Dynamic Vehicle-Impact Analysis of U-Channel Segmental Concrete Bridges

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Summary

A U-channel segmental concrete bridge has the advantages of reducing dead load and acting as a guard fence. It is necessary to analyze the behaviors of U-channel segmental concrete bridges and identify dynamic characteristics under vehicle-impact loading because they collapse when the edge beams have ruptured. In this study, static and dynamic vehicle-impact analyses were carried out for evaluating the safety of U-channel segmental concrete bridges under vehicle impact loading based on the AASHTO LRFD Specification (2007). Stresses and displacement from vehicle impact on a U-channel segmental bridge were analyzed. In addition, velocity and acceleration histories of vehicles were investigated.

Keywords: Impact Analysis; Vehicle Impact; Segmental Concrete Bridge; Edge beam.

1. AASHTO LRFD design specifications (2007) for bridge barriers

The AASHTO LRFD design specifications (2007) suggest two methods of vehicle impact testing for bridge barriers and railings. One is to investigate stability using static vehicle-impact testing based on the AASHTO LRFD design specifications (2007). The other is to evaluate stability using dynamic impact simulations.

2. Static vehicle impact analysis and its results

As a result of static vehicle impact analysis of U-channel segmental concrete bridges based on AASHTO LRFD Design specifications (2007), the maximum stress of each member is designed within the allowable design stress. Figure 1 shows FEM modeling of a U-channel segmental concrete bridge based on static analysis and Figure 2 shows the stress contour. Table 1 is the result of analysis.

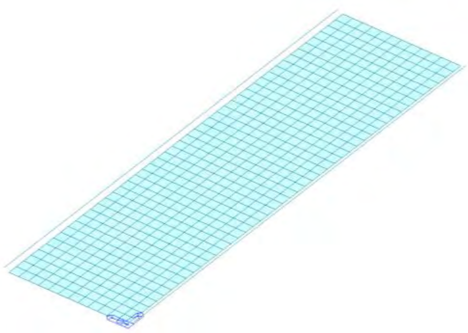

Figure 1. FEM Model for static analysis

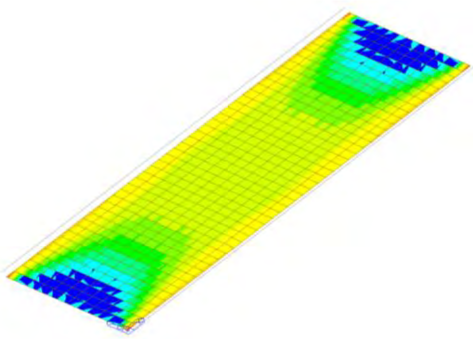

Figure 2. Stress Contour for static analysis

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Table 1. Static vehicle impact analysis results (Unit: MPa)

Test Level	TL-1		TL-2		TL-3		TL-4		TL-5		TL-6	
	Edge Beam	Slab	Edge Beam	Slab	Edge Beam	Slab	Edge Beam	Slab	Edge Beam	Slab	Edge Beam	Slab
Stress	5.69	8.24	9.54	10.12	11.87	13.24	12.24	14.85	14.89	16.99	17.14	18.24
Allowable Stress	20	20	20	20	20	20	20	20	20	20	20	20
Check	O.K	O.K	O.K	O.K	O.K	O.K	O.K	O.K	O.K	O.K	O.K	O.K

3. Dynamic vehicle impact analysis

When carrying out dynamic vehicle impact analyses, six UCB models with spans from 20 m to 45 m and widths of 12m were investigated. ANSYS/LS-DYNA, which is a dynamic impact analysis program, was used. Also, in this study, four kinds of vehicle models are used for dynamic vehicle impact analysis. Table 2 shows the analysis results.

Table 2. Dynamic vehicle impact analysis results

Vehicle Type	Impact Velocity & Angle	Impact Location	Stress (MPa)	Allowable Stress(MPa)	Check
Small Automobiles	50km, 20˚	Edge Beam	0.3	20	O.K
		Slab	0.2	20	O.K
	70km, 20˚	Edge Beam	0.5	20	O.K
		Slab	0.3	20	O.K
	100km, 20˚	Edge Beam	0.8	20	O.K
		Slab	0.4	20	O.K
Pickup Truck	50km, 25˚	Edge Beam	1.3	20	O.K
		Slab	0.5	20	O.K
	70km, 25˚	Edge Beam	1.6	20	O.K
		Slab	0.9	20	O.K
	100km, 25˚	Edge Beam	2.2	20	O.K
		Slab	1.3	20	O.K
Van Truck	80km, 15˚	Edge Beam	2.1	20	O.K
		Slab	1.9	20	O.K
Van Type Tractor Trailer	80km, 15	Edge Beam	8.6	20	O.K
		Slab	3.3	20	O.K

4. Conclusions

In this study, static and dynamic vehicle-impact analyses were carried out according to crash criteria based on the AASHTO LRFD Design Specifications (2007). In static analyses, because only vehicle-weight was considered, the results may differ from the behaviors of the UCB in a real vehicle crash. In order to expand the applicability of this study, the behaviors of the UCB through dynamic impact simulations were investigated. Stresses in all simulation results satisfied the concrete allowable stress of 20 MPa. Maximum stress at the edge beam was 8.6 MPa. We conclude that the UCB models which were considered in this study have enough stability for vehicle impacts.