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RECENT ADVANCES IN PROBABILISTIC PREDICTION OF SEISMIC SLIDING DISPLACEMENT OF SLOPES

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This paper presents the recent findings of the authors in the recent years regarding the assessment of seismic sliding displacement of earth slopes. It is known that the earthquake-induced sliding displacement of earth slopes is a key index for the landslide hazard estimation. The semi-empirical predictive models are commonly used to predict the seismic displacement of slopes through a simplified procedure, especially in regional scales. These models can be divided into two categories: the rigid block-based models, and the flexible block-based models. There exist some limitations (e.g., sliding mass rotation) in the rigid and flexible block analyses which caused the development of further modified methods (e.g. Jafarian and Lashgari, 2016, 2017). Several recent predictive models were developed based on the modified versions of the Newmark, decoupled, and coupled methods (e.g., Lashgari et al., 2018). The parameters used in the predictive models of sliding displacement of slopes can be divided into three main categories: (1) the earthquake record and its characteristics, (2) the material resistance of the slope, and (3) the failure geometry of the slope and its possible changes deriving from the rotation of the sliding mass during downward movement. Some new predictive models have been recently developed in order to tackle these challenges.

A computer code was developed to perform the coupled stick-slip-rotation (CSSR) analysis (Jafarian and Lashgari, 2016) as a new modified method for the different levels of yield acceleration coefficient (k_y), slip length (L), and fundamental period (T_s). The earthquake database selected for the analyses was constituted of 200 records of ground acceleration belong to the earthquakes occurred in Iran. It is shown that the regional model derived from the earthquake records of Iran is considerably more accurate than the global models developed based on the worldwide databases.

Figure 1 shows the comparison made between the global and regional predictive models and the results of the CSSR analyses for slip length 10 m and $k_y = 0.005$. It is found that the different characteristics of regional earthquake records can affect the seismic performance of slopes.

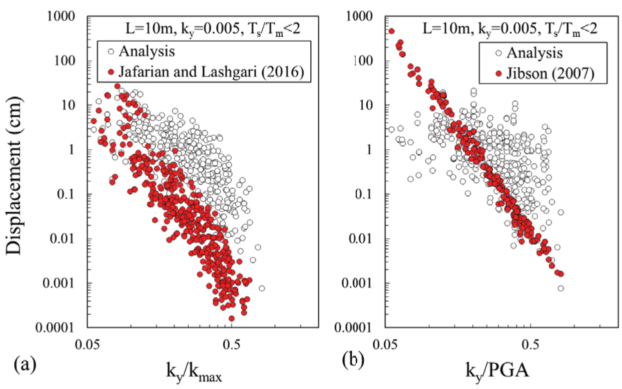

Figure 1. Comparison of the sliding displacements estimated by the CSSR analysis with the model proposed by Jibson (2007) for the earthquake records of Iran and L = 10 m.

Seismic fragility curves are commonly used to assess the earthquake-induced vulnerability of the structures by representing the probability of failure as a function of IMs (Jafarian and Miraei, 2019). Fragility curves of slopes are obtained by the probabilistic correlation between the seismic displacement of slopes, as a seismic damage or hazard index, and some ground motion parameters. These curves can be computed through a predictive model or direct incorporation of sliding displacement data regardless of any predetermined functional form (e.g., Jafarian et al., 2018). The fragility curves computed by three predictive models presented by Jibson (2007), Hesieh and Lee (2011), and Jia-Liang et al. (2018) were plotted in Figure 2 for $k_y = 0.1$ and two damage states of 5 and 15 cm. Figure 2 shows that the probability of displacement greater than 15 cm is about 1%, 25%, and 76% for Jia-Liang et al. (2018), Jibson (2007), and Hesieh and Lee (2011), respectively, at $I_a = 2$ m /s. This remarkable difference of probabilities indicates that the lack of proper use of the suitable predictive model, especially on a regional scale, can provide an inappropriate prediction of landslide hazard. Moreover, the multivariate fragility function obtained from direct assessment of data (Jafarian et al., 2018) can lead to landslide damage estimation in a more reliable manner, compared with the predictive models-based fragility curves based on a single intensity measure.

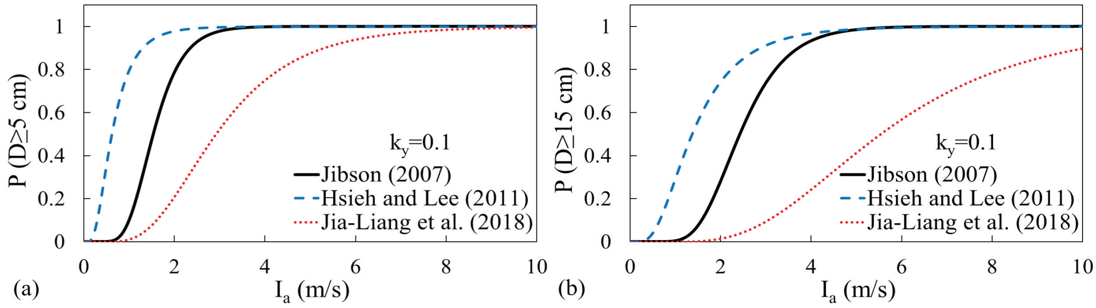

Figure 2. Fragility curves of sliding displacement based on three predictive models for $k_y = 0.1$.

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