

Research into the Coordination on Urban Three-Dimensional Transport and Environment Color

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Abstract—Chinese large-scale cities and robust megalopolis are building their own sea-land-rail three-dimensional traffic networks, such as underground mass transit; road-based public transport system and air traffic. Three-dimensional traffic overpasses have been all over city crossroads. By analyzing the distribution and characteristics of three-dimensional traffic of Wuhan, a super-large city in mid China, this paper considers the combination of the color of three-dimensional traffic and the features of the city, coordination with the surrounding architectures, as well as the relations between the color of the three-dimensional traffic and traffic safety. This paper also suggested a design code and principle for city three-dimensional traffic designs, to depict the developing prospects of Wuhan as a distinctive international metropolis.

Keywords—*psychological response of color; traffic safety; urban overpass; landscape design*

I. INTRODUCTION

As Chinese people's living standards generally improve, motor vehicle population in urban areas are acutely increasing, which leads to more serious traffic problems. For example, in Hubei province 2016, the number of civilian automobiles has reached 5933.3 thousand, which has increased by 17.6% than last year. In those numbers, 49.5% are private vehicles. This exploding trend of motor vehicle amount has effectively lead to traffic congestions that greatly affect citizen's everyday life and even limits city's development. Therefore, major cities have turned to three-dimensional traffic to tackle this problem.

Three-dimensional traffic (3D traffic) has now become the most important traffic pattern in modern large cities. All these viaducts are also play a significant role in city landscape. However, due to its monotonicity, most importantly pale in color, citizens have limited acceptability of 3D traffic's effect on city landscape.

This paper analyses 3D traffic's influence over environment, combines with global typical cases, and puts forward improving methods from the aspect of color, which might provide some reference for 3D traffic color designs.

II. THE THREE-DIMENSIONAL TRAFFIC BUILDING AND ITS IMPACT ON THE CITY

The rapid development of the city has promoted the development of urban roads, the traditional roads rapidly extended to the three-dimensional, four-dimensional traffic, and elevated road is one of the most important components. Although the three-dimensional traffic alleviate the heavy traffic congestion in the city, the urban residents, especially the residents living next to the three-dimensional traffic lines have more negative appraisals. Most of the citizens' concern is that the height of the viaduct is so serious that the original ecological landscape of the city is seriously damaged. The bridge can obstruct pedestrian's sight, which is likely to cause traffic accidents. Almost all of the elevated colors are gray-Monotonous, and does not blend with the surrounding environment, therefore traditional viaducts with gray-monotonous colors could cause damage to the city's basic context.

A. Features of three-dimensional traffic buildings

For the current large and super large cities in China, the distribution of three-dimensional traffic building is on the main traffic arteries, which is a main factor of urban road construction. Wuhan is a central megalopolis in mid China, whose main traffic intersections are three-layer four-to overpass. Each one of these intersections covers an area of nearly twenty thousand square meters. Buildings with 20 to 40 storeys surrounding the intersection viaducts are usually less than 20 meters away from the viaducts, and the distance is even closer if the intersection is located in the city center. Noise isolation walls are installed on the safe retaining walls near the side of buildings. It is made of transparent plastic board with steel skeleton. The height is 2 to 3 meters. Basically, Overpasses can ensure rapid passage without obstruction for left turns, right turns as well as going straight. The width of the straight road is mainly two-way four lanes. The appearance of the overpass is given priority to the color of reinforced concrete which is gray, the shape of the bridge is clunky without any modification, the bridge of the gray made the color of the three-dimensional traffic, and especially viaduct section more depressing, the pier shape is tall and

rugged. The color is consistent on the bridge and the collocation between the shape and color further increased the heavy sense of visual, which makes the elevated road became a featureless and non-individual character in the city, the color of urban space more drab, urban color pollution more serious.

B. Impact on the city

Kevin Lynch, a famous American urban planning theorist, mentioned in the book "Good City Form" that large-scale objects would lead to dwarfs of other buildings in the area and lose their original scale. At present, for Wuhan, the scale of three-dimensional traffic has been much greater than that of its surrounding roads and buildings, which destroys the original scale of the city. The elevated expressways visually overwhelm people from close range with its oversized volume. Many scholars have shown that if the person's line-of-sight distance is D, the height above the human eye level is H, the most appropriate ratio between the building height and the width of the road is $D/H = 1 : 1 \sim 1 : 3$. When $D/H < 1$, it can create a sense of pressure and proximity. When $D/H = 2 \sim 3$, there will be some distance, but there is sufficient space to appreciate the architectural form; When $1 \leq D/H \leq 2$, it can create a kind of closed space feeling if there is no sense of pressure [5]. According to survey, the viaducts in Wuhan whose D/H is below 1 account for as much as 55%. This phenomenon is particularly prominent along the First Ring Expressway. While going through condense residential areas and commercial centers, piers would occupy large spaces that are already very crowded. Also, bridge piers are usually lined up in certain intervals, which can obstruct the line of sight of both drivers and pedestrians and cause accidents.

In urban ecology, viaducts can bring considerable pollutions to the environment. These pollutions include noise pollution, air pollution and light pollution. However, they cannot be effectively resolved in short terms. For residents who have been living along the elevated expressways, the noise it brings greatly affects their lives, even damaging their nerve systems. For those live far away from the viaducts, the only enjoys the transportation convenience they bring and do not receive any other negative impact [5].

III. THE TRAFFIC-SENSING EFFECT OF COLOR

Color is an important performance factor in urban planning and landscape design. The rational use of color can not only improve the environment, but more importantly, can express different information on different road sections. This can give drivers more information and help them drive safe.

A. Color theory

Eye usually receives colors and shapes as a whole. But while differentiating things, people always turn to colors first. There are achromatic colors and colored colors. The part of achromatic colors includes black, white and gray; and the colors part mainly includes red, yellow, blue and other bright colors. Beside color property, color has three basic attributes, lightness, saturation and hue. Lightness refers to the value of the color brightness changes, saturation refers to the extent of the bright-colored, and hue is the appellation of color

appearance. People's ability, which could recognize attributes of color, is called color vision. It has a significant impact on the color design. Color differences are the main reason which brings on the difference of distance between two different color objects. In color, the long wavelength color like red and yellow will make us feel forward, the shorter wavelength color like blue and purple suggests good things. Warm and high purity color with a strong sense of stretching, muddy and low purity color has a sense of falling. Besides, color on different background can produce different sense of advance and retreat, such as high-definition color on deep background makes people feel very close, low-definition color on light background feels far. The sense of advance and retreat of color is closely associated with the background color. People's visual perception of color is far more than people's perception of the form. For example, people's feelings about colors vary in different parts of the country, depending on the local temperature and light (Fig.1.). People living in the tropics, for example, prefer the cooler colors of visual feeling, so they are more receptive to high-lightness color and colorless color (Fig.2.) while people in the Frigid Zone prefer the color of warm colors visually and psychologically [7].



Fig. 1. Color dilatancy

Fig.2. High-lightness

This study discovered that personal color vision is far above the form vision. For example, the effects of temperatures and illumination on perception of color. People who live in the tropics are far readier to accept the cold colors, so they are more receptive to the achromatic colors and cold colors of high lightness. However, the people who live in the cold climate prefer the warm color in visual and psychological. When a person looks steadily at a single color for a long time, cerebral cortex being constantly stimulated by single color, so some nerve cells can produce inhibition to the stimulation, which make the person unable to produce the sense of stimulation. Therefore, facing the same color of road traffic for a long time, the driver's visual perception will be hard to stimulated, leading to the drowsiness of the driver and causing the traffic accident [3]. At present, the main roads in Wuhan have been monotonous gray road-based, the driver in the long driving process facing the gray color of low saturation of the colorless is easy to feel the visual fatigue, which leads to the visual changes becoming slow, slower reflection, and the occurrence of traffic accidents eventually. In addition, we contact with the warm color whose lightness and color saturation is too high in a long time which stimulates the eye more seriously, and thus it's easy to make people feel tired in a short time. In addition to fatigue, the color also has a major feature called expansion. As can be seen from Fig. 1, it has the same form and size, but there is still a significant difference in visual perception. In a general way, the color with tall lightness and warm color feels with expanding to the person, the cool color with lightness and the color with low lightness give a person the sense with regressive, augment. For example, yellow feels with expanding to the

person, so the visibility of the yellow logo is relatively high in the gray-based road. In order to solve the problem of fast speed in China, on a long road, painted in dozens of yellow warning line. In the driver's view, these lines just look like water ripple, so drivers can focus on your attention and reduce speed meanwhile.

B. Color and traffic behavior

Driver's visual perception is the process of processing the external information taken in from visual receptors. It is a complex psychological system, which includes the psychological processes such as perception, attention and memory. Every psychological process is in correlative dependence and interaction. The driver interacts with the environmental conditions when driving. His physical and psychological will be stimulated to receive input from external factors, resulting in the corresponding driving behavior changes. In all the important driving information obtained, more than 80% of them are acquired through vision. Psychological studies have shown that when observing objects, the first element of the visual response is color. The first visual attention paid to color in the total visual response is 80%, and the external shape of the object is 20%. After 2 seconds, the attention to the shape increases to 40%, and the attention to color decreases to 60%. 5 seconds later, the attention to color and shape account for 50% respectively. In the case of rapid movement, the observation time of object next to the road is very short. So, color generally takes up more visual attention from the driver [1]. In different circumstances, due to the interference of various factors, color recognition can be very different. When driving in the evening under the influence of headlights, white and yellow can be the most easily identified in a short time, which is followed by green and red. Blue is relatively difficult to be identified among the headlights. Similarly, colors very bright during daytime may diminish in the evening [3]. Additionally, according to the study of US Minnesota security forces, in the morning and dusk and in misty rains, the probability of green and yellow cars being spotted from the same distance is generally four times than cars with dark colors. So yellow and green paint not only increase the visibility of the car, but also can cause nervous excitement of the driver, make the driver to be more focused.

IV. COORDINATION STRATEGY OF THREE - DIMENSIONAL TRAFFIC AND ENVIRONMENTAL COLOR

A. The general design principle of three - dimensional traffic color

The continuity of the elevated traffic brings people's activities space closer. Compared with the shape of viaducts, people are more likely to be attracted by the color. Taking advantage of this point, with the right color scheme, it can not only improve its aesthetic feeling and make the viaducts blend well with the environment; spaces can also be divided to induce traffic. Thus, simple variations in color become variations in the functionality highlighting the environment as its target. [4] On the other hand, although the color has something in common on human's visual and psychological sense, it's also influenced by the surrounding environment,

culture, geographical and other aspects. As the French color master Jean-Philippe Lenclos said, the environment color in different areas varies depending on the geographical location. People in different regions have their own unique preferences for different colors, and these preferences are reflected in the colors of surrounding environment and architectural. For example, Chinese people regard red as the most festive color, while yellow is the most distinguished color. Culture, art, religious beliefs of different regions creates a different character of the locals, which is embodied in the pursuit of different colors [6]. For example, in Newcastle, England, people in Indo-Pakistan prefer to the color of red and yellow, while white people are more biased towards black and white. Therefore, the overall color design of the elevated road is based on the overall positioning of the ambient color. The color of the surrounding environment is the main component as well as the main reference color in the color design process of three-dimensional traffic.

Elevated traffic is one of the main components of urban traffic. So, we must follow several design principles while choosing main colors: to keep the coordination with the surrounding environment; to take full account of the impact of surrounding environment on the viaducts; to consider the impact of color contrast; to avoid using strong contrasting colors in the same elevated; and take account of the light and shade contrast, climate changes and other natural causes on the color.

Respect local customs, traditional culture, color preferences, and in the color design appropriately add the color of local cultural characteristics. Use the color to make up for the problems like being bulky and monotonous, and create their own characteristics at the same time. Take full account of the impact of color on the driver. Color on the viaducts can act as an underlying guidance, and reduce the rate of traffic accidents. Color changes and design of the viaducts is only a means, the purpose is to improve the practicality of the elevated road, make the urban environment people-oriented, and reduce the probability of car accidents.

B. The color design of the main body of the elevated traffic

The main colors of the elevated road should comply to the publicity of the color. The so-called publicity is the color preferences of the public and the color of the city landscape. It is generally based on local cultural traditions and natural landscape, meanwhile the living environment and psychological needs of the surrounding residents should also be considered.

Color design of piers and bridge bottom. The sunshine duration of the pier and the bridge is short, but the amount of vehicles accounted for 50% to 55% of the total traffic on The First Ring Expressway. So, the color selection is dominated by high brightness and high reflectivity. Brighter colors reduce the sense of oppression and depression caused by the lack of light and improves the environment under the bridge. For short and thick piers, different colors can be used to weaken the sense of depression caused by the visual ponderosity. For thin and high piers, bright warm color schemes can be adopted to increase the heavy feeling of the pier.

Side railings of the bridge. The contrast between the bridge rail and the surrounding environment can serve as a warning sign with isolating effect. Barrier color of different areas varies based on the color of the surrounding environment. Taking Wuhan First Ring Road as an example, both sides of Xu Dong section are mainly commercial buildings and residential areas, and the color of main buildings is gray-based. In the gray-based surrounding environment, the fence can adopt light and pure colors, thus playing a warning role on pedestrians and non-motor vehicles. The fences of Xu Dong section actually use yellow as main color. The East Lake section of the First ring road is surrounded by parks and green vegetation mainly. As the contrast color of green, red is selected to be the main color of side railings, so red and green can be in stark contrast to improve the driver's vigilance.

C. Color of viaduct road

As mentioned earlier, the color of most of road in Wuhan is gray. Long driving can cause fatigue, apathetic, resulting in traffic accidents. So, the design of the road color has some changes. In the special sections, such as speed limit areas, turns, multiple traffic accident sections, you can use different colors, not only can it improve the driver's visual environment, but also stimulate the driver's nerves, making them maintain a high concentration of attention.

Taking the Yuejiazui interchange of Wuhan First Ring Road as an example, this section is one of the main ramps of the First ring. Huge amount of traffic flow converges and diverges from this intersection. The speed limit on the first ring line is 60km/h, while the speed limit is only 40km/h on the ramp, resulting in excessive overspeed vehicles here. The color of residential buildings next to the overpasses are mostly gray-based, so the color in the turning limit speed zone is dominated by the color of long wavelength, in this case, yellow. Because the expansion of yellow will make the driver notice the corner in the distance earlier and its visibility reduction is minimum in extreme weathers like fog and rain.

Additionally, on the ground level, drivers unfamiliar with this region often find it uneasy to spot the ramp entrance. Some drivers simply miss the entrance and have to double back, and others may try to change lanes near the entrance. Thus, unnecessary traffic stress is introduced. The fact is that signs on the elevated bridges are not obvious enough, and there are no special signs on the entrance. The color of the entrance ramp can be distinguished here. Green can be used to paint the road surface of the ramp, which is sufficiently prominent to act as a leading sign.

Moreover, the red color scheme can be selected in accident black spots. The visual perception of red is alert; therefore drivers passing through this road section can be more vigilant and prepared for unforeseeable accidents.

V. CONCLUSIONS

The color of the road has obvious influence on the driver's attention to the road and the speed, and the anti-collision wall on both sides of the road has obvious inducing effect on the speed of driving vehicles. Therefore, the reasonable design of pavement color and anti-collision wall signs has significant effect on traffic safety.

The color coordination design of the lateral and bottom of three-dimensional transport facilities is related to the urban style and the surrounding environment. Reasonable collocation will construct distinctive city features, improve urban affinity and influence, change existing unified situation of concrete gray, thus improving the overall image of the city

The design of urban landscape is inseparable with the color design of urban three-dimensional traffic, but the color design that serves traffic safety is the central problem that needs to be solved. Based on the preliminary analysis of traffic in Wuhan, this paper puts forward some design concepts, but the in-depth study of each situation still needs to be carried out.

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