Analysis of Limiting Speed and Traffic Capacity at Central Median Opening during Freeway Reconstruction and Extension

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Abstract. As “operating while constructing” model is widely used in the freeway reconstruction, in this paper, by analyzing the traffic conversion characteristics of vehicles, influence factors of the median opening capacity to build limited speed at median openings calculation model were respectively discussed, empirical formula and reference values of limiting speed at the median opening were given. And the median opening limiting traffic capacity of expression was given under the condition of different limiting speeds.

Introduction

Along with the increase of mileage and service life of the freeway in our country, there will be more and more freeways need to be reconstructed and extended or repaired, the ways of traffic organization while reconstructing and extending are fully enclosed construction, “operating while constructing” and so on. The latter is always used during reconstruction and extension when the freeway roadbed is monolithic and four-lane.

“Operating while Constructing” Model needs close lanes on one side of the constructed freeway and change the opposite side of the road to be two-way movement temporarily, in order to ensure the vehicle drive back to the original lane after driving through the construction area, it is necessary to open the median strip in front of the construction section to guide vehicles to drive to the opposite side of the road (figure 1). This method needs to make full use of original median openings or temporary median openings. The traffic safety and capacity will be affected at openings.

Traffic capacity refers to a certain vehicle running environment, the maximum number of transport entities (vehicles or pedestrians) passing a lane, a section or a certain intersection per unit time, it can evaluate the capacity of the road vehicle grooming. Limit capacity refers to capacity when traffic condition is limited, such as affections due to road construction, environmental conditions, traffic control. Based on the research of the four-lane freeway, the paper analyzes the capacity at the freeway median openings when it is reconstructed and expanded.

Figure 1. “Operating while Constructing” Model.
Analysis on Capacity Influence Factor

Generally, traffic capacity factors can be divided into two aspects including road condition and traffic condition. Road condition factors include lane width, lateral clearance, longitudinal slope, stadia and condition along the way, etc. Capacity at the workspace and median openings can be greatly influenced due to various conditions changes.

Analysis on Capacity Influence Factor at Work Area

Significant changes on road conditions, traffic conditions and traffic control conditions during freeway reconstruction and extension have a great influence on its capacity. Specific analysis for influence on capacity during freeway reconstruction and extension arise from the number of closed lanes, lane width, lateral clearance, speed through a workspace, the workspace length, road grade, lane closed form as follows:

The Number of Closed Lanes

It is necessary to close one or more traffic lanes because of the restriction by work condition during freeway reconstruction and extension, which will have great influence on the capacity of construction sections, the more closed lane number is, the greater impact on traffic capacity is.

Lane Width. Freeway reconstruction during the period of construction, the opened lane width has certain influence on the traffic capacity during the period of freeway construction and extension. It is generally believed that there is an optimal value for the lane width. When lane width reaches this value, the capacity value can reach its theoretic capacity, and its capacity will reduce when the lane width is less than or greater than this value.

Lateral Clearance. The influence of the lateral clearance refers to the impact on the marginal strip width of a median strip. Actual survey indicate that when marginal strip width is smaller than a certain value (standard value under ideal conditions, which is 0.75m taken from our country’s "highway capacity manual"), it makes the driver feel unsafe, which will result in slowing down or deviating from the lane and reducing the utilization rate of the adjacent lanes.

Speed Through Workspace. The speed limit through the workspace can improve security and reduce the probability of traffic accidents. At the same time, appropriate speed limit of vehicles through the work area can balance the speed of traffic and control traffic volume. Therefore the speed limit will affect capacity.

The Length of the Workspace. The longer the length of the workspace is, the higher requirements for the driver are. Drivers will drive more carefully when they are driving through overlong workspace, which will cut the traffic speed, and affect the capacity of workspace.

Road grade. Road grade has great impact on the design speed of the freeway and travel speed, especially for large vehicles when they climb or descend. American HCM2010 put forward that the coefficient of conversion from oversize vehicle into a passenger car on different slope sections should be considered in different situation. Covert coefficient varies with different grade, leading the reduction of road traffic capacity inordinately.

The Factors Affecting the Capacity of Median Strip Opening

The effect of median strip openings is to ensure the vehicle drive from one lane to the opposite lane, the main influence factors of capacity at median strip opening are the opening length, the speed limit at opening, the inside lane and width etc. This paper mainly studies the impact of median strip opening length, speed limit at opening on the opening capacity.

The shorter the median strip opening length, the smaller turning radius when a vehicle goes by and the lower speed is, which reduces the traffic capacity, and cause traffic congestion easily; When the median strip openings is too long, the speed through it will increase, and the capacity will rise, but
such condition will cause protection device lower protection ability, and it is easy to cause vehicles to rush to the lane out of control and serious accident. Therefore, to study the limit speed calculation model according to the median strip opening length under various conditions during freeway reconstruction and extension and other factors, and give the reasonable limit speed, to ensure construction of road traffic flow is smooth.

The speed limit at the median strip opening is the premise of guaranteeing for the vehicle driving safety. It can effectively control traffic volume and has important influence on traffic capacity. Below we will study the limit speed at median strip opening calculation model to analyze highway strip median openings and the capacity during the reconstruction and extension.

**The Median Strip Opening Limit Speed Calculation Model**

The median strip opening length should be selected to assure the vehicles within the limit speed pass safely. Vehicle passing median openings strip model simplify is shown in figure 2. Excessive segment is circular curve which radius is $R$.

![Figure 2. Opening of central reservation.](image)

When the car is driving to the opposite lanes, the radius $R$ should satisfy cars’ safety on the road which doesn’t set superelevation. According to the balance of the car on a curve, we can obtain:

$$R = \frac{V^2}{127(\varphi_h + i_h)}$$

(1)

In the formula, $R$ is turning radius of circular curve. $V$ is road link travel speed. $\varphi_h$ is lateral friction coefficient between which is about 0.035. $i_h$ is superelevation slope.

According to the geometric relationship and trigonometric function in Figure 2, the turning radius calculation model can be solved.

$$R = \frac{(L/2)^2 + \left(D_c + D_n/2\right)^2}{D_c + D_n}$$

(2)

Where $D_c$ is the intermediate belt width (including the median and the width of the side strip on both sides). $D_n$ is the width of the inside lane. The speed limit formula is as followed.
\[ v = \sqrt{\frac{127((L/2)^2 + (D_i + D_o/2)^2)(II_n + i_n)}{D_i + D_o}} \]  
\hspace{1cm} (3)

**The Median Strip Opening Limit Speed**

According to the formula (3), the vehicle's speed is not only related to the turning radius, but also with the road cross-sectional slope and road surface transverse friction coefficient which have been affected by the speed, road conditions and types of tires and other factors. In general, when on dry pavement, the lateral friction coefficient is 0.4 ~ 0.8; high speed on the wet asphalt concrete pavement, it reduces to 0.25 ~ 0.40; driving on icy roads or snow road, it is below 0.2. From a security point of view, we determine the lateral friction coefficient is 0.1. According to formula (3), limited speed which can ensure cars safely by at the median opening is calculated in different cases as follows:

<table>
<thead>
<tr>
<th>Cross slope (%)</th>
<th>Median Opening Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>60 65 70 75 80 85 90 95 100 105 110 115 120 125</td>
</tr>
<tr>
<td>3.0</td>
<td>70 75 80 85 90 95 100 105 110 115 120 125</td>
</tr>
<tr>
<td>4.0</td>
<td>80 85 90 95 100 105 110 115 120 125</td>
</tr>
</tbody>
</table>

According to calculation results in the table, it is obvious that median opening length is the most important factor of the restrictions speed at the median opening.

**Analysis of the Traffic Capacity of Median Strip**

According to the rate limiting look-up table, to get the basic traffic capacity value of freeway bicycle road under the ideal condition. Then use the formula (10) to modify the value to get the actual capacity under different speed limit. Its mathematical expression is given by:

\[ C = C_B \times f_w \times f_{HV} \times f_p \times f_i \times f_m \times n \]  
\hspace{1cm} (4)

In the formula, \( C \) is the traffic capacity of the workspace (pcu/h);
\( C_B \) is the traffic capacity of every lane of basic freeway sections under the speed limit condition;
\( f_w \) is the correction coefficient of lane width and lateral width;
\( f_{HV} \) is the correction coefficient of oversize vehicle;
\( f_p \) is the correction coefficient of environmental familiarity of driver;
\( f_i \) is the correction coefficient of the construction intensity of workspace;
\( f_m \) is the correction coefficient of the length of median strip;
\( n \) is the number of lane, taking natural numbers 1, 2, 3..., and here is 2.

The parameter selection can refer to traffic capacity analysis method of freeway basic section of reorganization and expansion.

From the above model, the major factors which limit the median opening speed: zoning in its mouth, and the length of the intermediate belt width and high transverse slope etc., the middle opening length is the most influential one. Zoning in the opening length increasing, the road traffic capacity and speed will be improved. So, the road construction period should comprehensively consider the traffic capacity of roads allow, the band width, transverse slope and other factors.
determine the speed limit and zoning in the opening length, and then according to the actual situation to adjust opening length, ensure the traffic capacity is the largest.

**Conclusions**

In recent years, the “operating while constructing” model is widely used in the freeway reconstruction, there are many related issues. In this study, the traffic conversion characteristics of vehicles are analyzed, and influence factors of the median opening capacity to build limited speed at median openings calculation model were respectively discussed; finally empirical formula and reference values of limiting speed at the median opening were given. And the median opening limiting traffic capacity of expression was given under the condition of different limiting speeds.

However, work zone is a complex environment, and the environment will impact drivers’ behavior. The mathematical model need consider more about drivers’ reaction time and workload during their driving; and simulated driving experiment need implemented for this area.

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**References**


