NUMERICAL SIMULATION OF COMPOSITE SAFETY BARRIER UNDER VEHICLE IMPACT

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Introduction

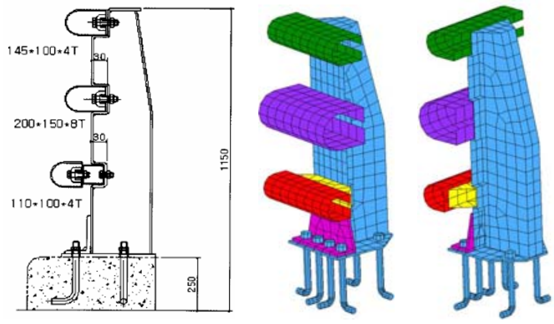
Performance of composite safety barriers under impact of vehicles is usually evaluated by large scale crash tests. However, it is relatively costly and time-consuming. Therefore, numerical simulation becomes an efficient approach for evaluation of safety barrier behavior under vehicle impact. Although several computer simulations of composite safety barrier crash tests were carried out in the last decade [1-3], these studies were limited to the behavior of the road safety barrier. Therefore, the behavior of bridge safety barrier needs to be investigated. In this study, the performance of a full scale composite bridge safety barrier is simulated by using the nonlinear explicit finite element code LS-DYNA. Two types of vehicle used in this study are passenger car and truck.

Finite Element Modeling

Modeling of Safety Barrier

The geometric dimension and finite element modeling of bridge safety barrier are shown in Fig. 1. This model consists of column, rib, anchor, concrete curb, upper, middle, and lower beams, and impact absorbing member. The barrier length is selected as 30 m which is identical with the barrier length in an actual crash test. The distance between two adjacent posts is 2 m. The column, rib, upper, middle, and lower beams, and impact absorbing member were modeled using full-integration shell elements. The anchors and concrete curb were modeled using solid elements. The total number of element of safety barrier is 32,476. The full modeling of the safety barrier is shown in Fig. 2

Material properties of the composite safety barrier are presented in Table 1. The configuration of composite laminate was designed as 8 laminas with the fiber architecture as shown in Table 2.



(a) Geometric dimension (b) Finite element modeling

Fig. 1. Finite element modeling of cross section

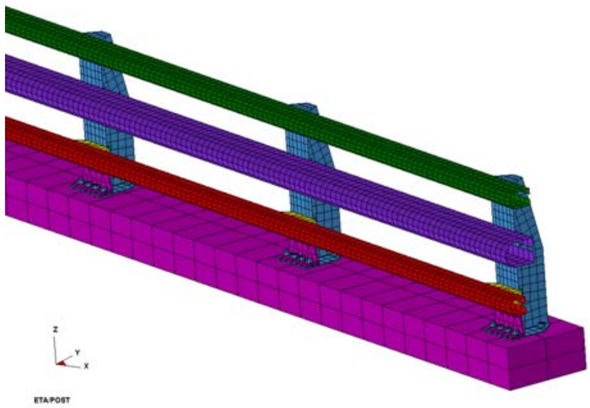


Fig. 2. Finite element modeling of bridge safety barrier

Table 1. Material properties of lower, middle, and upper beams of the composite safety barrier

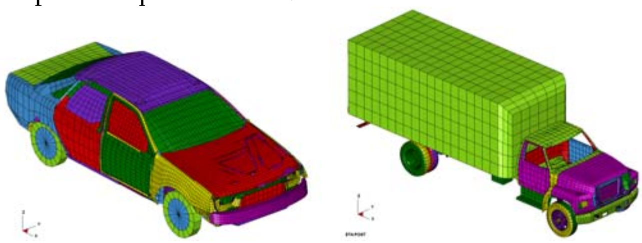
Properties	Unit	Lamina			
		Surmat	CSM	Roving	DBT
Density	t/m^3	2.62	2.62	2.62	2.62
E_1	MPa	28,619	28,619	53,400	53,400
E_2	MPa	28,619	28,619	14,100	14,100
ν_{12}		0.275	0.275	0.264	0.264
Sx	MPa	314.1	314.1	586.0	586.0
Sx’	MPa	621.7	621.7	1160.0	1160.0
Sy	MPa	314.1	314.1	106.0	106.0
Sy’	MPa	621.7	621.7	37.3	37.3

Table 2. Fiber architecture of lower, middle, and upper beams of the composite safety barrier

Layer	Lamina	Configuration	Thickness (mm)	
			Lower & upper	Middle
1	Surmat	——	0.0701	0.1402
2	CSM	▭	0.21035	0.4207
3	Roving	• • • • • • •	0.9827	1.9654
4	DBT	▬	0.28055	0.5611
5	Roving	• • • • • • •	0.9827	1.9654
6	DBT	▬	0.28055	0.5611
7	Roving	• • • • • • •	0.9827	1.9654
8	CSM	▭	0.21035	0.4207

Modeling of Vehicle

The finite element modeling of 1.3-ton passenger car (Ford Taurus) and 8-ton truck (Ford single unit truck) is taken from the National Crash Analysis Center [4] as shown in Fig. 3. The total number of elements of passenger car and truck is 28,578 and 20,727, respectively. To fulfill the weight standard regulations, the mass of the 8-ton truck was increased to 14 tons to adapt the required values.



(a) Passenger car (b) Truck

Fig. 3. Finite element modeling of vehicle

Crash Condition

Based on the standard regulations [5], the initial velocities of the passenger car and the truck are 100 km/h and 80 km/h, respectively. The impact angles between vehicle and safety barrier are 15^o and 20^o for the passenger car and the truck, respectively.

Crash Simulation Result

The results of computational simulations of the bridge safety barrier under the impact of passenger car and truck are shown in Fig. 4 and Fig. 5, respectively. It can be observed that the composite bridge safety barrier is strong enough to retain and redirect the vehicle back on the roadway. The safety barrier is not deformed under the impact of the passenger car.

Conclusion

The performance of the composite bridge safety barrier under the impact of passenger car and truck is simulated using the nonlinear explicit finite element code LS-DYNA. It can be seen that the design composite bridge safety barrier is strong enough to retain and redirect the vehicle back on the roadway. The proposed composite barrier satisfies the requirements of both strength performance and capability of absorption impact energy.

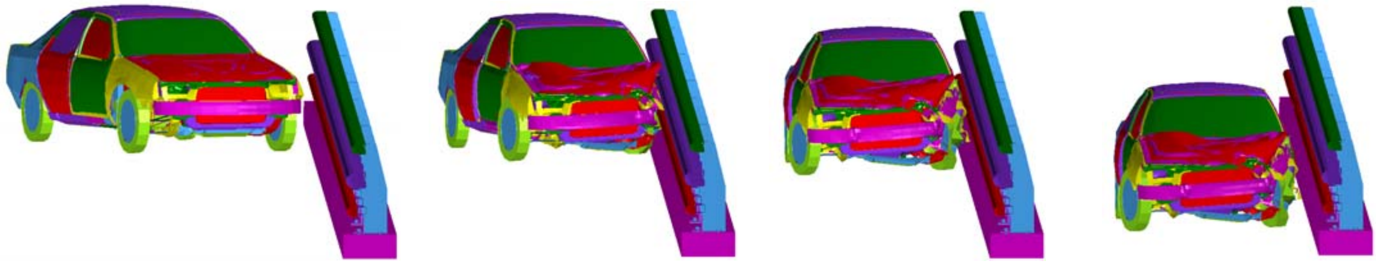


Fig. 4. Simulation of car impact

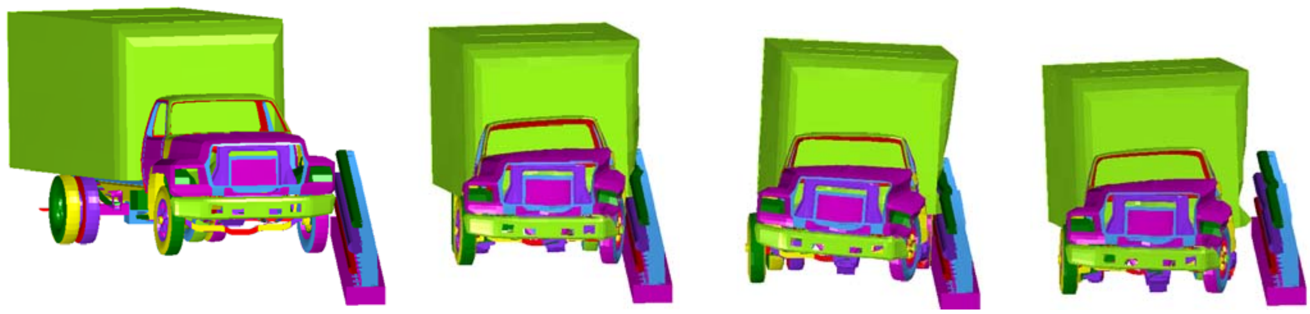


Fig. 5. Simulation of truck impact

Acknowledgement

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