Study on type selection of greening plants for the protection of Yongsan Road slope

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Abstract. This paper discusses the action mechanism of plant in slope protection, analyzes the failure characteristics of different slopes in Yongsan Road and the capacity requirements of slope protection by plants, selects the commonly used and applicable plants in local and Guangxi areas, and recommends many plant types for slope protection according to the characteristics of slopes and plants.

1. Introduction
S302 Yongfu (Guangfu) to Sanhuang Highway (hereinafter referred to as Yongsan Road) is an important part of "Horizontal Line 4" (Fuli)- Tian'e (Xialao) in Guangxi Provincial Highway Network Planning (2011-2030), with a total length of 58.823 km. It is of great significance for improving the regional road network structure and comprehensive transportation system, for improving the regional ordinary highway operation capacity and the overall service level of the road network, and for promoting economic and social development along the line. The highway project is located in a complex location with various topography. Two-thirds of the whole line is laid along the Luoqing River and Dabang River. The types of landform in the route corridor mainly include denuded low mountain landform, river landform, dissolved peak forest landform and dissolved plain micro hill landform, with developed chicken-claw ridge and dense mountain forest. The formation lithology along the line is complex, mainly distributed in sandstones of the Devonian and Cambrian sandstones, sandy mudstones and mudstone interbeds. Mudstone and shale which have poor weathering resistance are prone to water erosion and soil erosion, and are liable to cause geological disasters such as shallow landslides or collapses. Therefore, the problems of slope protection, and soil and water conservation are much more prominent. Due to investment control, masonry protection cannot be adopted on a large scale. Because the cost of plant protection and greening is relatively low, it is urgent and of important significance to select suitable plant types for slope protection according to different slope protection requirements to ensure slope stability and operation safety.

2. Discussion on the action Mechanism of Plants in Slope Protection
Planting different plants on various slopes can change the slope landscape, and beautify the environment. More importantly, it plays an effective role in the slope protection. Plants have many protection effects on the slope, such as mechanical anchoring effect, hydrological effect and ecological effect, which are elaborated as follows:
2.1. Anchoring Effect of Vegetation

2.1.1. Anchoring of Deep Roots. The vertical roots of the plant which cross through the loose weathered layer in the shallow layer of the slope body anchor themselves into the more stable rock and soil layer, providing an anchoring effect. Grass, leguminous plants and small shrubs have obvious soil strengthening effects at the depths of 0.75-1.5m underground. The anchoring effect of tree roots can affect deeper geotechnical layers. Tests have shown that the finer the diameter of the roots, the higher its tensile strength. The roots with a diameter of 2-5 mm have a tensile strength of 8-80 MPa.

2.1.2. Reinforcement effect of Shallow Roots. The root system is intertwined in the matrix and the soil, so that the matrix and the soil become a composite material of soil and grass root within its extension range, and the grass root can be regarded as a three-dimensional reinforced material.

2.2. Hydrological Effects of Plants

2.2.1. Reducing Pore Water Pressure of Slope. Rainfall is one of the important factors inducing slope instability. By absorbing and transpiring of the water in the slope body, plants can reduce the pore water pressure of the soil, increase the cohesion of the upper body, improve the shear strength of the soil, and contribute to the stability of the slope body.

2.2.2. Rainfall Interception, Splash Erosion Weakening. Some of the rainfall is intercepted before it reaches the slope and then re-evaporates to the atmosphere or falls to the slope. When the falling raindrop hits the slope surface directly, the kinetic energy is transmitted to the soil, and the splitting force is generated to separate and splash the soil particles. During the splashing process, the greater the kinetic energy of raindrops, the greater the impact splitting force, and the greater number of soil particles that were hit. Vegetation can intercept high-speed falling raindrops, dispersing raindrops, and reduce splashing energy and splashing soil particles.

2.2.3. Controlling Soil Particles Loss. The surface runoff takes away the soil particles that have been separated by splashing, which may further cause area erosion and gully erosion. Plants can inhibit surface runoff and weaken raindrop splash erosion, thereby controlling soil particles loss. In general, the amount of soil loss decreases sharply with the increase of vegetation coverage.

2.3. Ecological Function of Plant Root System.

The functions of interspersion, squeezing, division, network and cementation of the decomposition products secreted by the developed, dense root system in various soil micro-soils can help to prevent weathering and peeling of slopes. In addition, during the decomposing process of plant roots, carbon, nitrogen and other biological nutrients are added to the soil microbes, which leads to the mass reproduction of various soil microbes and contributes to the restoration of the slope ecological environment, thus leading to a virtuous cycle.

Different plants have different protection effects on slope surface. The slope protection effect of the herbaceous plants is mainly to enhance the erosion resistance of the slope surface; that of woody plants is more significant. The roots of woody plants can be divided into three types according to their morphological characteristics: main straight root type, scattered root type and horizontal root type.

The main straight root type and the scattered root type can be collectively referred to as a vertical root type. The main root of the vertical root woody plant can penetrate into the deep layer of the soil. The root system is connected with the surrounding rock and soil body by the friction between the main root and the lateral root and the surrounding soil. Combined with the characteristics of the vertical root system, the root system can be simplified into a full-length bonded anchor rods with the main root as axial rods and the lateral root as a branch rods to analyze its mechanical effect on the surrounding soil body. Such woody plants have significant reinforcement effects on the slope.
The horizontal root type is composed of fixed roots extending in the horizontal direction and a plurality of chain-like fine root groups. Its main roots are not developed, while its lateral roots or adventitious roots are relatively developed, which extend around with the length far exceeding that of the main roots. The roots are mostly distributed in the surface layer of the soil. Because the main root of the horizontal root woody plant is not deeply plunged into the slope, so the slope protection effect of this type of woody plant is mainly to enhance the erosion resistance of the slope, and its slope stabilization effect is not significant.

3. Requirements for Plant Protection of Yongsan Road Slope

3.1. Yongsan Soil Slope
The slopes is mainly composed of cohesive soil, mixed weathered macadam cohesive soil and fully weathered layer. The failure of the slopes is mainly due to the large pores and loose rock and soil structure. Under the influence of strong precipitation infiltration, the rock is prone to disintegration, resulting in soil erosion, and then developed into collapse, landslide. For such slopes, in addition to reducing the grade of the slope to make it in a state of self-stability, it is necessary to enhance the waterproof function of the slope surface and anchor it with plant roots, which requires the selected plants to have fast growth speed, strong growth ability, developed and vertically developed roots, strong soil-fixing ability and strong self-reproduction and replication ability.

3.2. Clastic Rock Slope
This kind of slope is composed of strong weathered siltstone and mudstone with soft rock quality, and generally has good self-stability. When the attitude of rock formation and the slope form a bedding relationship, bedding landslide occurs locally. In addition to reducing the grade of the slope and preventing the occurrence of "hanging feet" in the bedding layer to cause landslide, it is necessary to stabilize the slopes of joint development. The species to be selected for this type of slope greening needs to have the characteristics of fast growth speed, strong growth ability, drought resistance, developed root system, the ability that the root system develops horizontally to hold the clastic, and the ability to self-reproduce and replicate.

3.3. Semi-hard rock and mixed slope of semi-hard rock and soil
The upper part of the slope is cohesive soil and crucible cohesive soil, the thickness generally ranging from 1 to 8 meters with large variations. The following are mostly thin-powder siltstones and argillaceous siltstones between strongly weathered sandstones. Such slope damage often occurs as a small slump formed by the soil along the interface of the earth and rock, or a wedge-shaped damage formed along the fracture block along the cutting structure surface. Since the bottom base rock layer is relatively stable, the upper slope is mainly treated by reducing its grade. The plants selected for the upper slope are treated according to the soil slope. The lower slope mainly uses flower shrubs with fast growth rate, strong growth ability, drought resistance, strong climbing ability and many branches, in order to prevent the falling of small stones and to beautify the slopes.

3.4. Rock Slope
The slope is stable, and the selected plants is flower shrubs with fast growth speed, strong growth ability, drought resistance, strong climbing ability and many branches, in order to prevent the falling of small stones and also to beautify the slope.

3.5. Side Slope of Highway Supporting Project along River
There are a large number of retaining walls along the river section of Yongsan Road, and the river flows rapidly in rainy season with a large amount of water and a fast flow rate. The soil slope on the outer side of the retaining wall is loose, with large pores and poor erosion resistance. The species
selected for actual greening need to have high vegetation coverage, fast growth speed, strong growth ability, strong and developed root neck and strong self-reproduction and reproduction ability.

3.6. Adaptability Requirements with Natural Plants
The vegetation along the line is dense and lush. The original design of trees and shrubs has a high degree of color consistency with the environmental vegetation, which is easy to produce driving fatigue and the indication of the route is not clear. It is necessary to have a certain color difference in the road tree landscape. The selected species needs to have a height of crown diameter, a moderate width, a large corolla and a long flowering period with lively and bright colors.

4. Recommended Plants

4.1. Local Common Plant Species Along the Highway

4.1.1. Grass. Pasture, thatch, and sticktight.

4.1.2. Vines. Polygonum perfoliatum, boston ivy, and clematis.

4.1.3. Bamboo. Bitter bamboo.

4.1.4. Arbor. Willow, mulberry, paper-mulberry, jujube trees.

4.1.5. Shrubs. Triangle plum, Myrtle.

4.1.6. Land. Roadside chrysanthemum, Che Qiancao, cantella asiatica, dandelion.

4.2. Common Plant Types in Guangxi Local Highway Construction and Rock Desertification Control

4.2.1. Arbor. Paper mulberry, mulberry, sweet gum, bauhinia, Bean tree, idesia, Taiwan Acacia, Leucaena glauca, Choerospondias axillaris, Chinese toon, and Populus adenopoda.

4.2.2. Shrubs. Chinese wistaria, Cassia, Mountain Jute, Crotalaria, Pigeon pea, Cattail Bean, Gray Soybean, Vitex, Mountain Scallop, Wild Peony.

4.2.3. Ground Cover. Green box, clover, tuber fern, alfalfa, mantle, paved scorpion, collateral.

4.2.4. Herbs. Bamboo reed, Phyllostachys pubescens, bermuda grass, elephant grass, miscanthus floridulus grass, sugar dense grass, wide leaf gar.

4.2.5. Bamboo. Support bamboo, bitter bamboo, hanging silk ball bamboo, Guangning bamboo, sweet bamboo, Tang bamboo, Lei bamboo.

4.2.6. Vine. Boston ivy, mucuna, caulis spatholobi, dragon stalk, three-leaved leaf, morning glory, winter jasmine. Consultation: Agriculture Bureau, Landscape Bureau, Forestry Bureau, Supply and Marketing Cooperative, Garden Supplier.

4.3. Common Plant Species in the Garden Seedling Market

4.3.1. Arbor. Mountain ebony, Chinese toon, paper mulberry, mulberry, (camphor, weeping willow).

4.3.2. Shrubs. Lagerstroemia, wild peony, cassia seed, crotalaria, pigeon bean, (brown bamboo, red flower, Thai cherry), jaundice.
4.3.3. Grass. Bermuda grass, bamboo reed, sugar dense grass, broad-leaved gar (less).

4.3.4. Ground Cover Plant. Tubefern, trachelospermum jasminoides (honeysuckle), (red iron, mountain tube orchid, ophiopogon japonicus).

4.3.5. Bamboo. Bitter bamboo, sweet bamboo, Leizhu, (Gangzhu, gold silk bamboo).

4.3.6. Liane. Boston ivy, winter jasmine, (Ivy, safflower bougainvillea, purple red bougainvillea).

5. Selection of plant species for plant protection and greening on Yongsan Road slope

5.1. Slopes of Earth-filled Embankment
Slopes of earth-filled embankment can choose grasses, thatch grasses and bidens species with developed roots and strong growth and reproduction ability. Pasture and thatch are planned to be planted by nearby transplanted plum-shaped cuttings, grass seedlings, and bidens can be collected and sown nearby.

5.2. Cutting Slope

5.2.1. Soil Slope. Species such as thatched grass, pasture, bidens, and cogon grass with developed root system and strong growth and reproduction ability can be use together. In steep slope areas, grooves should be cut on the slope with a groove spacing and a plant spacing of 50cm. The groove surfaces should be inclined inward to ensure that the water and soil needed for later plant growth are not washed away by rain. At the foot of the slope, weeds with particularly developed roots can be planted.

5.2.2. Clastic Rock Slope. It can choose paper mulberry, mulberry, and also single or multiple roots of vines such as polygonum perfoliatum, boston ivy, and clematis. The roots of paper mulberry and mulberry are tiger-claw-like, with a certain grip on the stone chips, and drought resistance and strong growth ability.

5.2.3. Semi-hard rock and mixed slope of semi-hard rock and soil. The upper soil cover can be planted with pasture and thatch species to strengthen the soil; for the lower strong weathered slope, the thatch, paper mulberry, and bidens species can be planted, and the slope with grooved construction can be constructed with the technology of inwardly grooved soil attachment. For the rock slope without groove, the construction technology of pit planting soil attachment can be adopted, with the spacing of 50 cm crossing plum blossom, planting paper mulberry and thatch species. At the foot of the slope, a single or multiple species of vines such as polygonum perfoliatum, boston ivy, and clematis can be selected.

5.2.4. Rock Slope. Ivy, safflower bougainvillea, purple bougainvillea can be chosen. It is also possible to plant trees in small pits. The bougainvillea has a long flowering period, strong climbing ability and fast growth speed.

5.3. Outside the Retaining Wall of Linhe Road Section
Pasture, thatch, bidens and the hairy roots with developed root system and strong growth and reproduction ability to protect the slope surface. While bitter bamboo (clumped non-single bamboo), pasture, thatched grass and willow (weeping willow) with developed root system, strong growth and reproduction ability and strong self-healing ability can be selected. Bitter bamboo, willow, pasture and thatch are planned to be planted with plum-shaped cuttings nearby, and bidens can be collected and sown nearby.
5.4. Road Tree
Bauhinia, camphor tree, cassia surattensis and willow can be chosen. Bauhinia and cassia surattensis have a long flowering period and grow rapidly, forming a strong color difference with the surrounding environment. The weeping willow is mainly planted along the river section to increase the scenery along the riverside.

5.5. Crushing Platform
Murraya paniculata, fusang, oleander, bougainvillea and myrtle can be selected for the crushing platform. At the bottom of the shrub, Plantain herb, roadside chrysanthemum and centella and other plants species with strong growth ability and resistance to invasion can be selected to prevent the invasion of tall grass plants on the upper slope, and Plantain herb, roadside chrysanthemum and centella grow on the ground, which has great advantages in preventing the blockage of ditches.

6. Conclusion
By the analytical study of the variety of slope protection and compaction, the requirement of afforestation and the regular supply of flowers and seedlings in Yongsan Road, presented in this article were the suitable plants for Yongsan Road. Practice has proved that these plants possessed preferable functions of slope protection and compaction, and were qualified with better economical efficiency and lower cost at the same time, compared with masonry protection. It has a great popularization and application value in the cost controlled secondary road projects.

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