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THE EFFECT OF SPATIAL CORRELATION OF HORIZONTAL AND VERTICAL SPECTRAL ACCELERATIONS ON SEISMIC PERFORMANCE OF A BRIDGE NETWORK

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Quantifying the spatial correlation of ground-motion intensity measures (IMs) is necessary for assessing the seismic risk of lifeline networks (for example; transportation, electricity, gas, telecommunications, water supply) and building portfolios. Many ground motion prediction equations (GMPEs) have been developed to estimate IMs as a function of earthquake magnitude, source-to-site distance and variables such as local geological conditions at a single site. These include peak ground acceleration (PGA), peak ground velocity (PGV) and spectral acceleration (SA). However, GMPEs do not consider the spatial correlation of ground motion IMs among sites for a given earthquake event. However, it has been shown that the effect of spatial correlation on seismic risk assessment of spatially-distributed systems is significant and that ignoring or overestimating this may overestimate frequent losses and underestimate rare losses (Bastami, 2007).

Several spatial correlation models for different horizontal IMs have been introduced. These studies employed two approaches to develop spatial correlation models. In the first approach, the correlation ranges of each earthquake were investigated separately, then a model based on obtained ranges was proposed (Boore et al., 2003; Jayaram and Baker, 2009). However, in the other approach spatial correlations were investigated based on gathering the data from a group of earthquakes (Garakaninezhad et al., 2017; Pavel and Vacareanu, 2016).

In the most of aforementioned studies, the spatial correlation of the horizontal component of an earthquake was considered and vertical component has received less attention; however, in last two decades, the effect of the vertical component of earthquake on seismic damage to structures has been demonstrated in some earthquakes (Kobe 1995, Chi-Chi 1999 and Bam 2003). Garakaninezhad and Bastami (2019) have recently proposed a spatial correlation model for vertical PGA and SAs using 10 well-recorded earthquake events.

The goal of this study is to investigate the effect of both horizontal and vertical earthquake components on seismic performance of a bridge network. For this purpose, a hypothetical network including 225 bridges located in a 30 km×30 km is considered. In order to compare the effect of spatial correlation, three correlation ranges of 1 km, 5 km, and 15 km for both components were considered. The exceedance probability of engineering demand parameters (EDPs) of bridges are evaluated using 1000 realization of spatially-correlated horizontal and vertical SAs. Figure 1 shows the exceedance probability of normalized negative support moment (EDP considered in this study). As shown in this figure, normalized negative support moment will be underestimated if the spatial correlation is ignored. In addition, the effect of spatial correlation of horizontal component increases as correlation ranges of the vertical one increases.

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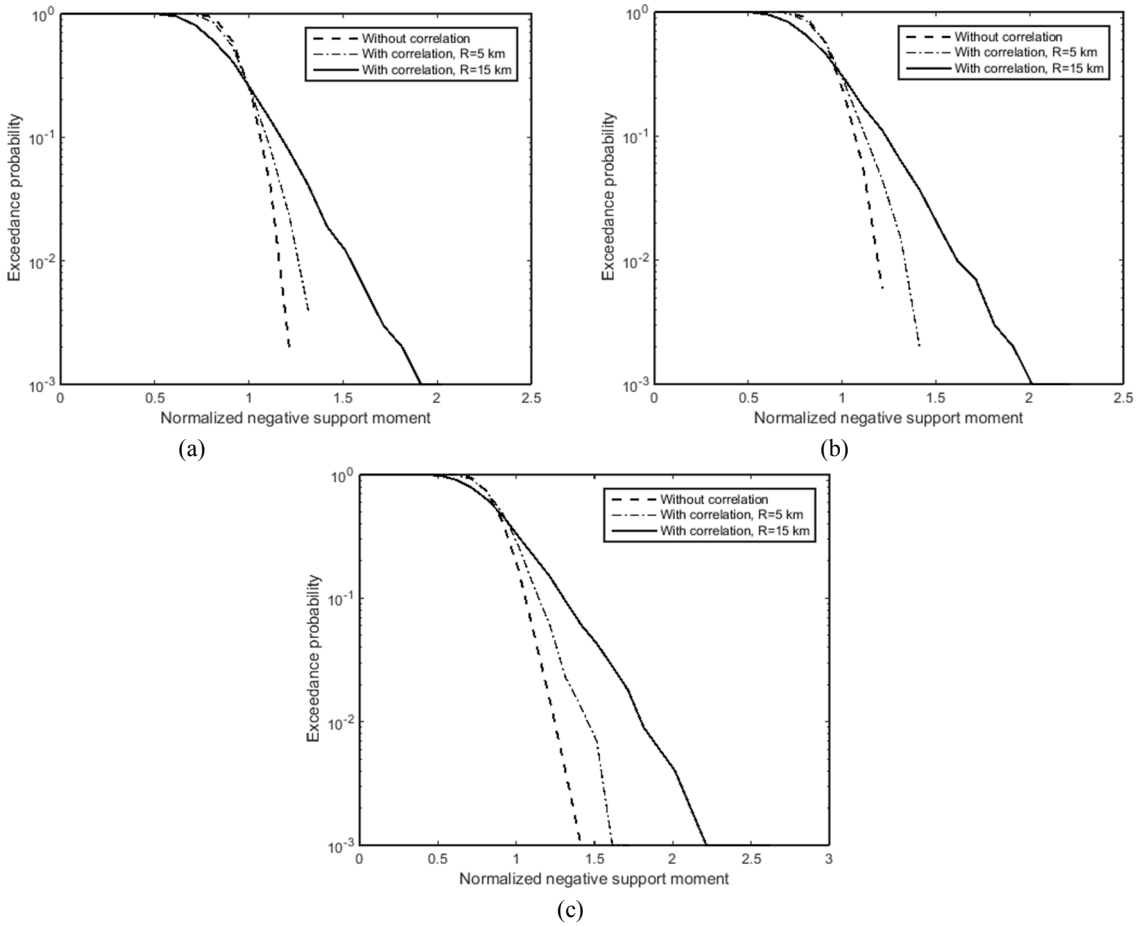

Figure 1. Exceedance probability of normalized negative support moment, (a) without correlation, (b) 5 km and (c) 15 km range of horizontal SAs.