Guang Yang, Hong-Ru Ren, Zhong-Yuan Piao and Jian-Gang Qiao

Based On the Test Track Minimum Radius of Expressway Ramp

Abstract: Interchange is the throat motorway. It affects not only the capacity of the highway, but also traffic safety. Through the research on the form of single-track and double-lane transformation of freeway, the ramp model of single and double lane ramp transformation is constructed. On the basis of collecting the data of ramp characteristic points on the spot, the speed variation law of different vehicles on the ramp is analysed. According to the characteristics of the freeway, the minimum radius of the ramp on the driving conditions is obtained, and the design of the ramp is designed, which provides a theoretical basis for the design of ramp standard revision.

Keywords: Track test, ramp, minimum radius, traffic flow.

1 Introduction

Freeway ramp area is among the freeway accident-prone area, which subjects to terrain, cost and other factors. Linear ramp will always be biased index limit value, sometimes even more than or less than the limits. Hameed Aswad Mohammed analyzed the influence factors of traffic accidents by using accident analysis method, and it showed that the number of lanes, the radius of the curve and the large longitudinal slope have great influence on traffic safety [1]. Ghazan Khan He found that the radius and length of the flat curve were the two factors that affected the safety. He also established the accident database of the 11427 flat curve section of the Wisconsin dry road network, and established the rural flat curve section Death and injury accident prediction model [2, 3]; Wilson He analyzes the accident rate on a sharp turn and a gentle turn to get a flat curve with a radius of less than 200 m. The accident rate on the corners is 4 to 5 times greater than the 900 m radius [4]; Mo Yang proposed structure the form of the ramp which meets the requirements of
the parking distance curve minimum radius ratio to the requirements of the lateral force coefficient [5]; Research by Li Zhou Feng have shown that small radius plane curve at the outlet increases the likelihood of an accident, which provided that it had no significant effect on the accident in the convergence section and inlet section [6]; Shen Qiang believes that the construction of Diamond Interchange area should be analyzed to identify the horizon, and checked the main line linear index. It calculate the range of the radius of the main line of the main line through the special interchange to identify the line of sight, and provide the basis for the selection of the special interchange index and the choice of the exit position. [7,8]. Through the investigation and collection of vehicle ramp traffic organization forms were analyzed each ramp with the position and speed characteristics of different types of vehicles, articulated vehicles, aimed at cars with the vehicle running track test, which ensure safe driving conditions was in the off-ramp minimum radius.

2 Ramp Traffic Organization Analysis Form

According to the field survey of a highway, we found mainly single, two-lane ramp gradient in the form shown in Figure 1-3:

![Fig. 1: Single lane entrance ramp connecting two-lane ramp form](image)

Figure 1 uses the deceleration lane for the single-lane, two-lane ramp form, making travel faster than small cars can enter from the left side of the ramp with large vehicles and large cars are not changing lanes on the right side.
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Fig. 2: Intermediate single-lane ramp connecting two-lane ramp form

Figure 2 is a single-lane ramp after the midpoint of the song becomes a two-lane ramp line ramp converted into a two-lane ramp acceleration lane having a functional, large-scale ramp right lane traveling by car, a small car accelerated into the left lane along the ramp mainline.

Fig. 3: Ramp midpoint of a two-lane ramp converted into a single-lane ramp form

Figure 3 is a two-lane ramp. You can pass through the middle of the ramp; the ramp will be converted into a single lane ramp, the right side of the vehicle lane into the left lane, the right side of the same set as the main hard shoulder for emergency parking. Vehicle lane change in advance into the acceleration lane can increase the safety of the main line.

When the deceleration lane is a single lane, the driver is accustomed to overtake on the left, so the entrance ramp connected by a single-lane ramp shift lane dual carriageway, traffic organization using the form on the left widened mainly; the terrain is limited short acceleration lane, it can widen the right of the lane from the ramp park midpoint of the curve, change to single-lane ramp traffic organization in the form of a two-lane ramp; the case of the acceleration lane to single lane, the vehicle is traveling in a two-lane ramp midpoint of the curve becomes traffic organi-
zation in the form of single-lane ramp to facilitate docking with the single-lane acceleration lane, lane will reduce the risk incorporated into the main line accidents.

3 Research On Operational Characteristics of Vehicles Ramp

Car on the ramp driving characteristics can be divided into: Split slowly down the process, uniform (or shift) and accelerated the process of merging with the process of moving. That left the main highway deceleration lane (shunt deceleration), into the ramp; the ramp (uniform or variable speed) driving; acceleration lane highway into the main line (confluence acceleration).

For some freeway interchange, the ramp is two-lane ramp, while shifting lanes is single-lane ramp, the split and form common single-lane ramp Frontage case two-lane ramp, at the confluence of the acceleration ramp run and there appear and two-lane ramp Cohesion single-lane ramp situation. Through Interchange on a branch point, gradual ramp segment, the midpoint of the song ramp, ramp confluence points to single-lane dual carriageway becomes a point of the vehicle speed data acquisition, will be divided into two axis model truck (2H), 3 axle truck (3H), 4 axis truck (4H), 5-axis truck (5H), 6-axis truck (6H), trucks (DH), small trucks (XH), minibuses (XK), the data finishing. We got Figures 4 and 5.

Fig. 4: Changchun southern interconnected ramp speed figure A
It can be seen from Figure 4 vehicle rules on the ramp; the vehicle from the deceleration lane diversion point has been decelerating until the vehicle speed linear ramp adaptation. Ramp with a gradient section gradually began to constant speed. After passing the midpoint, the vehicle started accelerating, but there would be a two-lane ramp to the single-lane ramp transition road when approaching the outlet and the vehicle would slow down again to converge on the lane. Finally enter the acceleration lane and started accelerating.

It can be seen from Fig 5. Large trucks with the increasing of the number of axes, the load of vehicle, the volume of the vehicle, the speed will slow down. From large trucks to small vans, it can be seen that speed of the passenger-car is the fastest, followed by the small truck, and speed of big truck is the slowest. In the operation of the ramp, the speed of the diversion point is the fastest, the speed of curved point is the slowest, two lane ramp to single lane ramp transform speed is lower than the standard section at the speed, not much difference with the transition section of the ramp, and the speed of the confluence point is also faster than the speed of the shunt.
4 Ramp vehicle trajectory Test and Analysis

In order to analyze the two-lane ramp to meet the minimum radius of the small passenger train in parallel with the hinge and hinge hinge Train Train parallel conditions permit, make the following test:

4.1 Parameter Selection

Vehicle parameters selected: minibus geometry shown in Figure 6, articulated vehicle geometry shown in Figure 7:

Fig. 6: Figure minibus geometry

Fig. 7: Figure articulated vehicle geometry
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Road parameter selection: test road cross section shown in Figure 8

![Test cross-sectional view](image)

**Fig. 8**: Test cross-sectional view

Select other parameters: ramp design speed: 30 km/h ~ 80 km/h; ramp curve radius: Usually value of 20 m ~ 280 m, limit: 25 m ~ 230 m; safe distance: 0.25 m.

### 4.2 Vehicle Trajectory Simulations and Analysis of Least Squares Curve Radius

Condition 1: Ruoshi articulated train kept in the inside lane, and the distance from the vehicle lane is more than 0.25 m, the minimum horizontal curve radius of 140 m, as shown in figure 9.

![Articulated train kept in the inside lane](image)

**Fig. 9**: Articulated train kept in the inside lane (lane edge line distance 0.25m)
Condition 2: Ruoshi articulated train kept in the inside lane, and the allowable distance from the vehicle lane is 0m, the minimum horizontal curve radius of 72 m, as shown in figure10.

![Fig. 10: Articulated trains (from the lane edge line 0m) in the lane](image)

Condition 3: If the train remains occupied the adjacent lane, but the use of the hard shoulder width, the body maintains a safe distance from the edge of the hard shoulder width of 0.25 m, the minimum horizontal curve radius of 41 m, shown in figure11.

![Fig. 11: Articulated train occupies the hard shoulder width with](image)

Condition 4: If the small articulated buses and trains all use the hard shoulder width parallel body to keep a safe distance from the edge of the hard shoulder width of 0.25 m, the radius of the circular curve for the two-lane ramp 25 m can meet in a small passenger train in parallel with the hinge, parallel safety spacing between vehicles is 1.1m, shown in figure 12.
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Fig. 12: Articulated trains and passenger cars in parallel with

Condition 5: If the vehicle maintain a safe distance from the edge of the hard shoulder width of 0.25 m, width 0.5 m between the vehicle remains safe, the two articulated train side by side in a two-lane ramp with, least squares curve radius required for the 43 m, shown in figure13.

Fig. 13: Articulated trains and articulated parallel with the train

Tab. 1: The condition of one ~ five analysed

<table>
<thead>
<tr>
<th>Vehicle location</th>
<th>Condition 1</th>
<th>Condition 2</th>
<th>Condition 3</th>
<th>Condition 4</th>
<th>Condition 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articulated train kept in the inside lane (lane edge line distance 0.25m)</td>
<td>Articulated trains (from the lane edge line 0m) in the lane</td>
<td>Articulated train occupies the hard shoulder width with</td>
<td>Articulated trains and passenger cars in parallel with</td>
<td>Articulated train with the hinge parallel with the train</td>
<td></td>
</tr>
<tr>
<td>Radius (m)</td>
<td>140</td>
<td>72</td>
<td>41</td>
<td>25</td>
<td>43</td>
</tr>
</tbody>
</table>
Table 1 shows that a single vehicle gradually smaller in the inner lane ramp with radius, reduced safety, the safest radius of 140 meters, the minimum safe radius of 41 meters; when the two cars at the same time in parallel lane dual carriageway ramp minimum safety radius of 43 m, the limit minimum radius of 25 meters.

## 5 Summary

Through the investigation single-ramp and double-ramp forms on the freeway, we learned the main form of single and double lane ramp transform. Based on field speed data collection, the characteristics of running vehicles on the ramp speed are analyzed. In this paper, the ramp trajectory test of the passenger car and articulated vehicle is carried out, and the results are as follows: (1) the average value of the ramp curve radius is 72m, and the limit value is 43m. (2) If the passenger car is only allowed in the inner lane of traffic control, and the vehicle speed is effectively controlled, and the minimum radius of the ramp can be 25m.

## References


Establishment of Key Components Testbed for Emergency Steering System Used in Heavy Duty Trucks

Abstract: Based on the working principle of emergency steering system of heavy-duty truck, the working principle and composition of hydraulic test-bed on key components of emergency steering system are introduced. The performance experiments of pump and valve are carried on. The results show that the emergency steering system performance of key components is capable to achieve the emergency steering of the vehicle.

Keywords: hydraulic system, emergency steering, data acquisition

1 Introduction

The heavy-duty vehicle steering load is usually very heavy, thus it is difficult to achieve anticipated steering relying on human manipulation alone. Therefore, heavy-duty vehicles are equipped with power steering systems. But when accidents happened such as engine flaming out or main power steering pump (hereinafter referred to as the main pump) failure, and when vehicle break down and get pulled, the power steering system failed to function. So the emergency steering system is usually installed based on the power steering system to achieve emergency steering [1, 2].

The emergency steering pump (hereinafter referred to as the emergency pump) and the emergency valve are key parts of emergency steering system, and their performance is directly related to whether the system function regularly. Therefore, it is necessary to establish a test-bed and carry on performance testing on the key components in the emergency steering system.
2 The Development of The Hydraulic System Test-Bed

2.1 Working Principle of Emergency Steering System

With regard to heavy-duty vehicles equipped with emergency steering system, when the vehicle power steering system fails to work, the kinetic energy of wheels in driving state transfers to the power source of power-assisted steering. Through the emergency steering gear drive system, the wheel kinetic energy (the lower bound of system design speed is not less than 15 km/h) is introduced from the front axle of vehicle. Then growth regulation driven the emergency pump, and the emergency pump output pressure oil through the emergency valve into steering cylinder and achieve power steering.

According to the contrast between main pump flow rate and its own, the emergency valve performs the switch of oil-way automatically between the main pump and emergency pump. When the main pump works normally, the output flow is greater than the emergency valve setting flow, and steering oil pressure is mainly provided by the main pump, and emergency pump is in unloading state; when the main pump flow is below the emergency valve setting flow, the emergency pump is switched to steering oil-way automatically. Fig. 1 is schematic diagram of the working principle of emergency steering system.

![Schematic diagram of the working principle of emergency steering system](image)

**Fig. 1:** Schematic diagram of the working principle of emergency steering system

2.2 Overview of The Emergency Steering System

The experimental table tests include the output characteristics of the emergency pump under different load conditions and the characteristics of emergency valve switching response under certain load conditions, the working principle and physical chart of the test bench for emergency steering system are shown in Figure 2.

The choice of the main pump, fluid medium and the diameter of the oil pipe in the experimental platform are consistent with the application of the real vehicle, and further guarantee the service function of the experimental platform. Based on
the maximum output power of the main pump and emergency pump, the main motor and emergency motor are selected, and using the overflow valve as adjustable load [3]. First, start the main motor and emergency motor, and make sure the system load as the design load of the real vehicle emergency steering system by adjusting the relief valve. Second, after two motor working together for a period of time, close the main motor and test the switching characteristics of the emergency valve and the output characteristics of emergency pump under rated load. In the test of maximum output characteristics of emergency pump, using the branch valve to change the oil circuit by the system pressure will exceed the pressure limit of the emergency valve. A self-developed data acquisition system is established in the experimental test platform, and the data sampling period is 20ms. The operation control software is compiled by Basic Visual 6, with it we can obtain the functions of data acquisition, process display, data processing, control, and storage and output are realized.

![Working principle and physical chart of the test bench for emergency steering system](image)

**Fig. 2:** Working principle and physical chart of the test bench for emergency steering system

### 2.3 Experimental Platform Data Acquisition Process

In the system of data acquisition, converting the physical quantity signal (pressure and flow signals) into electrical signal by using the sensor. In order to suppress the signal of the high frequency component of the interference noise signal, the signal should be filtered and limited, and then the signal is transmitted to the MCU (Micro-
controller unit) by the interface circuit. And the single chip microcomputer is responsible for the upper computer for communications transmission [4, 5]. The concrete sampling flow is shown in Figure 3.

![Flow chart of experimental platform data acquisition](image)

**Fig. 3: Flow chart of experimental platform data acquisition**

The lower computer of the acquisition system is MCU MC9S12DP256, and that is also the core of the data acquisition system. MCU MC9S12DP256 is mainly used for system initialization, serial interface to achieve control, signal acquisition and processing, and meet the needs of data communication and transmission with the host computer. The upper computer control procedures get written based on Visual Basic Microsoft 6.0. The upper computer control procedures is applied to assist the work of the lower computer, receive data, complete the real time display and data processing and complete the results summary and print.

### 3 Emergency Valve Test

Figure 4 shows the switch response of the emergency valve and the actual test results of the high-pressure working characteristics of the emergency pump.

![Switch response curve of the emergency valve](image)

**a) The switch response curve of the emergency valve**
b) The characteristics of the emergency pump itself high pressure curve

Fig. 4: Test results of the valve performance of the emergency steering system

The measured results show that the load switching time under the emergency steering valve is 80ms rated in the vehicle, the pressure switch is 6.5MPa, can realize the fast handover and ensure that the required minimum power steering. Emergency steering pump load and its stability in the nominal pressure zone, pressure fluctuation is less than 3%, the flow fluctuation in about 0.1%, can provide plenty of power steering. This also shows the reliability of the real vehicle emergency steering system.

4 Conclusion

The test device can carry out the vehicle emergency steering performance test of key parts of the system in the emergency valve. The repeated experimental results showed that the testing principle is reliability, the test data is precise. The test device has functions of data storage and data output data under data post-processing. The automatic test has been realized in the test procedure, and the operation procedure is facility.

The performance test of the vehicle emergency steering performance test of key parts of the system show that, the Valve of hydraulic pump is rapidly switch able and it can provide stable steering power. This can make sure the vehicle could drive safely under the unexpected accident.
References