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RotD100 target spectral compatible bi-directional ground motions: effects on orientation dependence and structural response

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ABSTRACT

The intensity of horizontal bi-directional ground motions varies with orientation azimuth. In this study, two suites of RotD100 response spectrum compatible bi-directional ground motions were developed: (1) directly match by simultaneously modifying two horizontal components; (2) pursuing the match of RotD100 while maintaining the orientation dependence of the seed records in their elastic spectral response. The strong motion characteristics of the two RotD100 compatible and a suite of amplitude-scaled records were investigated. Idealized single column reinforced concrete bridge piers with different geometric and reinforcement configurations were modelled in OpenSees. Nonlinear time history analysis was conducted with the three suites of bi-directional ground motions applied to the piers through 360° at an angle increment of 9°. An iteration process was implemented to determine a scaling factor (SF) to achieve a failure probability of 50% in all directions. The differences in the expected SF and structural response under three suites of bi-directional ground motions were discussed. It is shown that the RotD100 spectrum compatible records having the real orientation dependence as the seed records retain better the strong motion characteristics compared to the suite of amplitude-scaled records. Regarding the effect on the structural seismic response, results suggest that direct matching of RotD100 is more seismic demanding than the other two suites. RotD100 response spectrum compatible bi-directional ground motions having the real orientation dependence generate a closer result to the amplitude-scaled suits. This suggests that design based on the direct matching of RotD100 ignoring the orientation dependence is more conservative concerning real seismic demand.

Keywords: Bi-directional ground motions, nonlinear response analysis, orientation dependence, seismic design.

1 INTRODUCTION

The intensity of horizontal bi-directional ground motions varies with azimuth angle. The RotD100 response spectrum proposed by Boore (2010) gives the value of maximum spectral demand for every natural period being considered. The US standard, ASCE 7-16 (2017), has adopted the RotD100 spectrum as the target response spectrum. In other words, when nonlinear time history analysis (NTHA) is conducted to demonstrate that a structure possesses acceptable strength, stiffness, and ductility under seismic excitation, the input bi-directional ground motions should be RotD100 response spectral compatible.

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