Investigating the Influences of Various Complexity of Hydrogeological Models on Pore Water Pressure Buildup Triggered by Seismic Wave Propagation

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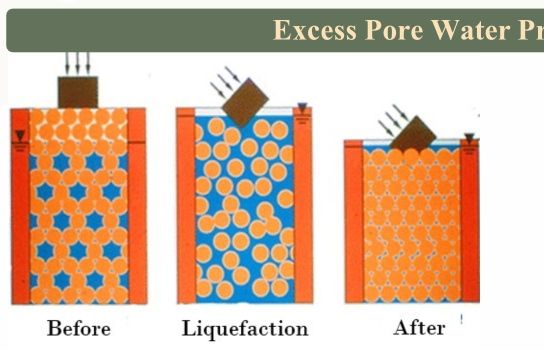
I Introduction

Excess Pore Water Pressure and Soil Liquefaction



Principle of effective stress (Terzaghi, 1936):

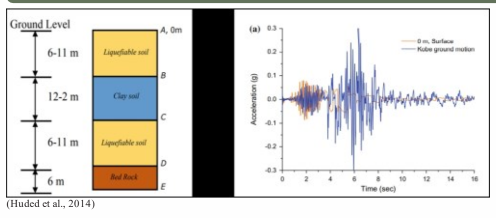
$$\sigma' = \sigma - p$$

where σ' is the effective stress, σ is the total stress and p is the pore water pressure. Full Liquefaction occurs when the effective stress is equal to 0, where,

$$\sigma = p$$

when the total stress is equal to pore water pressure, the saturated soil loses its shear strength and behaves like a liquid.

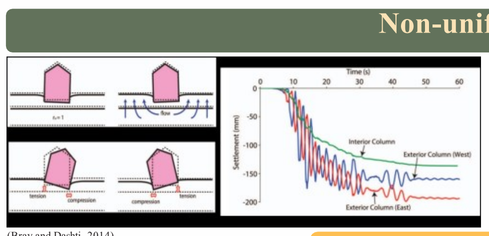
Seismic Wave Propagation in Soil Layer



Do you see the difference between the input acceleration, i.e., the Kobe Earthquake of 1995 and the acceleration measured on the ground surface?

This study shows how seismic waves modify by the presence of liquefiable soil layers.

Non-uniform Ground Settlement



Luque & Bray (2017) try to analyze non-uniform ground settlement in area under the structure (interior Column) and 'free field' area (exterior Column).

Traditional Study:
- Homogeneous System
- Perfect Layer System

How about various hydrogeological models??

II Method

Flow Chart:

Synthetic Hydrogeological Model
→ Simplified Model: Perfect Layer System; Pinch-out System; Lens System
→ Complex Model: Shallow Soil Profile; Deep Soil Profile
→ Boundary condition and parameter settings
→ Dynamic displacement and pore water pressure simulation
→ Asses the acceleration behavior and the distribution of displacement and pore water pressure
→ Assess the soil liquefaction events

Simplified Model

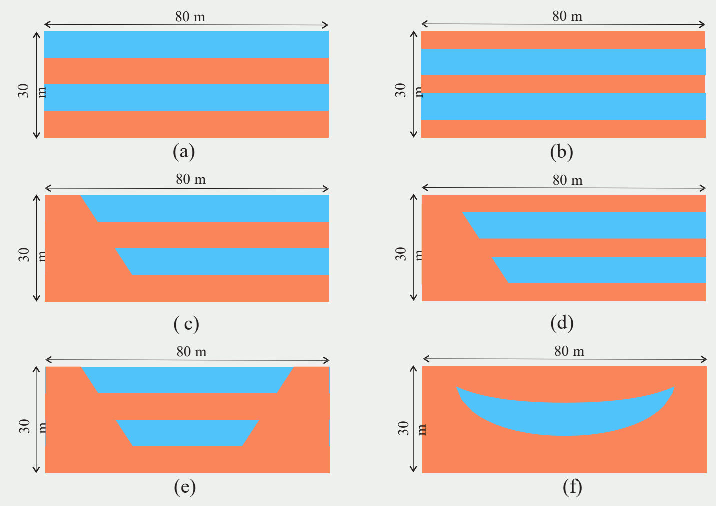


Figure 3. Illustration of synthetic hydrogeological model of; **(a)** & **(b)** perfect layer system, **(c)** & **(d)** pinch-out (stratigraphic trap) system, and **(e)** & **(f)** lens (riverbed deposit) system.

Complex Model

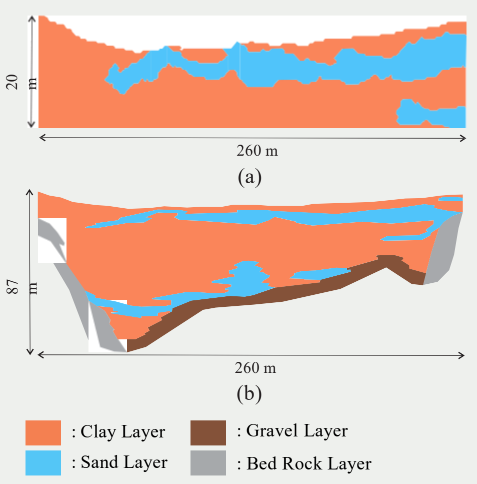
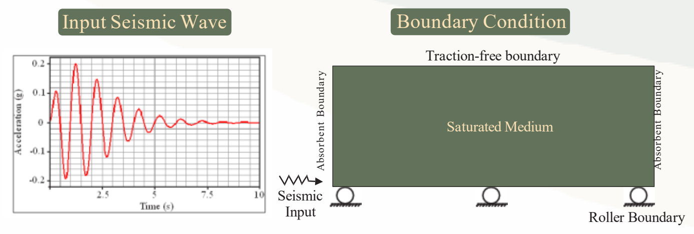


Figure 4. Illustration of complex hydrogeological model of; **(a)** shallow, and **(b)** deep soil profile.

Simplified Model

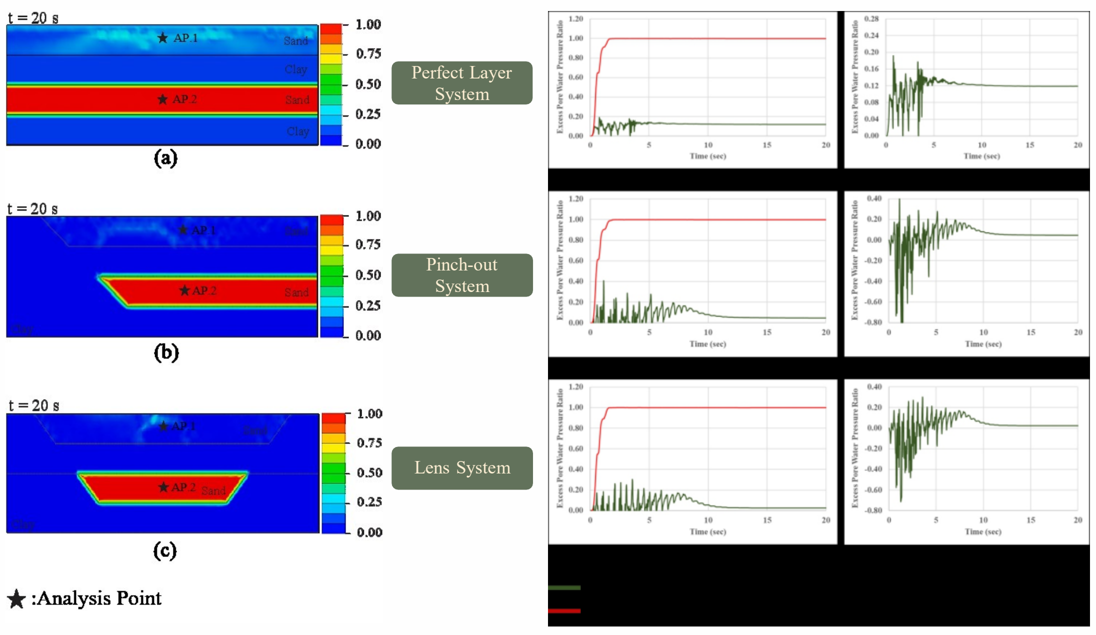


UBC-Sand Model

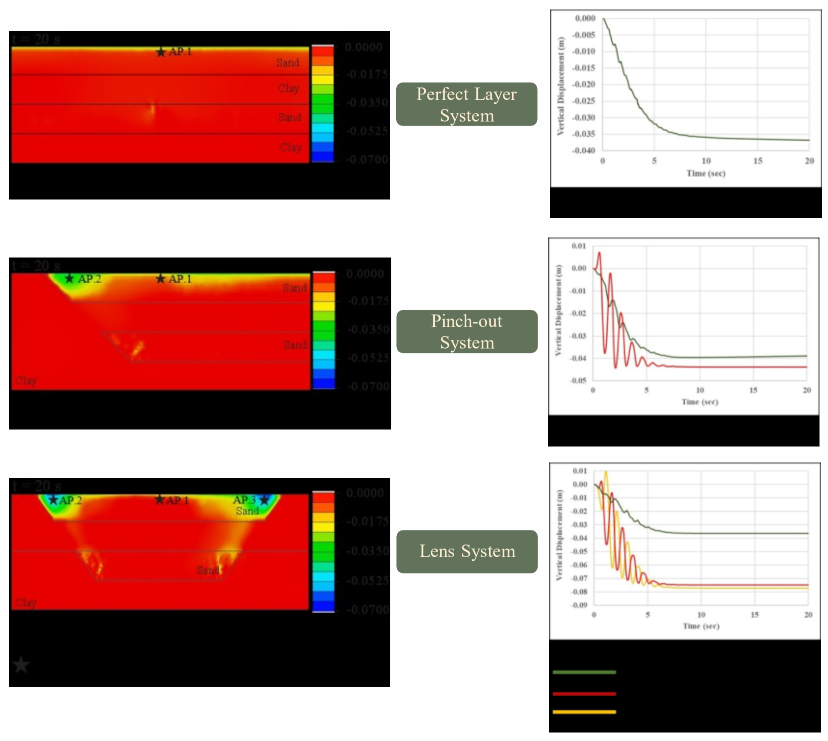
The UBC-SAND model is a simple elasto-plastic stress/strain model for simulating the liquefaction phenomenon of sand witha relative density less than 80% (Puebla *et al.*,1997). A UBC-sandmodel-based software, namely Midas GTS NX, was adopted to simulate seismic waves in a saturated porous medium.

III Results

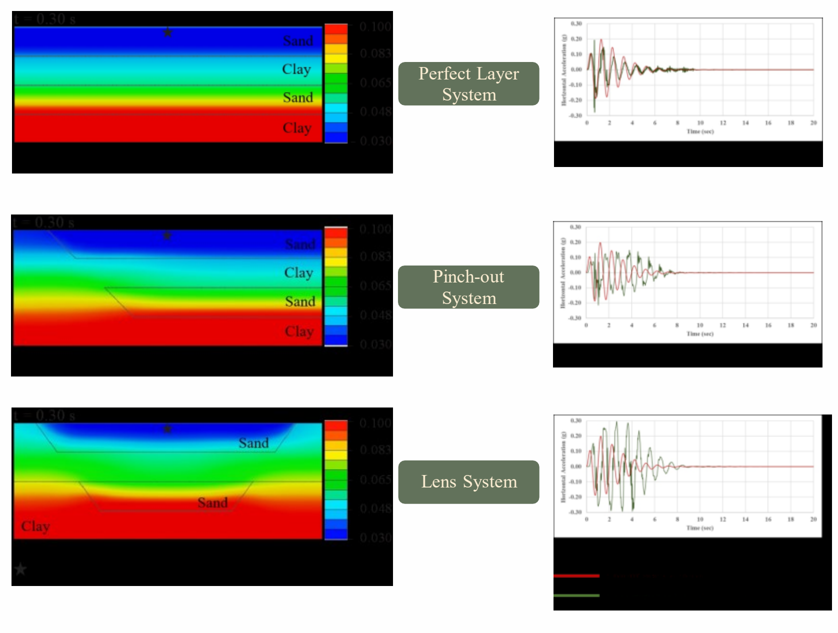
Drained Excess Pore Water Pressure



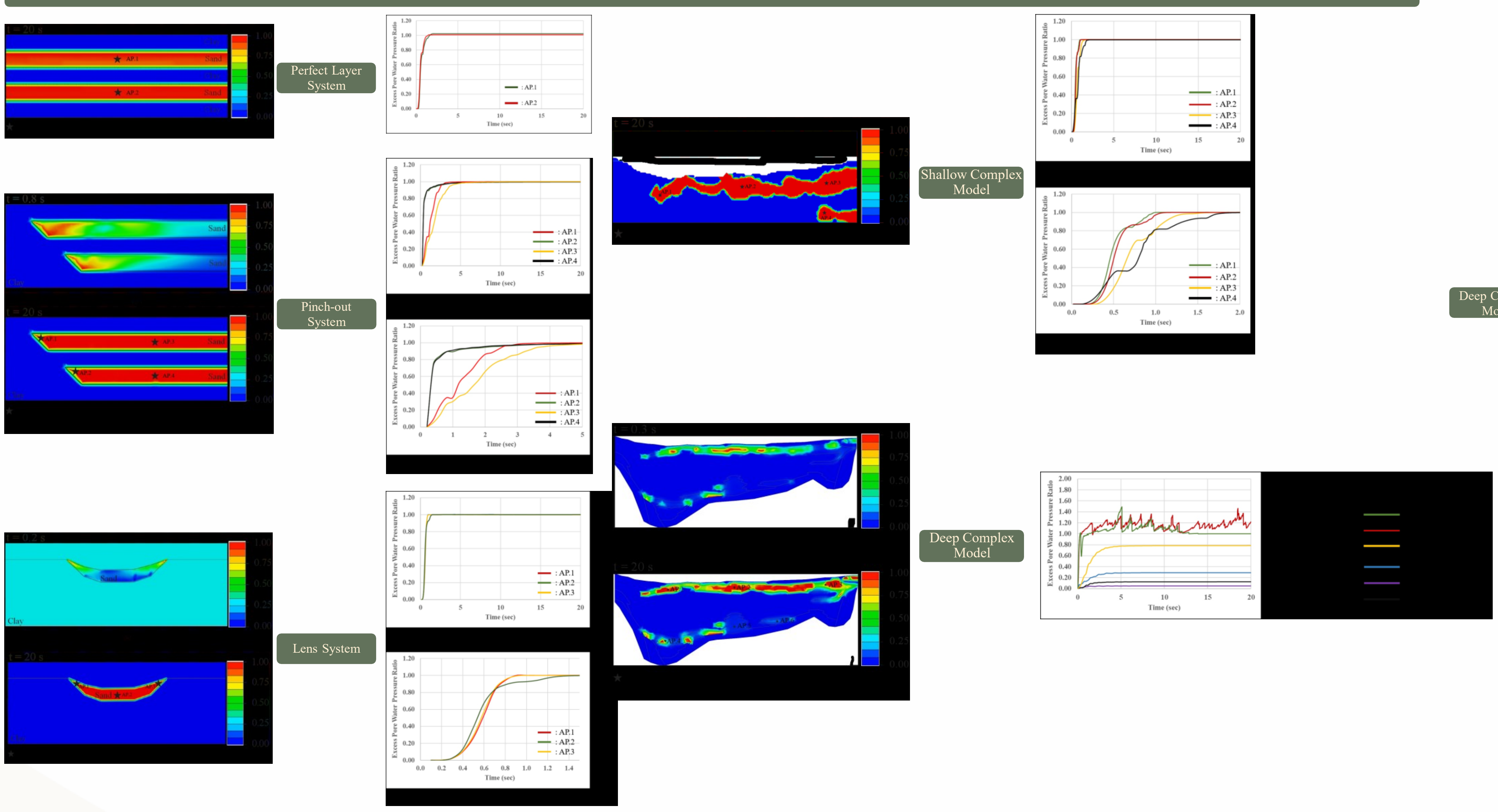
Vertical Displacement (Ground Settlement)

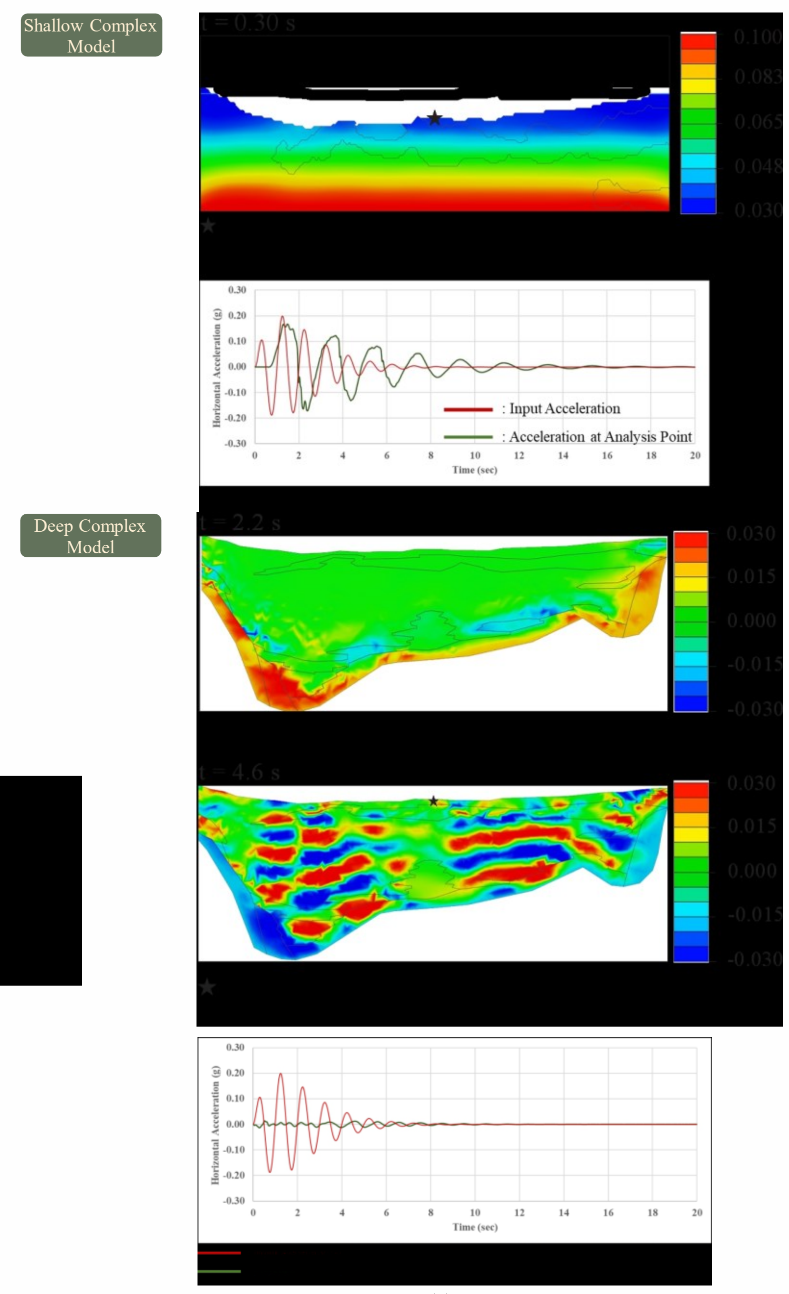


Horisontal Acceleration



Undrained Excess Pore Water Pressure





(c)

IV Conclusions

- Excess pore water pressure build-up:

The presence of the angle in the pinch-out, lens, and real case system led to an accumulation of pore water pressure in the corner area, which has a high potential to reach the liquefaction limit. In addition, the deeper sand layer has higher total stress value which need higher excess pore water pressure to reach the liquefaction limit.

- Vertical displacement (ground settlement):

The pinch-out system has non-uniform ground settlement as well as the lens system which lead the higher risk for the building to collapse due to soil liquefaction.

- Horizontal acceleration:

Results prove the presence of sand layer and clay layer attenuate and amplify the wave acceleration, respectively.

So, the difference in the geological model significantly affected the transient behavior of acceleration, pore water pressure, and vertical displacement.

V References

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