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Research on the Dynamics Collision Response of Pedestrian /Two-wheelers Controller Head

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Abstract: The head collision response of pedestrian /two-wheelers rider was studied in accident repetition form in laboratory based on the Chinese road traffic accident datum. It shows that the moving trail of two-wheelers rider and pedestrian is similar in the process of collision, and two-wheelers rider's head impact point position is more rearward. The results of study provide references for the new vehicle design and regulation formulation in pedestrian and two-wheelers rider protection.

Keywords: Two-wheelers protection , Head impact, Accident repetition， Moving trail

1 Introduction

The world health organization (WHO) statistics show that the global traffic accident killed about 1.2 million people a year, and 2-50 million people were injured. 50% of deaths involved the so-called "vulnerable road users": pedestrians, bicycles and electric bicycles [1,2].

Pedestrian is the most vulnerable to damage in traffic accident. The pedestrian head injuries is one of the most common type of injury, and it is also one of the leading causes of pedestrian injuries and deaths [3,4]. Motorcycles, bicycles and electric bicycles are collectively called two-wheelers. In traffic accidents, drivers of two-wheelers are vulnerable groups, and their risk of injury is greater than that of people in the vehicle [5-6]. In recent years, with its characteristics such as a high speed, a big mass and a large volume, electric bicycle has replaced bicycle and motorcycle in cities, and its number of holdings grew rapidly [7,8]. However, at the same time, traffic accidents, injuries of cyclists and the number of deaths involving electric bicycles rose sharply. To a large extent, the reason is that people riding electric bicycles and bicycles do not follow the traffic rules. They are often in a weak position in traffic accidents (relative to the vehicle), and become the main victims in traffic accidents [9,10]

China issued GB/T 24550-2009 Impact Protection of Motor Vehicle for Pedestrians [11-15] in 2009. Its technical requirements are basically consistent with foreign pedestrian protection laws. All those laws is to conduct the pedestrian head model, legs and thighs module impact test to evaluate the vehicle's safety protection performance to pedestrian. Its maneuverability is strong, but it can't reflect how different parts of the body affect each other in the process of collision. The data lack of relevance, so the standing posture pedestrian impact test research emerged. At present, there are few researches on the impact between two-wheelers and vehicle, and most researches are in the stage of theoretical analysis.

Based on the above background, according to Chinese traffic accident, this paper studies deeply traffic accident investigation data from 2011 to 2015, and design impact characteristic parameters. In the laboratory, through the reproduction of the impact test accident between two-wheelers and vehicle and image analysis technique, the response characteristics of pedestrian and two-wheelers controller were analyzed, which provided reference for improvement and formulation of automotive safety standards.

2 Accident statistics

Based on Chinese traffic accidents, the research group made an in-depth study on statistical results of passenger cars and pedestrians or two-wheelers (including electric bicycles) from 2011 to 2015. But the cases that involve children or adult who contact secondarily bumper after fall are excluded. As a result, the original data of impact accident for 144 cases of vehicles and pedestrians and 125 cases of vehicles and two-wheelers was selected. The data record the model and speed of vehicle and injuries of two-wheelers controllers in detail.

In order to refine and differentiate the head impact location of two-wheelers controller, the top view of a vehicle was divided into 15 areas with code, as shown in Figure 1.

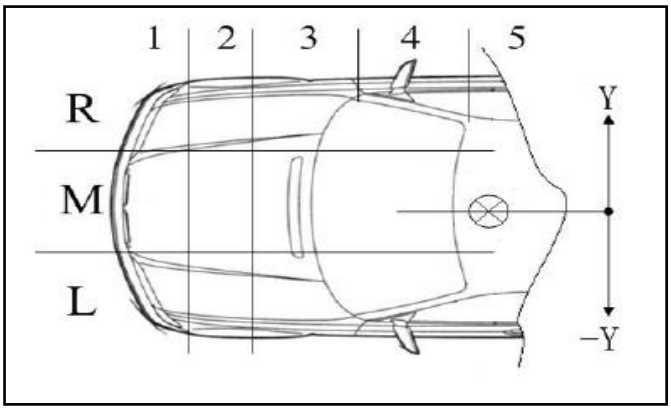

Fig.1 Code of head impact location

According to the original data of 169 impact accidents mentioned above, referring to the partition method of the front end of the vehicle in Figure 1, statistics were made for the head impact area of pedestrians and two-wheelers controller. The statistical results are as shown in Figure 2. It can be seen that the location with the most head impact contact is from the front door of the vehicle to the A-pillar area, and the front of the vehicle also occupies a certain proportion.

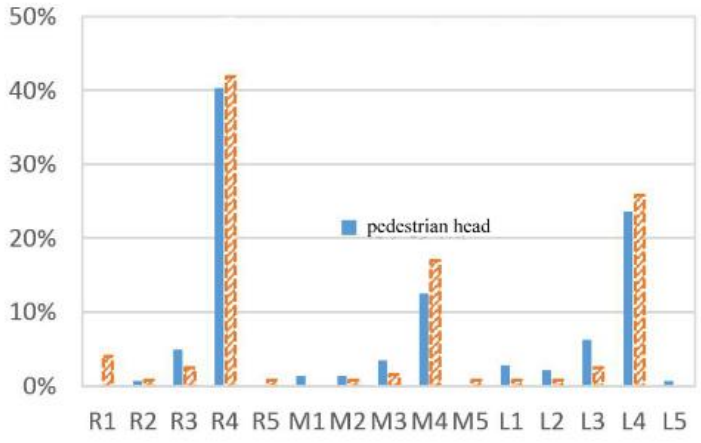

Fig.2 Statistics of head impact location

Figure 3 shows the speed of vehicle in the cumulative percentage distribution in vehicle and pedestrians or two-wheelers impact accidents. It can be seen that the average speed in pedestrian impact accidents was 52km/h. The speed of about 50% of the total accident in cumulative probability is 50 km/h. The average speed in two-wheelers impact accidents was 51km/h. Figures 4 shows the percentage of different accident speeds. In most traffic accidents, the speed was 40-50km/h.

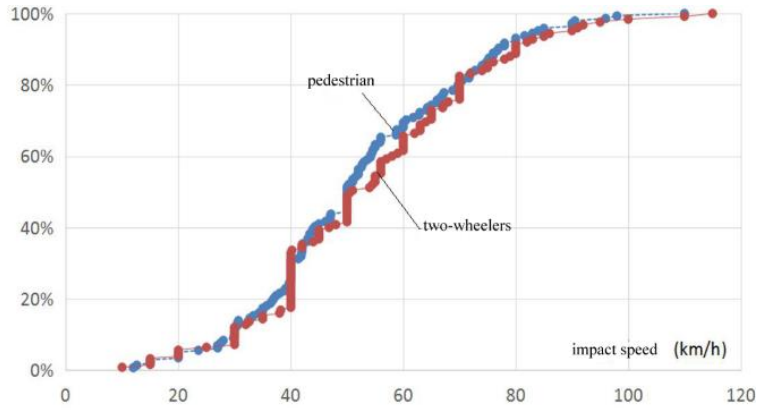

Fig.3 Velocity statistics of 156 traffic accidents

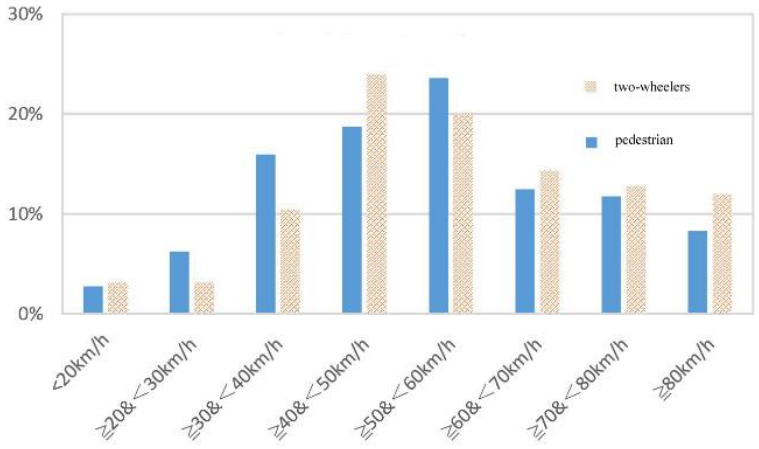

Fig.4 Statistics of velocity distribution

3 accidents pattern restoring

To compare the head collision response of the two kinds of accident form, the research group conduct repetition of accident in the lab, and use the high-speed cameras filmed at a speed of 1000 frames/s.

In the test in which vehicle impact pedestrians, POLAR II standing position dummy which is developed by Honda is employed. In the test in which vehicle impact two-wheelers, the researcher use the 16 inches electric bicycle that sells on the market, and place the modified Hybrid III 50% dummy whose pelvic parts and abdominal sponge is improved.

In consideration of the intervention of active safety configuration (such as AEB) in recent years, the trend of vehicle collision speed is decreasing[16], so the vehicle collision speed is selected by 40km/h in the test. At the same time, the brake system is developed for simulating the brake control of the accident vehicle (Fig. 5). The working principle is as

follows. The compressed air pushes the piston rod of the gas cylinder, and then the piston rod pushes the brake pedal to simulate the driver's braking action. The control part consists of a solenoid valve, a radio triggering module, and a radio receiving module. The use pressure of compressed air in the braking device is 0.5Mpa, and the diameter of the gas cylinder is 50mm. It can produce a thrust of about 980N, which is equivalent to the force produced when a person with a weight of 100KG stands on the pedal. The "full brake" requirement can be met.

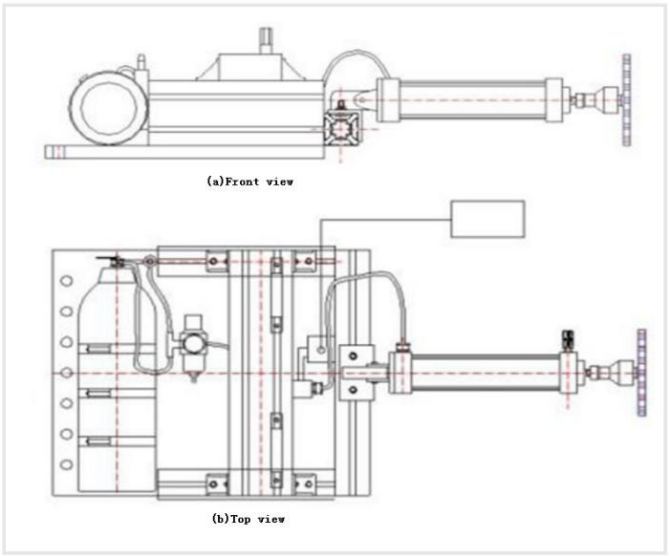

Fig.5 Brake Robot Structure Diagram

Figure 6 shows the test results of vehicle impacting standing position dummy and two-wheelers. It can be seen that the two-wheelers controller and standing position pedestrian showed similar motion response in the collision process. At about 40ms after the collision, the upper body of the human body remains almost the initial state. Then the upper body was rotated toward the cover. Finally the head hit the car on the cover, and the upper body almost level. But there are different in two-wheelers collision, the left leg of rider that is impacted by vehicle bents, and knee and the front of the engine cover flush. It can be characterized as the rider slip rearward on the engine cover surface. But for standing position pedestrians, the entire lower limb and pelvis was blocked by the engine cover, therefore the leg suffered more damage.

Fig.6 The test of vehicle front impact two-wheelers and pedestrian

Image analysis method is used to analyze the trajectory of the dummy. The geometric triangle plane relation between the three states of the marker position, the ruler position and the camera position in parallel state is shown in figure 7, and the displacement expression of the target measuring point is

$$X=A（d1+d2）/d1-A=A*d2/d1 \quad （1）$$

Where: D1 represents the distance from the optical sensor to the ruler position of the high-speed camera. D2 represents the distance from the gauge to the marker, and the A is the length gauge.

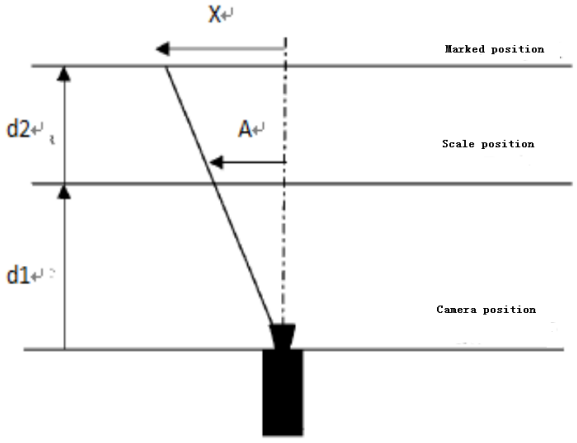

Fig.7 Schematic diagram of image analysis

The trajectory of the dummy head and pelvis relative to the vehicle during the two impact tests is shown in figure 8. The right end of the curve represents the position of the initial collision moment in Figure 8. The larger the human body, the head trajectory is farther above the existing trajectory, and the probability of the head contacting the window region is also higher. The results show that the difference of head collision position between two-wheelers controller and pedestrian is related to the position of pelvis at the moment of impact. In the initial stage of the collision, the height of two-wheelers controller and standing position pedestrians' pelvis have little difference. The rider suffer small barrier from the front engine cover due to the rider's leg bending posture. So two-wheelers controller sliding on the cover, and the head impact position is more rearward in Figure 8.

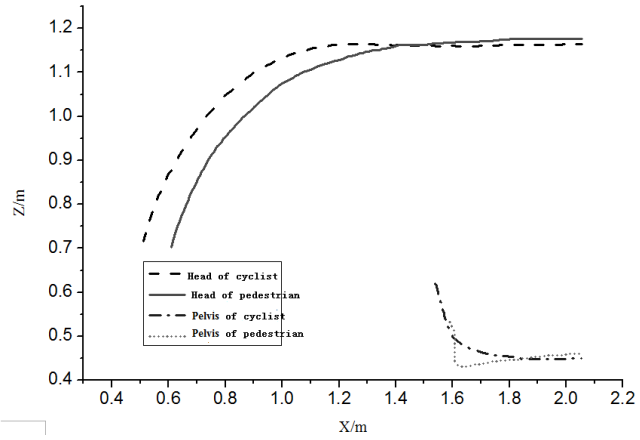

Fig.8 the moving trail of dummy head and pelvis relative to a vehicle

4 Data comparison and analysis

In the test in which a vehicle impacts two-wheelers, the distance WAD is usually used to quantitatively characterize the location of the head impact. WAD (wrap around distance) refers to the rotation distance of pedestrians or two-wheelers controller, which can be measured according to the damage and deformation traces of the head collision position on the windshield and hood, as shown in figure 9. It is defined as the length of the head impact point around the front of the vehicle vertically from the ground.

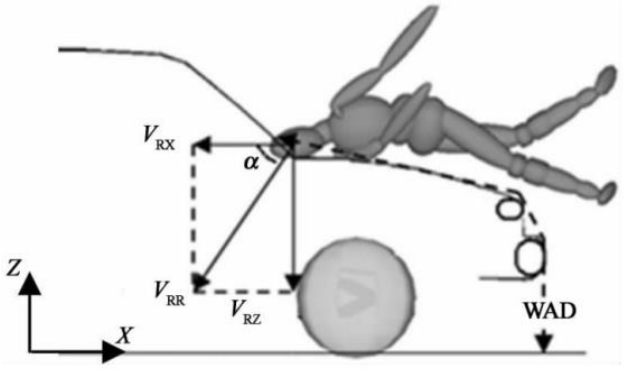

Fig.9 Definition of WAD

Figure 10 is the distribution of WAD positions at different speeds in pedestrian and two-wheelers controller crashes. The trend of the overall distribution of WAD increases with the increase of vehicle collision speed. Compared with pedestrians, the overall trend of the head collision point position of the riders is farther rearward under the same speed. It is consistent with the results of the image analysis.

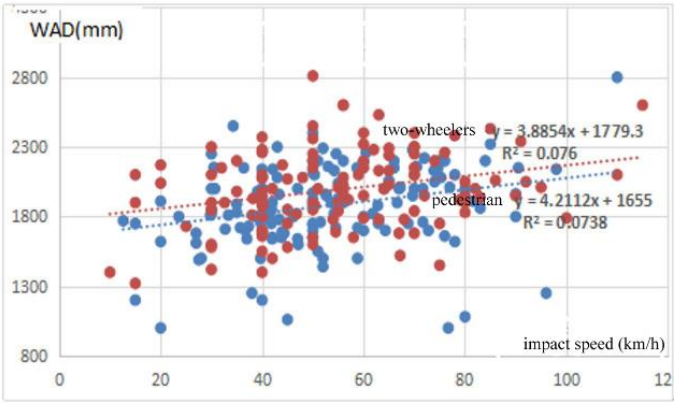

Fig.10 Relationship between head collision position and vehicle speed

In the pedestrian and bicycle accidents, the weighted average of the accident proportion (Pi) under the collision speed interval and accident collision point (WAD value) under this speed divided by corresponding body height. It is the ratio of collision position (WAD) and pedestrian height (H) in an accident.

$$k = \sum_{i} P_i \times WAD / H \qquad (2)$$

Pedestrian and two-wheelers controller's K value can be calculated by formula (2). Table 1 is the result of calculation. It can be seen that the K values of the two kinds of collisions are greater than 1 in the collision with the ordinary car (class A/B), while the K value is less than 1 in the collision with the micro car. It indicates it is obvious for ordinary cars the human body slide rearward on the engine cover surface because of its lower height; while the sliding displacement of human body on micro bus engine cover surface is smaller than ordinary cars due to its higher engine cover. The K values of two-wheelers rider is bigger for the same level models under the same speed. It indicates the relative collision position of two-wheelers controller is more rearward.

Tab. 1 the K values of pedestrian and two-wheelers rider

	pedestrian			two-wheelers		
velocity	A-Class	B-Class	minibus	A-Class	B-Class	minibus
<20km/h	—	0.03	0.03	0.03	—	0.03
≧20&＜30km/h	—	0.06	—	0.04	0.04	0.06
≧30&＜40km/h	0.16	0.19	0.14	0.16	0.12	—
≧40&＜50km/h	0.19	0.21	0.22	0.25	0.28	0.2
≧50&＜60km/h	0.27	0.31	0.21	0.21	0.25	0.33
≧60&＜70km/h	0.14	0.15	0.14	0.16	0.18	0.16
≧70&＜80km/h	0.12	0.15	—	0.15	0.17	0.12
≧80km/h	0.15	0.10	—	0.15	0.15	—
K value	1.04	1.19	0.73	1.17	1.19	0.89

5 conclusion

(1) Vehicle collision speed and human head collision position has high similarity in vehicle impacting pedestrian and two-wheelers accident by making an in-depth study on Chinese traffic accident investigation data from 2011 to 2015.

(2) The accident form of the car-pedestrian and car- two-wheelers collision was reproduced in the lab. Through the image analysis, the dummy trajectory is analyzed. It is shown that the two-wheelers rider and standing position pedestrian show similar motion response, and the two-wheelers controller head impact position is more rearward.

(3) Compared the test result, the current pedestrian protection regulations can reflect simultaneously the pedestrian and cyclist injury situation by expanding the head collision interval and WAD range, modifying and adjusting the relevant parameters.

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