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Research on Collision of Concrete Retrofit Guardrail

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Abstract

The rapid development of the domestic highway industry, the continuous expansion of the scale, followed by the maintenance of the road. Many roads are heightened on the original basis, so the height of the original guardrail cannot meet the protection requirements of the road. Therefore, this paper studies the "F-type" reconstruction scheme of the concrete guardrail in the maintenance project of a certain road; uses the finite element method to simulate and analyze the collision of the reconstructed guardrail, and uses the passenger car to collide. By analyzing the buffering, blocking and guiding functions of the guardrail. The results show that the reconstructed guardrail can meet the protection requirements of the guardrail.

Keywords

Concrete Guardrail; Guardrail Retrofit; Finite Element Analysis R.

1. Introduction

All The guardrail mainly has three functions: blocking, buffering, and guiding. When the vehicle collides with the guardrail, it blocks the vehicle from passing through the guardrail, and at the same time, lifts the vehicle to a certain height to release energy and relieve the momentum. At the same time, the guiding function guides the vehicle back to the original trajectory. It can reduce the level of loss, reduce the safety risk of occupants, and at the same time ensure that the vehicle will not break through or cross the guardrail to avoid secondary injuries [1].

This paper attempts to study the heightening and reconstruction of the F-type concrete guardrail with a protection level of A, and the reconstruction of the original road surface with a height of 30 cm. , that is, the raised guardrail is still an F-type guardrail. By establishing the model of the guardrail, and then using the finite element software to carry out the collision between the car and the guardrail, by analyzing the collision energy between the guardrail and the car, it is analyzed whether the protective ability of the guardrail meets the three functions of the guardrail.

2. Guardrail Model Establishment

2.1 Original Guardrail and Modified form

The original guardrail of the highway is a grade A F-type concrete guardrail.

2.2 Finite Element Model of Guardrail

The model of the guardrail is established in CATIA, and its three-dimensional model is shown in Figure 1.

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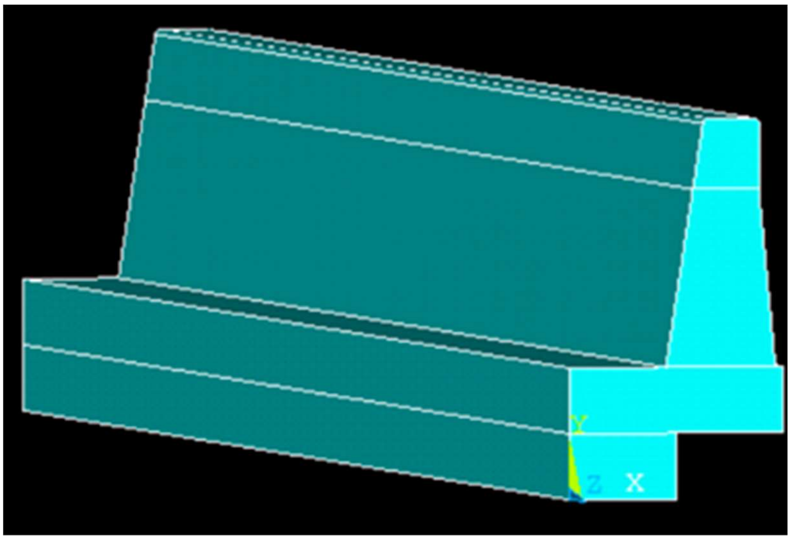

Figure 1. Three-dimensional model of the guardrail

The model is then imported into HyperMesh for preprocessing to mesh different parts of the guardrail. Simultaneously define different parameters as well as design values. The foundation, the impacted part of the guardrail, and the stirrup and longitudinal reinforcement are all classified and integrated. As shown in Figure 2.

In the finite element model, the deformation of the foundation under the guardrail is not considered, so it is considered as a rigid body. The upper half of the guardrail is divided into concrete modules, and the steel bars are divided into different steel reinforcement groups according to the diameter required by the location.

The upper part of the concrete guardrail part and the base part should also be meshed, using free division, the mesh size is 20mm, and the division result is shown in the figure below. Then, the overall coupling processing of the model can be carried out to obtain the finite element model of the guardrail.

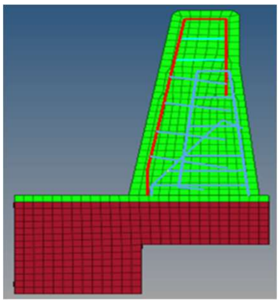

Figure 2. Solid element meshing diagram

3. Finite Element Model of the Vehicle

The establishment of the finite element model of the car is difficult, and the existing finite element model of the car is generally used. As shown in Figure 3, the length of the model is 3915mm, the weight is 1500Kg, the height is 1413mm, the width is 1566mm, the total number of nodes is 18220, and the number of units is 16464. Integrate vehicle and guardrail collision models with HyperMesh.

According to the relevant national standards and regulations, the length of the guardrail is not less than 40m, so the length of the modified guardrail model is 40 meters, and then the relative height of the vehicle and the guardrail is set in HyperMesh. Set the collision angle to be 20°, the collision point is at 1/3 of the length of the guardrail, the collision speed is 100km/h, and the collision simulation can be performed after the parameters and keywords are defined.

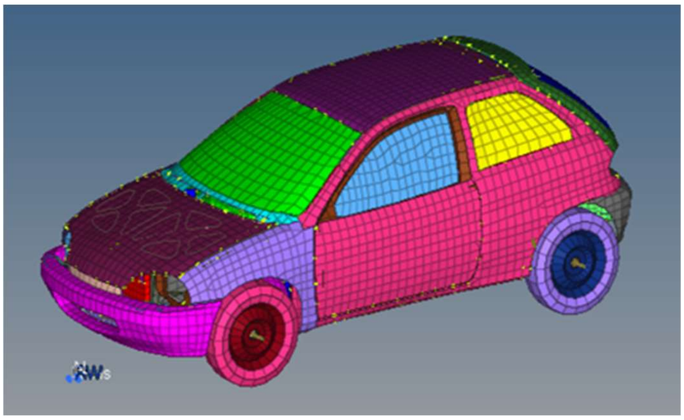

Figure 3. Finite element model of small car

4. Collision Process Analysis

The system energy change of the collision between the vehicle and the modified guardrail in this study is shown in Figure 4. From the figure, we can know that the kinetic energy of the vehicle at the beginning is equal to the total system energy. When the vehicle collides with the guardrail, when the vehicle begins to deform, the momentum in the system begins to decrease. This is because the vehicle collides and deforms, and the friction between the vehicle and the guardrail increases the internal energy. After the vehicle contacts the guardrail, the tire of the vehicle climbs along the slope of the guardrail, the center of gravity of the vehicle rises, and part of the kinetic energy is converted into gravitational potential energy [2]. , in general, the energy of the system is conserved.

At the same time, the hourglass energy accounts for a very small proportion of the total energy, far less than 10% of the total energy of the system, so it can be shown that this simulation has a high reliability [3].

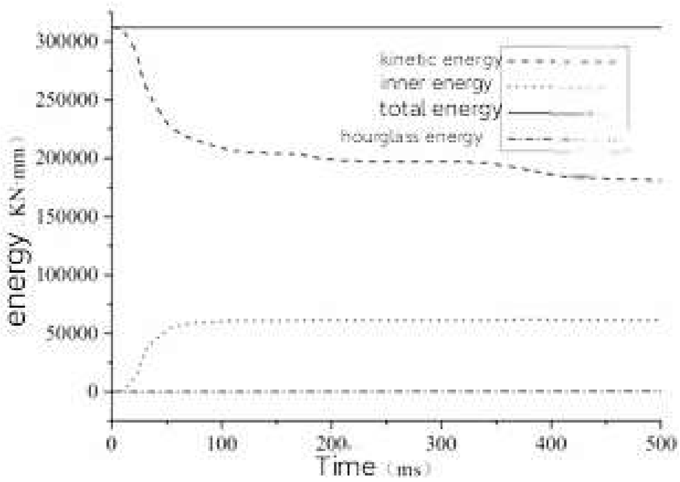

Figure 4. System energy change

4.1 Guardrail Safety Evaluation

According to the "Highway Guardrail Safety Performance Evaluation Standard" (B05-01-2013), the protective performance of Class A concrete guardrail to vehicles must meet [4]:

(1) Blocking function: The guardrail should be able to effectively prevent the vehicle from overturning, and the components and breakaway parts should not intrude into the riding space of the vehicle.

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(2) Buffer function: the longitudinal and lateral components of the collision speed shall not be greater than 12m/s, and the longitudinal and lateral components of the post-collision acceleration shall not be greater than 200m/s2.

(3) Guidance function: The vehicle shall not roll over after a collision, and the vehicle shall meet the relevant specification requirements when it drives out of the off-track.

4.2 Safety Evaluation of the Guardrail after Renovation

Blocking function: View the collision animation between the modified guardrail and the vehicle, and the vehicle does not cross, climb over and ride over the guardrail. Using HyperView to check the collision results, it can be seen that the vehicle will have a certain climbing height in the vertical direction after touching the guardrail, but it does not cross the guardrail, so the reconstructed guardrail meets the "Highway Guardrail Safety Performance Evaluation Standard" (B05-01-2013) required blocking function.

Buffering function: Visually draw the calculated number results. From the acceleration curve in Figure 5, it can be seen that the components of the acceleration along the x and y directions after the car collision do not exceed 200m/s2, and the acceleration curve is calculated. By integrating processing, the speed curve of the vehicle can be obtained. As shown in Figure 6, the components of the vehicle speed along the x-direction and the y-direction are not greater than 12 m/s.

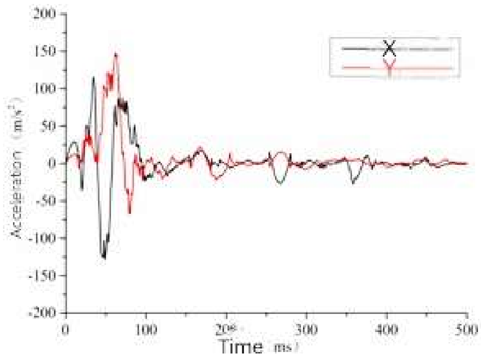

Figure 5. Vehicle acceleration

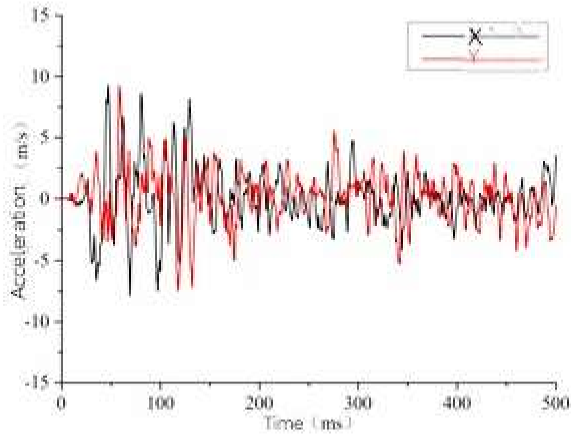

Figure 6. Vehicle speed

Since the shape of the guardrail design has a certain slope with the area in contact with the vehicle, the vehicle can climb a certain height, so that a part of the kinetic energy can be effectively converted into gravitational potential energy to release the collision energy. It can be seen from the collision process that the vehicle has a certain displacement in the vertical direction after the vehicle contacts the guardrail [5]. The displacement at the center of mass of the vehicle is shown in Figure 7. It can

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be seen from the figure that the center of gravity of the vehicle is between 0ms and 30ms. The change is negative, because the vehicle and the guardrail begin to contact the vehicle's center of gravity. When the tires of the vehicle contact the guardrail, the tires will climb up a certain distance along the slope, so the center of gravity of the vehicle will gradually rise from 30ms to 280ms, and at about 280ms, the vehicle will The center of gravity reaches the highest point, and the vehicle begins to separate from the guardrail after 280ms. Due to its gravity, the center of gravity of the vehicle begins to fall, and the height gradually decreases. At 480ms, the center of gravity of the vehicle returns to the original height. With a downward speed, after the tire touches the ground, due to inertia, the height of the center of gravity will continue to drop by a small distance, and the distance is negative.

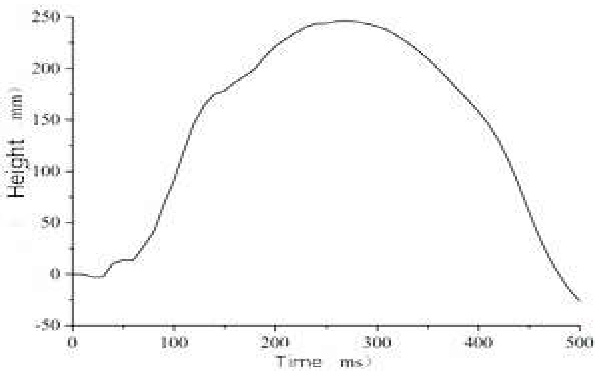

Figure 7. Changes in the height of the center of gravity of the vehicle

Through the above acceleration, speed and vertical displacement, it can be concluded that the heightened guardrail form meets the requirements of the "Highway Guardrail Safety Performance Evaluation Standard" (B05-01-2013) for the buffer function.

Guidance function: During the collision between the actual vehicle and the guardrail, the vehicle may bounce back to the road due to the angle and other problems after the collision, which may affect other normal vehicles and cause secondary accidents. Therefore, the guidance function of the guardrail is also very good. an important indicator. The smaller the distance that the guardrail bounces the vehicle, the better, and at the same time, it can guide the vehicle in the direction of the road without affecting other vehicles, and can avoid the occurrence of secondary accidents [6].

The collision trajectory of the vehicle and the guardrail is analyzed and drawn, and five time intervals are selected for drawing, and the time interval is 100 milliseconds. According to the Highway Guardrail Safety Performance Evaluation Standard (B05-01-2013), it can be known that the width of this guide frame is 4.39m and its length is 10m. The vehicle trajectory diagram is shown in Figure 8.

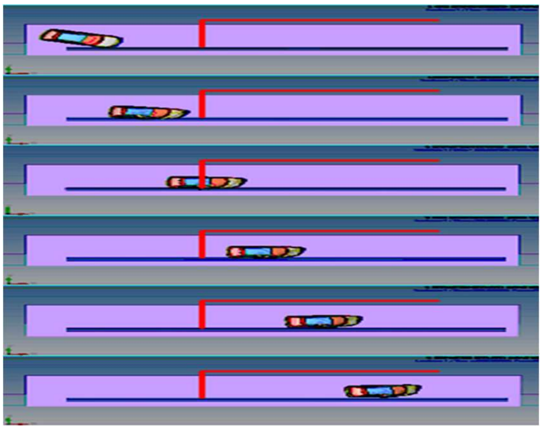

Figure 8. Vehicle trajectory

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From the trajectory diagram of the vehicle form, it can be seen that the modified guardrail does not cause the vehicle to leave the guardrail and cross the red frame of the safety area shown in Figure 10, so it meets the "Highway Guardrail Safety Performance Evaluation Standard" (B05-01- 2013) requirements for the guiding function of guardrails.

5. Conclusion

From the results of the collision between the car and the reconstructed guardrail, it can be known that the hourglass energy in the energy curve does not exceed 10% of the total energy of the system, and the simulation results have high reliability; the collision acceleration component does not exceed 200m/s2, The maximum acceleration is about 150 m/s2; the velocity components are all 12m/s exceeding the standard requirements, and the maximum speed is less than 10m/s. Based on the calculation results of this study and the provisions of the "Highway Guardrail Safety Performance Evaluation Standard" (B05-01-2013), it can be concluded that the modified F-type guardrail meets the blocking function, buffering function and guiding function. It has a good protective effect and reaches the protection standard of Class A guardrail.

At the same time, it can be known that when the vehicle collides with the reconstructed F-shaped guardrail, the stress mainly exists in two areas. The first area is the impact of the tire on the lower part of the slope of the guardrail when the vehicle climbs along the lower part of the guardrail and the front of the car. The impact caused by the wall, the second area is the secondary impact of the rear of the vehicle on the guardrail after the vehicle is raised as a whole. This is of great significance for further research on guardrails and vehicle safety.

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