VICTORIA UNIVERSITY A NEW SCHOOL OF THOUGHT

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Effects of vertical heterogeneity of soil sediments on seismic soil response

Summary: Site effects are resulted from the non-linear filtering mechanisms within the soil sedimentary layers overlying bedrock. In contemporary design codes, site effects are taken into account by introducing different site factors for different site classes. The prescribed site classification systems are based on averaging shear wave velocity in the soil sediments. However, significant amplification of the seismic displacement demand may be developed from mechanisms which can result in resonance behaviour. In such situations, soil amplification cannot be determined accurately by considering the average shear wave velocity of the sediments alone. The effects of vertical heterogeneity in the soil sediments have not been explicitly parameterised in the conventional code provisions. This paper presents results from parametric studies showing the influence of vertical heterogeneity in the soil sediments on the soil amplification behaviour. A methodology for modelling soil heterogeneity is described. Importantly, the presented results quantify the influence of vertical heterogeneity on the seismic soil response behaviour. It is found that variations in the sub-soil layers properties can accentuate soil amplification by up to 1.6 times. It is expected that information presented in this paper would be useful for engineering design applications.

Objectives: The objective of this paper is to quantify the effects of vertical heterogeneity of soil profiles in seismic soil response.

Methodology: [1] Simulate pseudo soil sites with shear wave velocity (SWV) in the range of 150 m/s, 300 m/s and 500 m/s; 30 m over all depth and dissect the soil layers into 2.5 m thickness each (pseudo site with SWV = 300 m/s presented in Figure –1; [2] Define soil amplification factor `S' based on soil response analysis using quasi non-linear one dimensional shear wave analysis program SHAKE-91 and using ground motions developed through GENQKE (Figure-2); [3] Define soil SWV profile factor `S_ψ' (Figure 3). [4] Calculate the soil SWV profile factors for ground motion with peak ground velocity (PGV) range (15 mm/s to 300 mm/s) (Figures 4 to 6). [5] Analyse trends and identify conclusions and constraints.

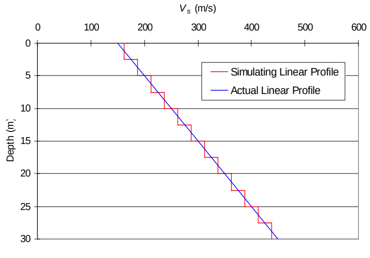

Figure 1. Simulation of a Linear SWV profile of soil with mean SWV = 300 m/s

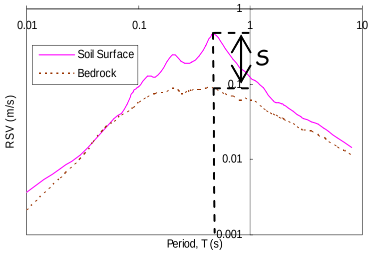

Figure 2. Definition of soil amplification factor `S'

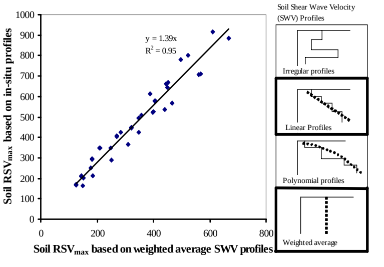

Figure 3. Definition of soil SWV profile factor `S_ψ'

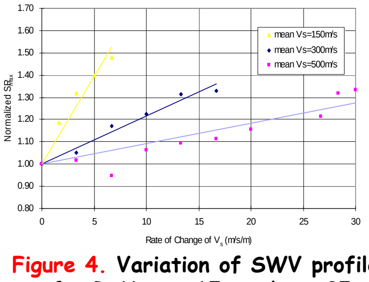

Figure 4. Variation of SWV profile factor for RSV_{rock} = 15 mm/s to 25 mm/s

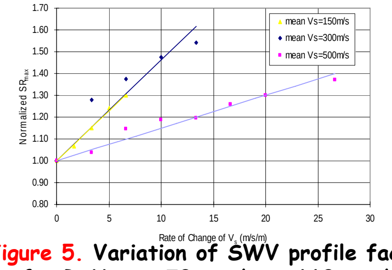

Figure 5. Variation of SWV profile factor for RSV_{rock} = 70 mm/s to 110 mm/s

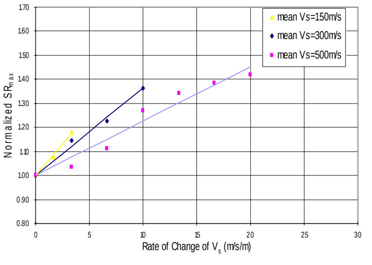

Figure 6. Variation of SWV profile factor for RSV_{rock} = 320 mm/s to 360 mm/s

Conclusions:

- Soil SWV profile factor ($S\psi$) increases with increasing gradient of the soil SWV profile.
- The rate of increase of the profile factors ($S\psi$) decreases with increasing averaged SWV in the soil.
- The concept of using 'effective impedance' as a measure of variations in the soil SWV can be explored. S
- ψ varies typically between 1 and 1.6 (1 being the reference case of weighted average SWV profile) for sites with a linear variation in the soil SWV.
- Considering the random nature of real soil sites, results presented in this study should be adopted with careful judgement.