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Demonstration and analysis of urban bridge reconstruction under the concept of sustainable development

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Abstract. Urban bridge across the river as an important urban traffic arteries, the completion of the bridge changes the traffic conditions, industrial layout and urban planning, and provides opportunities and development power for economic development. With the rapid growth of urban expansion and traffic volume, the contradiction between the demand of urban road traffic flow and the carrying capacity of road network is becoming increasingly prominent, and the capacity of some Bridges across the river can not meet the growing travel needs of the people, becoming the traffic bottleneck of urban traffic. This paper takes the reconstruction project of Longgang Bridge in Nanning city as an example, insists on the concept of sustainable development, demonstrates and analyzes the necessity of construction combined with the characteristics of the project, discusses the methods and technical points of sustainable demonstration analysis, and provides technical guidance for the reconstruction of urban bridge across the river.

Keywords: sustainable development; urban bridge across the river; bridge reconstruction; demonstration analysis

1. Introduction

The existence of traffic bottlenecks in urban roads leads to a sharp reduction of local road capacity, which greatly restricts the capacity of corresponding roads and even regional road networks, and is one of the main causes of urban traffic congestion [1-2]. Urban cross-river Bridges assume the connection function between many important regions, and their capacity directly affects the normal operation of the urban road network [3]. With the rapid growth of traffic volume, the capacity of some Bridges across the river has been unable to meet the increasing traffic demand, and a new bottleneck has been formed. Sustainable development is the basic consensus of urban development and construction in all countries in the world. Urban bridge reconstruction and design should follow the concept of sustainable development, construct sustainable demonstration and analysis paths, ensure that the city develops in the direction of ecology and science, and promote the harmonious development of economy, society, humanity and environment [4]. The document of the Communist Party of China clearly requires that "through urban design, urban architectural layout should be coordinated from the overall plane and three-dimensional space, urban landscape style should be coordinated, and urban regional characteristics, ethnic characteristics and style of The Times should be reflected" [5]. With the comprehensive implementation of the idea of ecological civilization, the sustainable development of cities puts forward new requirements for urban design theory and becomes an important proposition of urban design research in the new era [6]. Taking the reconstruction project of Longgang Bridge in Nanning City as an example, this paper summarizes the principles of demonstration and analysis of the necessity of sustainable development through the analysis of regional function positioning and traffic volume prediction, and draws the conclusion of the analysis of the necessity of construction, which can provide some reference and valuable practical experience for similar design work in the future.

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2. Project Overview

2.1 Overview of Longgang Bridge

Nanning Longgang Bridge across the Yongjiang River, running through the north and south, with Rongmo Avenue Qingxiu District in the north, Longgang Avenue Wuxiang New District in the south. The bridge is 1190m long and 28m wide, with four lanes in both directions. It was completed and opened to traffic in 2008.

The red line width of Longgang bridge is 28m, with four two-way lanes for motor vehicles and a design speed of 50km/h. The standard cross-section of the current Longgang bridge is shown in FIG.1, which adopts the form of one board arrangement, namely: 2.25m pavement +11.5m non-mixed carriageway +0.5m central isolation barrier +11.5m non-mixed carriageway +2.25m pavement. The 11.5m non-mixed carriageway is arranged as follows: 3.75m non-motor carriageway + 2×3.5m motor carriageway +0.75m curb belt.

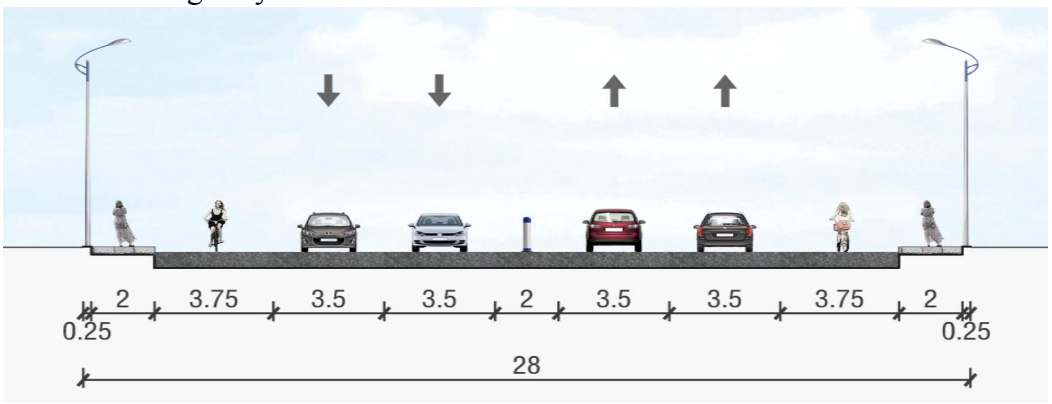

Figure 1. Standard cross-section of Longgang Bridge

2.2 Overview of the North Shore Project

The north bank is the current Rongmo Avenue, with a red line width of 50m and 6 two-way lanes for motor vehicles, with a design speed of 50km/h.The standard cross section of Rongmo Avenue is shown in FIG. 2. It adopts the form of three boards, namely: 5m road side belt +6.75m side road +2m side belt +11.25m motor vehicle road +0.5m central isolation barrier +11.25m motor vehicle road + 2M side belt +6.75m side road +5m road side belt. 11.25m motor vehicle road layout: 0.25m curb belt + 3×3.5m motor vehicle road +0.25m curb belt.

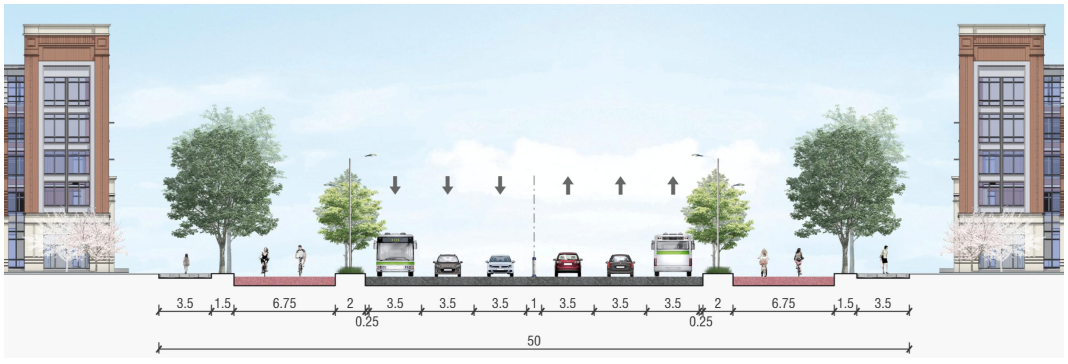

Figure 2. Standard cross-sectional view of the rear road of Rongmo Avenue

2.3 Overview of the South Bank Project

The south bank is the current Longgang Avenue, the red line width of the road is 60m, the motor vehicle two-way 8 lanes, the design speed of 60km/h.The standard cross section of Longgang Avenue is shown in FIG. 3, which adopts the form of 4 boards arrangement, namely: 4m road side belt +5.5m side belt +2.25m side belt +15.25m motor vehicle road +6m central divider +15.25m

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motor vehicle road +2.25m side belt +5.5m side road + 4M road side belt. 15.25m motor vehicle road is arranged as: 0.5m curb belt + (3.75m+ 3×3.5m) motor vehicle road +0.5m curb belt.

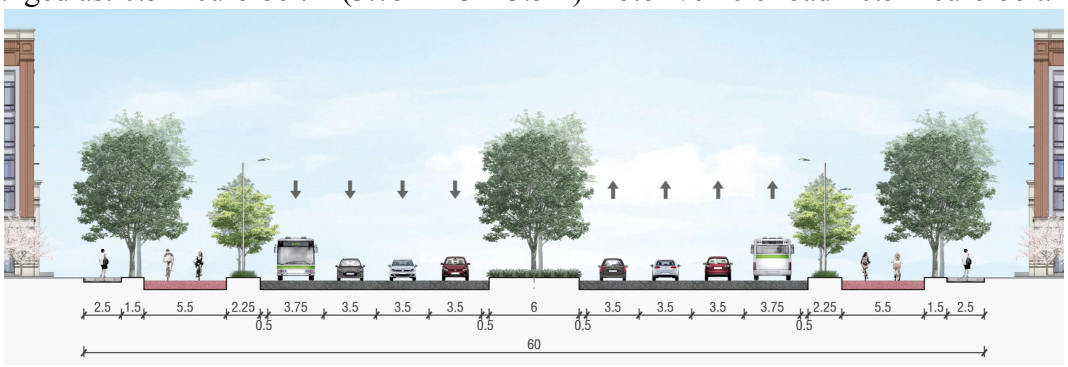

Figure 3. Standard cross-sectional view of Longgang Avenue

3. Principles of argumentation and analysis of sustainable development

The construction of roads and Bridges strives to save resources, effectively protect the environment, and achieve harmony between man and nature, so as to promote economic development and progress and ensure people's quality of life. The demonstration of sustainable development is mainly analyzed from the aspects of network framework, project function orientation, regional network and traffic volume prediction. The main principles are as follows:

3.1 Adhere to the principle of traffic function

Bridge is an important part of urban traffic and plays the function of connecting the two sides of the river. The traffic function is the most basic function, through the construction of cross-river arteries to open up the traffic links in each area of the city, so that the urban traffic in all directions. The demonstration and analysis of the project should be based on the traffic satisfaction, and the overall demonstration from the functional orientation of the project. The urban bridge is not only the connection node of the urban traffic system, but also the important carrier of the main area of the city. Demonstrate and analyze the function of the traffic channel where the bridge is located.

3.2 Adhere to the principle of scientific traffic prediction

Traffic volume prediction is an important content of feasibility study of proposed project and a decisive factor to determine the standard of project scale. It is very important to predict the traffic volume of urban cross-river channel for the construction of urban Bridges. By collecting accurate and reliable survey data and relevant land and population planning data, the traffic situation and traffic volume in the area where the project is located are investigated and analyzed to form the basic data of traffic volume prediction. According to the development plan of the region where the project is located, the scientific and effective analysis method is adopted to predict the traffic volume required within the planning period, calculate the design capacity of the lane, demonstrate and analyze the number of vehicle lanes required by the project, and determine the relevant technical standards.

3.3 Adhere to the people-oriented principle

Adhere to the people-oriented design concept, adhere to the actual needs of human design, road construction optimization innovation, by improving the function of road construction to provide people with a comfortable and convenient traffic road. In the distribution of the right of way, the demand of public transportation, non-motor vehicles and pedestrians should be taken into consideration. From the starting point of ensuring people's safety and comfort, the design of facilities should reflect the concern for people. In the city bridge there are different speed of the main body, for the crowd more need to protect its safety, to give people a sense of safety and

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comfort, fully pay attention to people's psychological feelings, which is also the urban bridge design is important and difficult.

3.4 Adhere to the principles of ecological design

Carrying out the concept of cultural landscape integration and sustainable development, the construction of the project strives to achieve resource conservation and effectively protect the original natural environment. While ensuring the basic performance of the project construction, attention should be paid to the impact on the surrounding environment, so as to ensure the sustainable development of urban environmental protection and achieve the perfect integration of urban projects and nature. Therefore, bridge design needs to be coordinated with urban development and consistent with the environment to achieve the consistency of urban development and landscape integrity. Especially for the old bridge reconstruction and expansion project, more attention should be paid to cohesion. The bridge reconstruction project and the landscape on both sides of the river are considered comprehensively, focusing on creating a cross-river landscape bridge with a high degree of integration of natural ecology and cultural landscape, so as to achieve sustainable development of natural resources and promote ecological balance.

4. Functional positioning analysis

Longgang Bridge spans Yongjiang River, runs north and south, connects with Qingxiu Xianhu Group in the north and Wuxiang New District in the south, which has played a great role in promoting the development and construction of Qingxiu District, Wuxiang New District and Longgang New District. It has been 14 years since the completion of Longgang Bridge, which has laid a solid foundation for the convenient access between Xianhu and Wuxiang New Area, and built an important traffic channel between Rongmo Avenue, Longgang Bridge and Longgang Avenue in the east of Nanning City. See Figure 1 for location of Longgang Avenue.

Rongmo Avenue is the main urban road connecting Xianhu and Qingxiu District and Santang District from north to south. Longgang Avenue is the north-south urban main trunk road between Xianhu Group Tuan and Yongning Group Tuan, and along with Changfu Road and Rongmo Avenue, it forms the north-south urban traffic main trunk road traffic channel connecting Santang, Sigang Group Tuan, Xianhu Group Tuan and Yongning Group Tuan, and mainly undertakes the traffic between Xianhu Group Tuan and Longgang area. According to the comprehensive transportation planning of Nanning City [7], Rongmo Avenue extends from the north of Liucannan Expressway to Xinwaihuan Expressway, connecting Xianhu District, Qingxiu District and Santang district, with a total length of 16km. Longgang Avenue extends from the south of Yudong Avenue to the new Outer Ring Highway, with a total length of 14 km.

5. Traffic volume prediction and analysis

Since Longgang Bridge was completed and opened to traffic in 2008, with the passing of time and the further expansion of Nanning's urban skeleton, the contradiction between the demand for urban road traffic flow and the carrying capacity of the road network has become increasingly prominent. The traffic pressure of Xianxu area and Wuxiang New Area is mainly concentrated on Longgang Bridge. According to the comprehensive traffic planning of Nanning City [7], the survey time of Longgang Bridge was from 06:00 to 24:00 on June 30, 2016, a total of 18 hours. The traffic volume of motor vehicles was 20674, and that of non-motor vehicles was 9142, with a total traffic flow of 29,816 and a passenger flow of 62,727. In the morning rush hour, evening rush hour, rush hour and holiday rush hour, the traffic flow increases sharply compared with the flat peak period, which is easy to cause congestion.

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5.1 Traffic volume prediction results

The traffic simulation software PTV VISUM is used to input the road network, traffic district and OD matrix of each future year, and the indicators such as road network flow and road section traffic load are calculated. This study forecasts the traffic volume in 2025, 2030, 2035 and 2040 under the conditions of the planned road network, and the results are shown in Table 1.

Table 1. Prediction Results of Traffic Volume of Longgang Bridge (Unit: PCU)

2025		2030		2035		2040	
Main direction during peak hours	All day bidirectional (24h)	Main direction during peak hours	All day bidirectional (24h)	Main direction during peak hours	All day bidirectional (24h)	Main direction during peak hours	All day bidirectional (24h)
1531	26798	2261	36177	2713	48839	3434	59584

5.2 Calculation of lane design capacity

According to the design specification [8], when the design speed is 50km/h, the basic capacity of one lane in the basic section of the urban trunk road is 1350pcu/h. When there are two or more lanes in the same direction, the capacity of each lane is affected by the proportion of slow traffic on both sides of the lane and The Times of entering and leaving the lane. If the capacity of the first lane of the main road near the center line is 1, then the capacity of the second lane is 0.8 to 0.89 (0.85 for this project), the third lane is 0.65 to 0.78 (0.75 for this project), and the fourth lane is 0.50 to 0.65 (0.55 for this project). The capacity calculation method of multi-lane main road is shown in Equation (1).

$$N_P = N_1 \sum K_m \tag{1}$$

In Formula (1), N_1 is the capacity of the first lane; $\sum K_m$ is the sum of lane coefficients; N_p is capacity modified to account for multi-lane capacity.The calculated design capacity of one-way 2 lanes, 3 lanes and 4 lanes is shown in Table 2 below.

Table 2. Design Capacity of Multi-lane (PCU/H)

1 lane design capacity	2 lane design capacity	3 lane design capacity	4 lane design capacity
1350	2498	3510	4252

5.3 Calculation of the number of vehicle lanes

Number of one-way motor lanes = one-way peak hour traffic volume/designed capacity of one lane.

The number of one-way lanes required within the design period is calculated according to the predicted traffic volume in the direction of peak hours of this project, and the calculation results are shown in Table 3.

Table 3. Calculation of the required number of one-way lanes

Fixed number of year	Predicted Peak Hour Traffic Volume (PCU /h)	Number of lanes required for design years
2025	1531	2
2030	2261	2
2035	2713	3
2040	3434	3

According to Table 3, the peak hour traffic volume in 2030 is close to the designed capacity of two lanes. In 2035, motor vehicles need to adopt six lanes in both directions to meet the increasing

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demand of traffic volume. In other words, the current two-way four lanes will reach congestion in 2035, which will not meet the demand of traffic volume.

5.4 Service level analysis

Road saturation (V/C) refers to the ratio between the actual traffic volume and the capacity of the road. The larger V/C is, the more congested the road is, the greater the vehicle delay is, and the lower the service level is. The service level of the main road with a design speed of 50km/h is shown in Table 4. The current two-way 4 lanes are adopted. The saturation of traffic volume and service level in peak hours are shown in Table 5. The road traffic saturation and service level in peak hours are shown in Table 6.

Table 4.Adopted values of main road service level division

Service level	First order (free flow)	Second stage (steady stream upper section)	Third stage (steady flow)	Class IV (unstable flow)
V/C	<0.30	0.30～0.55	0.55～0.77	>0.77

Table 5. Saturation and Service level of traffic Volume in peak hours (using the current two-way 4 lanes)

2025		2030		2035		2040	
Saturation	Service level	Saturation	Service level	Saturation	Service level	Saturation	Service level
0.61	Third stage	0.91	Class IV	1.09	Class IV	1.37	Class IV

It can be seen from Table 5 that Longgang Bridge adopts the current two-way four-lane traffic, which will reach the level of four-level traffic service in 2030. The vehicles are unstable flow, and Longgang Bridge is congested.

Table 6. Saturation and Service Level of traffic Volume in peak hours (Widened and transformed into 6 lanes in both directions)

2025		2030		2035		2040	
Saturation	Service level	Saturation	Service level	Saturation	Service level	Saturation	Service level
0.44	Second stage	0.64	Third stage	0.77	Third stage	0.98	Class IV

From Table 6, it can be seen that after the extension and transformation of Longgang Bridge into two-way 6 lanes, the traffic service level will be level 3 in 2035, with steady flow of vehicles and no congestion on Longgang Bridge.

5.5 Conclusion of traffic volume analysis

(1) According to the calculation of the number of lanes, the peak hour traffic volume of Longgang Bridge in 2030 is close to the designed capacity of two-lane traffic, which needs to be widened to six two-way lanes to meet the demand of traffic volume growth.

(2) According to the calculation of service level, Longgang Bridge adopts the current two-way four-lane traffic, which will reach the four-level traffic service level in 2030. The vehicles are unstable flow, and Longgang Bridge is congested. After the expansion and transformation to six lanes in both directions, the traffic service level will be three in 2035, and the vehicles will be steady flow.

(3) In order to improve the capacity of Longgang Bridge, break the traffic bottleneck and meet the traffic demand, it is suggested to widen and transform it into six two-way lanes.

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6. Analysis of construction necessity

6.1 It can improve the bridge capacity, break the traffic bottleneck, and meet the traffic travel demand

North shore Rong Mo Avenue after the transformation of the main road for two-way 6 lanes;Longgang Bridge for motor vehicles two-way 4 lanes; South coast Longgang Avenue main road motor vehicles for two-way 8 lanes. Comparison of standard cross-sections of the three sections is shown in Figure 4.

Through the analysis of the present situation and surrounding environment of Longgang Bridge, Longgang Bridge has become a bottleneck restricting the traffic in Longgang area. The capacity of the bridge can be improved by increasing the motor vehicle lane through the transformation, matching with the road lanes on both sides of the bridge, breaking the traffic bottleneck and meeting the traffic travel demand. Bridge renovation will support the overall spatial structure layout of the urban area, effectively relieve the north-south traffic pressure and the pressure of the river crossing, and serve the regional traffic on both sides.

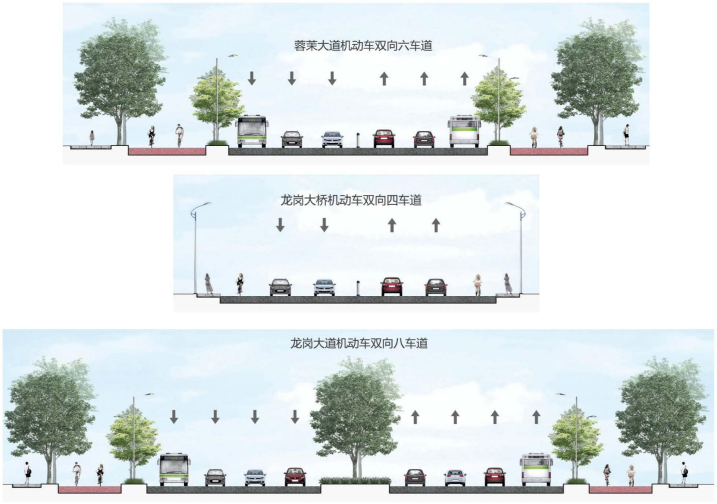

Figure 4. Comparison of standard cross-sections of three road sections

6.2 The transformation of Longgang Bridge can largely eliminate traffic safety hazards

The current situation of Longgang Bridge is that motor vehicles and non-motor vehicles share the same board, and there is no isolation facility for motor vehicles and non-motor vehicles, as shown in FIG. 5. According to the design specification [8], isolation facilities should be set up between motor vehicles and non-motor vehicles on urban roads with a design speed greater than or equal to 40km/h. The safety of non-motor vehicles can be guaranteed by increasing the isolation facilities between motor vehicles and non-motor vehicles through renovation, and the people-oriented design concept can be implemented.

6.3 By adding anti-collision guardrail, ensure the safety of vehicles passing on the bridge and avoid vehicles falling off the bridge out of control

According to the design specification [9-10], when it is an urban bridge with A design speed greater than or equal to 50km/h, it is appropriate to set an anti-collision guardrail on the outside of the vehicle lane, and the protection level of the anti-collision guardrail is class A. The concrete guardrail is on the outside of the sidewalk of Longgang Bridge, and there is no anti-collision guardrail on the outside of the roadway. The safety of vehicles and pedestrians on the bridge can be ensured by retrofitting and adding anti-collision guardrail, so as to avoid losing control of vehicles and falling under the bridge, causing heavy casualties and property losses.

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6.4 Rebuild Longgang Bridge to enhance the overall image of Longgang area and promote land development and industrial development

The rconstruction and expansion of Longgang Bridge will improve the regional road network, improve road accessibility, ensure smooth and convenient traffic function, strengthen the communication between the area and the outside, promote the development of land and industry along the road, constantly improve the living environment, improve the quality of the city, and better serve the people's high-quality living needs.

6.5 Pay more attention to the integration of bridge landscape and Yongjiang River environment through the renovation of Bridges

Since the completion of Longgang Bridge 14 years ago, the Yongjiang River landscape has undergone tremendous changes. Through the transformation of the bridge, not only to beautify the environment, but also to change the urban landscape of Longgang area, promote the city status of Longgang area, create a more attractive urban environment, promote the healthy development of the city. Longgang area will be built into a modern city life carrier with rich humanistic spirit.

7. Conclusion

With the continuous expansion of economic development and urban construction scale, the contradiction between the capacity of some cross-river Bridges and the growing travel demand of the people has become increasingly prominent, and the importance of the reconstruction of urban cross-river Bridges has been paid more and more attention. How to carry ON THE function analysis, THE traffic volume analysis and the necessity analysis, to provide the decision support FOR the project establishment, is the problem that every urban design practitioners should pay attention to. Based on the demonstration analysis on the principle of sustainable development, studies the necessity to reform the nanning city longgang bridge engineering, the concept of sustainable development under the guidance of scientific analysis and rational argument, exert the function of urban Bridges in the urban development and construction necessity analysis conclusion, for the bridge across the river in the future construction plays a certain reference significance.

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