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Determination of Main Design Indicators of Patrol Road in Nature Reserves

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Abstract In principle, nature reserves are managed and controlled according to the core area and the general control area. At present, there is no relevant design specification for the design system of patrol road in various protected areas. This paper analyzed the factors to be considered in determining the grade, horizontal and vertical design indicators, and cross section indicators of the patrol road in the protected area, and came up with the corresponding design indicators and parameters, so as to provide a certain reference for the subsequent patrol road design.

Key words Nature reserves, Patrol road, Design indicators, Road design

1 Introduction

Natural resources and natural environment are important objective conditions for human survival and development, and nature reserves is an important place to protect natural resources and carry out natural environment research. According to the authenticity, integrity, systematicness and inherent laws of the natural ecosystem, and based on the management objectives and effectiveness, the nature reserves can be divided into national parks, nature reserves and natural parks according to their ecological value and protection intensity. According to the functional orientation of various nature reserves, national parks and nature reserves are controlled by core protected areas and general control areas, and natural parks are generally managed by general control areas[1].

Carrying out necessary patrol work in nature reserves can effectively prevent many kinds of natural resource destruction activities, and is also one of the most effective ways to discover and combat the destruction of natural resources. Patrol methods include daily patrol, inspection patrol, monitoring patrol and armed patrol, among which daily patrol is a fixed patrol set according to the annual patrol management plan[2]. The patrol road plays an important role in the management and protection personnel's access to the management station and the management and protection point and in the execution of patrol and inspection tasks. At present, there are no relevant design standards and specifications on how to reasonably design the indicators of patrol road according to the resource distribution and functional layout of protected areas.

In accordance with the current *Standard for Construction of Nature Reserves Project* (JB195-2018)[3], *Specifications for Design of Highway Route* (JTG D20-2017)[4] and other specifications, combined with years of experience in infrastructure construction in nature reserves, In this paper, we analyzed the main design indicators of nature reserves patrol road and patrol footpath, in order to provide a certain reference for better application of patrol road design indicators.

2 Determination of road grade

The patrol road network includes trunk roads, secondary trunk roads, patrol roads, and patrol walkways. The selection of road grade shall be based on the demonstration and determination of highway functions, combined with the comprehensive transportation system, long-term development planning and design traffic volume of the region. For patrol road design, single lane or double lane can be set up according to work requirements. In order to facilitate the analysis of traffic volume, we carried out calculation and comparison according to the two-lane Grade 4 highway, and finally determined the reference indicator of patrol road. According to the formula for Annual Average Daily Traffic in *Specifications for Design of Highway Route* (JTG D20-2017), the calculation is as follows:

$$AADT = C_D \times R_D / K$$

where *AADT* is Annual Average Daily Traffic (pcu/d); C_D is design traffic capacity; R_D is direction distribution coefficient of road; K is the designed hourly traffic volume coefficient.

Considering the requirement that ecosystem integrity and important species habitat should not be compromised within nature reserves, design capacity within the reserve should be strictly controlled. At the same time, due to the different management and control requirements of different functional zones of nature reserves, most human activities are generally prohibited in the core protected area, and the patrol road in the area is only used for pa-

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trol work, so the design indicator of the core protected area does not consider the driveway standard. The normal production and life of some original residents are allowed in the general control area, and the patrol road in this area needs to take into account the patrol work and the possible travel of the surrounding residents. According to the daily patrol task and other factors, the design traffic capacity (C_D) should be less than 100 pcu/d, and the C_D value is 100; the round-trip traffic volume of the patrol task is basically equal, so the R_D value is 1. Generally, the interval value of designed hourly traffic volume coefficient (K) is 0.13 – 0.18. For better estimation of the *AADT*, combined with the reference value of "designed hourly traffic volume coefficient (K) of each region" in *Specifications for Design of Highway Route* (JTG D20-2017), K takes 0.135. Through calculation, *AADT* = 740(pcu/d) for general nature reserves. For the road grade with *AADT* less than 2 000 pcu/d, it can be designed by referring to the standard of Grade 4 highway. The design speed of Grade 4 highway is 20 km/h. Then, referring to the design indicator of Grade 4 highway, the grade of patrol road and the design speed indicator are recommended as shown in Table 1.

Table 1 Patrol road grade and design speed indicator of nature reserves

Functional zone	Road form	C_D//pcu/d	*AADT*//pcu/d	Road grade	Design speed//km/h	Scope of land use//m
Core protected areas	Patrol walkway	≤100	–	Suitable for walking and motorcycle	–	0 – 0.5
General control areas	Patrol driveway	≤100	<2 000	Not higher than Grade 4 highway	≤20	0.5 – 1.0
	Patrol walkway	≤100	–	Suitable for walking and motorcycle	–	0 – 0.5

3 Horizontal and vertical design indicators

The roads in nature reserves shall be laid out on the principle of meeting the needs of nature reserves management, scientific research, monitoring, fire prevention, environmental protection and living. The existing conditions shall be fully combined with the function of fire prevention access, and the farmland in the village shall be occupied as little as possible. The nature of use determines that the road alignment should comply with nature, do not engage in large-scale excavation and filling, and try not to destroy the surface vegetation and natural landscape[5]. Since the horizontal and vertical design indicators of patrol road are not directly related to the control requirements of functional zones of nature reserves, we do not distinguish the horizontal and vertical design indicators of patrol road in different functional zones. Through simple traffic volume analysis, the grade of patrol road in nature reserves is determined to refer to the design indicators of Grade 4 highway. Combined with the principles of road layout in the protected area, compared with the design indicator of the Grade 4 highway, the minimum radius of the circular curve of the Grade 4 highway is generally 30 m. However, the main vehicles in the protected areas are mostly small vehicles, and it is recommended that the general design value of patrol road is 15 m, which is enough to meet the traffic requirements. The maximum longitudinal slope of Grade 4 highway is 9%. Considering the traffic volume in nature reserves and the patrol characteristics of vehicles, it is considered that "the maximum longitudinal slope should not be greater than 15%" can fully meet the traffic requirements of patrol vehicles. However, for the plateau area, the longitudinal slope reduction shall be considered. When the altitude is above 3 000 m, the longitudinal slope reduction shall be 1% for every 1 000 m rise, and the maximum longitudinal slope reduction shall not be less than 8%. The widening and superelevation of the road can refer to the design indicators of Grade 4 highway and be adjusted appropriately according to the actual terrain. Therefore, the main horizontal and vertical design indicators of patrol road of nature reserves are recommended as shown in Table 2.

Table 2 Main horizontal and vertical design indicators of patrol road

Road form	General value of minimum radius of circular curve//m	Limit value of minimum radius of circular curve//m	Transition curve	Maximum gradient of longitudinal slope	Widening//m	Superelevation
Patrol driveway	15	10	Not set	15% (reduced by altitude for plateau area)	≥2.5 (reduced half for single lane)	≤8%
Patrol walkway	It shall be arranged according to the natural terrain, and artificial stepped roads can be built if necessary.					

4 Cross-section indicators

The cross section design of the road is an important part of the whole design process. The form of cross section is not only related to the cost and scale of the project, but also plays a decisive role in the safety of road operation in the future. Sight distance requirements within the scope of highway construction on both sides of the road section shall also be considered in the design of the road cross section. As one of the quality indicators of highway use, driving sight distance is very important[6]. The patrol road in nature reserves has special functional requirements. In order not to destroy the integrity of the ecosystem, more consideration should be given to the diversity design of the section form under the existing terrain conditions, so that the traffic function of the patrol road can be reduced appropriately and the service function can be gradually strengthened. On the premise of not damaging the ecosystem of the whole nature reserve, it will play an important role in the daily pa-

trol of nature reserves. Therefore, it is suggested that the general design drawings of the patrol road bed section of nature reserves are shown in Fig. 1 and Fig. 2.

The patrol driveway in nature reserves is mainly used for the patrol of motor vehicles, while the patrol walkway is more used for going deep into nature reserves. According to the characteristics of nature reserves, it can be divided into different forms such as horse riding, bicycle, motorcycle or walking, so the section forms of the two roads are different. According to the different control requirements of different functional zones of nature reserves, the cross section indicators of patrol road shall be different. In addition, regional differences, characteristics of protected areas, topographic conditions of patrol sections and other factors will also affect the form of the cross section. According to the road bed width of the driveway and the walkway, the relationship between the pavement of the driveway and the subgrade shall be considered comprehensively, and the appropriate camber slope shall be set to facilitate the distinction of surface drainage. Combined with the general design of the road given in Fig. 1 and Fig. 2, the cross section dimensions of the proposed patrol road bed are shown in Table 3.

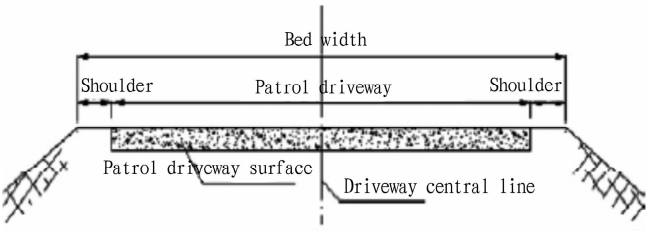

Fig. 1 General design for cross section of patrol driveway

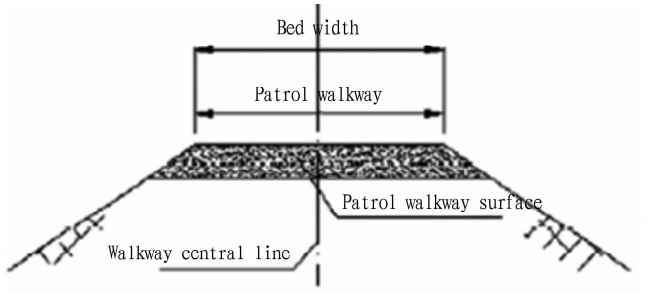

Fig. 2 General design for cross section of patrol walkway

Table 3 Main dimensions of cross section of patrol road

Functional zone	Road form	Driveway or walkway width // m	Driveway or walkway width // m	Unsurfaced road shoulder width // m	Crown slope
Core protected areas	Patrol walkway	1.0 (single walkway) 2.0 (double walkway)	1.0 (single walkway) 2.0 (double walkway)	Not set shoulder	One-sided slope 2%
General control areas	Patrol driveway	4.5 (single driveway)	3.5 (single driveway)	0.5 (single driveway)	Double-sided slope 3% (double driveway)
	Patrol walkway	1.0 (single walkway) 2.0 (double walkway)	1.0 (single walkway) 2.0 (double walkway)	Not set shoulder	One-sided slope 2%

For the specific indicators of road bed width, pavement and protection works in the road, the specific design shall be carried out according to the actual situation, and the construction shall be carried out with local materials as far as possible without changing the natural landscape pattern. For example, the pavement can be made of mud stone, gravel, block stone, bullet stone structure, *etc.*, and the protection can be made of stone masonry, wood structure, *etc.*, which can not only meet the needs of road structure composition, but also maintain the integrity of the local ecology.

5 Conclusions

Road design involves a complex design indicator system, not an individual indicator or a simple reference value, especially the patrol road in nature reserves, which should not only consider the use function of the road in the design process, but also pay attention to the perfect combination with the regional ecology according to local conditions. We only discussed several main indicators of patrol road in the future nature reserves, so as to provide a certain reference in the design process. Finally, it is hoped that the indicator system of patrol road design specification of nature reserves will be released as soon as possible, so that designers can follow the rules when designing patrol road.

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