Research on Highway Landscape Design Based on Driver's Visual Characteristics

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Abstract. In order to improve the theoretical system of highway landscape design, the road landscape design method based on driver's visual characteristics was studied. Firstly, the changes of the visual characteristics of the driver's light and dark adaptation, color perception, dynamic vision, and fixation point are analyzed. Secondly, from the perspective of different highway engineering structures, the landscape design methods based on visual characteristics are studied, including: central dividers, tunnels, flyovers and service areas. Finally, the scientific application of visual characteristics in highway landscape design is discussed in combination with Guangna high-speed physical engineering. The results show that the distance, structure shape, scale and color of highway engineering structures will affect the driver's landscape perception experience, and the highway landscape design considering visual characteristics is more scientific and reasonable.

1. Introduction
Highway landscape design has a positive significance for relaxing the mentality of the passengers, focusing on driving and improving the road operating environment. Also, highway landscape design covers many fields, including: environmental science, psychology, behavioral science, and engineering and art [1]. The traditional highway landscape design lacks the analysis of the public aesthetics experience law. The lack of research on the visual characteristics and cognitive rules of the passengers has gradually failed to adapt to people's pursuit of highway aesthetics [2]. It is of great significance to study the visual features of drivers in highway landscape design.

2. The drivers' visual characteristics

2.1 Light and Shade Adaptation
Dark adaptation refers to the process in which the visual sensitivity gradually increases, and the surrounding objects can be distinguished when strong light enters the darkness. On the contrary, due to the strong light, the initial moment will feel dazzling and can not see outside things. Tall trees can be planted within a certain distance from the tunnel entrance, which can play a role in mitigating light or alleviating the effect of dark adaptation.
2.2 Characteristic of color vision
Color perception refers to the reaction of different wavelength light acting on the retina in the human brain. The color of landscape material in high temperature area can be chosen as cold color to create a cool atmosphere. In a word, scientific and rational use of color sense can make highway landscape structure more harmonious.

2.3 Kinematic vision decreases with the increase of speed
Kinematic vision refers to the visual acuity of people in the state of movement, which is highly related to the speed of carrier movement or the speed of environmental change. Relevant research shows that when the vehicle travels at a speed of 60km/h, it can see the object 230m in front of the vehicle, and when the speed increases to 80km/h, the distance that can be clearly identified can be reduced to 160m.

2.4 The fixation point moves forward with the increase of velocity
In the course of vehicle driving, the driver's visual boundary becomes narrower with the increase of vehicle speed, while the depth of gaze point increases with the increase of vehicle speed. When the speed is 60 km/h, the gaze point is 46m ahead. And when the speed is 120 km/h, the gaze point is 500m ahead. Therefore, the larger the distance, the larger the size required to be clearly identified by the driver.

3. Highway Landscape Construction Based on Visual Characteristics

3.1 Central dividing zone
The plant-type central dividing zone has become the mainstream choice of highway landscape design industry because of its functions of guiding sight, reducing noise and adjusting humidity. Firstly, the greening height in the plant-type central partition zone should be about 1.5m higher than the road surface, and the angle of shading and anti-glare should be set between 9 and 20 degrees to ensure the anti-glare function of the partition zone [3]. Secondly, the faster the speed of the road is, the larger the landscape scale is needed. Landscape length should be no less than 5 seconds drive by car. The color or season of plants in different units change regularly.

3.2 Tunnel

3.2.1 Tunnel Port. Landscape elements of tunnel portal section include tunnel portal form, tunnel portal slope, central partition zone and roadside green belt. Each landscape element also contains many forms, The central dividing zone can be divided into separate type and small net distance type. The overall effect of different combination of landscape elements is quite different, which has different effects on the visual perception and psychological effect of the crew. Therefore, the landscape elements of tunnel entrance should be combined scientifically and reasonably. Tables 1 and figure 1 show the relationship between the ratio of eye flashes and fixation times and landscape elements [4].

Table 1. The Relation Table between the Increase of the Ratio of Eye Flash and Watching Number and the Combination of Landscape Elements in Different Locations

| Distance from tunnel entrance | 300-240 (m) | 240-180 (m) | 180-120 (m) | 120-60 (m) | 60-0 (m) |
|------------------------------|-------------|-------------|-------------|------------|---------|
| Combination 1: A+C+E         | 11.4%       | 21.8%       | 31.1%       | 53.2%      | 76.5%   |
| Combination 2: A+D+E         | 15.1%       | 28.7%       | 36.6%       | 58.4%      | 81.2%   |
| Combination 3: A+C+F         | 12.9%       | 23.6%       | 33.8%       | 63.5%      | 79.1%   |
| Combination 4: A+D+F         | 9.5%        | 34.1%       | 38.9%       | 64.8%      | 86.4%   |
| Combination 5: B+C+E         | 6.1%        | 15.6%       | 20.1%       | 43.2%      | 56.1%   |
Combination 6: B+D+E

| Ratio increase | 10.2% | 18.3% | 25.9% | 47.2% | 57.9% |

Combination 7: B+D+F

| Ratio increase | 8.8% | 14.5% | 22.6% | 48.1% | 55.9% |

Combination 8: B+D+F

| Ratio increase | 14.2% | 17.9% | 29.2% | 49.1% | 61.2% |

Note: A: Endwall  B: Cutting Bamboo  C: Separated  D: Small Clear Spacing  E: Road Side Green Belt  F: No Road Side Green Belt

Figure 1. Relation between the Increase of the Ratio of Eye Flash and Watching Number and the Combination of Landscape Elements in Different Locations

From Table 1 and Figure 1, it can be seen that when the driver is driving on the tunnel entrance section of Landscape Elements Combination 1 and Combination 5, the increase range of the ratio of eye flash times to fixation times is the smallest. It shows that the landscape environment is good at this time and it is relatively easy to obtain road and traffic information. Therefore, the combination of end-wall portal + separated tunnel + roadside greenbelt or bamboo-cut portal + separated tunnel + roadside greenbelt is recommended for the landscape elements of tunnel entrance section.

3.2.2 Tunnel interior. The influence of light and shade adaptation and color perception is more considered in the landscape construction of tunnel tunnel tunnel. The color of the tunnel landscape should be in harmony with the surrounding environment, and the decorative color should be strictly distinguished from the traffic safety color. In terms of scale, the landscape characteristic section in tunnel should be set after the transition section from outside to inside. Usually, the starting point of landscape characteristic section can be 3-3.5 kilometers after entering the cave. Its travel time should not be less than 5 seconds. Practicality and economy should be taken into account. It can be reasonably controlled according to the overall length of the tunnel. The actual traffic shows that when the tunnel landscape characteristic section length is 250-350 meters and the passage time is 9-11 seconds, it can not only meet the requirements of safe driving, but also form obvious visual memory [5].

3.3 Foothbridge

The overall landscape effect of overpasses should consider the coordination with the environment. When the superstructure design is simple, the piers and abutments should not be cumbersome. Bridge treatment should be based on large-scale. In terms of color, we should follow the principle of harmony with the environment. On the premise of determining the tone of environmental color, reasonable spraying of bridges is carried out to achieve the target effect [6]. In addition, the rational use of color sense of cold and warm, while sublimating the aesthetic sense of the bridge.
3.4 Service area
The layout of service areas should be scientific and rational, and the service facilities should be adequate. Landscape in service area can be designed in combination with local culture [7]. Greening can be combined with modern gardening techniques. Plant collocation should follow the principle of diversity. In addition, plants create a comfortable and beautiful space environment for the passengers. Finally, as an important part of the landscape of the service area, the signs and signs should be handled in detail.

4. Engineering application
Guangna Expressway starts at Guangnan County Town and ends at Nasa Town. The total length of Guangna Expressway is 49.6 kilometers, including 41 medium-sized bridges and 12 tunnels. The ratio of bridge to tunnel is as high as 48.95%.

4.1 Central dividing zone
The height of trees in the partition zone is suitable, and the lateral vision is good, which ensures the anti-glare function. The color or seasonal phase of plants among different units is in harmony with the highway environment, as shown in Figure 2. While preventing the visual fatigue of the passengers, it also increases the aesthetic and comfortable sense of color sense.

![Figure 2. The central dividing zone of Guangna high-speed](image)

4.2 Tunnel
The arch circle is shaped by arc, and the gradient waterproof paint from white to grey is used to unify the visual effect. The tunnel increases the external structure of the arch ring. Plant restoration and topographic construction in the front of the cave not only reduce the time of light and shade adaptation, but also coordinate the transition with the surrounding environment, as shown in Figure 3.

![Figure 3. Entrance of Anlaga Tunnel](image)

4.3 Footbridge
The overpass follows the principle of large-scale treatment. The main arch is painted in vermilion, the pier is painted in Pearl white, and the double-sided guardrail network is blue-green. It is not only the bright spot of the joints, but also unified with the overall color, as shown in Figure 4.

![Figure 4. Footbridge](image)
4.4 Service area
The combination of landmark system, landscape sculpture, landscape sketch and greening in Banmao service area shows the cultural regional customs and historical accumulation along the line. It reflects the rationality and diversity of highway landscape design, as shown in Figure 5.

5 Conclusion
The concept of landscape construction based on visual characteristics not only meets the driver's visual and psychological needs, but also improves the safety of highway operation. It has important theoretical significance to improve the landscape design of expressway. The main conclusions are as follows:

(1) Driver's visual characteristics are closely related to highway landscape design. Adjusting the change of light intensity in driving environment can alleviate the light and shade adaptation of drivers. Dynamic vision and gaze point are of great significance to determine the spacing and scale of landscape facilities reasonably.

(2) The greening in the central partition zone should be 1.5m higher than the road surface. The anti-glare angle should be 9-20 degrees. And the length of the landscape unit should not be less than the distance of 5 seconds driving by the car.

(3) Landscape elements of tunnel entrance section are more recommended to adopt the combination of end-wall portal + separated tunnel + roadside greenbelt or bamboo-cut portal + separated tunnel + roadside greenbelt. The landscape features should be set to 50-350 meters in length, equivalent to 9-11 seconds of travel time.

(4) The treatment of overpasses should be based on large scale. Its overall landscape effect can be coordinated with the environment. It can also highlight the visual sense of overpasses and make them more distinctive.

(5) The plant collocation in the service area should be diversified, and the signs should be handled in detail, which should have strong recognition, intuition and readability.
Acknowledgments
This research work was sponsored by the Project of the National Natural Science Foundation of China [Grant No.51608470] and the science and technology innovation demonstration project of Yunnan provincial department of transportation of China [Grant No. YJKJ﹝2018﹞33].

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