Simulation Study on Collision between Car and Wave Beam Guardrail

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Abstract: In order to test the effectiveness of the blocking effect of Class B corrugated beam guardrails on cars that are about to rush out of the road, a finite element model of cars and corrugated beam guardrails is established, and computer simulation software is used to complete the collision experiment of the corrugated beam guardrail, and the dynamic calculation software LS-DYNA, under this software environment, complete the large deformation calculation of the collision between the vehicle and the guardrail. After obtaining the test results, use Hyper View to extract the result file and observe the deformation of the guardrail and the acceleration curve of the vehicle. Finally, analyze and summarize the data of the collision experiment results.

Keywords: Corrugated beam guardrail; Collision; Simulation

1. Introduction

The corrugated beam guardrail is a kind of guardrail widely used on highways in my country. It uses the deformation of the column foundation, column, and corrugated beam to absorb the collision energy, and force the runaway vehicle to change direction and return to the correct driving state.

In recent years, the rapid development of nonlinear finite element technology has greatly promoted the development of automobile crash simulation technology. The main advantage of computer simulation analysis is that it can carry out multiple repeated tests, and can calculate the impact response to changes in various structural parameters, which is an effective method. It can simulate the whole collision process of different vehicle types and different initial conditions of collision, and can provide details of the collision process that cannot be observed by the experiment, and can also save a lot of money. There-fore, based on the above points, this paper chooses the method of computer simulation analysis for research.

This article takes the B-level corrugated beam guardrail in the existing specifications as the research object, and selects the ordinary car for modeling. The ANSYS/LS-DYNA software developed by the American ANSYS company is used to establish the finite element model of the vehicle and corrugated beam guardrail, to simulate the physical collision, and finally to analyze and summarize the data of the collision experiment results.

2. Establishment of Finite Element Model of Car and Corrugated Beam Guardrail

2.1. Establishment of corrugated beam guardrail

The goal of this article is to explore the common B-level corrugated beam guardrails on highways. These guardrails are composed of two wave-shaped corrugated beam plates, brackets and circular columns, which are connected by high-strength bolts. First, the three-dimensional software SolidWorks was used to build a three-dimensional model of corrugated beam guardrail, and then Hyper Mesh was used for pre-processing such as meshing, material and attributes definition.

Corrugated beam slabs, brackets and circular columns are all made of LS-DYNA No. 24 elastoplastic material, the density is 7860kg/m3, the guardrail beam slab material's Young's modulus is 210GPa, Poisson's ratio is 0.3, for The beam-slab unit uses the Belytschko-Tsay shell element form, and the value of the stress-strain curve of the Q235 structural steel, the material of the class B corrugated beam guardrail, is input into the Hyper Mesh software.

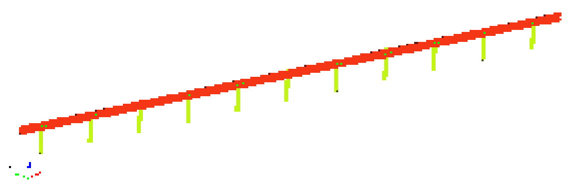


Figure 1. Finite element model of B-level corrugated beam guardrail

Connections between the three components of the corrugated beam guardrail are all high-strength bolts, which can resist a large collision force when subjected to a collision, and there is almost no separation between the components. In addition, when the actual collision occurs, bolt failure rarely occurs. Therefore, in the finite element modeling, a rigid connection may be considered to simulate the role of the bolt to connect the various

ISSN: 2518-0215, Volume 5, Issue 3, September, 2020

components of the guardrail. At the same time, according to the relationship between the column and the ground systematically explored by a Japanese research institute, it is concluded that when the guardrail is subjected to a car impact, no matter how long the column is buried in the ground, the maximum bending moment is located at 400mm underground, and the structural size of the column is irrelevant. For this study, the interaction between the column and the foundation can be simulated by constraining the six degrees of freedom at 400 mm below the column ground.

2.2. Vehicle finite element model

Taking a certain car model as an example, a finite element model of the vehicle is built. The mass of the vehicle is 1263kg, and there are 393165 nodes in total. In order to verify the availability of the car model, we judge by analyzing the energy curve of the vehicle for frontal collision whether its model is reliable. Set the speed of the car collision to 56km/h as required. Accelerometers are placed at the center of mass of the vehicle, the seat, and the engine. After the pre-processing is completed, LS-DYNA is used for calculation. Finally, the post-processing software is used to view the desired results file.

Figure 2. The finite element model of car frontal crash

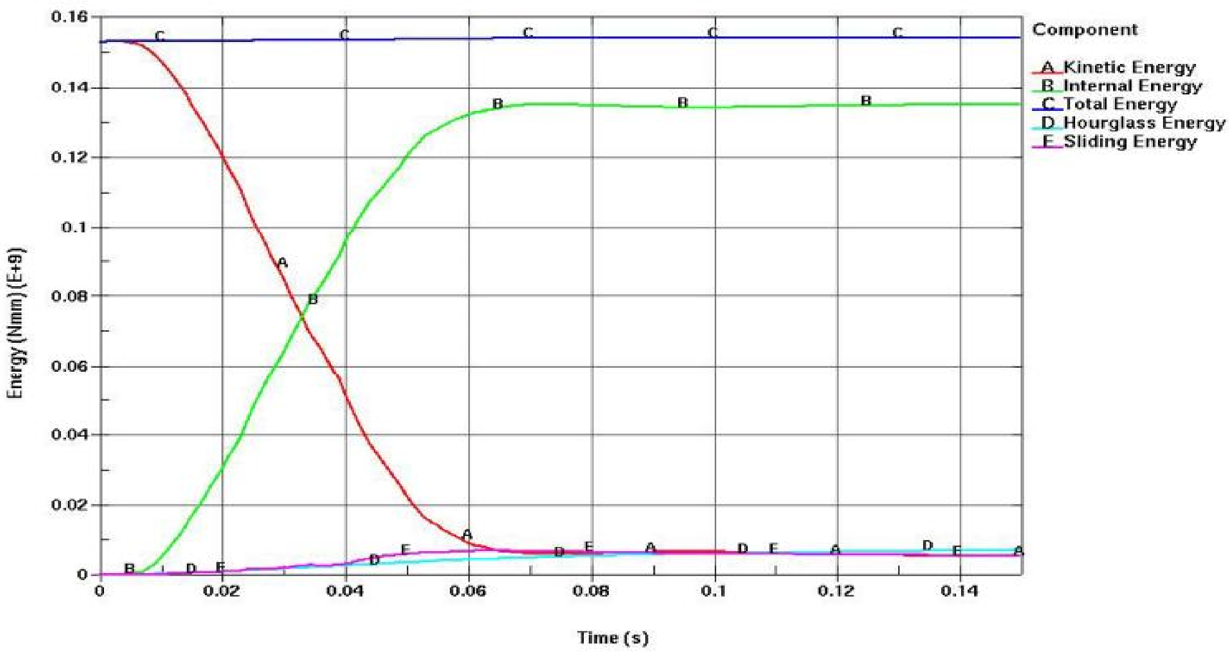


Figure 3. The energy of the car changes with time during the frontal crash

To view the required results in Hyper View, you can first extract the time-dependent curves such as the internal energy of the relevant kinetic energy. Figure 3 shows the changes in the total energy, kinetic energy, internal energy, and hourglass energy of the collision system with the impact time. By observing the curve in the figure, we can see that the model is consistent with the actual performance, the hourglass energy is also less than 5% of the total energy, and the mass increase curve also meets the requirements. Therefore, the car model is reliable and can be used as a car model for collision guardrails. At the same time, the result of the collision is also more universal and feasible.

2.3. Car and guardrail collision simulation system

Collision angle: The collision angle is the angle between the driving direction before the car hits the beam and the direction where the wave beam and beam are located. The collision angle is different, the degree of damage to the occupants, and the energy absorbed by the guardrail will be different, so it is very critical to choose the appropriate collision angle during simulation. According to the related collision angle investigation, the collision angle of most vehicles and guardrails is less than 20°, so this paper sets the angle between the vehicle's driving direction and the B-level wave beam guardrail as 20°.

Collision speed: Because the B-level corrugated beam guardrail is generally installed on the highways of the second grade and below. The allowable driving speed of the vehicle is generally around 60km/h. When a dangerous situation occurs, the driver will generally take some measures such as braking or steering to reduce the vehicle speed. Therefore, the collision speed selected in this paper is 60km/h, to simulate the anti-collision performance of the guardrail under normal driving conditions of the car.

Contact settings: In addition to defining the contact between the internal components of the car itself, the collision simulation of the car and the guardrail also needs to define the contact of the guardrail itself, the contact between the car and the ground, and the contact between the car and the guardrail components. The contact type is set according to the actual collision between the vehicle and the guardrail. The car itself and the wave guardrail itself are set to the automatic single-sided contact form. The three models and the wave guardrail are set to the automatic face-to-face contact form. The contact type of the wheel and the ground is defined as an automatic point-to-surface contact form, and the friction coefficient of the contact is set to 0.15.

According to the above parameters, a collision simulation system of automobile and guardrail is established, as shown in Figure 4 below.

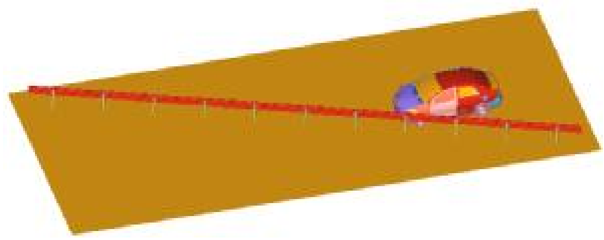
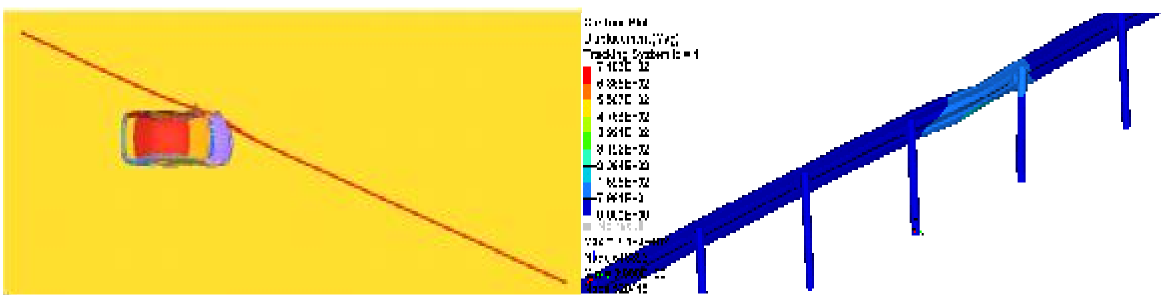


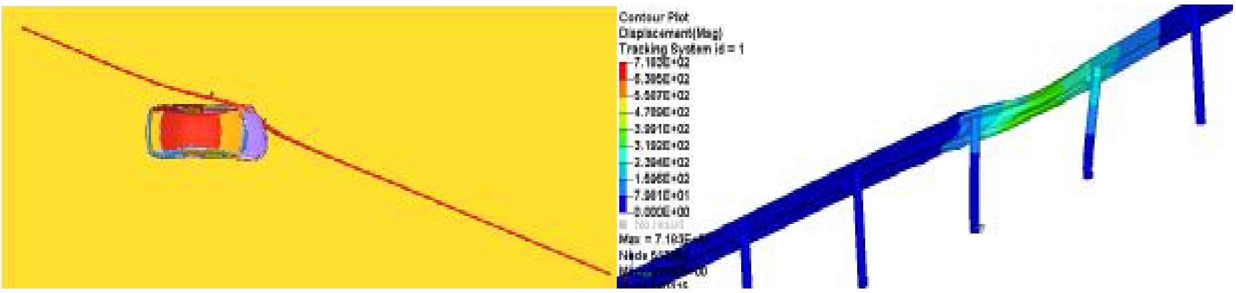
Figure 4. Finite element model of vehicle crash waveform beam guardrail

3. Analysis of Simulation Calculation Results

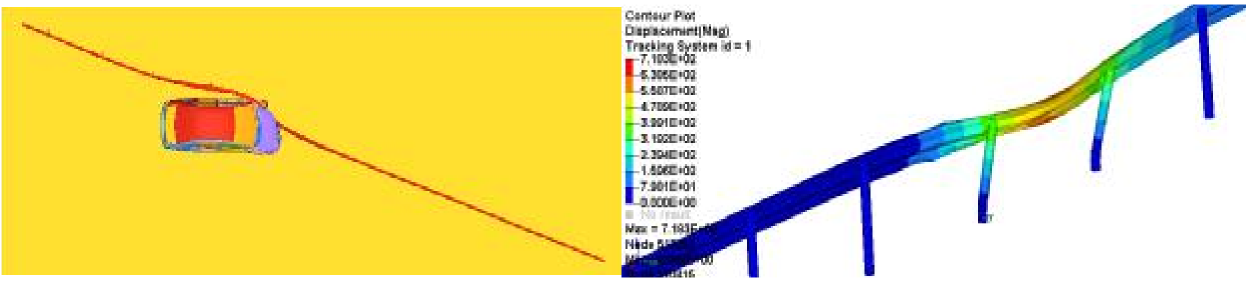
Figure 5 reflects the whole process of collision between the car and the guardrail, from which you can see the complete process of the deformation of the guardrail and the movement characteristics of the car during the impact. The car began to contact the guardrail at about 0.02 s, and the two began to deform under the force. With the passage of time, the car continues to move forward, the lateral displacement increases at 0.06 s, the deformation of the car and the guardrail also gradually increases, and the position of the contact point between the car and the guardrail continues to approach the column. Where the corrugated beam and plate are impacted, there is a high degree of stress concentration and strain concentration. Before the corrugated beam and plate break, they must absorb considerable energy. At the moment of collision, when the collision force exceeds the yield limit of the corrugated plate, the corrugated plate begins to undergo plastic deformation, and the corrugations gradually extend to absorb the collision energy. The role of the vehicle and the guardrail continuously changes its position over time, the ripples are unfolded, absorb energy, and the collision force gradually decreases. During the collision, when the bracket with relatively weak stiffness was crushed, the column closest to the collision point appeared plastic deformation from the lower end, and the entire column began to fall down until the end of the collision process at 0.3 s. This process is consistent with the actual collision results.



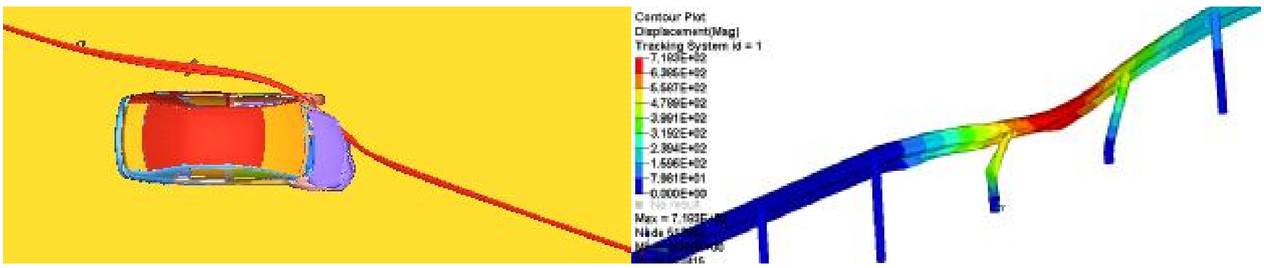
(a) t=75ms



(b) t=150ms



(c) t=225ms



(d) t=300ms

Figure 5. The whole process of collision between the car and the corrugated beam guardrail

It can be known from Figure 6 and Figure 7 that the maximum acceleration of the center of mass is 63.72 m/s2, and the maximum deformation of the guardrail is calculated by LS-DYNA to be 0.7183 m.

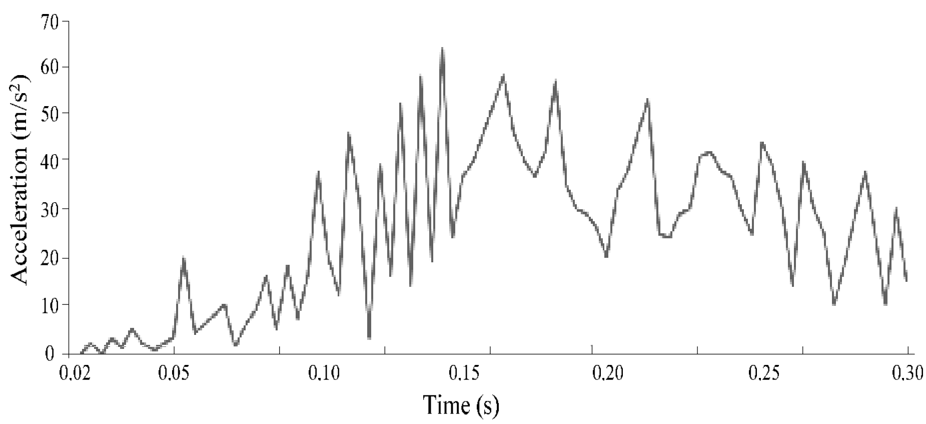


Figure 6. Car centroid acceleration curve

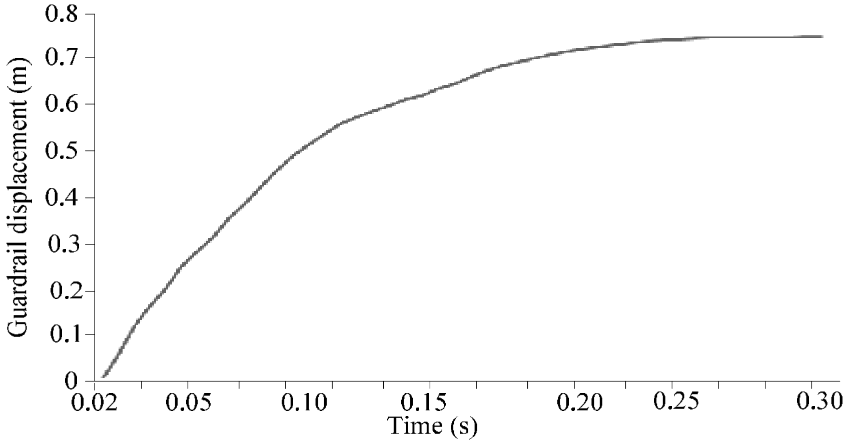


Figure 7. Guardrail displacement curve

4. Conclusion

The whole process of the collision between the car and the corrugated beam guardrail shows that the correction of the driving direction of the car is mainly achieved by the deflection of the front of the car. It can be observed in the model that the car did not pass through the guardrail during the impact, indicating that the class B corrugated beam guardrail has good anti-crossing capability. Although the front left side of the cab was deformed and damaged, there was no tendency for the vehicle to roll or roll over. This shows that the B-level corrugated beam guardrail has better export ability and rollover restraint ability for the car.

In this paper, the numerical collision simulation analysis method is used to study the collision between the Class B corrugated beam guardrail and the car. From the aspects of the deformation of the corrugated beam guardrail and the acceleration change of the car, the following conclusions are obtained: Class B corrugated beam guardrail Compared with the car, it has good protection performance, including its stopping ability and rollover ability. The good anti-collision performance of the B-level beam guardrail can provide a reference for real car experiments and practical application, especially in the western mountainous areas. Highways of Grade 2 and below have more growth and downhill slopes. Consider increasing the proportion of Grade B guardrails in the corresponding parts, which can effectively avoid the occurrence of malignant accidents. At the same time, the corresponding data of the simulation analysis of the finite element model of the wave beam guardrail of automobile collision. It is also beneficial to further improve the structure of the corrugated beam guardrail, which can reduce the number of real vehicle collisions and provide a theoretical basis for the design of new guardrails.

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