PERCEPTUAL PAVEMENT MARKINGS AND THEIR APPLICATION

Li Chang-cheng¹², Tang Jun-jun², Han Hui²
(¹ Beijing University of Technology, Beijing 100124, China; ² Key Laboratory of Road Safety Ministry of Transport, Research Institute of Highway Ministry of Transport, Beijing 100088, China)

ABSTRACT

Pavement marking is a kind of traffic safety facility that plays important role in road safety. As the development and application of ergonomics in traffic engineering and road safety, perceptual markings appeared in Japan, America and Europe. Perceptual markings warn drivers of potential danger or inform drivers of road condition change by special figure, color, alignment, textile or their combinations that can offer drivers visual, tactile or aural sensations. This paper gives an overall introduction of perceptual markings and their typical application and practice, which can be referred by traffic practitioners.

Key words: traffic, safety, pavement markings, speed, accident

1 PAVEMENT MARKINGS AND TRAFFIC SAFETY

Pavement markings, as an important traffic control facilities, play a key role in defining right of way, warning of danger condition, and offering auxiliary information. Pavement markings are of low-cost and high-effect traffic safety measures. Studies showed that edge line, median line, lane line had the benefit-cost ratio of 21-103. And the benefit-cost ratio of markings used at urban area was double that of those used at suburban area. Accident rate could be decreased by 21% when applying traffic lane lines on road. A study by Bali showed that on two-way-two-lane roads at suburban areas accidents could be reduced by 21% if using edge and median lines, and the figure was 8% if adding edge lines only at roads with median lines.[1] A study by Zhang Dianye indicated that vehicles were ready to maintain in the middle of lane on roads with edge lines than on roads only with median lines or without pavement markings. Edge lines could help stable and accurate driving, improve traffic safety. Tests of heart rate variability coefficient of drivers showed that drivers were not easily fatigued when driving on roads with edge lines. [2] A study by Geni showed that raised pavement markings applied on accident black spots at two-way-two-lane roads in New York helped reduce total accidents and accident at nighttime. For four lane and heavy traffic...
roads with ADT more than 20000, raised pavement markings could decrease accident at nighttime and under slippery road conditions significantly. [3]

2 PERCEPTUAL PAVEMENT MARKINGS

Beside traditional longitudinal pavement markings such as edge line, median line, lane lines, more and more new types of or new application pattern markings appeared with the development and application of ergonomics in traffic safety fields. These new pavement markings are usually called “perceptual markings”, which are characterized by special figure, color, alignment, textile or their combinations that provide drivers more visual, tactile or aural stimulus or a feeling of illusion (for example, drivers will feel faster than usual at the same speed if they meet perceptual markings).

A literature discussed the factors than impact speed selection, pointed out that psychology was a key factor for driver to determine driving speed. Four major factors affecting speeds were: roadside development, road physical characteristics, traffic condition and environment (such as time, weather, etc.).[4] One researcher put forward a new concept of speed estimation based on sensory or perceptual cues. The author also considered that drivers mainly used edge visions to determine appropriate speed.[5]

The function of perceptual markings in traffic safety are expressed by reduce vehicles speed. The sensation of vibration and vision offered by perceptual markings helps to make drivers notice the change of road condition subconsciously, or feel that current speed is incompatible with prevailing road and traffic conditions. Perceptual markings are recommended to use following road segments or sections: high rate of speeding, accident black spot, long down slopes or sharp curves, ramp entrances, village or town road sections, etc. that are necessary to control or reduce driving speed.

3 THE APPLICATION OF PERCEPTUAL MARKINGS

Several common perceptual markings of different principles are introduced as follows: chevron pavement markings, transverse speed pavement markings, special figure pavement markings. Some markings give drivers illusion that traffic lane turns narrow; some markings make drivers feel faster and faster if they do not control driving speed; some markings create a special visual effects that it seems some obstacles exist on road and drivers would hit them if they do not reduce speed to certain extent so as to discern “what they are”. The most common conditions are that perceptual markings are applied to provide drivers vibration sensation and a feeling that vehicle is accelerating, thus to draw drivers’ attention and inform the change of road conditions.
3.1 Chevron Pavement Markings

A. Kozaki conducted a study to evaluate the effect of chevron pavement markings in 1991 in Japan. Evaluations showed that vehicles began to slow down before they entered curves. This kind of markings gives drivers a feeling of acceleration especially when vehicles run down slopes. Figure 1 shows application case of chevron markings in Japan. [6] Figure 2 displays the use of chevron markings before the exit of ramp in USA. Investigation showed that the average speed at exit decreased from 113km/h to 85 km/h two months after chevron markings were installed. [7][8]

Chevron markings are usually paved by group, and every group consists of equal number of chevrons which range from 4 to 10. Each chevron with the width of 15cm, paves at the interval of 5cm, and the angle is 60 degree. The spacing of each group is determined by the entrance speed at the start of the chevron markings, the expected exit speed at the end of the chevron markings, and the estimated decelerate rate applied by drivers. Decelerate rate of 1-2m/s² and 2-3 groups passing by vehicle every second are usually used to calculate the group spacing.

Figure 1 chevron markings application at the entrance of curve on double-lane roads

Figure 2 chevron markings application before the exit of ramp

3.2 Transverse Pavement Markings

Transverse pavement markings are commonly used in China, and they are also called speed pavement markings, which are applied to advise drivers to reduce speed. Transverse pavement markings can be set at long down slopes (lanes of down slope direction), relatively sharp curves (lanes of outside curve), entrance of convex vertical curve with limited sight distance (lanes of up slope direction), etc. This kind of markings can be paved flexibly; they can be set continuously, or by group at the spacing
of 20-50m according to local conditions and demands. Figure 4 shows the application case at one section of national route 103 in Beijing. Before and after analysis of the transverse pavement markings used in speed management pilot project showed that V85 (85 percentile speeds) decreased by 5km/h or 6.4%, and the dispersion of speed was also reduced.

Figure 3 application example at one slope and curve section on expressway

Figure 4 application example at national route 103 in Beijing

3.3 Peripheral Speed Pavement Markings

Godley and others evaluated and contrasted the effects between transverse and peripheral (not throughout, only set at lane edge) speed pavement markings. Result showed that on the whole, both of them had the same effect. The implementation costs of peripheral speed pavement markings are lower than that of transverse speed pavement markings. [9] As the judgment of the driver to speed mainly depends on the visual experience near the edge of lane, the peripheral speed pavement markings can also play a role even though they are short.

Peripheral speed pavement markings are usually set in the vertical directions of traffic, which extend from the lane line or edge line to inner side of travel lane, 45cm in length and 30cm in width. The peripheral speed pavement markings are arranged at unequal spacing, to make vehicles through the same number of marking lines at the same time interval (generally designated 2-5 marking lines each second) as far as possible. As shown in Figure 6, survey results of the pilot application at one section of national route 103 in Beijing showed that V85 speed dropped by 7.2km/h or 9.2%.
3.4 Longitudinal Speed Pavement Markings

In 1997, N. Takada et al. evaluated the effectiveness of longitudinal speed pavement markings paved at curves or slopes. Results showed that the vehicle average speed decreased by 1.6-5.7 km/h; the dispersion of speed was declined; vehicles decelerated significantly in down slope directions at night; the number of lane change was reduced.[6]

The longitudinal speed pavement markings create drivers an illusion that lane turns narrow or lane exist obstacles. They help enhance drivers’ attention and reduce speed in time. This kind of visual markings can be set at sections where the vehicles’ speed need to be decrease (such as entrance of intersection, curves, village or town sections) if necessary. Figure 7 is an example that longitudinal speed pavement markings applied at road section across a town. As shown in Figure 8, survey results of the pilot application at one accident black spot section of national route 103 in Beijing showed that V85 speed dropped by 7.4 km/h or 8.5%. 
3.5 Other Perceptual Markings

Figure 9 and 10 are other kinds of perceptual markings (also called illusive speed markings in China) that applied on some sections of National route 109 in Mentougou district, Beijing. These kinds of markings can create three-dimension visual effects when they are seen at certain distance. It seems that some objects are placed on the road, thus, force drivers to brake and reduce speed timely. Illusive speed markings are creatively designed markings mainly used to reduce travel speed and improve traffic safety by their special visual effects.
4 CONCLUSION

Perceptual markings, as new types of or new application pattern markings were first studied and applied in Japan, USA, etc. Some of them were adopted in standards and specifications so as to extend their applications. As the rapid progress of study and practice on traffic engineering in recent years in China, perceptual markings drew more attentions and were introduced; at the same time, improvement and innovation of perceptual markings are conducted continuously according to local conditions in China. Some evaluation surveys show that perceptual markings have significant effects on reducing speed and providing warnings. They can reduce speed by 5-10km/h; however, it found that it’s difficult to decrease speed more than 10km/h only by perceptual markings. This limit implies that applying comprehensive countermeasures may be a practical way to achieve expected targets of speed control and safety improvement.

REFERENCE