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Research Article

Research on Superelevation Design in Highway Route Design

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Abstract: Superelevation design can basically be regarded as an important part of highway route design system. In the specific design process, designers need to strictly comply with the requirements of superelevation design specifications to ensure the driving stability of curved road section. However, due to the differences of road operation conditions in different regions of China, there are many uncertain factors in the design of super elevation, resulting in design errors. In order to reduce design errors as much as possible, this paper mainly based on the highway route design, highway route design problems and key measures are summarized for reference.

Keywords: Road route; Super high design; Driving safety

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1 Introduction

For China's highway route, the curve section is prone to traffic accidents. The reason is that the vehicle driving in the curve section will be affected by the centrifugal force, which makes it difficult for the vehicle to maintain stability, and then leads to traffic accidents. In order to effectively avoid this problem, the work of highway route design in China focuses on the overall planning and reasonable deployment of Superelevation Design of curved road segments. It is required that the designers and constructors should strictly follow the design standard of road section superelevation and strengthen the implementation of the superelevation problem of curved road section, so as to reduce the instability of driving. However, due to the different conditions of road sections involved in the construction of highway projects in China, there are differences in Superelevation Design. In other words, in the specific design process, we should combine the vehicle composition and road nature of the highway area and other factors to establish a scientific and reasonable Superelevation Design Scheme to ensure driving safety.

2 Design principle and condition analysis of highway superelevation

For highway Superelevation Design, designers need to reasonably determine the curve section in advance. In the formal design process, designers should strictly follow the principle that the inner side is lower than the outer side, and give priority to the one-way cross slope design to realize the design process. The main reason is that the one-way cross slope design can effectively offset the centrifugal force of the vehicle in the process of turning. However, it should be noted that if the super-high one-way cross slope is designed, the feedback of design results needs to be combined with the specific type of pavement and curve radius and other related factors for accurate research and analysis[1]. It can be expressed in the following ways:

$$i = \frac{v^2}{R.127} - u$$

(where, V: Vehicle speed; R: Radius of curve section; u: Lateral force coefficient

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According to the conversion relationship of the above formula, we can basically clarify the driving relationship between the transverse force coefficient and the superelevation value. According to the previous practical research, when the radius of the circular curve and the design speed meet a certain proportion, the value of the transverse force coefficient u will be the lowest. In this way, the vehicle will not be affected by the centrifugal force in the driving process, and the safety and stability of the driving process will be ensured to the maximum extent. At the same time, under this condition, the curvature will not appear obvious superelevation problem. In other words, in the specific design process, designers should pay close attention to the problem of transverse force coefficient.

Generally speaking, when the vehicle is driving in the curvature section, there will be a lateral friction force between the ground and the vehicle. Among them, the numerical performance of friction force is often related to road conditions and tire materials. When the coefficient of lateral force is less than 0.10, the driver will not feel the impact of driving instability on the curve section; When the coefficient of lateral force is between 0.10 and 0.15, the driver will feel the fluctuating influence of the curve section[2]. However, the impact of this fluctuation is relatively controllable, and the overall driving is still in a stable state; When the coefficient of lateral force is between 0.15 and 0.35, the driver can directly feel the unstable influence of curve line on driving safety. If it exceeds 0.40 or above, the passengers will feel obviously uncomfortable during turning driving. In serious cases, it may even overturn.

In order to avoid the above unsafe driving problems in time, designers should attach great importance to the design of transverse force coefficient when they design the entrance section. According to the action relationship of the above formula, when the transverse force coefficient is constantly decreasing, the design superelevation will increase significantly. In other words, designers should reduce the lateral force coefficient properly to ensure the safety and stability of the driving process.

3 Analysis on key problems and measures of Superelevation Design in highway route design

When carrying out highway route design work, designers should always adhere to the combination with the actual situation, and make overall planning and reasonable deployment from the two aspects of economy and comfort. Combined with the previous design experience, the route conditions, topography and other factors can have a certain impact on the driving safety. Therefore, in the process of Superelevation Design, designers must comprehensively consider a number of factors, in order to reasonably determine the superelevation value and ensure the safety and stability of the driving process.

3.1 Reasonable selection of maximum superelevation

In most cases, the superelevation value of curve section can be calculated scientifically according to the above formula. Combined with the previous experience, the maximum superelevation value of curve section in China is mainly 8%. At present, in the process of highway operation, truck overload is more common, and the speed is relatively low. According to the relevant data, the speed of the freight car driving on the curve section is lower than the design speed. If the super-high cross slope is greater than 6%, the car is easy to overturn under the centripetal force.

In view of this, for large and medium-sized truck traffic flow and frequent rain and snow weather section, the maximum superelevation value should be kept at about 6%. For the section with fast operation speed and high design speed, it can be set as 10%. It should be noted that for highways in plain areas, the superelevation design can be reduced by 1% within the allowable range. In addition, for the mountainous highway, because of its high truck traffic rate, the lateral stability and safety of vehicles can be comprehensively enhanced by reducing the superelevation value.

3.2 Design points of super high transition section

The so-called super-high transition section mainly refers to the straight section in the subgrade cross section, from the two-way crown cross slope to the one-way cross slope. For the super-high design of this part of the road, designers need to focus on not only the effect of centrifugal force, but also the structure and pavement drainage and other factors. Combined with the previous design experience, in the design of super-high transition section, we can make reasonable planning and design from two aspects of double slope

stage and rotation stage[3].

Among them, in the double slope stage, in order to meet the requirements of road drainage slope, designers should strictly control the super elevation gradient rate of the section. For example, it can be controlled in $\geqslant 1 / 330$.At the same time, the outer soil shoulder should be excluded from the superelevation design process, just to ensure the normal cross slope. In the rotation stage, the designer should rotate the inside and outside carriageway and the outside hard shoulder at the same time, and ensure that they keep the same height with the inside hard shoulder. At the same time, the hard shoulder should rotate with the inside and outside carriageway, and keep the same height with the inside Earth shoulder. Finally, ensure that the inner soil shoulder, hard shoulder and inner and outer carriageway can keep the same height with the super-high section. It should be noted that in this design process, in order to prevent the turning line from being too long, the setting personnel should strictly grasp the setting position of super-high starting point. For example, it can be set at a position where the curvature value is equal to the minimum radius of the segment without superelevation.

3.3 Design points of transition curve length

From an objective point of view, the visual effect of road alignment is often related to the length of transition curve. When the design of transition curve length does not meet the specification requirements, it is difficult to show the effect of curvature gradient. At the same time, it will directly lead to the unnatural transition between transition curve and circular curve, which poses a threat to traffic safety. If the length of transition curve is too long, it will further lead to the difficulty of super elevation design.

In order to avoid this problem in time, it is suggested that designers should set a scientific and reasonable curvature to ensure that it is consistent with the change of driving trajectory and reduce the adverse effects caused by centrifugal force. In addition, the setting personnel can also use the transition curve as the super-high transition section to ensure the road traffic safety[4].

4 Conclusion

In a word, there are many key contents involved in Superelevation Design in highway route design. In the specific design process, designers should make overall planning and reasonable deployment from various aspects in strict accordance with the requirements of superelevation design specifications. At the same time, designers should take the initiative to combine the highway route and vehicle composition to establish a scientific and reasonable Superelevation Design Scheme to provide a good guarantee for driving safety. In addition, the design should be based on the superelevation design scheme of different curved road segments, and the current design scheme should be properly improved in order to reduce the design errors.

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