Study on the Alignment Design of Secondary Highway in Southeast Area ——Taking Luqian to Baoshupo as an Example

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Abstract. This design is designed for the second-class highway from Luqian to Baoshupo, which is located around Xianyou County, Fujian Province. The design scheme will reduce the traffic pressure of the existing highway to a certain extent, and divert part of the traffic flow to the route, greatly shortening the travel time and fuel consumption from Lingtou to Baoshupo, and improving traffic convenience. In the design process, based on the requirements of the specification, to ensure the rationality of the road design. Combined with the local hydrogeological conditions, annual rainfall, temperature, traffic flow and other factors, the analysis is carried out to form a road suitable for the two places.

Keywords: Secondary highway ; route design ; graphic design ; vertical section ; design specification ;

1 INTRODUCTION

Road transport has a broad and narrow sense of difference. In a broad sense, road transport refers to the process in which goods move purposefully along the road through a certain means of transportation. At present, automobiles are widely used as the mode of transportation in the world. Therefore, in a narrow sense, road transportation refers to automobile transportation. Land is much more convenient than waterways, aircraft and pipelines, and the access rate is much higher. Although the speed of land is not the fastest, land transportation has the following characteristics : flexible and adaptable ; can do ' door to door ' transport, medium and short distance transport fast. However, its shortcomings are : less load, higher freight per ton ; the safety is not high, causing serious pollution to the environment.

From the perspective of industrial development, road freight, as the most important circulation mode in the logistics industry, is also an important entry point for realizing the intelligent transformation of the industry. With the continuous development of China 's economy, China 's highway transportation network has expanded rapidly. There are different degrees of roads between provinces, between provinces and cities, between cities and counties, between counties and villages. These roads not only make

G. Chen et al. (eds.), *Proceedings of the 2024 International Conference on Rail Transit and Transportation (ICRTT 2024)*, Advances in Engineering Research 254,
https://doi.org/10.2991/978-94-6463-610-9_26

great contributions to the development of the national economy, but also provide a favorable guarantee for people 's travel and communication needs. Therefore, it becomes very important for highway construction. In the construction of highways, the linear combination design of its lines is the focus of construction [1].

2 ROUTE DESIGN

2.1 Plan Alignment Design

The basis of graphic design route design. In the design of highways, straight line design is the most commonly used one. It has the characteristics of short, fast, straight, and easy to operate by the driver. However, due to the design of the straight line to meet the driving requirements, affected by the topography, geological conditions, structures and other factors along the route, the route can not be a long straight line. Otherwise, it will affect the driver 's manipulation and cause a car accident [2].

Firstly, according to the terrain and geological conditions, according to the basic principle of plane linear design, the general direction and turning point of the design line are determined. Then, according to the grade of the design scheme and the design speed, the minimum radius of the circular curve is determined from the specification. Then, combined with the actual terrain, the design parameters such as the length and radius of the circular curve are determined.

The area is dominated by middle and low mountains and hills. The terrain is generally tilted from the northwest to the southeast, and the main body of the landform is horseshoe-shaped opening to the east. The area is located on the southeast coast and belongs to the IV area in the natural division. It is a subtropical marine monsoon climate. The light is abundant, the rainfall is abundant, the four seasons are distinct. The average annual temperature is 20.6 degrees Celsius, the sunshine hours are 1832 hours, the rainfall is 1200mm, and the frost-free period is 318 days.

The minimum length of the straight line is clearly defined, which stipulates that the minimum length of the straight line between the same circular curves should not be less than 6 times the design speed, and the minimum length of the straight line between the reverse circular curves should not be less than 2 times the design speed [3].

In this design, the length of the straight line between the three intersection reverse circular curves is 264.992 m, which is greater than 120 m. The length of the straight line between the same-direction circular curves is 587.769 m, which is greater than 360 m and meets the requirements of the specification.

Table 1 gives the specified value of the minimum radius of the circular curve on the secondary highway.

Table 1. Minimum radius of circular curve

Design speed（km/h)	Minimum radius of circular curve (general value)（m)	The minimum radius of circular curve (limit value)（m)
60	200	125

According to the provisions of the ' Highway Engineering Technical Standards ', the radius of the circular curve is 290 m, 310 m and 320 m respectively.

The transition curve should be set on the highway. The purpose of the transition curve is to make the transition from the straight line to the circular curve more stable, so that the driving vehicle can turn smoothly and comfortably, and its minimum length should also meet the requirements of the specification [4].

2.2 Profile Alignment Design

The design of the longitudinal section should be smooth, coherent, and coordinated with the terrain of the design area to ensure the driver 's driving safety [5]. The design of highway profile should be based on the terrain, geology and hydrology along the line, and consider the use and nature of the highway. In order to ensure the safety and comfort of the vehicle, the slope should be smoothed. In the design of plane and vertical section, it is necessary to meet the cross design conditions of horizontal curve and vertical curve, and to meet the requirements of " flat envelope vertical " . When designing the longitudinal slope, it is necessary to consider the topography, geology, hydrology and other factors. In order to save the budget, the balanced filling and excavation should be considered as much as possible in the design. In order to ensure the stability of the roadbed, it should meet the minimum requirements of the longitudinal slope [6].

The design process is mainly : preliminary work, marking slope, pile number, elevation, collecting relevant information. Then the control points are marked, the slope is tested, and the linear gradient design is carried out for various forms considering the change of the surface control points. The corresponding slope curve is consistent with the design specification, and the layout and selection of the slope are compared to determine whether the design parameters meet the relevant national standards. After confirming that all the data of the slope point are correct, the data of the straight slope line are determined. Finally, set the vertical curve.

The minimum slope of this design is 0.83 %, which is greater than the minimum slope specified in the specification. It can meet the drainage requirements, prevent water seepage to the roadbed, and affect the stability of the roadbed slope.

The purpose of designing vertical curve is to ensure the safety of driving sight distance and adapt to the change of terrain, especially in the case of night or complex terrain, to ensure that the driver can see the road ahead. The provisions of the vertical curve of this design are shown in Table 2 :

Table 2. Minimum radius and minimum length of vertical curve

Design speed （km/h）	Crest vertical curve （m）		Sag vertical curve （m）		Minimum length of vertical curve （m）	
60	General value	Limiting value	General value	Limiting value	General value	Limiting value
	2000	1400	1500	1000	120	50

The radius of the vertical curve considered in this design is 9000m, 12000m and 8000m. These values have been carefully determined, and the corresponding lengths are 351 m, 237.6 m, and 325.524 m, respectively.

The parameters of the vertical section in this design are summarized, as shown in table 3 :

Table 3. Vertical section design parameters

<table>
<tr><td>Design speed (km/h)</td><td>Maximum longitudinal slope (%)</td><td>Minimum longitudinal gradient (%)</td><td>Minimal longitudinal grade length (m)</td></tr>
<tr><td>60</td><td>3.07%</td><td>0.83%</td><td>304.5</td></tr>
<tr><td rowspan="2">Crest vertical curve</td><td colspan="2">Maximum radius (m)</td><td>Minimum radius (m)</td></tr>
<tr><td colspan="2">12000</td><td>9000</td></tr>
<tr><td rowspan="2">Sag vertical curve</td><td colspan="2">Maximum radius (m)</td><td>Minimum radius (m)</td></tr>
<tr><td colspan="2">8000</td><td></td></tr>
<tr><td>Minimum length of vertical curve (m)</td><td colspan="3">237.6</td></tr>
</table>

Taking the variable slope point 1 in this design as an example to calculate the vertical curve, the formula is as follows:

$$L = R\omega \tag{1}$$

$$\omega = i_2 - i_1 \tag{2}$$

$$T = \frac{L}{2} \tag{3}$$

$$E = \frac{T^2}{2R} \tag{4}$$

In the formula :

R-vertical curve radius (m) ;

L- The curve length of vertical curve (m) ;

T- The tangent length of vertical curve (m) ;

E- The outer distance of the vertical curve (m) ;

ω - The algebraic difference (%) of two adjacent longitudinal slopes.

The vertical curve radius R = 9000 m, the front longitudinal slope gradient i_1= 3.07 %, and the rear longitudinal slope gradient i_2= -0.83 %.

Through the above formula, the vertical curve elements of the variable slope point 1 are as follows :

JD1: L = 351m ; ω = -3.9 %, is a convex vertical curve ; T = 175.5m ; E = 1.7111 m.

Similarly, the vertical curvature of the line elements of the remaining variable slope points is shown in table 4 :

Table 4. Vertical section design parameters

	L(m)	ω(%)	T(m)	E(m)
Slope change point 1	351	-3.9	175.5	1.7111
Slope change point 2	237.6	-1.98	118.8	0.5881
Slope change point 3	325.52	4.069	162.762	1.6557

The vertical section of this design is shown in Fig.1：

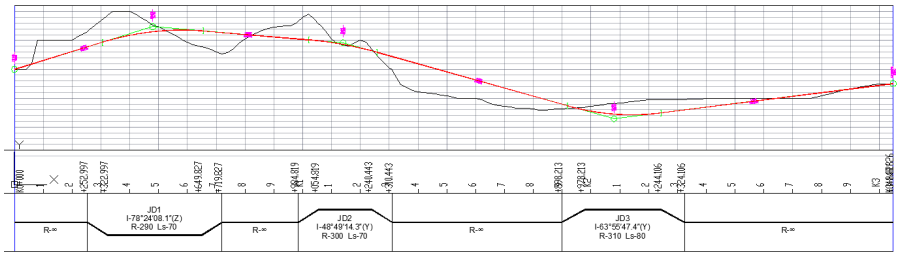

Fig. 1. Vertical section design

3 CONCLUSION

This paper mainly focuses on the linear design of the second-class highway from Luqian to Baoshupo, which has strong pertinence and practicability. In the route design, the factors such as plane linearity, vertical section linearity and traffic flow are comprehensively considered to ensure the safety of the road. In the design, the relevant specifications are strictly followed, and the straight line length, circular curve radius and longitudinal slope are optimized to improve the comfort of the road. The design scheme will reduce the traffic pressure of the existing highway to a certain extent, and divert some traffic flow to the route, greatly shorten the travel time and fuel consumption from Luqian to Baoshupo, improve traffic efficiency, and effectively promote local economic development. However, the consideration of environmental protection in the design process is not comprehensive enough, and the protection of ecological environment needs to be further strengthened in the future. There are few researches on intelligent design of highway, and the application and development of intelligent technology for highway can be further explored in the future. For the future, the design of secondary roads will face more opportunities and challenges. We should pay more attention to sustainable development, give full consideration to the rational application of

resources and environmental protection, and use advanced technologies and concepts to improve the quality and performance of roads.

REFERENCES

1. Zheng Lanfeng. Optimization design of highway linear and linear combination [J].Sichuan Cement,2020, (05) : 1-2.
2. [2] Luo Jinbiao, Lin Chaowei. Research on the application of the minimum radius of circular curve in highway graphic design [J].Road and automobile transportation, 2023, (02) : 53-55.
3. Tang Yang, Ren Rong, He Hongbin, etc. Analysis of linear design of rural roads in mountainous areas [J].Qinghai Traffic Science and Technology, 2021, 33 (03) : 69-72.
4. Zhang Zhiqing. " Road Survey and Design " [M]. 4th ed. Beijing : Science Press, 2022
5. Wang Lei. Key points of linear design of longitudinal section of mountainous highway [J].Technology and market, 2018, 25 (02) : 150-151.
6. Yang Min. Zheng Haibing. Analysis of Key Design Points of Longitudinal Section of Highway Route [J]. Transport Manager World, 2023 (02) : 37-39.