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# Simulation Analysis of SUV-Pedestrian Accident Based on Multi-factor Influence

Guang De Han[a], Yan Wang[b], Wei Zhao[c]*, Ling Yun Xiao[d], Chang Li Zhao[e], Gang Xu[f]

[a]*Guangde Han, No. 5001 Haitang Road, Changqing District, Jinan City and 250023, China*
[c]*Wei Zhao, No. 5001 Haitang Road, Changqing District, Jinan City and 250023, China*

**Abstract**

In this paper, pedestrian traffic accidents on the intersection are analyzed. The six parameters of the engine hood leading edge hei ght to ground, engine hood trailing edge to the ground, pedestrian' s height, pedestrian' s weight, Vehicle collision speed, Pedestr ian's speed are taken as the analysis factors. The orthogonal test method is used to analyze the impact of these six parameters on t he pedestrian-thrown distance. Furthermore, the orthogonal test is applied to the analysis of the influence of the factors to the ped estrian-thrown distance, as well as the different weight of the six factors and significant factors. Regression analysis and verificati on are conducted for the significant factors.



*Keywords:* *pedestrian crossing; influencing factors; orthogonal test*

## 1. Factor Selection

Considering the convenience and accuracy of the parameters, this paper mainly takes six parameters as consideration factors, involving engine hood leading edge height to ground, engine hood trailing edge to the ground, pedestrian' s height, pedestrian' s weight, Vehicle collision speed, Pedestrian's speed. Other relative factors with little impact, such as the length of the hood, the height off the ground of the lower and upper edges of the bumper

* Wei Zhao. Tel.:18765808227.
*E-mail address:*1412471548@qq.com.


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and so on, take the default values of the original vehicle. At the same time, other factors related to accidents are restricted, as are shown in Table 1:

Table. 1. Other factors limiting vehicle and pedestrian accidents

| | |
|---|---|
| Collision angle between vehicle and pedestrian | 90° |
| Road adhesion coefficient | 0.78 |
| Adhesion coefficient between pedestrians and roads | 0.6 |

With the traffic accident simulation software PC-Crash as the test software, under the premise of ensuring the accuracy of test factors at different levels, the orthogonal test method is used to reduce the number of tests[1]. Pedestrian-thrown distance is easier to obtain in the road accident scene, and the farther the pedestrian-thrown distance is, the more serious the pedestrian injuryed[2]. Therefore, the pedestrian-thrown distance is used as the evaluation index of pedestrian injury[3]. In addition, each related factor takes three levels, in which the SUV model takes Volkswagen Tiguan as the reference prototype. The selection of the front dimensions of the vehicle is mainly based on the relevant dimensions of large, medium and small SUV. The collision speed of the vehicle is selected according to the common urban speeds of 30km/h, 40km/h and 50km/h. When pedestrians crossing the road contact with the vehicle, three forms including stopping, walking and fast walking are considered. The speeds of the three patterns are 0km/ h, 5.4km/h, 7.2km/h respectively. Besides, given that vehicle will immediately take the brake after collision with the pedestrian. The corresponding level of the orthogonal test is shown in Table 2:

Table. 2. Factors and corresponding levels in orthogonal test

| Level | engine hood leading edge height to ground (cm) | engine hood trailing edge to the ground (cm) | Pedestrian's Height (cm) | Pedestrian's Weight (Kg) | Vehicle collision speed (km/h) | Pedestrian speed (km/h) |
|---|---|---|---|---|---|---|
| 1 | 0.80 | 1.00 | 160 | 55 | 30 | 0 |
| 2 | 0.90 | 1.11 | 170 | 65 | 40 | 5.4 |
| 3 | 1.00 | 1.26 | 180 | 75 | 50 | 7.2 |

## 2. Orthogonal test

### *2.1.Test process*

In this paper, the orthogonal table L18 ($3^7$) is used in the orthogonal test. The orthogonal test process of SUV and pedestrian-crossing-road traffic accidents is shown in Table 3:

Table.3. SUV and pedestrian crossing road traffic accident experimental process

| Test number | engine hood leading edge height to ground | engine hood leading edge height to ground | Pedestrian's height | Pedestrian's weight | Vehicle collision speed | Pedestrian speed | Empty column | Throw distance |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.80 | 1.00 | 160 | 55 | 30 | 0.0 | | 8.77 |
| 2 | 0.80 | 1.11 | 170 | 65 | 40 | 5.4 | | 14.99 |
| 3 | 0.80 | 1.26 | 180 | 75 | 50 | 7.2 | | 27.34 |
| 4 | 0.90 | 1.00 | 160 | 65 | 40 | 7.2 | | 14.95 |
| 5 | 0.90 | 1.11 | 170 | 75 | 50 | 0.0 | | 23.23 |
| 6 | 0.90 | 1.26 | 180 | 55 | 30 | 5.4 | | 10.54 |
| 7 | 1.00 | 1.00 | 170 | 55 | 50 | 5.4 | | 23.29 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 | 1.00 | 1.11 | 180 | 65 | 30 | 7.2 | | 9.87 |
| 9 | 1.00 | 1.26 | 160 | 75 | 40 | 0.0 | | 20.09 |
| 10 | 0.80 | 1.00 | 180 | 75 | 40 | 5.4 | | 13.46 |
| 11 | 0.80 | 1.11 | 160 | 55 | 50 | 7.2 | | 22.99 |
| 12 | 0.80 | 1.26 | 170 | 65 | 30 | 0.0 | | 10.12 |
| 13 | 0.90 | 1.00 | 170 | 75 | 30 | 7.2 | | 9.16 |
| 14 | 0.90 | 1.11 | 180 | 55 | 40 | 0.0 | | 15.81 |
| 15 | 0.90 | 1.26 | 160 | 65 | 50 | 5.4 | | 30.83 |
| 16 | 1.00 | 1.00 | 180 | 65 | 50 | 0.0 | | 21.92 |
| 17 | 1.00 | 1.11 | 160 | 75 | 30 | 5.4 | | 10.70 |
| 18 | 1.00 | 1.26 | 170 | 55 | 40 | 7.2 | | 18.14 |

### *2.2.Result analysis*

The results of orthogonal test are analyzed by SPSS software, and the results are shown in Table 4.

Table .4 .Orthogonal test results of SUV, car and pedestrian crossing road traffic accidents

| source | Class III quadratic sum | Degrees of freedom | Mean Squared | F | Significant |
|---|---|---|---|---|---|
| engine hood leading edge height to ground | 4.8540 | 2 | 2.427 | 0.832 | 0.488 |
| engine hood trailing edge to the ground | 59.240 | 2 | 29.620 | 10.155 | 0.017 |
| Pedestrian’s height | 9.807 | 2 | 4.904 | 1.681 | 0.276 |
| Pedestrian’s weight | 1.737 | 2 | 0.868 | 0.298 | 0.755 |
| Vehicle collision speed | 686.968 | 2 | 343.484 | 117.760 | 0.000 |
| Pedestrian’s speed | 1.285 | 2 | 0.642 | 0.220 | 0.810 |
| errors | 14.584 | 5 | 2.917 | | |

As shown in Table 4, here is the influence degree of factors related to pedestrian-thrown distance in SUV and pedestrian-crossing-traffic accidents ranking from the top to the bottom: Vehicle collision speed, engine hood trailing edge to the ground, pedestrian’s height, engine hood leading edge height to ground, pedestrian’s weight and pedestrian’s speed. The significant influence factors include vehicle collision speed and engine hood trailing edge to the ground.

## 3. Significant influence factor analysis

For the significant influence factors of the above tests, the PC-Crash software is used for quantitative analysis[4]. The parameters of the prototype vehicle are used in the orthogonal test and restrictions on other factors related to accidents are shown in Table 5. Other factors with relatively slight influence are using default values. The relevant parameters of PC-Crash software are shown in Figure 1.

Table.5. Selection of relevant factors for vehicle and pedestrian accidents

| | |
|---|---|
| Pedestrian’s height | 170cm |
| Pedestrian’s weight | 65Kg |
| Pedestrian’s walking speed | 5.4km/h |

| | |
|---|---|
| Collision angle between vehicle and pedestrian | 90° |
| Road adhesion coefficient | 0.78 |
| Adhesion coefficient between pedestrians and roads | 0.6 |

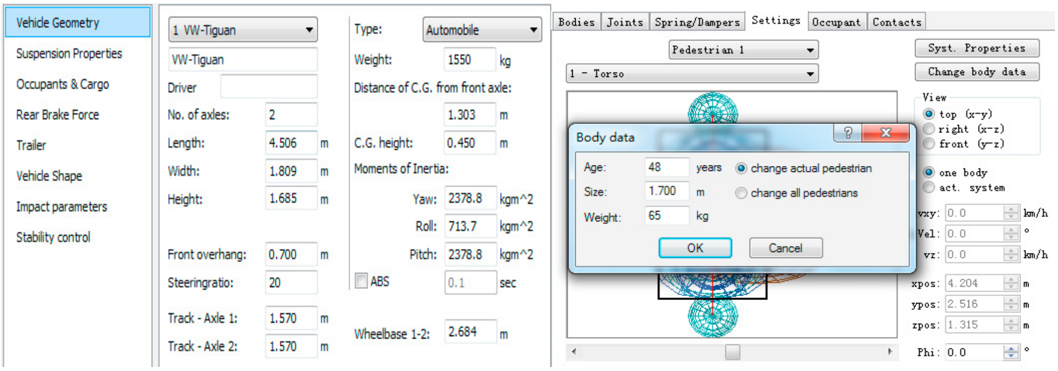



Fig.1. Correlation parameter diagram

### 3.1. Speed factor

After the simulation experiment, the regression curve of vehicle speed and pedestrian-thrown distance is shown in Figure 2:

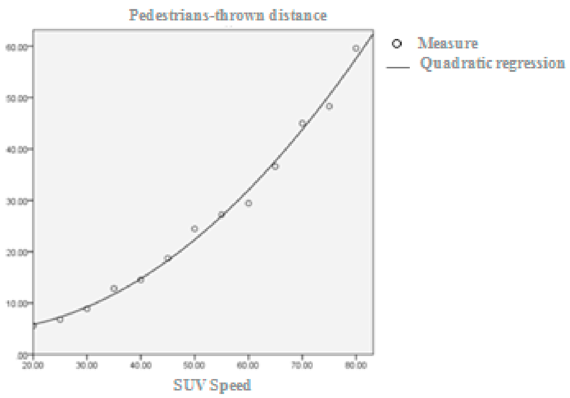



Fig.2. Relation diagram of vehicle speed and pedestrian-thrown distance

The regression model of vehicle speed and pedestrian-thrown distance is shown in Table 6.

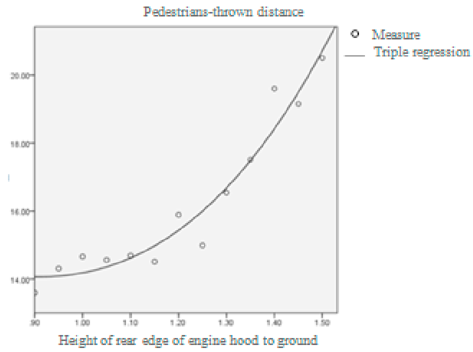
Table 6. Vehicle speed and pedestrian-thrown regression equation

| Vehicle Type | Regression equation | $R^2$ | Adjusted $R^2$ |
|---|---|---|---|
| SUV | $Y=5.24-0.18X + 0.01X^2$ | 0.997 | 0.993 |

### *3.2.Height of rear edge of engine hood to ground*

Select speed of 40km/h, and other parameters as shown in Table 5.

The regression curve of the trailing edge height of the SUV hood and the pedestrian-thrown distance is shown in Figure 3.




Height of rear edge of engine hood to ground

Figure.3. Regression curve of the trailing edge height of the SUV hood and the pedestrian-thrown distance

The regression model of the trailing edge height of the SUV hood to ground and the pedestrian-thrown distance is shown in Table 7:

Table.7. Regression equation of SUV hood trailing edge to the ground and pedestrian-thrown distance

| Vehicle Type | Equation | $R^2$ | Adjusted $R^2$ |
|---|---|---|---|
| SUV | $Y=17.70X-13.23X^2+9.71X^3$ | 0.943 | 0.932 |

## 4. Case Verification

At 8 o'clock on the 21st of December, 2017,in a certain section of the Xulai Mountain District, The Harvard H5, which runs from west to east, collides with pedestrians crossing the road from north to south, causing damage to the vehicles and pedestrians dying on the spot. According to the site investigation and inquiry transcription, the driver's sight is affected by the backlighting , leading to the pedestrian not detected in time and further the accident occurring. After the collision, the driver takes the braking measures and stops. In the inquiry record, the driver reported that the speed of the accident occurring was around 30km/h , and the accident scene is shown in Figure 4:


Figure.4. Accident scene

（1）Formula method

According to the accident scene photos and site investigation data, it can be known that the road surface is dry asphalt pavement and the car brake imprint is obtained by the equation:4.4+2.7=7.1m. Calculate the speed of the car in the event of an accident by formula:

$$v = 3.6\sqrt{2\mu gs} = 3.6\times\sqrt{2\times 0.76\times 9.8\times 7.1} \approx 37.02km/h \quad (1)$$

In the formula:

μ—Adhesion coefficient

g—Gravity acceleration

s—Braking distance

（2）Regression equation calculation method

The pedestrian-thrown-distance is about 13.82m, which is calculated according to the regression equation:

$$Y=5.24-0.18X + 0.01X^2$$

$$X = 39.64$$

By comparison, the vehicle speed error calculated by the two methods is less than 3km/h, which is in the acceptable range. Hence the feasibility of linear regression prove to be feasible.

## Conclusion

In SUV and pedestrian-crossing-road traffic accidents, vehicle collision speed and engine hood trailing edge to the ground have significant effects on pedestrian-thrown distance. Among the other four factors selected in this paper, the influencing degree of the factors related to pedestrian-thrown distance from top to bottom is pedestrian height, engine hood leading edge height to ground, pedestrian's weight and pedestrian's speed. The curve fitting analysis is carried out for the vehicle collision speed and engine hood trailing edge to the ground and the pedestrian-thrown distance, which provides a powerful reference for the vehicle speed analysis.

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## References

1.Fuqiang Li. A Study on Accident Reappearance and Liability Identification of the Pedestrian-Vehicle Collision Based on PC-Crash Analysis[D]. Xihua University, 2017.

2.Liran Liu. Research on Vehicle Speed Calculation in Pedestrian-Vehicle Accident Based on Uncertainty Theory[D]. Chang'an University, Xi'an, China,2017.

3. Ming Ma. Research of Urban Road Crash Analysis based on Multivariate Statistical Techniques[D].Wuhan University of Technology,2010.

4.You-li HUI. Research of Velocity and Human Height Effect on the Risk of Pedestrian Injury in Vehicle-pedestrian Accident [J]. Machinery Design & Manufacture,2016(05):261-264.