

Study on the Design Scheme of Vehicle Flow Lines in Unilateral Agglomerative Open Service Area

Tengfei Gong*

China Merchants Chongqing Communications Technology Research & Design Institute Co., LTD., Chongqing 400067, China

*Corresponding author: Tengfei Gong, 1213785973a@gmail.com

Copyright: © 2024 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: In recent years, with the introduction of the strategy to strengthen the country's transportation infrastructure and the continuous implementation of new economic development models such as integrating transportation with tourism, various open service areas integrating highway service areas with local tourism have emerged nationwide. Examples include the Yangcheng Lake service area in Jiangsu and the Lengshui service area in Chongqing. This paper focuses on the design example of the Dazu Stone Carving service area on the Chongqing section of the Yurong Expressway, comprehensively considering factors such as construction scale, terrain conditions, and local urban planning. It analyzes and studies the traffic flow design of unilateral agglomerative open service areas around two vehicle traffic conversion links: between the main expressway and the service area, and between the service area and local roads. The aim is to provide a case study reference for similar projects.

Keywords: Unilateral agglomeration; Open service area; Traffic flow line

Online publication: July 11, 2024

1. Introduction

In recent years, as the high-speed road network has largely taken shape, China has entered the era of mass tourism. The focus of highway construction has gradually shifted from “more” to “better.” Regulatory authorities such as the Ministry of Transport are increasingly emphasizing the development of service areas. The model of “high-speed roads + tourism + intelligent, distinctive + diversified + specialized” has become a new trend.

While ensuring the self-contained operation, safety, and effective toll management of highways, exploration is underway to integrate service areas with local economic development. This approach supports the open or semi-open development of service areas within their respective regions. For instance, by integrating electronic toll collection stations to connect service areas with local roads, a comprehensive transportation and tourism network known as “fast transit, slow tourism” can be established ^[1]. The concept of open service

areas has evolved from these initiatives. Current research underscores the importance of scientifically and logically planning traffic flow routes to enhance the operational quality and safety of service areas, significantly influencing their management and operation.

This paper focuses on the Dazu Stone Carving service area as the research subject, primarily discussing the design of traffic flow organization both inside and outside unilateral agglomerative open service areas. The aim is to provide technical references for similar projects, which hold practical significance.

2. Project overview

The Dazu Stone Carving service area is located on the south side of Dazu District in Chongqing City. The construction site is situated within the Longgang-Tangxiang planning area of Dazu District. The total land area occupies approximately 300 acres. The service area is rectangular in shape, oriented from east to west, with flat terrain. It is situated close to the west of the Five-Star Avenue.

The service area is located along the Chongqing section of the Chongqing-Chengdu Expressway (Yurong Expressway). The main expressway adopts a dual six-lane standard, with a design speed of 120 km/h. The roadbed width is 33.5 meters. The Yurong Expressway is equipped with a total of five service areas, with three in Sichuan Province and two in Chongqing. The average distance between service areas is 53.28 kilometers, as shown in **Figure 1**.

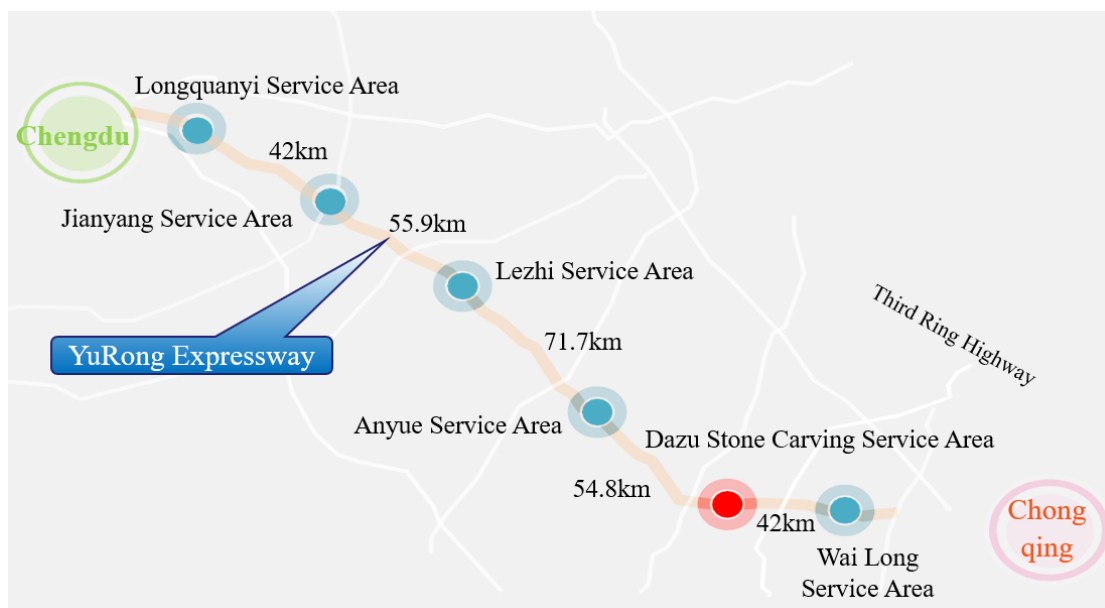


Figure 1. Distribution map of the service area of Yurong Expressway

The Dazu Stone Carving service area occupies a total land area of 280.00 mu (approximately 18.67 hectares), with 20 mu reserved for future use. The total constructed area amounts to 10,124.26 square meters.

The project is positioned as a “Dazu Impression Theme + Open Service Area,” constructed according to the five-star service area technical standards. Visual representations of the service area are depicted in **Figure 2**.



Figure 2. Aerial view of Dazu Stone Carving service area

3. Vehicle flow line design ideas

3.1. Overall design principles

Inside the service area, the traffic organization prioritizes separating pedestrian and vehicular flows to minimize their intersection and mixing ^[2].

- (1) The flow follows a “park first, then refuel” process, with streamlined designs for entering the service area, parking, refueling, and exiting.
- (2) Vehicle-type designs minimize interference between different types of traffic flows.
- (3) Routes are designated for both vehicles refueling at designated stations and those refueling directly.
- (4) Specialized vehicles such as maintenance vehicles, fuel transporters, hazardous material transporters, and livestock carriers have relatively independent traffic routes.
- (5) Consistent directional flow at exits is maintained, favoring one-way traffic to avoid intersections.
- (6) The layout of traffic flows and service area buildings are integrated to form an organic whole.
- (7) Meeting maintenance and management requirements of the service area to optimize construction investment.
- (8) Close integration with local urban planning maximizes the functional role of the open service area.
- (9) The geometric design of traffic routes meets highway standards to ensure smooth and safe driving. At intersections where traffic flows converge or diverge, visibility is optimized, making it easy to discern the direction of each flow.

3.2. Limiting factors

3.2.1. Existing reserved lands

This project is a new construction service area located on the existing reserved land on the north side of the main expressway. The reserved land has been developed with a Type B single trumpet interchange ^[3], facilitating traffic transitions between the main expressway and the planned service area.

As shown in **Figure 3**, it is evident that the basic layout of this service area is unilateral agglomerative, with entrance and exit ramps constructed for traffic flowing towards Chengdu and Chongqing.



Figure 3. Map of the service area

3.2.2. Local road network planning

According to the urban planning of Dazu District, the construction site is located in the Longgang-Tangxiang planning area. The existing land on the left side is already developed with the Five-Star Avenue, which serves as the north-south axis of Dazu District. The design of traffic flow lines for the open service area should be closely integrated with the local urban road network planning (**Figure 4**).

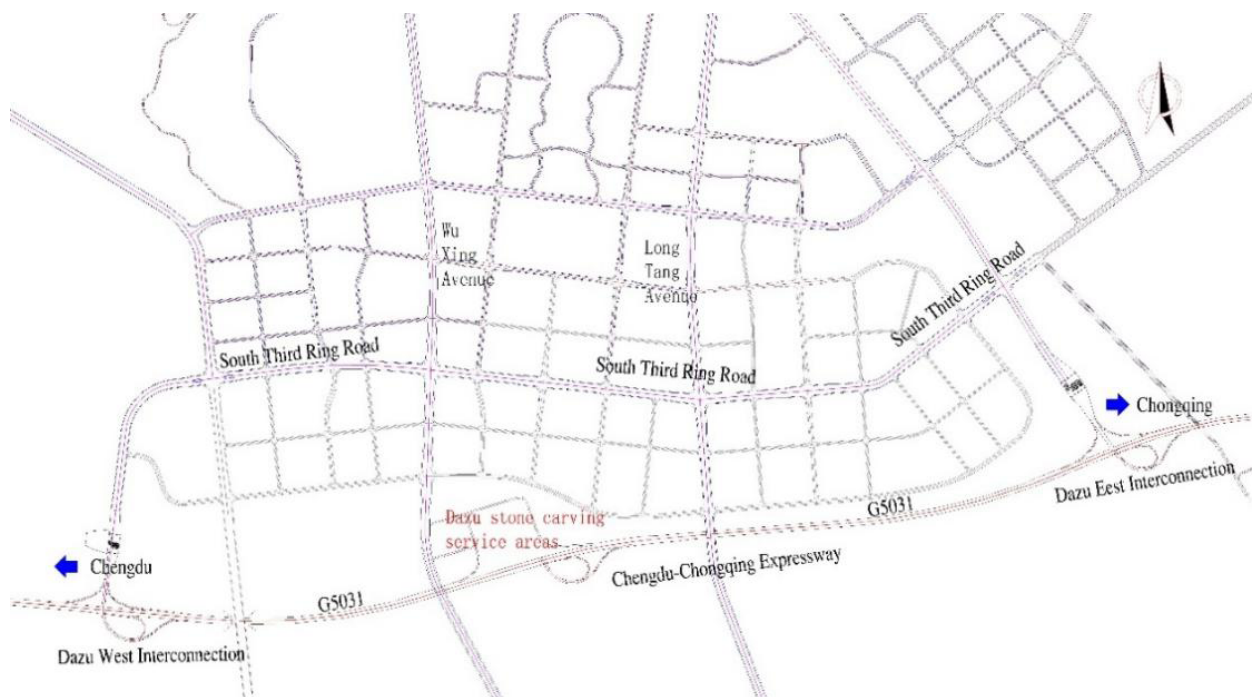


Figure 4. Road network planning of Begonia Area

3.2.3. Terrain conditions

The original terrain of the construction site is characterized by shallow erosional hills. Currently, the site has undergone leveling work, with ground elevations ranging approximately from 374.6–386.5 m, presenting a relative height difference of 11.9 m. The overall terrain slopes gently from west to east, exhibiting a generally flat topography.

4. Open service area traffic flow line design

4.1. Original traffic flow design scheme of the service area

According to the original design drawings of the Chongqing-Chengdu Expressway (Yurong Expressway), the original service area plan adopted a traditional closed unilateral agglomerative layout^[4]. The main traffic flow lines for the site are depicted in **Figure 4**.

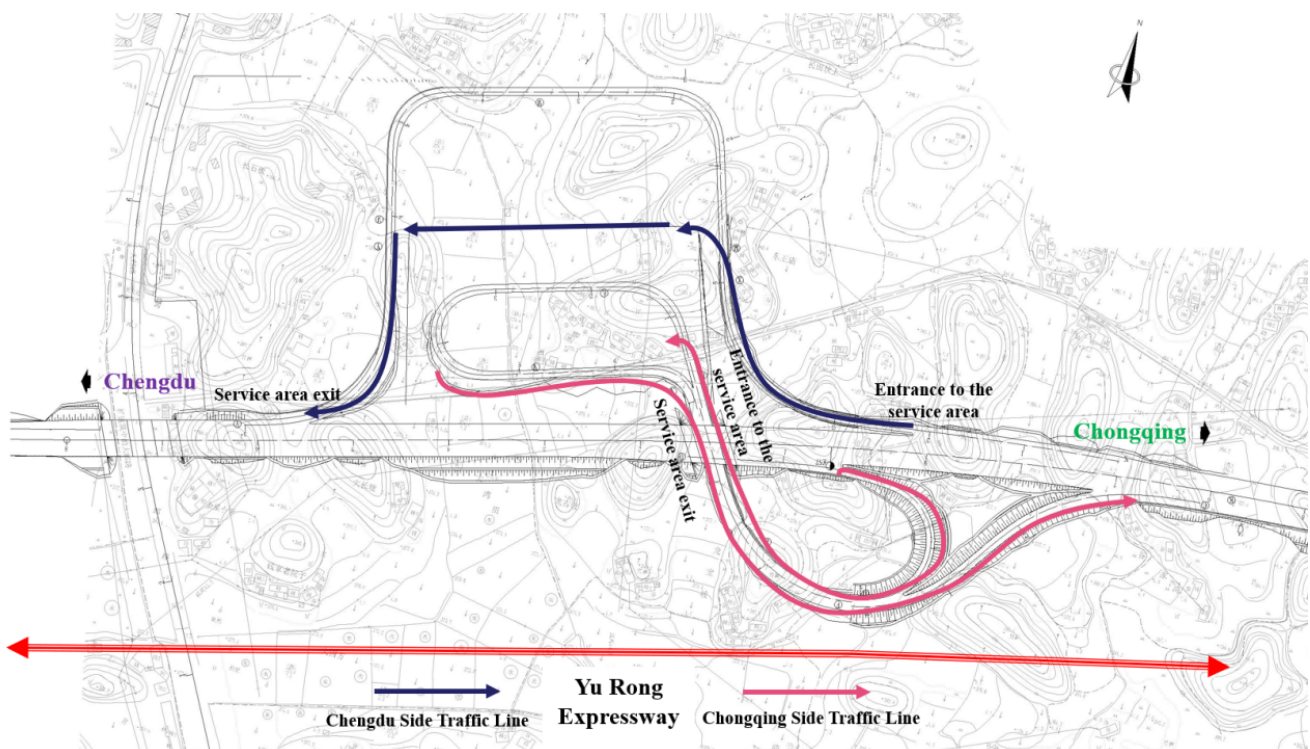


Figure 5. Traffic flow line planning of the original service area

Since the full opening of the G5013 Chongqing-Chengdu Expressway in September 2017, it has served as the shortest and fastest high-speed route between Sichuan and Chongqing. With continuous economic and social development, the traffic volume on the mainline of the Yurong Expressway has been increasing, accompanied by a growing demand for services. Improving the construction of service areas along the Dazu section of the Yurong Expressway and enhancing the overall road network service capacity have become pressing issues that need to be addressed promptly.

Furthermore, Dazu District boasts rich tourism resources such as stone carving culture and grotto culture, including several 5A and 4A tourist attractions. The planned construction site is located in the southern urban area of Dazu District. Aligning with local government development priorities, the intention is to develop the service area as an open service area. This approach aims to create a multifaceted complex imbued with Dazu's unique cultural heritage and strong regional characteristics, envisioned as a lively “city that never sleeps” in

eastern Sichuan.

Based on this, this paper proposes two designs for traffic flow lines from the perspectives of traffic transition between the main expressway, service area, and local roads. These designs are elaborated below, taking into account factors such as the functional requirements of the service area, site traffic organization, surrounding road networks, and terrain conditions.

4.2. Open service area traffic flow line design scheme 1

The central placement of the integrated building in this plan’s service area facilitates vehicular traffic transitions between the main expressway, the service area, and local roads via newly constructed onsite roads. Traffic from both directions of the Yurong Expressway transitions into the service area through a Type B single trumpet interchange. Local roads use segregated ETC stations to transition vehicles into the service area. The main traffic flow lines are illustrated in the accompanying diagram.

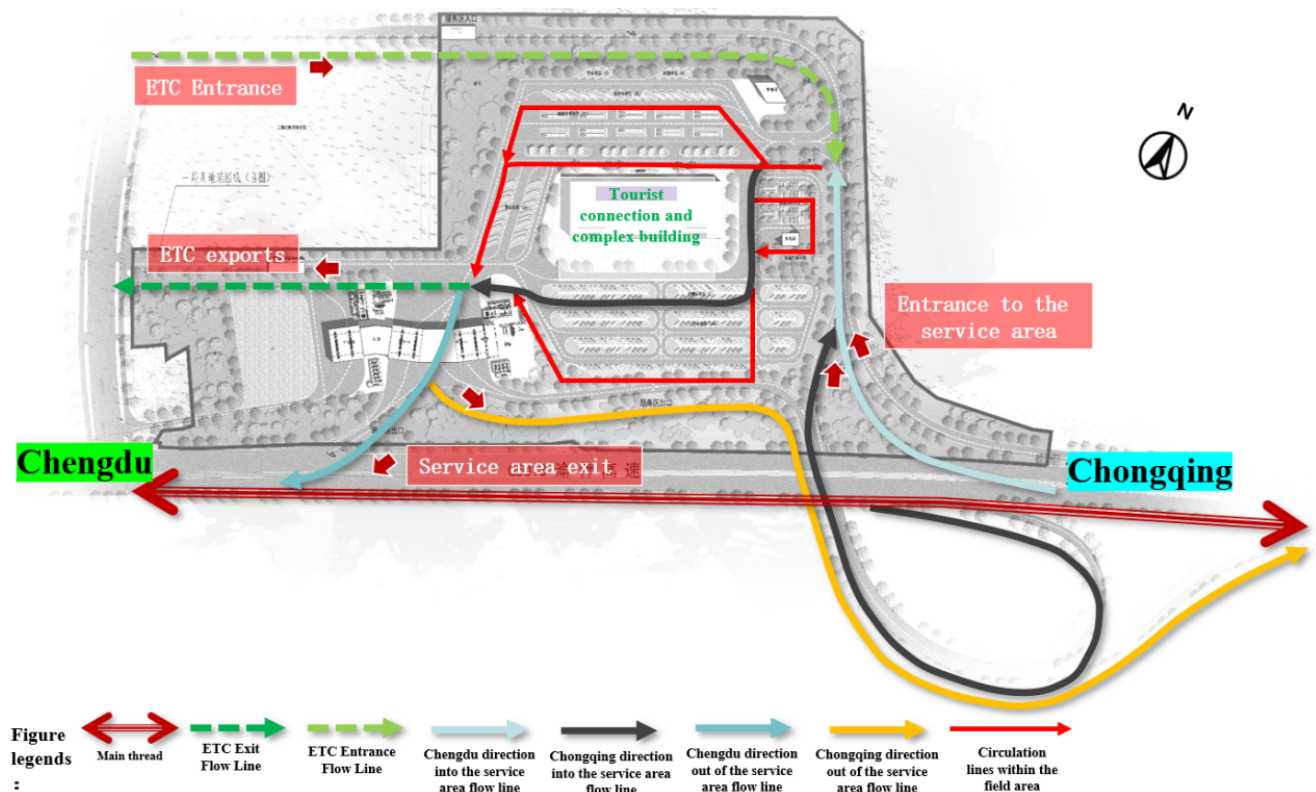


Figure 6. Vehicle flow line of Scheme 1

4.3. Open service area traffic flow line design Scheme 2

This plan situates the integrated building of the service area centrally. Vehicular traffic from the main expressway, service area, and local roads transitions through newly constructed onsite roads within the service area. Traffic from both directions of the Yurong Expressway transitions into the service area through a Type B single trumpet interchange. Local roads use centralized ETC stations to transition vehicles into the service area. Additionally, the integrated building acts as the central axis, forming a circular flow of traffic to enhance fault tolerance. The main traffic flow lines are illustrated in Figure 7.

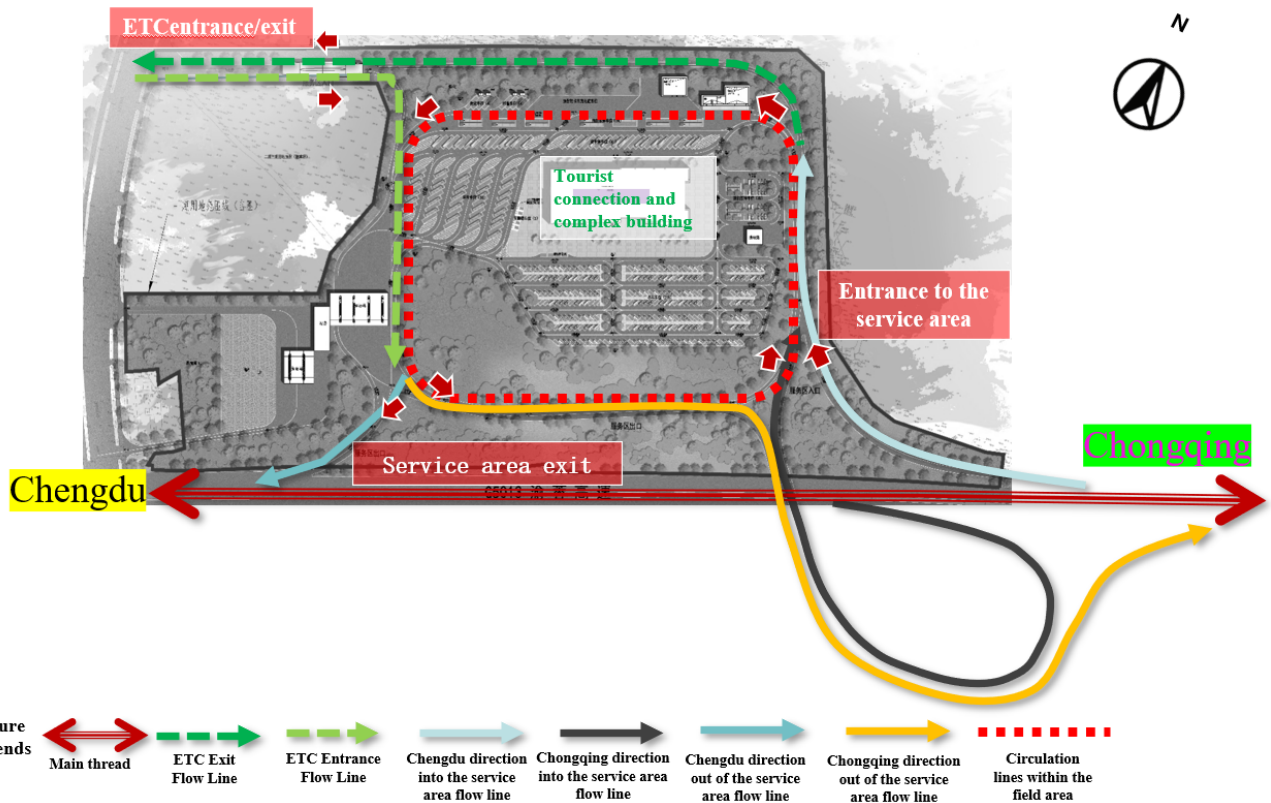


Figure 7. Traffic flow line of Scheme 2

Through the analysis of the traffic flow design of the two open service areas mentioned above, the comparison of technical indicators and engineering scale and the analysis of advantages and disadvantages of both schemes are shown in **Tables 1 & 2**.

Table 1. Comparison of technical indicators and project scale between the two design schemes

Indicator name	Scheme 1	Scheme 2
Design speed (km/h)	20	20
Lane width (m)	3.5/7.0/10.5	3.5/7.0
Minimum radius of road curve (m)	20	20
Maximum longitudinal slope (%)	4.98	4.98
Road length (km)	1.11	1.36
Earthwork (m)	1262	1285
Culvert (channel)	3	3
Road surface (m ²)	7675	8012
Protection works (m ²)	430	543
ETC toll station	1	2
Cost (yuan)	2456800	2564640

Table 2. Analysis of the advantages and disadvantages of the design options

Scheme	Pros	Cons
1	The traffic flow organization in the service area is relatively smooth. The centralized placement of ETC stations facilitates management, and the engineering scale is relatively low.	Within the site, there are X-shaped intersections between east and west side roads, which can lead to congestion during holidays and peak periods.
2	Traffic flow on the east and west sides is less likely to intersect, making it easier to set up and recognize traffic signs.	The traffic flow entering and exiting the toll station needs to detour through the service area, which can easily conflict with the service area traffic flow. The separate placement of the toll station makes it difficult to manage. The toll station roads intersect with local roads in two places, which complicates recognition. This results in a larger engineering scale.

Through comparison, it can be observed that although there is a slight difference in cost and scale, Scheme 1 generally offers smoother traffic flow and stronger fault tolerance. Moreover, the centralized placement of ETC toll stations facilitates management. Therefore, after a comprehensive evaluation, Scheme 1 is recommended as the preferred construction plan.

4. Conclusion

As open service areas continue to thrive, it is crucial to fully consider factors such as terrain and urban planning when designing traffic flow patterns. Rational and scientific placement of traffic flows in unilateral agglomerative service areas is essential for the operational efficiency, safety, and management of open service areas along highways. This approach contributes to establishing a new highway service system, promoting efficient, safe, and stable highway operations^[5].

Disclosure statement

The author declares no conflict of interest.

References

- [1] National Tourism Bureau, 2017, Opinions on Promoting the Integration and Development of Transport and Tourism, viewed March 28, 2024. https://zwgk.mct.gov.cn/zfxxgkml/cyfz/202012/t20201213_919247.html
- [2] Chongqing Transportation Bureau, 2021, Standardized Design Guide for the Overall Layout of Highway Service Areas, viewed March 28, 2024. https://jtj.cq.gov.cn/zwgk_240/zfxxgkml/gggs/tzgg/202104/P020210420602019125665.pdf
- [3] China Highway Engineering Consulting Group Co., 2014, Highway Three-Dimensional Intersection Design Rules, JTG/ T D21-2014, viewed March 28, 2024.
- [4] Guangxi Zhuang Autonomous Region Administration for Market Regulation, 2019, Design Specification for Highway Service Area, DB45/T 2052-2019, viewed March 28, 2024.
- [5] Wang Y, 2022, Discussion on the Design of Open Service Area in Motorway. *Traffic World (Lower Decade)*, 2022(7): 4–6.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.