

Mountain Highway Design Based on New Green Design Concepts

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Abstract: This article analyzes the implementation of new environmentally friendly design practices in the construction of mountain highways. It covers topics such as green highway design concepts, alignment principles, and green practices specifically for mountainous highway design. This analysis aims to provide useful insights for creating green mountain highways that meet the demands of modern times.

Keywords: Mountainous areas; Highways; Green design concepts

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1. Introduction

Mountainous highway projects are challenging due to the complex environmental conditions and diverse ecosystem of mountains. Therefore, extra caution is needed to minimize the damage to the environment.

2. Green highway design concept and route selection principles

2.1. Green highway design concept

The green highway design concept is to ensure the highway application functions as a premise and minimizes the adverse impact of highway construction and operation on the natural environment along the route to improve the ecological and environmental protection performance of the overall highway project^[1]. Design concepts that are currently adopted in green highway projects, the main include the following aspects: (1) adopting technologies, equipment, and systems that minimize emissions and are energy-saving; (2) minimizing the consumption of resources such as land and materials, (3) minimizing the adverse impact of highway engineering construction on the surrounding biodiversity^[2]; (4) reducing noise generated by the construction of the highway.

2.2. Green highway route selection

2.2.1. Avoiding ecological red lines

For mountainous highways, designers should pay special attention to the reasonable avoidance of ecological

protection red lines in the specific design. The overall construction plan should be reasonably formulated based on the condition of the site and with environmental protection in mind. The route for the mountain roads should be rationally designed to avoid ecological red lines ^[3]. Bridges within the ecological protection red line can be designed as box girders and tunnels outside the ecological red line can be designed as underground tunnels. In this way, the reserve areas within the mountainous highway project can be well-protected.

2.2.2. Protecting land resources

The highway route that occupies the least land resources should be selected. The topography and other characteristics of the area where the project is located should be fully considered during the design stage. By doing so the land resources occupied by the project can be reduced ^[4]. For example, when selecting a tunnel route, designers should try to minimize its damage to the mountain's structure; when selecting a bridge route, they should avoid occupying farmland resources. In this way, the rational utilization and protection of land resources can be achieved, and the goal of green highway design can be fulfilled to the greatest extent.

2.2.3. Fulfilling local demands

Because mountainous highways mainly serve the locals, so designers should take the locals' needs into account when designing specific routes. The local's opinions can be understood by conducting surveys on the residents along the project line. Through soliciting opinions and suggestions for highway project management, combined with the local conditions, the mountainous highway's selection plan can be optimized. This can further improve the satisfaction of the locals and create favorable conditions for subsequent green construction of highways in mountainous areas ^[5].

3. Green design in mountainous highway design

3.1. Route selection and planning

3.1.1. Minimizing intervention on natural terrain

The natural terrain along the highway will be affected to a certain extent during the construction and operation of mountain highways. To minimize their impact on the natural terrain, designers should take the following measures: (1) Highways should be built in areas with gentler terrain and areas with larger slopes should be avoided; if the terrain in the construction area is very complex, locations with steep slopes and ridges should be avoided minimize the modification of the natural terrain. (2) Highways should be constructed in areas with small undulations to avoid "bottleneck" terrain, especially tunnels and bridges; they should be built at the foot of slopes to avoid interfering with the natural terrain. (3) Designers should pay attention to minimizing the amount of mountain excavation and filling in the highway construction area to minimize the impact on the natural terrain ^[6].

3.1.2. Utilizing the terrain's advantages for route planning to reduce cutting and filling

The overall construction effect of mountain highways is usually tied to the mountain's topography. Therefore, when planning their routes, designers should try to make full use of the terrain. Designers must consider the coordination between highways and the natural environment to avoid over-cutting and over-filling. They should maintain the coordination between the highway and its surrounding environment to avoid damaging the environment ^[7]. For example, when planning such routes, designers should try to avoid areas with good natural landscapes and plan the amount of cutting and filling properly. During this process, designers also need to cooperate with the local environmental protection department to formulate subsequent ecological environment

restoration plans.

3.2. Drainage and flood control system

3.2.1. Ecological drainage system

The ecosystem and ecological environment in areas along mountainous highways are usually relatively fragile. Therefore, a reasonable ecological drainage system should be built to save water resources in the area. There are usually many passages and culverts along the highway in mountainous areas with relatively complex terrain. The surrounding environment will be greatly affected if these passages and culverts are not effectively treated^[8]. Hence the ecological drainage systems in such areas should be set up in a way that isolates these channels and culverts. Filter ditches can also be built in the drainage system to collect and filter rainwater. Another option would be to build water treatment systems in wetlands to improve water quality and utilization. In addition, vegetation drainage layers can also be designed at the slopes.

3.2.2. Rainwater collection and reuse

The reuse of rainwater is crucial in mountainous areas. Therefore, when designing such highway projects, designers must fully consider issues like rainwater collection and utilization. Rainwater collection tanks should be installed at roadbeds, tunnels, bridges, etc. based on the site conditions, and the rainwater collected can be used for greening or farmland irrigation and road cleaning. It can also be used to improve the water quality of nearby rivers^[9]. When designing a rainwater collection tank, it is important to minimize the damage to the existing vegetation and the surrounding environment. This can be achieved by setting up a buffer layer of appropriate thickness to avoid environmental pollution and problems such as water and soil erosion.

3.3. Tunnel and bridge design

3.3.1. Tunnel entrance design based on the surrounding environment

To prevent significant changes or migrations of natural terrain caused by tunnel entrance construction, the shape and size of the tunnel entrance should be designed based on the site conditions and the structural characteristics of other surrounding buildings. Besides, the resources in the construction area should be utilized to reduce the impact on the surrounding ecological environment. Furthermore, the tunnel entrance should be kept away from ecologically sensitive areas. A protection plan should be developed for its surrounding environment to meet the needs of the tunnel entrance while preserving the surrounding environment as much as possible.

3.3.2. Application of green bridge materials and ecological compact bridge structures

Using green materials and compact ecological structural design are important elements of modern highway bridge design. When working on mountainous highways, designers strive to achieve green design. Green bridge materials such as concrete precast hollow slabs should be used instead of traditional concrete materials. Precast hollow slabs reduce the amount of materials needed, accelerate the construction process, and extend the bridge's service life. Traditional bridge structures should also be replaced with standardized prefabricated bridge structures to make the overall structure more compact and ecological. Ecological vegetation should also be adopted to create compact bridge structures. These green design requirements ensure that the surrounding environment is well-protected.

3.4. Anti-noise design

3.4.1. Sound barriers at road edges

Reducing noise pollution during the operation of the highway is crucial. Edge sound barriers can be created to

isolate noise to reduce noise pollution. The sound barrier should be set up 20 meters away from the highway guardrail. Sound barriers can also be built 10 meters away from the highway guardrail to absorb the noise from the vehicles ^[10]. Care should be taken to not obstruct the driver's vision when selecting the height of the sound barriers. By doing so, noise pollution of mountainous highways can be effectively reduced, achieving green design.

3.4.2. Pavement material selection to reduce noise

Pavement materials with noise-reduction properties can be used to further reduce noise pollution in mountainous areas. This will help to reduce friction noise between vehicle tires and the road surface. For reserves and residential areas along the highways, designers should choose low-noise pavement materials, such as low-noise asphalt mixed materials, double-layer concrete, and porous asphalt concrete. By doing so, the friction noise between the vehicles' tires and the road surface can be effectively reduced.

3.5. Recycling of old asphalt pavement materials

In modern highway engineering, with the continuous increase of traffic load, the service life of asphalt pavement is getting shorter and shorter. As asphalt and aggregates are used in large quantities and are non-renewable resources, they need to be recycled to avoid wastage. The milled asphalt mixture can be recycled when designing mountain highway projects, which can not only reduce the use of asphalt mixture resources but also avoid the discard of old pavement asphalt mixture. A reasonable recycling plan for the asphalt materials of the old pavement should be formulated. Then, combined with the actual technology and performance indicators of this type of engineering pavement, a reasonable screening ratio should be designed for the old asphalt mixture material so that it can fully meet the functional needs of the highway and it is compatible with new asphalt materials. However, the asphalt material of the old road surface cannot be reused directly due to the unique terrains of mountains. Therefore, they should be processed before being used in the project like mixing them with new asphalt materials or heating regeneration and excavation regeneration.

4. Conclusion

Green design concepts should be applied in designing highway projects in mountainous areas. Green design allows for minimum resource consumption and environmental damage. Ultimately, this promotes the sustainable development of highways in mountainous areas.

Disclosure statement

The authors declare no conflict of interest.

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