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Optimal Design of Mountain Expressway Based on Natural Environment Protection

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Abstract: Optimizing the design of mountain roads can improve the service life of highways, reduce the maintenance costs in the later period, and promote the economic development of mountain areas. Based on the actual situation and data analysis of mountain expressway lines, this paper summarizes the natural ecological environment conditions and topographic and geomorphic features involved in the geological survey report, and discusses and studies the highway design according to the natural environment characteristics along the line. On the premise of ensuring the safety and reliability of the project, the ecological scheme is adopted to apply the optimal design scheme of mountain expressway, Under the condition that the base is stable and the landscape along the line is not strongly affected, the high dam scheme can be selected by increasing the base compactness, reducing waste and waste utilization, so as to reduce the project cost.

1. Introduction

Mountain highway is an important part of transportation in China, and its design quality is related to whether the whole expressway project can be carried out orderly. In the process of highway route optimization in mountainous areas, it is necessary to fully consider the natural conditions on road capacity, traffic safety, economy and other factors [1, 2]. First, the best scheme should be determined according to the local terrain and geological conditions. Second, the traffic distribution characteristics and influencing factors along the road section should be analyzed. Finally, the best design scheme should be selected in combination with the requirements of relevant specifications and the construction drawing budget should be completed to ensure the scientific and effective operation and safe maintenance of the highway [3, 4].

Many scholars have studied the expressway. The research on expressway design theory in foreign countries is earlier than that in China. Highway safety evaluation methods are mainly based

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on probability theory and mathematical statistics. Some scholars analyze the factors affecting traffic volume in mountainous areas from different perspectives [5, 6]. Britain, the United States and other developed countries have some research results in the distribution of traffic accidents on highways and the causes of accidents. These experts put forward the problems in road engineering and proposed solutions. However, the theoretical research of expressway design in China started late and did not form a complete system, which led to incomplete road safety evaluation indicators and could not meet the requirements of expressway driving environment [7, 8]. Therefore, based on the natural environment protection, this paper optimizes the design of mountain expressway.

With the rapid development of China's economy, mountain roads play an increasingly important role in transportation, which has caused great damage to the regional ecological environment. This paper analyzes the optimization design methods and related theories of expressway from the perspective of natural environment protection. First, the paper introduces the current situation of natural environment protection, then expounds the selection principles and influencing factors of highway route schemes of Class I, Class II and above mountain rocks, finally, studies and evaluates the geological and geomorphic characteristics, and puts forward new ideas for the development of rational and effective utilization of mountain resources, which provides a reference for the scientific planning of mountain highways.

2. Discussion on Optimal Design of Mountain Expressway Based on Natural Environment Protection

2.1. Development of Mountainous Expressway

Mountainous expressway is an important part of transportation in our country. whether its design and planning are reasonable or not is directly related to the smooth progress of highway transportation projects. At present, the mountain area is developing rapidly [9, 10]. Since the founding of the People's Republic of China, nine township (county, district) traffic routes have been built, and the "six vertical and four horizontal" mainly run through the western region with the provincial trunk line as the central line. During the "12th Five Year Plan" period, expressways were built between Sichuan and Chengdu New Huaxia, as well as Jiulian Expressway, a major thoroughfare of Chongqing trunk road and Sichuan Chongqing two lane expressways, forming a number of mountain road networks across the Southwest Ring Road. In recent years, with the continuous expansion of national highways and the increase of new line construction projects and the acceleration of driving speed, traffic congestion has been caused. At the same time, the increasingly serious environmental pollution around the highway and the reduction of the traffic rate of highway operating vehicles have slowed down the driving speed of the highway, resulting in an increasing frequency of traffic accidents. During the design and construction of expressway in mountainous areas, geological conditions, landform and other natural factors are greatly affected. At the same time, there are also some problems in tunnel construction. The surrounding environment of mountain roads is complex, because mountain roads and other special sections have caused great damage to the local ecological environment, and the vegetation on both sides of the road is less and the coverage rate is low. In addition, most of the places along the road are plain areas and hilly areas, most of which are relatively gentle areas, steep terrain and other terrain are dangerous or prone to landslide or collapse. Mountain expressway is an indispensable part of China's transportation system, which plays an important role in the development of the national economy, and also has a very significant impact on regional economic construction [11, 12]. There are many difficulties in the process of highway transportation due to the large topographic relief in mountainous areas and the limitations of natural conditions. Figure 1 shows the risk safety level structure of mountainous expressway.

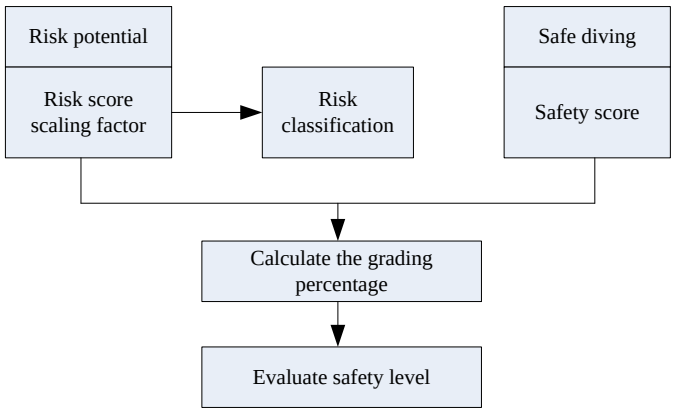

Figure 1. Mountain area expressway risk and safety grade structure

2.2. Natural Landscape Characteristics of Mountainous Expressway

The natural landscape along the highway refers to the artificial factors and engineering activities existing in the natural environment, including landform, hydrogeology, etc. The influence of these factors on the surrounding environment of the road shall be taken into account in the design of mountainous expressway. Mountains and hills, plains, and forest and grass vegetation will cause damage to a certain extent, while steep mountains are prone to landslides or collapses, resulting in threats to vehicle traffic on both sides of the road and even traffic accidents. When selecting the route, it is necessary to ensure that there are good natural environment characteristics and landscape characteristics along the highway. Figure 2 is the structure diagram of the natural landscape of mountain expressway.

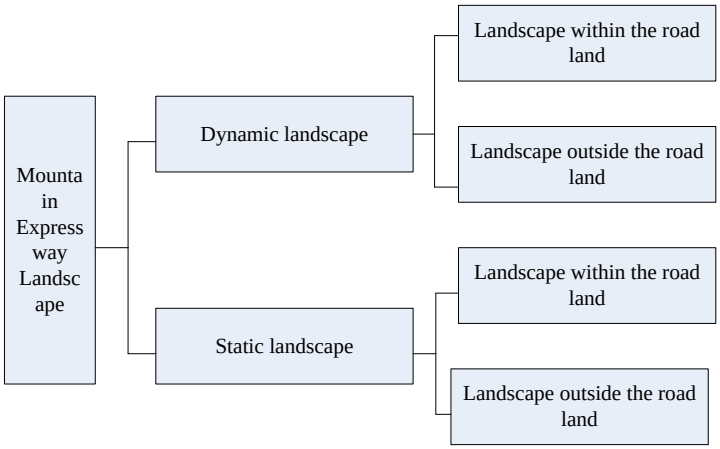

Figure 2. Highway landscape structure diagram

The characteristics of natural landscape of mountainous expressway are mainly shown in the following aspects:

(1) The traffic volume is large. From the aspect of road width, the expressway section in mountainous areas is mainly concentrated between steep slopes and cliffs, while high-grade roads account for a large proportion, which determines that the highway has low requirements for pavement structure. At the same time, due to significant topographic relief ratio, complex geological conditions and other reasons, the expressway has also caused certain potential safety problems, In addition, due to uneven terrain or abnormal groundwater level, it is very easy to cause traffic accidents and other traffic incidents [13, 14].

(2) The terrain is complex. As the mountain is high and the road is far, the terrain on both sides of the mountain highway needs to be considered in the construction process, so there are many highway lines. Correspondingly, the road sections with gentle terrain and beautiful natural scenery and steep and steep mountains will also be affected by natural environmental factors when designing highways.

(3) Strong regional characteristics. Because the mountain is high and the road is far, obstacles of different grades, lengths and heights are often set on both sides of the highway. When driving on the mountain expressway, the vehicle will cause damage to the driver under the action of large impact torque, and when encountering special road sections, it will also bring traffic accident hazards such as inappropriate driving conditions to a certain extent. Therefore, the expressway design should be reasonably arranged according to the specific terrain conditions to ensure driving safety and comfort [15, 16].

2.3. Expressway Optimization Algorithm

The optimization design of expressway is a complex process, which involves many factors, such as natural environment, construction conditions and traffic volume. Many problems need to be considered when analyzing and dealing with these influencing factors. Among them, the most important thing is to determine the optimal plan according to the natural ecological environment factors, tunnel structure characteristics and highway grade, and select the optimal design plan according to the functional requirements of the tunnel. In the design process of mountainous highways, the natural ecological environment needs to be considered to reduce the amount of highway construction and improve the investment efficiency. Therefore, it is necessary to realize the combination optimization of highway alignment and vertical horizontal alignment in mountainous areas, use the mountain terrain to determine the slope profile, and select appropriate construction methods and schemes based on the analysis of terrain, geology and other factors on the number of subgrade fill and excavation, soil type, hydrological conditions and climatic and environmental characteristics, and design in combination with the characteristics of the highway itself, On the premise of ensuring the quality and safety of highway engineering, we should reasonably arrange the relationship between various investment scales and structure proportions. Finally, we should determine a reasonable, feasible and cost-effective route plan in combination with the engineering geological conditions, the surrounding environment and the highway grade, so as to ensure that the expressway can be carried out in an orderly manner during the design process and achieve the expected goals [17, 18]. The roadside vibration belt can only be installed when the length of the section without lateral traffic flow interference is greater than a certain value. The minimum length without lateral traffic flow interference can be calculated according to the following formula:

$$L = \frac{1}{30} \bullet V \tag{1}$$

In the formula, L represents the minimum length of paved roadside vibration belt, km; Design speed of section V, km/h. The safety and risk of different sections of mountainous expressway are closely related. Through the analysis of the meaning of safety and risk, it can be seen that when other factors are constant, the safety of the system and the safety of the system are in the same direction, while the risk of the system is inversely proportional to the safety of the system. Therefore, the calculation formula for establishing the safety evaluation model is shown in Formula 2:

$$D_i = \frac{S_i}{R_i} \times 100\% \quad (2)$$

D safety level, S represents safety factor, R represents risk factor.

3. Experimental process of Optimal Design of Mountain Expressway Based on Natural Environment Protection

3.1. Optimal Design Model of Mountain Expressway Based on Natural Environment Protection

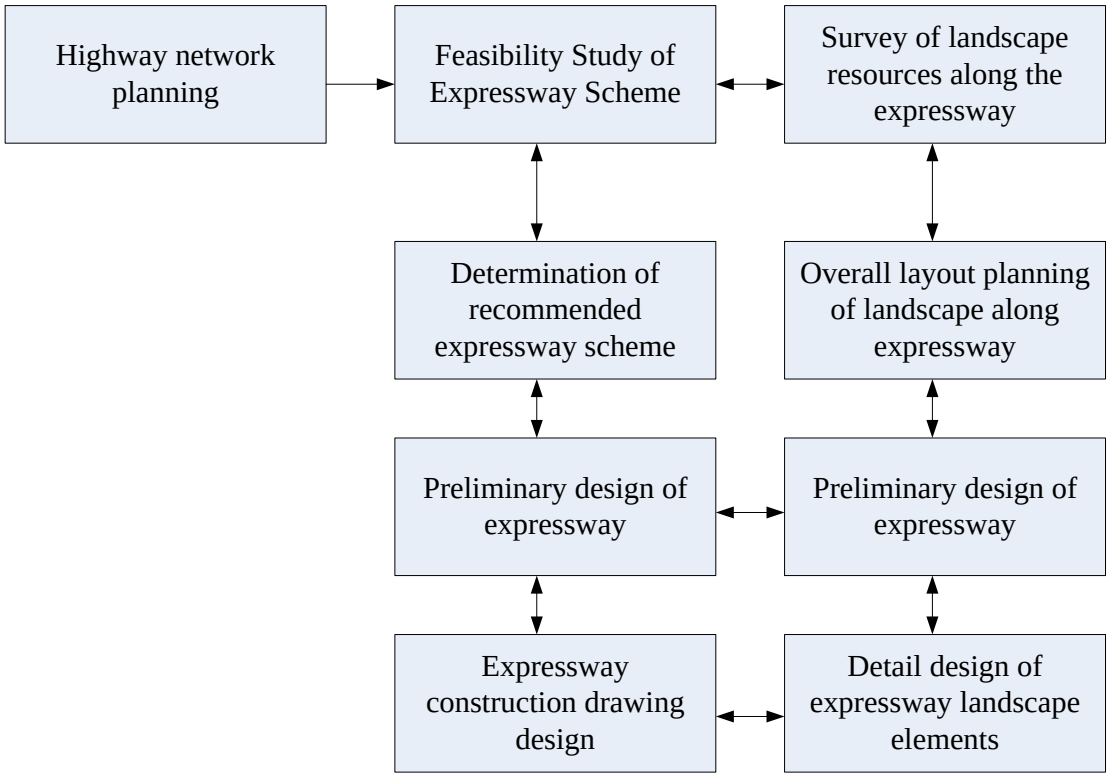

Figure 3. Highway design drawing

In the process of highway design, it is necessary to consider the impact of natural factors on the expressway, especially the tunnel construction and subgrade filling in mountainous areas. Due to geological conditions, landform and other reasons, tunnel excavation will produce a large number of slopes. Therefore, the line shape of mountainous expressway is complex. In order to avoid unnecessary losses caused by these phenomena and reduce the huge economic benefits and social and environmental impacts brought by the construction phase, it is one of the most important, necessary, feasible and effective ways to choose the optimal scheme. In the process of highway design, it is necessary to consider the problems existing in the impact of natural factors on the highway project. In the design of mountainous expressway, the flat section with subgrade as the main line is a tunnel in front of the mountain. The long points of the highway route are generally set between the slopes and cliffs on both sides of the road, outside the cross section and near the central separator. The width of the road is determined by about two to three meters. The elevation of both ends of the road is set according to the local terrain. One or two steps are set in the middle or on both sides (as shown in Figure 3), Its main function is to guide drivers to drive vehicles and ease the

conflict between mountain highways and the surrounding environment.

3.2. Functional Test of Optimal Design of Mountain Expressway Based on Natural Environment Protection

The test is mainly to evaluate the functions of mountainous expressway. Its functions include comparing the highway design indicators with the actual situation, determining the optimal design scheme through field investigation and data collection, and comprehensively analyzing the influencing factors in the selection of expressway route scheme. According to terrain conditions, hydrogeology, climate and environmental characteristics, etc. The length and traffic density of the road section shall be reasonably arranged according to the size of the works and the requirements of the construction period, and the construction difficulty of the project shall be evaluated to determine whether this road design standard is preferred. At the same time, the optimal design scheme shall be determined through actual investigation and data collection.

4. Experimental Analysis of Optimal Design of Mountain Expressway Based on Natural Environment Protection

4.1. Functional Test Analysis of Optimal Design of Mountain Expressway Based on Natural Environment Protection

Table 1 is the comparison table of speed scores for experimental design of mountainous expressway.

Table 1. Vehicle speed score comparison table

Risk score	Speed (unit: km/h)
0	<40
3	40-60
6	60-80
9	80-100
12	>100

Table 2 is the definition table of risk parameters for experimental design of mountain expressway.

Table 2. Risk parameter definition table

Risk parameters	Explain	Risk score value
Horizontal alignment	Radius of horizontal curve	0-6
Profile line shape	Longitudinal grade	0-8
Section length	Route length	0-5
Surface condition	Asphalt concrete, cement concrete	0-9
Section climate environment	Severe climate conditions	0-12

The function path data in the design optimization model of mountain expressway is shown in Table 1 and Table 2. The simulation mainly includes the following aspects: first, the mutual conversion relationship between different sections is considered when calculating the road network length; second, the number of vehicles to be driven under different speeds and traffic volume distribution and other relevant information are set on the simulated road, According to these data, the best traffic capacity and safety of expressway are obtained. It can be seen from these data that

the geological environment of highway construction in mountainous areas has been improved by optimizing the engineering design. At the same time, we also realize that the excavation of deep foundation pit has damaged the good vegetation in the original mountain area, and the road environment is rigid, which has brought inconvenience to the production and life of local people. Deep cutting is not the best solution. However, the construction of viaducts in deep valleys saves arable land, avoids environmental damage, and integrates roads with surrounding areas. On most mountain highways, the amount of garbage is greater than the amount of fill, which makes it difficult to balance the filling and excavation. Considering the factors such as garbage management, landfill and bridge head filling height control, when the amount of garbage along the line is large and it is difficult to choose the bag location, full consideration can be given to the high fill foundation and spoil ground. Under the condition that the base is stable and the landscape along the line is not strongly affected, the high dam scheme can be selected by increasing the base compactness, reducing waste and waste utilization, so as to reduce the project cost.

5. Conclusion

Mountain roads are an important part of China's transportation, and their driving safety will be greatly affected when the traffic volume is large and the transportation pressure is large. This paper analyzes the impact of the natural ecological environment on the tunnel construction. The research shows that the ups and downs of the mountains and the complex terrain in the area where the tunnel project crosses may cause difficulties for vehicles to pass. At the same time, due to geological conditions and climate and environmental factors, the subgrade slope is prone to landslide and cause traffic accidents. Therefore, the optimal design of mountain expressways is to solve these problems It is of great significance to ensure road safety.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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