INVESTIGATION OF THE BRIDGE'S DESIGN CODES THROUGH NEAR FAULT'S EARTHQUAKES

Mirhasan MOOSAVI
Science and Research Branch, Islamic Azad University, Department of Civil Engineering, Tehran, Iran
mirhasanmoosavi@yahoo.com

Mansour ZYIAEEFAR
IIEES, Tehran, Iran
mansour@iiees.ac.ir

Javad MOKARI RAHMDEL
Urmia University of Technology, Urmia, Iran
j.mokari@uut.ac.ir

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Many structural engineers presume that vertical component of the earthquake is not important. Contemporary seismic design code requirements do not consider vertical motion effects accurately. However design codes simply consider ground motion effects by increasing or decreasing the dead load multiplier in load combination. Vertical effects were explicitly considered in design. They are typically represented by a response spectrum which is two-thirds of horizontal response spectrum in the related site. Present study clearly demonstrates that this method of considering vertical seismic load effects is not accurate especially in near-field earthquakes and structures with short period of vibration (Button et al., 2002).

First we review various design codes viewpoints about vertical component of ground motions. Design codes that have been reviewed in this study are: Iranian Codes for Seismic Design of Roads and Railway's bridges, Caltrans, Euro Code, AASHTO LRFD Bridge Design Specification's, AASHTO, AASHTO Seismic Isolation Guide Specifications, ASCE, IBC2012 and UBC97.

Iranian codes for seismic design of roads and rail way's bridges respects only horizontal components and in spite of ignoring vertical component, recommends increasing the design forces for deck support bolts. Caltrans applies a vertical load in ordinary and standard bridges that their site's PGA exceeds 0.6g and recommends to conduct a case study for considering vertical component effects for important and complicated bridges. In bridges with above conditions, a uniform vertical load which is equivalent to one fourth of the deck dead load is applying to the deck in upward and downward directions. This is shown in Figure 1 (Caltrans).

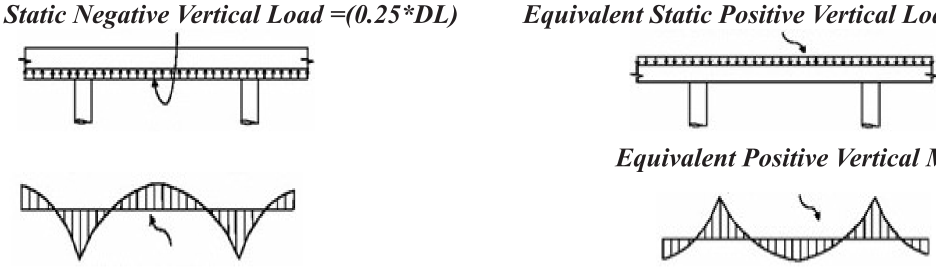
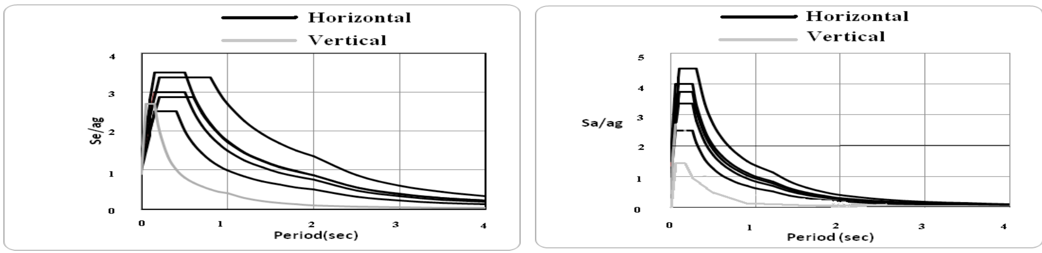


Figure 1. Equivalent static loads in up and down direction & moments (Caltrans)

Euro code considers vertical earthquake motion effects explicitly during design procedure and offers vertical response spectrum for different soil types. Figures 2 and 3 represent Type I & Type II Response Spectrum for Vertical and horizontal components according Euro code (Euro code 8).



a) Type I b) Type II

Figure 2. Response Spectrum for Vertical and Horizontal Components (Euro Code)

AASHTO do not have a direct method for applying vertical component on bridges but instead AASHTO Seismic Isolation guide specification uses +/- 20% of dead load (i.e. load factors of 1.2 and 0.8) in the testing requirements to represent vertical effects, irrespective of earthquake magnitude, fault distance and soil type (AASHTO seismic Isolation guide specifications).

In the second part of this study a database consists of 31 near fault earthquake is gathered. These records consists 61 horizontal and 31 vertical components of 31 worldwide earthquakes (reported by PEER-NGA database). The recorded data sites are very close to the faults and their earthquake magnitude are great. Then individual and mean and mean +/- standard deviation response spectra plotted for selected 31 earthquakes. Figure 3 represents mean and mean +/- standard deviation response spectrum for vertical component beside response spectrum according Euro Code8. This figure represents mean spectrum is approximately two times greater than Euro Code spectrum in short periods regions. Thus usual assumption that vertical component spectrum equal to 2/3 horizontal spectrum isn't correct for short periods. Figures 4 and 5 represents mean and mean +/- standard deviation response spectrum for parallel and normal to fault directions respectively beside response spectrum according Iranian code of 2800 for Type II soils. This figure represents trend of mean spectrum and code's spectra are approximately accommodate and difference of these two spectrums is not large as large for vertical component.

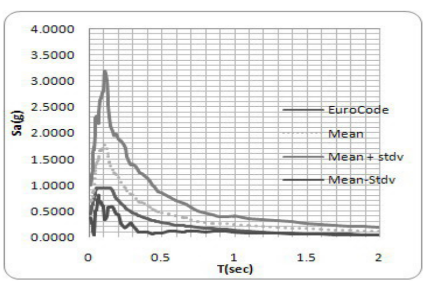


Figure 3. Vertical response spectrum

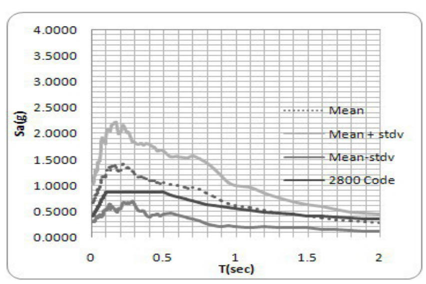


Figure 4. Fault parallel response spectrum

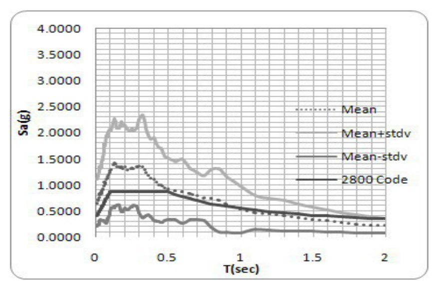


Figure 5. Fault normal response spectrum

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Euro Code 8: Design of Structures for Earthquake Resistance, General rules, seismic actions and rules for buildings

Iranian codes for seismic design of roads and railway's bridges

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