Proceedings of the Peradeniya University Research Sessions, Sri Lanka, Vol.12, Part II, 30th November 2007

Seismic Review Sheet for Evaluation of Earthquake Risk of Bridges

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Introduction

Sri Lanka, which is situated away from major plate boundaries, is considered to be in a non-seismic zone. However, there have been many seismic events within Sri Lanka in the recent past, which were small in magnitude and with epicenters far from Sri Lanka. Scientists and geologists believe that formation of a new plate boundary, which divides Indo-Australian plate, is about 400 km away from Sri Lanka and could pose a possible risk of future earthquakes in Sri Lanka.

If an earthquake occurs, the whole transportation system could become crippled when the road network is damaged. It is undisputed that key elements of any road network are bridges. This happened in the earthquake trigged tsunami disaster of 26 December 2004 in Sri Lanka. Considering the above, it is very important to evaluate the potential earthquake risk of existing bridges to withstand potential earthquakes.

It is indispensable to perform condition evaluations of all existing bridges for potential earthquake risk on bridges of any road network. However, it is a time-consuming and costly work to evaluate the condition of each and every bridge in Sri Lankan road network. To overcome this difficulty, vulnerable bridges can be identified easily by visual inspection and then a detailed inspection can be performed based on scoring of visual screening of the bridges of a network.

The objective of this research is to upgrade a Seismic Review Sheet by modifying the Seismic Review Sheet (SRS), prepared by Bandara *et al.*, (2006) and then apply the sheet to existing bridges.

Methodology

The improving of the Seismic Review Sheet (SRS) shown in Table 2 was done by modifying SRS prepared by Bandara *et al.*, (2006). It converts the building seismic review sheet by Federal Emergency Management Authority (FEMA, USA) to cater for bridges. Effects of parameters were adjusted considering their relative importance. In order to improve the weight of the SRS, a simple bridge model was designed. Then the bridge model was redesigned changing some items of SRS such as piers (single pier, or multiple piers) in order to improve the weight and the factor while keeping others as constant in that model bridge. Finally, the weight and the factor were improved by considering the displacement of the bridge model.

Total weight in the SRS is 100 and it was distributed among items depending on their importance when considering seismic force resistance.

The visual screening was done using the SRS for the following six bridges.

1. Gannoruwa bridge
2. Highway bridge at Peradeniya
3. Kuruduwaththa bridge
4. Steel railway bridge at Paradeniya
5. Gampola bridge
6. Akbar bridge

Table 1. Results obtained with SRS for six bridges

Bridge	Score out of 100
Gannoruwa bridge	87.3
Highway bridge at Peradeniya	34.7
Kuruduwaththa bridge	54.9
Steel railway bridge at Panideniya	44.3
Gampola bridge	62.3
Akbar bridge	46.5

As shown, in Table 1, lower scores represent a higher risk against possible earthquakes.

In such a case, it is better to analyse such bridges in detail as the displacement criterion becomes important in earthquakes. In this context, the highway bridge at Peradeniya and Akbar bridge in Table 1 were analyzed in detail to find maximum possible displacement.

Table 2. Seismic Review Sheet

SEISMIC REVIEW SHEET						
Bridge Name			Bridge No.			
Evaluator			Date			
Bridge Type : □ Arc □ Beam □ Cantilever □ Truss □ Suspension						
SPAN :			**SLAB DEPTH :**			
PIER HEIGHT :			**PIER THICKNESS :**			
SEAT LENGTH :			**SKEW ANGLE :**			
No	**Item**	**Weight**	**Evaluation Content (Factor)**		**Gr.**	**Point**
1	Historical Events	11	□ Yes (0)	□ Yes (0)		
			□ Grade I (1.0)	□ Grade I (1.0)		
2	Damage	9	□ Grade III (0.6)	□ Grade IV (0.4)		
			□ Grade V (0)			
3	Importance	9	□ High (0)	□ Medium (0.5)		
			□ Low (1.0)			
4	Age	7	□ Before 1960 (0.1)	□ 1960 - 2980 (0.1)		
			□ 1980 - 2000 (0.6)	□ After 2000 (1.0)		
5	Material	7	□ RC Bridge (0.6)	□ Steel (1.0)		
			□ Wood (0.4)	□ Composite (0.8)		
			□ Pre-Stressed (0.8)			
6	Deck	3	□ Beam & Slab (0.8)	□ Void Slab (0.3)		
			□ Solid Slab(0.5)			
7	Pier	5	□ Single Pier (0.5)	□ Multiple Pier (1.0)		
8	Abutment	3	□ Open (0.3)	□ Open (0.5)		
			□ Special (1.0)			
9	Foundation	6	□ Shallow (0)	□ Deep (1.0)		
10	Bearing	3	□ Rubber (1.0)	□ Fixed (1.0)		
			□ Expansion (0.7)			
11	Soil Condition	6	□ Hard l (1.0)	□ Medium (0.5)		
			□ Soft (0)			
12	Span Depth Ratio	3	□ s/d >0.5 (0.3)	□ s/d < 0.5 (0.7)		
13	Seat Length	7	□ N>minimum (1.0)	□ N<minimum (0.0)		
14	Skew Angle	5	□ $\alpha < 25^0$ (1.0)	□ $\alpha > 25^0$ (0.0)		
15	Pier Ratio, r	3	□ r > 1.5 (1.0)	□ 1.0< r > 1.5 (0.5)		
16	Redundancy	2	□ None (1.0)	□One Direction (0.5)		
			□ Both Direction (0)			
17	Expansion Joint	3	□ 30 mm (0)	□ Required (1.0)		
			□30mm<Required (0.5)			
18	R/f	4	□ Rectangular (0.4)	□ Circular (0.6)		
			□ Hollow (1.0)	□ No r/f (0)		
19	Stirrup and Crosstie	4	□ Having 135^0 (1.0)	□ Less than 135^0 (0.0)		
Total Points		100				

Maximum displacement of the highway bridge at Peradeniya (middle of span) is 465 mm.

Maximum displacement of the Akbar bridge (middle of span) is 360 mm.

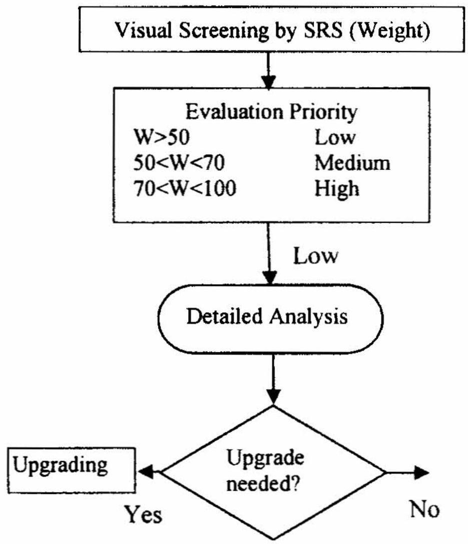

Figure 1. Procedure for seismic risk reduction

Discussion

By applying the aforementioned procedure to a seismically less resistant bridge, this can be validated to have a reasonable accuracy.

The total weight indicates vulnerability. If the total score is low, the vulnerability is high and if total score is high the vulnerability is low. To get a marginal score a survey has to be carried out and then detailed analysis should be done for bridges in a particular network.

According to the method used in this research, the most seismic vulnerable bridge is the highway bridge at Peradeniya and it has a score of 34.7 and the Akbar bridge has a score of 46.5. Considering their displacement, it can be said that the Peradeniya bridge has higher vulnerability than the Akbar bridge. The result obtained from the SRS also indicated similar results. Therefore, it can be said that the SRS has enough accuracy. Using this SRS, one can evaluate the condition of potential earthquake risk on existing bridges.

References

Bandara A.C.R., Priyadarshana G.S. and Tennakoon N.C. (2006) Condition evaluation of bridges for potential earthquake risk, *Undergraduate Research Report, Department of Civil Engineering, University of Peradeniya*, Sri Lanka.