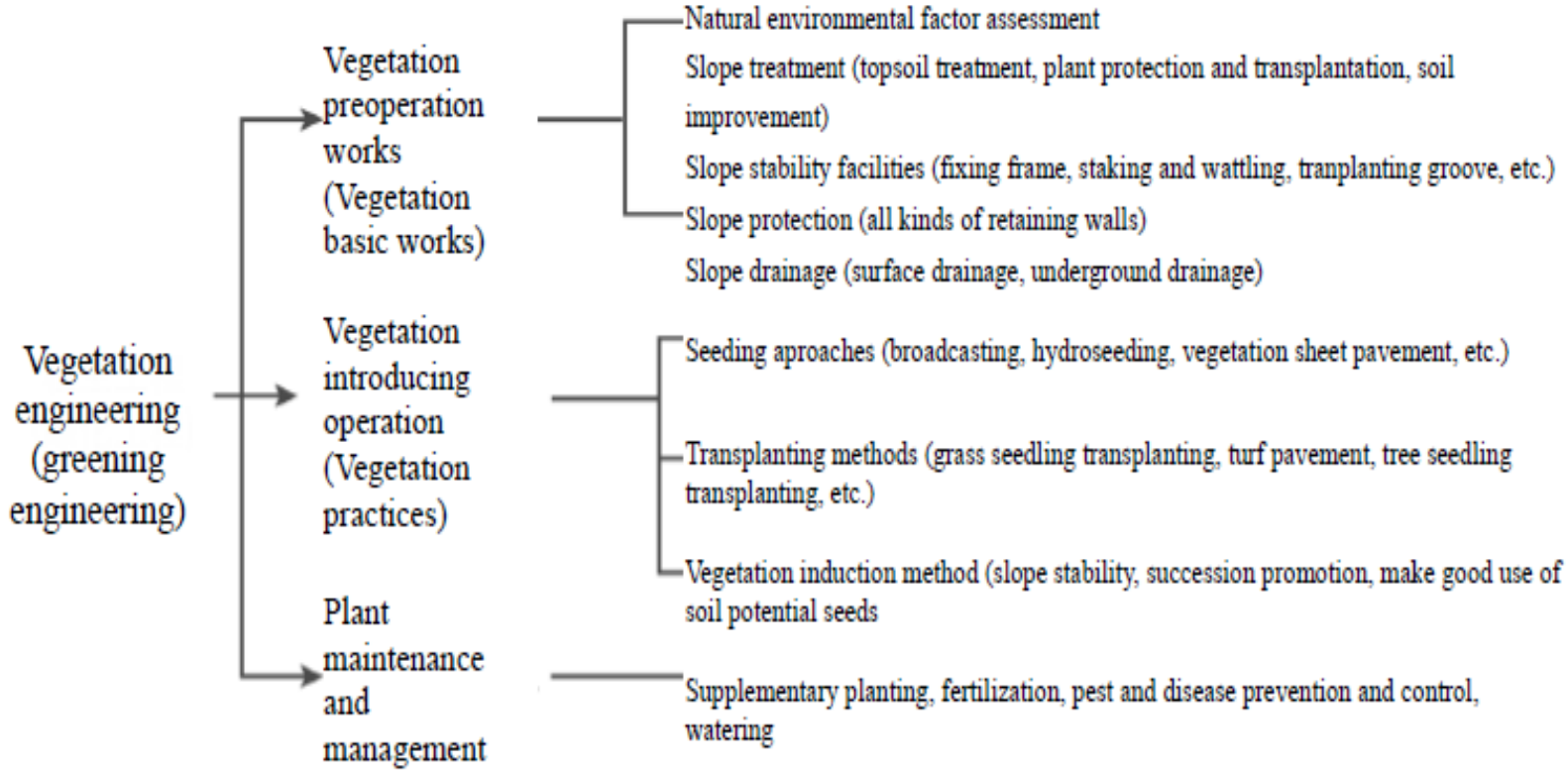
2. Vegetation introducing operation

Refers to the suitable operational methods used to enable plants to proliferate and grow on the base according to slope conditions and the purpose of vegetation. The methods of vegetation introducing operation can be roughly divided into seeding method, transplanting method and vegetation induction method.

3. Vegetation maintenance and management

Refers to the measures required to ensure the effectiveness of the vegetation engineering.

Key Items of Vegetation Engineering Planning



Schematic diagram of the work items of vegetation engineering

Basic Types of Vegetation Engineering Design Objectives

1. Soil and water conservation type

The rapid vegetation covering method used in artificial development, vegetation destruction areas or exposed areas of natural disasters for the purposes of soil and water conservation, erosion reduction, disaster prevention, etc., Better effectiveness can be achieved if cooperates with soil and water conservation engineering.

2. Landscape green land type

Cooperating with artificial structures to carry out vegetation introducing operations. In principle, local plants and landscape plants are mainly used to create green land space and landscape beauty.

Basic Types of Vegetation Engineering Design Objectives

3. Nature conservation type

Natural plant succession to reach vegetation communities near its apogee with the use of native plants as principle, in order to restore the status of the existing vegetation, usually is used in natural forest park or conservation area.

4. Coordinating afforestation type

Mainly for forestry operation and management, reach artificial forest community in short term through the transplanting of economic forest tree species and artificial tending. Tree seedling and small seedling transplanting is often used to ensure that trees (roots) grow normally and the goal can be achieved with more economic operation.

Basic Types of Vegetation Engineering Design Objectives

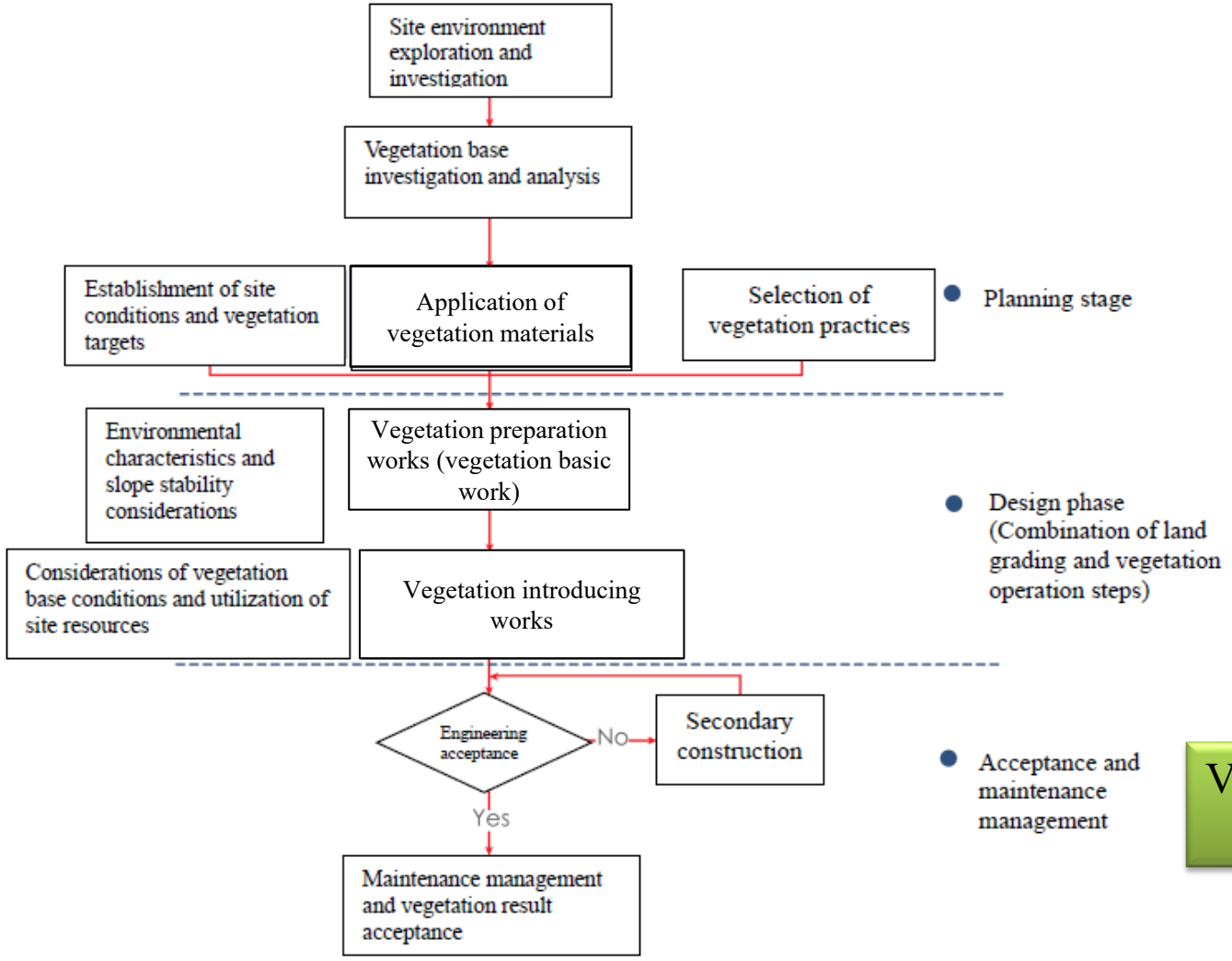
Comparison of basic design types of vegetation engineering
(Source: Soil and Water Conservation Handbook, 2005)

Type / Characteristics	Soil and water conservation type	Landscape green land type	Nature conservation type	Coordinating afforestation type
Plant materials	• Covering grasses • Herbaceous plants • Fast-growing tree species • Green manure plants	• Gardening plants • Landscape plants • Ecological greening plants • Ornamental plants • Habitat conservation plants	• Native plants • Potential vegetation cover (local seed seedlings) • Habitat revegetation plants	• Afforestation tree species • Economic forest tree species • Ecological greening plants
Applicable locations	• Green buffer strip • Earth and sand disaster area • Should be conserved area • Artificially developed area	• Park • Garden landscaping • Urban green space • Road green space • Vegetation buffering zone	• Natural park • Primeval forest • Protection forest • Conservation area	• Compartment land • Coastal forest • Protection forest • Buffering forest belt

Basic Types of Vegetation Engineering Design Objectives

Comparison of basic design types of vegetation engineering
(Source: Soil and Water Conservation Handbook, 2005)(Continued)

Transplanting and management	• Small quantity plant maintenance and management • Fast-growing plant seeding • Broadcasting, hydroseeding or seedling transplanting	• Plant competition control • Tree seedling transplanting • Mature tree transplanting • Clustering transplanting • Limiting harmful organisms	• Natural competition of plants • Natural plant succession • Human-assisted management	• Hazardous plant control (weeding, vine removal) • Small tree seedling transplanting • Long-term care management
Purpose and efficacy	• Vegetation covering • Soil erosion control • Sideslope stabilization • Rapid forest	• Landscaping and gardening • Environmental greening beautification • Artificial landscape beauty • Health care and self-cultivation • Atmospheric purification (urban forest)	• Habitat conservation • Soil and water conservation • Atmospheric purification (green resource conservation) • Natural beauty (primeval forest form)	• Wood production • Natural artificial beauty (economic forest form) • Forest recreation • Atmospheric purification • Carbon accumulation



Vegetation engineering plan flowchart

Site Conditions and Corresponding Strategies of Vegetation Engineering

Plant growth is affected by the surrounding environmental conditions, including as follows:

- climatic factors

  (sunlight, atmospheric temperature, rainfall, strong winds, etc.),

- soil factors

  (effective soil depth, physical properties of soil chemical properties of soil)

- terrain and geology

  (gradient), etc.

Site Conditions and Corresponding Strategies of Vegetation Engineering

◆ **climatic factors**

A. Sunlight

Plants need plenty of sunlight to thrive, under strong light conditions the plants robustly growing and developed are called sun plants. Sun plants usually have the ability to withstand high temperature and drought, and they have the pioneer plant characteristics that are fast grow in early period and can firstly develop on exposed ground and survive.

B. Atmospheric temperature

The atmospheric temperature is affected by latitude, altitude, wind and terrain and topography, but when the latitude is similar, the altitude is an important factor affecting atmospheric temperature.

Site Conditions and Corresponding Strategies of Vegetation Engineering

◆ **climatic factors (Continued)**

C. Rainfall

Due to the interaction of monsoon and topographic factors, Taiwan has abundant rainfall. The average annual rainfall is about 2500 mm, but the rainfall is unevenly distributed. In the absence of rainfall, vegetation must choose drought-tolerant plants, otherwise plants will be stunted or die due to lack of water.

D. Wind

Drying effect: Moisture can be blown away from the surface of plant leaves, promoting evapotranspiration, which can lead to dry leaves and closed stomata, reducing the effectiveness of photosynthesis.

Mechanical effect: Plants would have the situations such as ruptured leaves, broken branches and causing flag and compression wood if they were blown and attacked by strong winds. Shallow rooted trees are easy to fall or incline because of the effect of wind.

Site Conditions and Corresponding Strategies of Vegetation Engineering

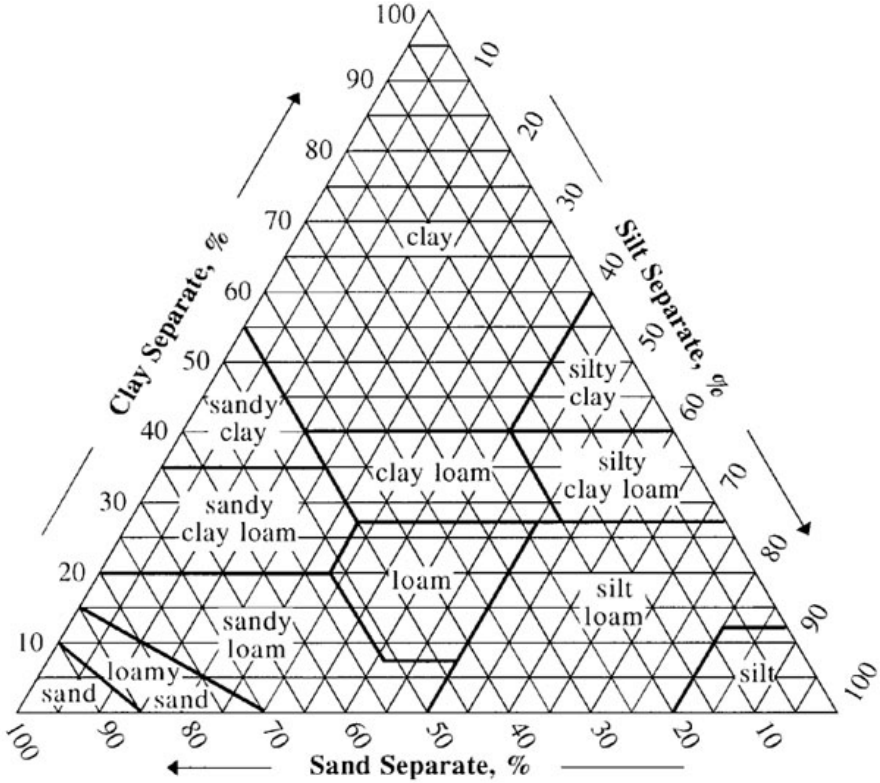
◆ Soil texture

In addition to affecting the maintenance and supply of nutrients and water, soil's physical properties also affect the development and distribution of system roots and the activities of microorganisms. When soil is in the natural state, its physical properties are very important to plant growth and soil fertility, in addition, the permeability rate and water preservation of the water conserved in the forest are also affected by the physical properties of the soil.

Site Conditions and Corresponding Strategies of Vegetation Engineering

There are several soil physical properties that affect plant growth.

A. Soil stone content
B. Soil hardness
C. Combination of three phases of soil
D. Soil texture



soil texture triangle

◆ Soil chemical properties

- The chemical components of the nutrients required for plant growth in the soil include content, proportion, and properties, these are collectively referred to as chemical properties of soil. To maintain good plant breeding, needs the fertilizer three elements nitrogen, phosphorus, and potassium, coupling with calcium, and magnesium, the total five elements are most important.
- The availability of the contents of these elements in the soil is comprehensively affected by soil reaction, water, and proportions of the amount of each element, therefore, when determining whether the plant nutrients are rich or not, must be evaluated from the overall chemical properties composition of the soil.

◆ Soil chemical properties (Continued)

➢ Soil pH value

The soil solution often contains H+ and OH- ions, and the content of the two varies depending on soil type, which makes the soil acidic, neutral and alkaline, and is usually expressed by pH value. The large or small of pH value is related to whether nutrients can be absorbed and utilized by plants. Too high or too low pH value may cause toxicity caused by certain nutrients. In general plants prefer to grow in the soil environment with a pH value of about 6.5.

◆ Soil chemical properties (Continued)

➢ Soil nutrients

Deficiency or excess of soil nutrients will affect plant's growth, which may occur in the symptoms are described as follows:

- ✓ **Nitrogen fertilizer:** When it is lacking, the leaves will become a unclear yellow to green; when excessive, the leaves will be in dark green, the leaves will be juicy and soft, and the flowers will be delayed and fruits will be less.
- ✓ **Phosphate fertilizer:** When it is lacking, the cell division is declining, the plant is poorly developed, the leaves are narrow, and the old leaves appear red; when excessive, leaf flesh is thick and the trunk is short, the root grows poorly, fruit is excessively mature and yield reduces.
- ✓ **Potassium fertilizer:** When it is lacking, the planting stock is short, the tip of the leaf is brown, and in severe cases, gangrene is produced; when it is excessive, the new leaves tend to become larger and the planting stock is elongated and the growth energy is weak.

Base Site Conditions and Vegetation Engineering Treatment

1. Side slope gradient

Required coordinating engineering treatments when conducting vegetation on different gradients (Source: modified from Yoshinari Yamadera, 1988)

Gradient	Vegetation growth situation	Coordinating engineering treatment
Below 35°	1. Plants grow well. 2. Plants naturally invade and generally grow well. 3. May restore to arbor-based plant society.	1. Mainly based on drainage and slope treatment measures. 2. Can apply vegetation treatments such as turf pavement, vegetation sheet pavement, hydroseeding, etc. 3. Carry out vegetation treatment after simple foundation works of trench diggings and slope drainage

Base Site Conditions and Vegetation Engineering Treatment

Gradient	Vegetation growth situation	Coordinating engineering treatment
35°~45°	1. The main plant communities are shrubs and herbs. 2. Transplanting arbor is dangerous and easy to incur the instability of the breeding base. 3. If the gradient exceeds 35°, the plants' naturally invasion and breeding are slower.	1. Vegetation after simple basic engineering treatment. 2. Retaining wall, retaining fence, staking and wattling, wire cylinder slope protection, digging planting pits, etc. 3. Net paving and hydroseeding, shaping frame, etc.
45°~60°	1. The main plant communities are shrubs and herbs. 2. 45°~50° is the critical gradient of planting arbor. 3. Slope stability is difficult, and the terrace surface of the whole slope is coordinated with transplanting plants.	1. Fixing frame, retaining wall. 2. Laying 3D net, composite net coordinated with guest soil hydroseeding.
More than 60°	It is not easy to transplant plants or natural invasion and growth are difficult.	1. Retaining wall, free beam frame. 2. Setting buffering belt or rockfall prevention measures.

2. Soil hardness

The measured value of Yamanak a hardness tester is usually used as standard of indicator of soil hardness. The Yamanaka hardness tester has a length of 23cm, a diameter of 5cm and a weight of 0.65kg. When inserting the tip of the cone into the soil, then the retraction length of the spring contained inside, which is of 8kg resistance strength, is the measured value of the soil hardness tester.

The Yamanaka hardness tester

Base Site Conditions and Vegetation Engineering Treatment

Principles of vegetation engineering treatment methods for different soil hardness

Soil hardness measurement value (H)	Plant breeding situation	Coordinated with vegetation engineering
H<10mm	1. The soil is soft and dry, the water preserving ability of the soil is poor, and the plants germinate and grow poorly. 2. When the slope is not treated or is larger than the resting angle, it is easy to fall.	1. Measures for preventing drying such as covering with straw mats. 2. Fixing frame and guest soil vegetation. 3. Covering with straw mats after seed spraying.
10~20mm	1. The roots stretch well. 2. Seed germination and growth are good.	1. Woody plants can be planted. 2. Vegetation methods such as hydroseeding method, vegetation sheet, soil bag, net paving and guest soil hydroseeding can be used.

Base Site Conditions and Vegetation Engineering Treatment

Soil hardness measurement value (H)	Plant breeding situation	Coordinated with vegetation engineering
20~26mm	1. The plants grow well. 2. There may be a rapid decline in the hydroseeding of exotic grass species.	1. Woody plants can be planted, but the design of pit planting and guest soil volume are still needed to be strengthened. 2. Can be coordinated with the seeding practice of applying middle layer materials.
26~30mm	1. Root growth is blocked or may decline rapidly. 2. If the soil has big hole spaces , the growth of plant roots is still possible.	1. Improving soil hardness by drilling holes or digging trenches. 2. Avoiding the use of the vegetation methods such as transplanting, seed broadcasting and stem burying. 3. Better to use seed spraying after 4. drilling holes, or paving vegetation sheet, laying ne t and guest soil hydroseeding, fixing frame and guest soil vegetation and the like after thickening guest soil.

Base Site Conditions and Vegetation Engineering Treatment

Soil hardness measurement value (H)	Plant breeding situation	Coordinated with vegetation engineering
H> 30mm	1. The plant root system is unable to invade and grow. 2. Breeding is difficult.	1. Guest soil hydroseeding after drilling holes. 2. Wire cylinder coordinated with guest soil, shaping frame guest soil vegetation.

Guest Soil

Definition

Guest soils refer to the soils containing rich organic matters and better physicochemical properties casted in construction site in order to **improve** soil conditions of vegetation environment and facilitate growth of introduced plants. The natures of guest soil materials are usually different from those of the original soil of the slope, and after improving original ground topsoil or adding organic materials, and then casting on surface as vegetation base materials, the soil properties is different from the original surface soil, this also belongs to the operational method of guest soil.

Guest Soil

Applications

In exposed area of large area slope development, slope of road cutting and filling, mudstone area or mining area, because of its innate site and soil conditions are poor, causing considerable difficulties in plant growth; in addition, seedling pit planting site or vegetation engineering construction site which needs fast growth of dense turf, also needs guest soil treatment in order to reach expected results of vegetation.

Mudstone area

Mining area

Thanks for your attention.