Model of deceleration lane length calculation based on quadratic

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Report Contents

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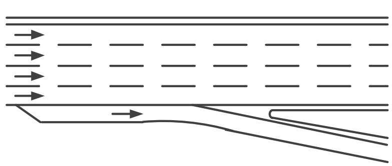
1 INTRODUCTION

Through observation and data analysis of the eight-lane highway deceleration lane existing in China, paper propose a calculation method and the recommended length of the deceleration lane based on the theory of quadratic.

2 FORMS OF DECELERATION LANE

Two forms of highway deceleration lane are the direct type and parallel type. The characteristics are as follows:



Parallel-type deceleration lane

This type lane can provide striking export region for drivers, but the track of the shunt vehicles are S-shaped which does not match with the deceleration lane. So the driving comfort is poorer, and it is prone to rear-end collision accident.

2 FORMS OF DECELERATION LANE

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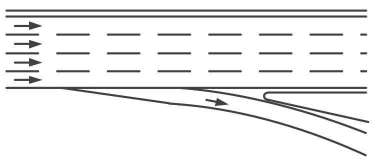

Direct-type deceleration lane

This type lane is better meet the drivers' directly driving track. Vehicles can directly drive into the gradual deceleration lane along the triangle transition section. Therefore, it is advantageous for vehicles' quickly and smoothly driving out and it can reduce the accidents. So in this paper , it is recommended as the deceleration lane type.

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3 MODEL ESTABLISHMENT

By actually measuring the running speed of different kinds of vehicles on the four sections of the eight-lane direct-type deceleration lane, the paper got the statistical graph of running vehicles' speed.

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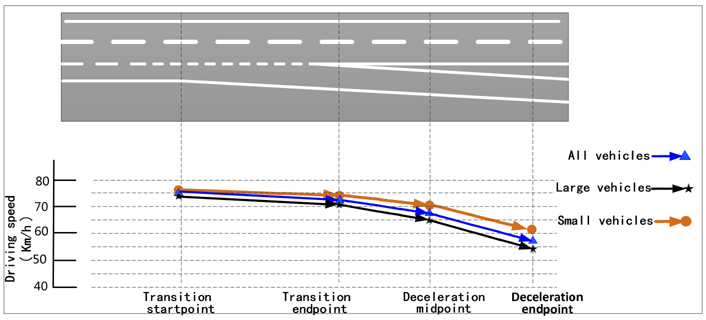
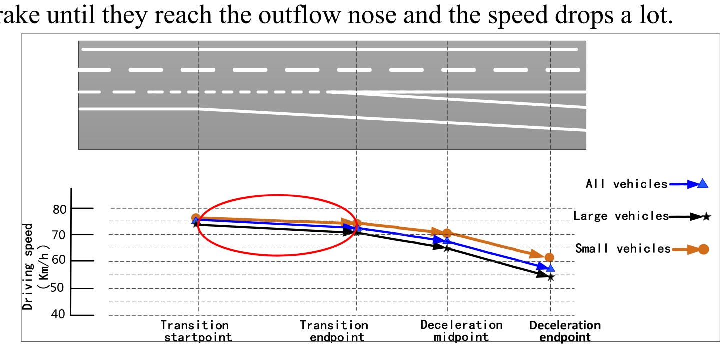


Running speed of direct-type deceleration lane

3 MODEL ESTABLISHMENT

Vehicles maintain speed in the triangle transition section, and the speed is related to the mainline designing speed; In the first deceleration section, vehicles speed down by the engine and the speed descend a little; In the second deceleration section, vehicles speed down by the brake until they reach the outflow nose and the speed drops a lot.



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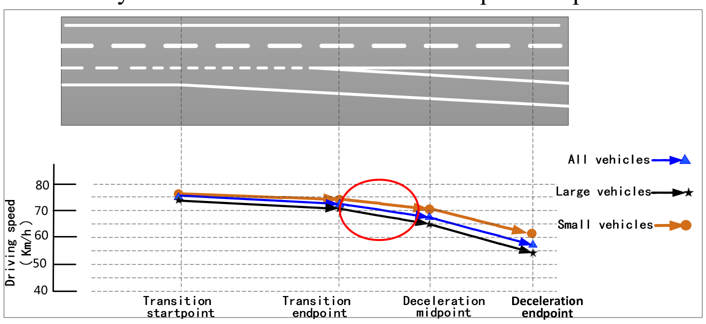

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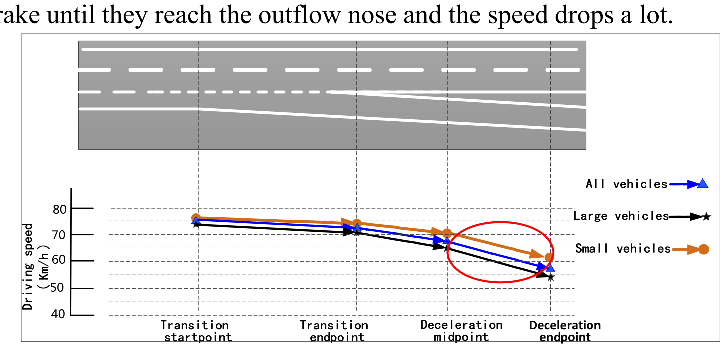

Running speed of direct-type deceleration lane

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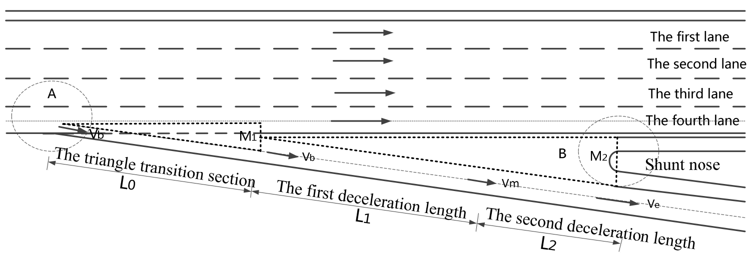
3 MODEL ESTABLISHMENT

According to the assumption of the eight-lane highway deceleration lane model, it got an illustration of the lane length . The length of deceleration lane L is the combination of the three sections. That is,

$$L=L_0+L_1+L_2$$

In which L_0(m) is the triangle transition section length, L_1(m) is the first deceleration length and L_2 (m) is the second deceleration length.



Schematic deceleration of the lane length calculation

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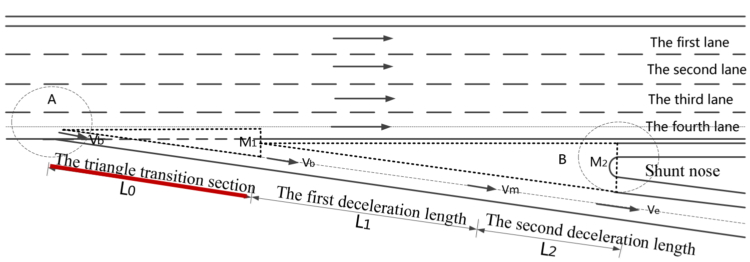
3 MODEL ESTABLISHMENT

(1)The triangle transition section length

The triangle transition section is vehicles complete horizontal movement and with the initial outflow speed drive into the deceleration lane . The section's calculation formula is determined according to the geometry relationship as follows:

$$L_0=\frac{M_1\cdot(L_1+L_2)}{M_2}$$



Schematic deceleration of the lane length calculation

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$$L_0 = \frac{M_1 \cdot (L_1 + L_2)}{M_2}$$

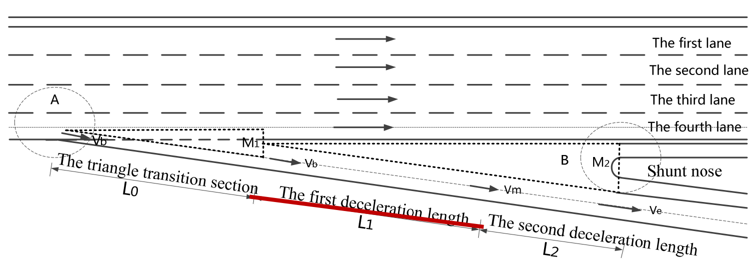
In which M_1(m) is the width of horizontal movement in the triangle transition section, and M_2(m) is the width of horizontal movement in the one-lane deceleration section.

3 MODEL ESTABLISHMENT

(2)The first deceleration length

The first deceleration length is vehicles pass through the triangle transition section and the vehicle speeds down by engine. The vehicle makes uniformly retarded motion. According to kinematics, it got the formula for the section as follows:

$$L_1 = \frac{V_b t_1}{3.6} - \frac{a_1 t_1^2}{2}$$



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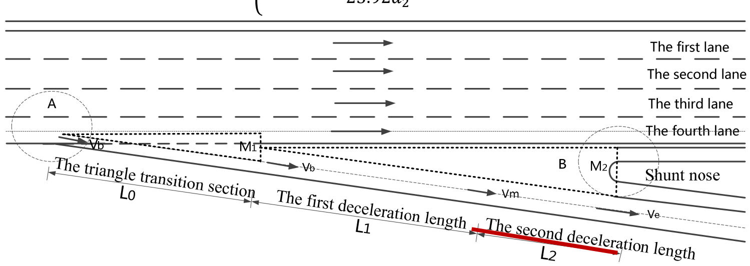
In which t_1(s) is the time for first deceleration section and it is usually 3s; V_b(km/h) is the initial speed at shunt point; a_1（m/s2） is the engine deceleration

3 MODEL ESTABLISHMENT

(3)The second deceleration length

The second deceleration length is from the full width of the ramp sections to end of the deceleration lane. And the vehicles use the brake to deceleration According to kinematics, it got the formula for the section as follows:

$$\begin{cases} V_m = V_b - 3.6a_1t_1, & \text{if } V_m > V_e \\ V_m = V_b \quad , & \text{if } V_m \le V_e \\ L_2 = \dfrac{V_m^2 - V_e^2}{25.92a_2} \end{cases}$$



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In which V_m (km/h) is final speed of the first deceleration; V_e (km/h) is nose shunt end speed; a_2（m/s2） is brake deceleration.

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4 MODEL PARAMETER AND RECOMMENDED VALUE

(1) The initial speed of outflow point

The measured outflow speed of eight-lane highways is close to that of Japan, so the paper uses the value of Japan. The designed speed of mainline and the corresponding initial speed of outflow points show out in Table 1(Japan highway design essentials 1991).

Table 1 Outflow point initial speed

Mainline design speed（km/h）	120	100	80	60	50	40
Outflow point initial speed（km/h）	90	80	70	60	50	40

(2) The end speed of outflow nose

According to the “specification” in ramp designation in China and the recommended value of AASHTO, the paper uses the value as shown in Table 2.

Table 2 Outflow nose end speed

Ramp design speed（km/h）	80	70	60	50	40	35	30
End speed of outflow nose（km/h）	70	63	60	50	40	30	30

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4 MODEL PARAMETER AND RECOMMENDED VALUE

(3) Retarded speed on deceleration lane

AASHTO provide the retarded speed of engine and brake in terms of "driving comfort" discussed in the two reduction theory. In this paper, it lists the first and second retarded speed in Table3

Table 3 Retarded speed

Initial speed of branch point（km/h）	90	80	70
Engine retarded speed （m/s²）	1	0.9	0.8
Brake retarded speed （m/s²）	2	1.8	1.6

4 MODEL PARAMETER AND RECOMMENDED VALUE

(4)Efflux angle and the length of triangle transition section

The "Specification" clearly provide the nose radius, the width of main line hard shoulder and the ramp hard shoulder, so the lateral offset value and the width of triangle transition section can be calculated, as shown in Table 4.

Table 4 The width of lateral offset and triangle transition section

mainline design speed（km/h）	120	100	80
the nose radius r（m）	0.6	0.6	0.6
the width of main line hard shoulder C1（m）	3.5	3.0	3.0
the width of left hard shoulder of ramp C2（m）	0.6	0.8	0.8
the lateral offset value M2（m）	3.5-0.5+1.2+1.6=5.8	5.5	5.5
the width of triangle transition section M1（m）	3.5+0.5=4.0	4.0	4.0

5 CONCLUSIONS

Through the analysis and study of the eight-lane highway deceleration lane, the paper draws the following main conclusions:

(1)By analyzing the changes of the speed and track of vehicles traveling, the paper determines eight-lane highway deceleration lane should adopt direct-type.

(2)The paper point direct-type gradual deceleration lane is made up of triangle transition section, the first and second deceleration. Besides, it gives the calculation method and the recommended length for each part.

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THANKS