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NON-LINEAR DYNAMIC SOIL STRUCTURE INTERACTION USING BOUC-WEN TYPE HYSTERETIC MODELS

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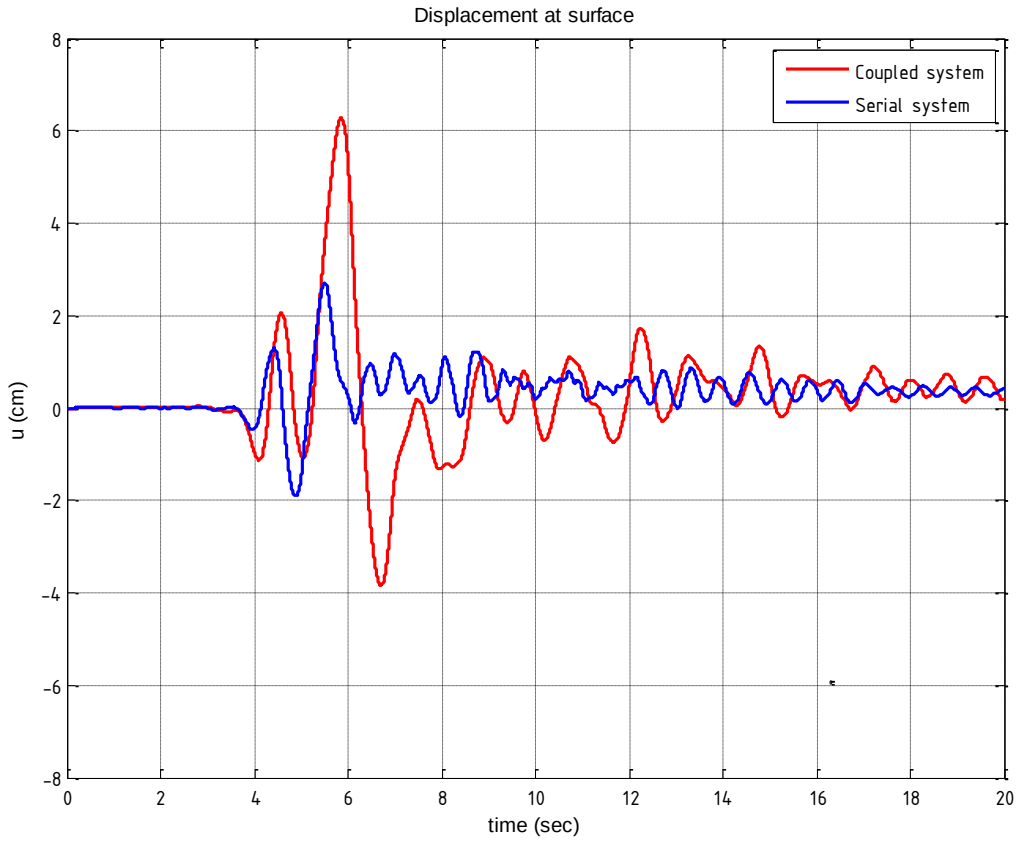
ABSTRACT

In this work a simple model of seismic soil-structure interaction is proposed. The interchange of mechanical energy between the soil and the superstructure and accumulation of plastic deformations in either parts can be decisive for the overall behaviour. Usually the seismic excitation is applied directly to the structure's base, which is considered either fixed or connected with the soil with linear or non-linear springs and viscous dampers to account for the soil behaviour. The effect of soil-structure interaction enters as period lengthening of the superstructure together with an additive equivalent dissipation of energy at the foundation level. This idealization cannot incorporate accurately the reflection-refraction and dispersion of seismic waves that takes place at the soil and the interface and affects the solution. In the present work the superstructure is modelled as an inelastic Timoshenko cantilever beam with distributed mass. The cantilever is founded on the soil through a rigid foundation plate of sufficient area that ensures no uplift. The soil profile under examination is a deep homogenous layer on a horizontal bedrock. The seismic excitation is applied to the bedrock and two alternative formulations are considered, compared and discussed. The first is applied in two phases, where initially the excitation is transferred upwards as a shear wave propagation through the soil profile with zero traction boundary conditions at the interface. The resulting excitation is subsequently applied at the cantilever base. The second formulation considers both the soil and the superstructure as a single coupled system. For the response of superstructure, the hysteretic Bouc-Wen model is used, as presented by Triantafyllou & Koumousis [4], [5]. The soil behaviour is simulated using the Bouc-Wen model which is modified herein to account also for degradation phenomena incorporating damage considerations. The model parameters are calibrated based on Drosos et al. [1] and Gerolymos and Gazetas [2]. The excitations of Kobe Fukiai, Kobe Takatori and Mexico City are utilized. A comparison is performed between the different formulations, examining the hysteresis loops in both the soil and the superstructure and the tip displacement of the superstructure. The ductility demand versus fixed-base elastic structural period is presented, that provides evidence for the role of dynamic soil structure interaction. The main feature of the proposed formulation is that it indirectly reveals the hyperbolic nature of the phenomenon introduced through the examination of the wave propagation through the entire depth of the soil layer, accounting more accurately for the dissipated energy in the form of hysteresis caused by

reflection and dispersion of seismic waves and determines the detrimental or beneficial nature of the interaction [3]. In addition the influence of the superstructure on the soil amplification, as compared to free field response, is investigated based on acceleration time histories. A typical figure for displacement at surface for both formulations is shown below.



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