



## Landscape design of mountain highway tunnel portals in China

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### ABSTRACT

Landscape design of tunnel portals has been under intensive study in recent years. This paper summarizes the general development of highway tunnels and the main problems concerning highway tunnel entrances during this development phase in China. It then analyzes the significance of mountain highway tunnel landscape design in terms of preventing travel fatigue, visual adaptation, communicating and displaying culture, land marking, and environmental protection. Thirdly, it lays down the principles for landscape design, e.g. safety, failure prevention, physiological, anthropological, blending and economic principles. Lastly, it discusses the diversity of landscape designs in China, including types of tunnel portals, integration with local cultures (subdivided into ethnological culture, regional culture and historical culture), environmental protection awareness, lighting transitions in tunnel entrances, blending with the surrounding environment, symbolic and metaphorical skills in tunnel portal landscape design, and special decorations. The results suggest that landscape design of tunnel portals is a comprehensive artistic endeavor, involving local culture; bionomics; psychology; environment protection; lighting; structural techniques; new material implementation; and new technical arts. In conclusion, good landscape design requires intensive and collaborative interdisciplinary studies.

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### 1. Introduction

Worldwide, tunnel entrance construction presents challenges because:

- (1) The cover depth at the tunnel entrance is shallow as it often moves through a mountain surface layer whose rocks are usually broken and seriously weathered. So, the surrounding rocks at a tunnel entrance have poor stability and have no arching strength.
- (2) Tunnel entrance excavation destroys the balance and the stability of the original slope, easily leading to landslides or collapses.
- (3) The unsymmetrical loading at a tunnel entrance is formed when a tunnel obliquely passes through a mountain or some rock layers, which will cause bigger bending moments and stresses in the supporting structure and bring potential danger.

The outside framework of a tunnel portal possesses several functions. It primarily acts as a structural support against earth pressure and may stabilize surrounding rocks as well as prevent

the adjacent road area from rockfall and avalanche damage. Secondly, it buffers brightness differences between the inside and outside of the tunnel, providing a lighting transition for visual safety and driving comfort. Thirdly, the tunnel portal may serve as a landscape element which can harmonize the tunnel with the surrounding environment. In addition, surface water can be diverted above the tunnel portal at the same time.

In China, before the 1990s, a winding mountain road or path was almost the only choice for crossing mountainous areas and tunnels were rarely used. This was because of the economic situation, technological level and classification grade factors. So, the question of tunnel portal landscape design did not arise. Along with the rapid development of the Chinese economy and the increasing investment in construction of infrastructure facilities in recent years, mountain highways have been developing quickly all over the country. As a result, tunnels are widely employed today in traversing mountains.

Peila and Pelizza (2002) argued that “the architectural and landscape aspects related to tunnel portals become very important as the awareness of environment protection by designers gives rise to elevated concerns of integrating an infrastructure with its surroundings”. In China, attention has been increasingly accorded to the landscape function of tunnel portals (Guan, 2004; Lin, 2007; Li, 2008; Wu, 2008; Ye et al., 2009). As a result, landscape design of tunnel portals has become a focus and a variety of highway tunnel portals have been built recently. Portals are not only utilized as

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tunnel entrances, but also regarded as places for demonstrating regional cultural and esthetic accomplishments. Hence, landscape architecture in connection with tunnel portal design has become connected to the social interests of the region.

This paper mainly discusses several issues in relation to tunnel portal landscape design and highlights some exemplary portals for highway tunnels designed recently in China.

**2. The general development situation of Chinese highway tunnels**

In the last decade, with the rapid development of mountain highways, tunnel construction has become the first choice for highway alignment because of its advantages for optimal alignment, shortening mileage, saving traveling time and enhancing operation efficiency. In fact, China has already become the country with the most highway tunnels and the longest highway tunnel mileages (Li, 2008). Fig. 1 shows the general development situation in terms of the number of highway tunnels and their length in China in recent years.

**3. Main problems of highway tunnel entrance engineering in early periods in China**

*3.1. Unreasonable tunnel portal position*

Generally speaking, a tunnel often enters a mountain at a ridge or near a ridge position due to the following advantages: (1) there

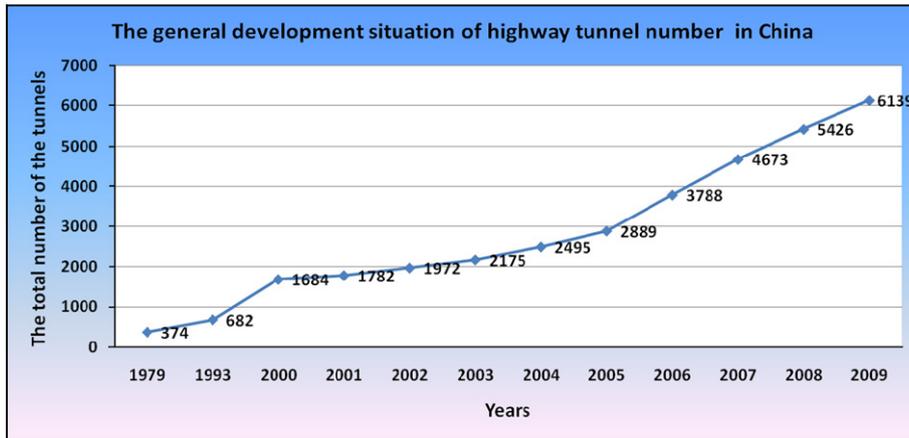
is a good geological condition at the mountain ridge with only a shallow accumulation of loose materials; (2) the slope is gentle at the mountain ridge, which is good for slope stability; (3) drainage is convenient around the tunnel portal.

But highway tunnels often enter a mountain through a valley in practical tunnel engineering due to general route planning or economic considerations. This kind of tunnel portal not only brings negative effects on slope stability, but also causes surface water within the valley to flow into the tunnel portal, thus increasing the difficulty of portal drainage (shown in Figs. 2 and 3).

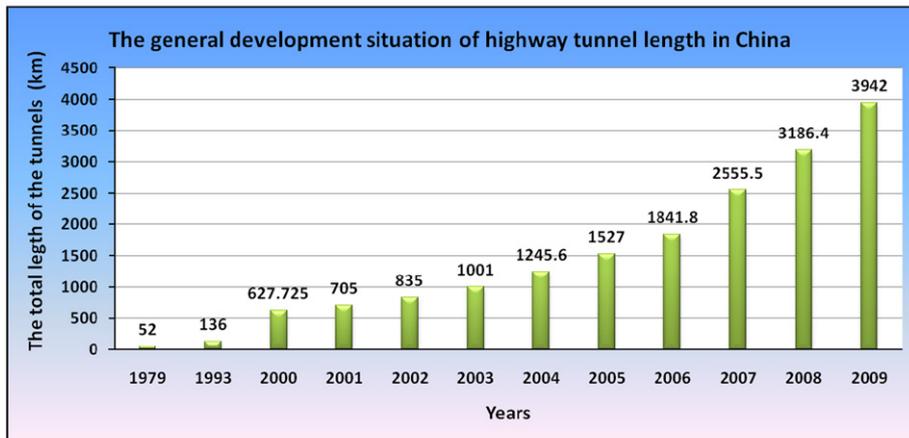
*3.2. Deep and wide excavations were often used in tunnel portal engineering*

For a long time, deep and wide excavations were often used in tunnel portal engineering because of construction cost advantages (see Fig. 4). In this case, the ground was often stripped as much as necessary and concrete supporting walls remained a dominant visual feature. Also, a slope supporting wall was frequently used for enhanced stability of slopes in the neighborhood of tunnel portals (see Fig. 5).

At the same time, the deep and wide excavation can destroy the intrinsic equilibrium state and the stability of the original slope, and lead to an increased landslide or collapse potential. Furthermore, this excavation severely damages the natural environment and the volume of ground to be removed from the site.



(a)



(b)

Fig. 1. The general development situation of the total highway tunnel numbers and length in China.

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