# EVALUATION OF SEISMIC CAPACITY OF EXISTING HIGHWAY BRIDGES IN SRI LANKA

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## DECLARATION

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## ABSTRACT

Sri Lanka is an island located in the Indian Ocean and it lies in the large Indo-Australian plate seemingly far away from any of the plate boundaries. Therefore, many people believe that this fortuitous scenario makes Sri Lanka safe from earthquakes.

But an intra-plate earthquake can occur anywhere at any time. Some geologists pointed out that the Indo Australian plate is being separated into two and its boundary lies 500km away from the southern coast of the country. Therefore, Sri Lanka has a moderate risk to face an earthquake.

There are over 4000 bridges on National Road Network with length varying from 3.0m to 500.0m. These bridges have varying widths about 3.0m to 25.0m and some of these have been constructed more than 50 to 100 years back. They were constructed using steel concrete composite or steel. These bridges have not been designed for seismic loads and they have not been detailed for seismic effects. Therefore, it is a must to evaluate the seismic capacity of those bridges and retrofit those if necessary.

This study was focused to develop a priority list (Bridge Rank) for the purpose of further investigation on seismic capacity. It was also focused to carry out a case study for a selected bridge from the developed priority list to find out its seismic capacity.

Bridges on the "A" class roads with the overall length of the bridge is greater than 25m were considered in this study. To develop the priority list for thesebridges, the method given in the "Seismic Retrofitting Manual for Highway Bridges" published by the Federal Highway Administration (Report No. FHWA-RD-94-052) was used. The parameters required to input to the above methodology were obtained from the previous research findings and the bridge inventory that is maintained by the Planning Division of RDA, Sri Lanka.

The bridges considered under this study have low risk to fail due to possible earthquake loadings with local conditions since the bridge rank is between 0 to 24 on the scale of 100.

Bridge No 1/1 on PeliyagodaPuttalam road (Japanese Friendship Bridge) was selected for further investigation from the developed priority list since it gives the bridge ranking 12. A response spectrum analysis was carried out to find the actions of the bridge during an earthquake. For the analysis of the bridge, a Finite Element Model was developed using SAP 2000. Codes of practices for Australian standards were used to find out the seismic capacities of the substructure and the actions of superstructure was compared with the originally designed actions.

The bridges considered under this study have low risk to fail due to possible earthquake loadings since the bridge rank is between 0 to 24 on the scale of 100. It is proposed to replace the bridge bearings of the bridge no 1/1 on PeliyagodaPuttalam road based on the results of the case study.

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Keywords: Earthquake, Bridges, Bridge rank, Retrofitting

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U.L.Aluthapala

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| | | |
|---|---|---|
| a | - | Acceleration coefficient |
| $A_g$ | - | Gross cross sectional area of the member |
| $A_s$ | - | Area of tension reinforcement |
| AVR | - | Abutment vulnerability |
| B | - | Width of the deck |
| b | - | Width of the section |
| $b_{max}$ | - | maximum transverse column dimension |
| CVR | - | Column vulnerability |
| D | - | Dead load |
| d | - | Effective depth to tension reinforcement |
| E | - | Seismic hazard rating |
| e | - | Eccentricity of the prestressing force |
| EP | - | Earth pressure (Soil pressure + Surcharge) |
| EQ | - | Earthquake loading |
| F | - | Framing factor |
| $F_v$ | - | Site factor depend on long term spectral acceleration |
| $f_{cf}'$ | - | Characteristic flexural strength of the concrete |
| $f_{cu}$ | - | Characteristic strength of concrete |
| $f_y$ | - | Yield strength of reinforcement |
| $F_v$ | - | Site factor depend on short term spectral acceleration |
| H | - | Average height of piers/columns supporting the bridge deck. |
| $H_r$ | - | Total elastomer thickness |
| $K_H$ | - | Lateral Stiffness |
| $k_u$ | - | Neutral axis parameter |
| $K_v$ | - | Vertical Stiffness |
| $K_\theta$ | - | Rotational Stiffness |
| L | - | Length of the bridge deck. (From seat to adjacent expansion joint) |
| Lc | - | effective column length |

LVR - Liquefaction vulnerability

$M_u$ - Ultimate resistance moment

$M_{uo}$ - Ultimate strength in bending without axial forces

N - Required seat length

P - Prestressing force

PGA - Peak ground acceleration

$P_s$ - amount of main reinforcing steel expressed as a percent of the column cross sectional area

R - Bridge rank

S - Site factor

$S_1$ - Long term spectral acceleration

SRC - Seismic retrofitting category

$S_s$ - Short term spectral acceleration

V - Structural vulnerability

$V_1$ - Superstructure vulnerability

$V_2$ - Substructure vulnerability

$V_{uc}$ - Shear strength excluding shear r/f

$V_{us}$ - Shear strength contributed by shear r/f

W - Load of the wearing surface

Z - Section modulus of the uncracked section

z - Lever arm

$\alpha$ - angle of skew

$\phi$ - Capacity reduction factor

$\varepsilon_{sc}$ - shear strain at edge of bonded surface due to loads normal to bearing surface

$\varepsilon_{sh}$ - shear strain at edge of bonded surface due to force tangential to the surface or movement of the structure or both

$\varepsilon_{sr}$ - shear strain at edge of bonded surface due to relative rotation of bearing surface to bearing surface

$\delta_a$ - maximum shear displacement tangential to the bearing surface

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