Approximation of Equivalent Linear Ground Response Analysis at Low Strain by Strain Dependent Linear Ground Response Analysis for Typical Site at Delhi, India

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ABSTRACT

The applicability of available dynamic soil property curves (G/G_{max} and Dcurves) from other regions in region specific local site effect is a matter of debate. Authors in previous studies have clearly shown that in widely followed equivalent linear ground response analysis (ELGRA), solutions are governed by one set of dynamic soil properties (shear modulus 'G' and damping ratio 'D') for each soil layer corresponding to one value of shear strain (γ). Thus, complete G/G_{max} and D curves are not required in final response at a known γ. Further, this value of γ up to 0.5% is a function of depth of that soil layer (z) as well as input bedrock motion (PHA) as per recent studies by the authors. In this work, empirical correlations between γ, z, and PHA are proposed for a typical site in Delhi based on 300 ELGRAs for sand and clay. Further, to verify the feasibility of proposed correlation, linear ground response analysis (LGRA) of one typical borehole near to earlier used boreholes, using above proposed correlations, based on known z, and PHA are performed using 2 randomly selected ground motions and found comparable with ELGRA for these both boreholes. Thus, avoiding dependence of ELGRA upon complete G/G_{max} and D curves, not available on regional scale, LGRA which uses in situ test properties, is a better and site specific approximation as proposed in this work.

INTRODUCTION

As seismic waves travel between the bedrock and the surface, these get trapped, resulting in change in amplitude, frequency content as well as the duration of ground motion. As a result, there will be significant change in ground motion characteristics between the bedrock and the surface. It is this altered ground motion, which is responsible for damages caused during an earthquake (EQ). Induced effects such as landslides, liquefaction, and amplified ground shaking are the outcomes of altered ground motion. Numerous examples on ground motion change, due to local soil conditions exist across the globe. Examples include; 1985 Michoacan EQ (Mw=4.8) where several places located about 360 km away from the epicenter experienced devastating damages stated by Chávez-García and Bard (1994). Amplification factors up to 50 between the bedrock and the surface motions in the frequency range 0.25 to 0.7 Hz were observed. Similarly, during 1989 Loma Prieta EQ(Mw=6.9), immense damages happened due to the local soil effect in San Francisco-Oakland region, located about 80 km away from epicenter. The 2011 Tohoku EQ (Mw=9.0) in Japan is another example of far field damages due to local site effects. In India, 1991 Uttarkashi EQ (Mw=6.8), 1999 Chamoli EQ (Mw=6.5), 2001 Bhuj EQ (Mw=7.7) and 2011 Sikkim EQ (Mw=6.9) are the some of the examples where modified ground motion caused enormous damages even at larger epicentral distance. Thus, for understanding the surface ground using obtained subsoil properties, LGRA can be done. Thus, present limitation of not having regional DSPC can be minimized using proposed approach.

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