Effect of the soil's suction history on the small strain behavior

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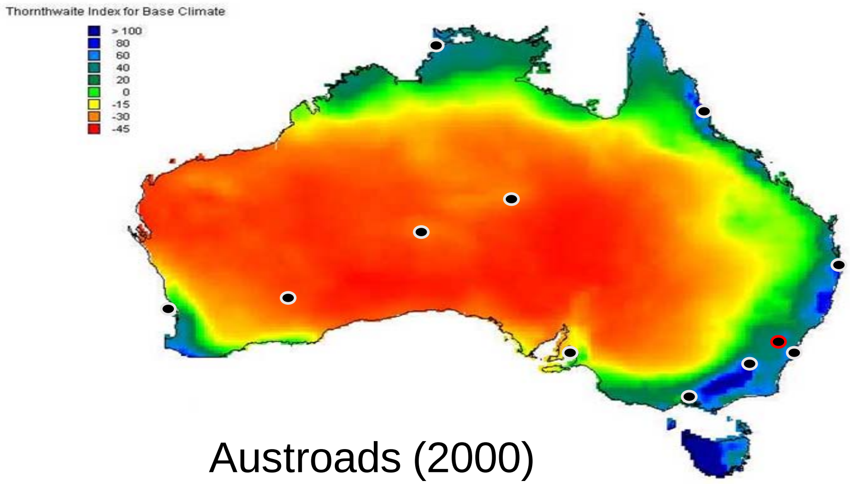
Suction history : wetting and drying

- **Climate change and earth structures**
  - most earth structures experience changes in hydraulic behaviour owing to the climatic changes (i.e. rainfall or extended periods of drought),

Suction history: wetting/drying cycles



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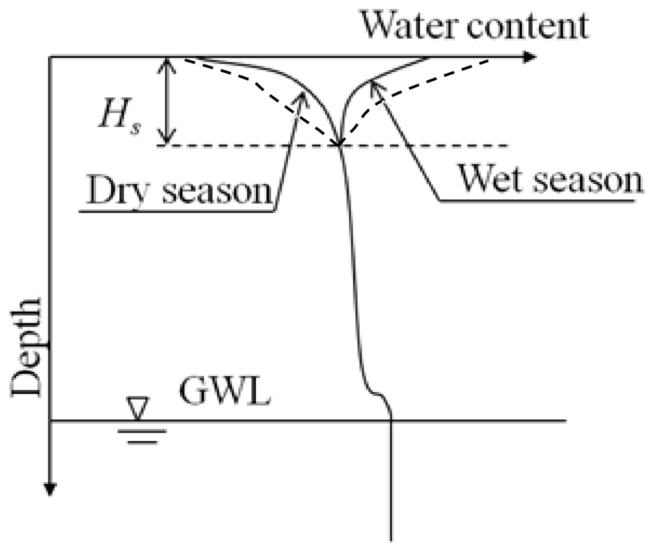
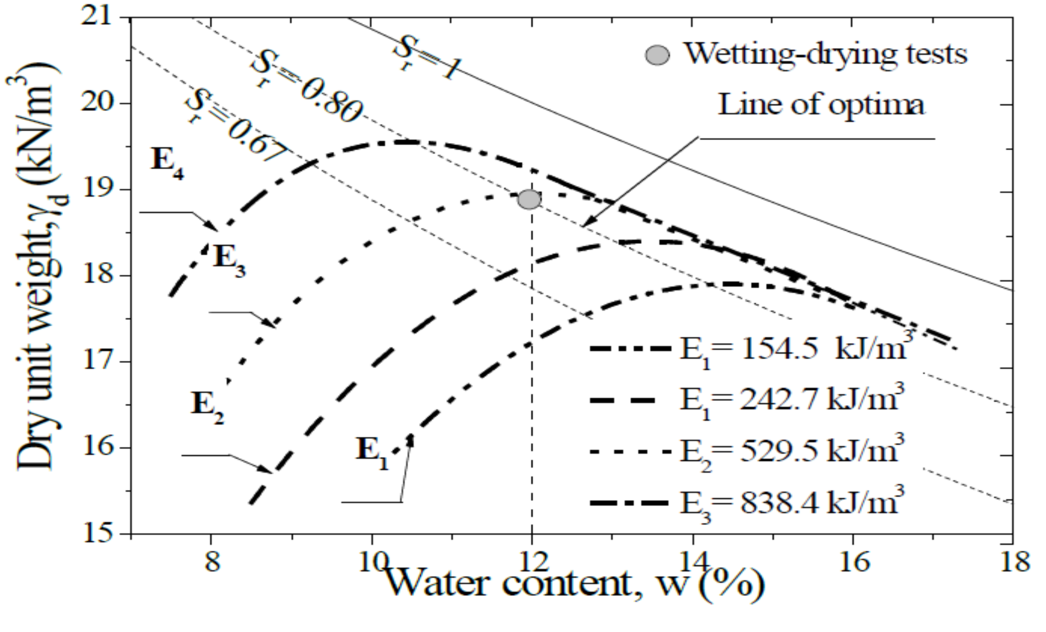


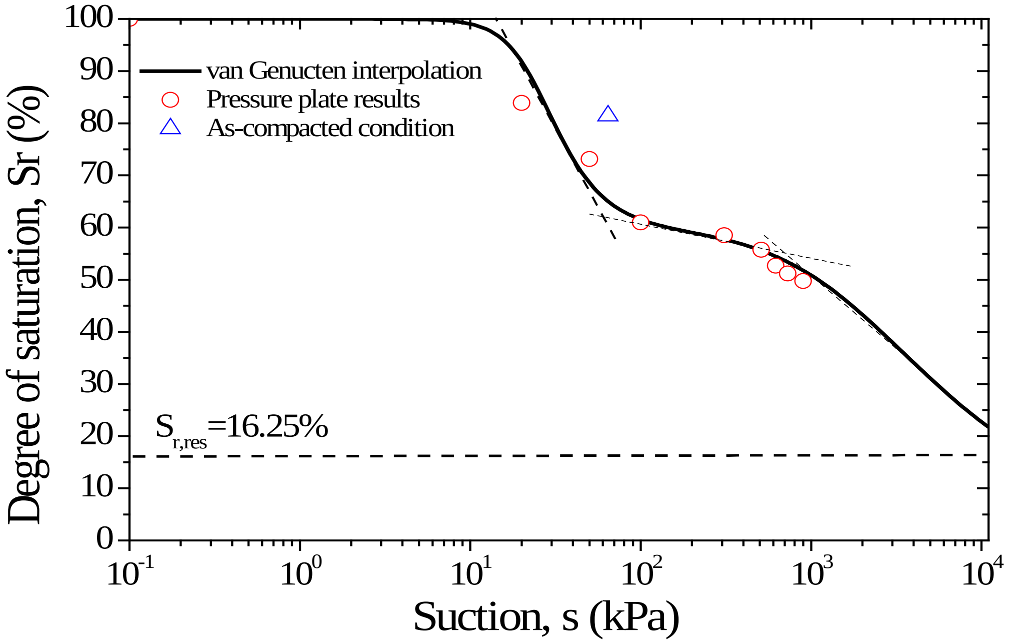
The effect of suction history on G0 (Ng et al., 2012 and Heitor et al., 2014) :

- hydraulic cycles,
- recent suction history
- the current suction ratio (CSR) with $CSR = \frac{s_{max}}{s_{current}}$

Materials

- Silty sand (SP-SC 89% sand and 11% fines)
- LL = 25.5% and PI = 10 and G_s = 2.7
- Specimens compacted ∅50×100mm mould





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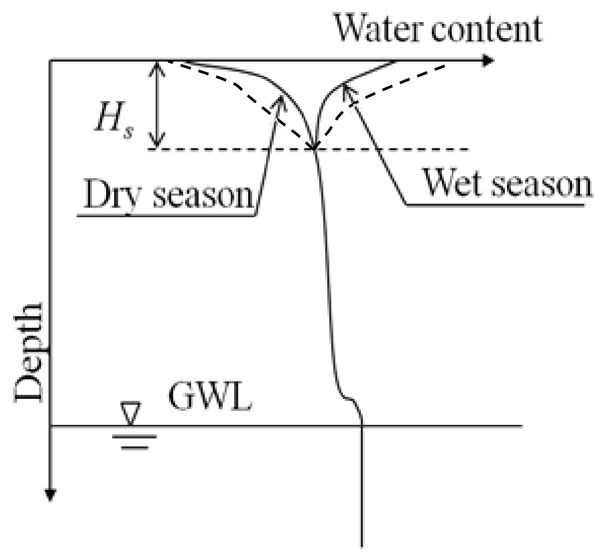
Testing program

- Effective net stress applied of 50kPa ≈ Hs

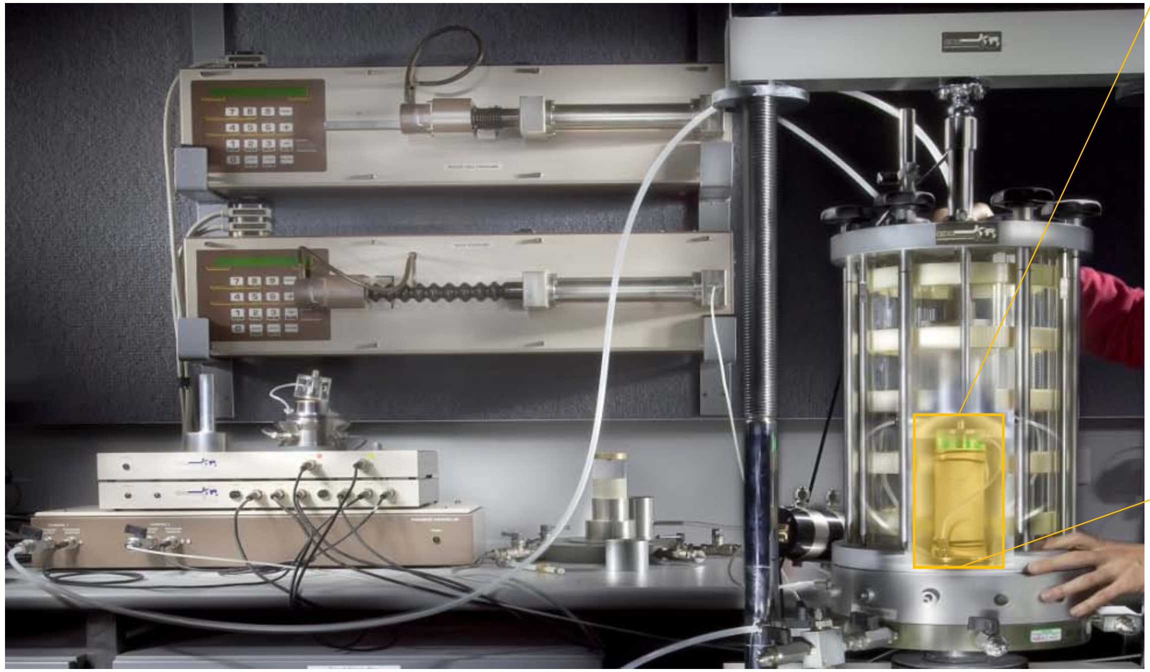
- Role of suction history (wetting and drying)
  - 2 specimens (≈ 48-60 hours equilibrium = 2 months)
  - Suction increments of 50kPa (0.16kPa/min)
    - E_2=529.5kJ/m^3 (equivalent to standard Proctor level)

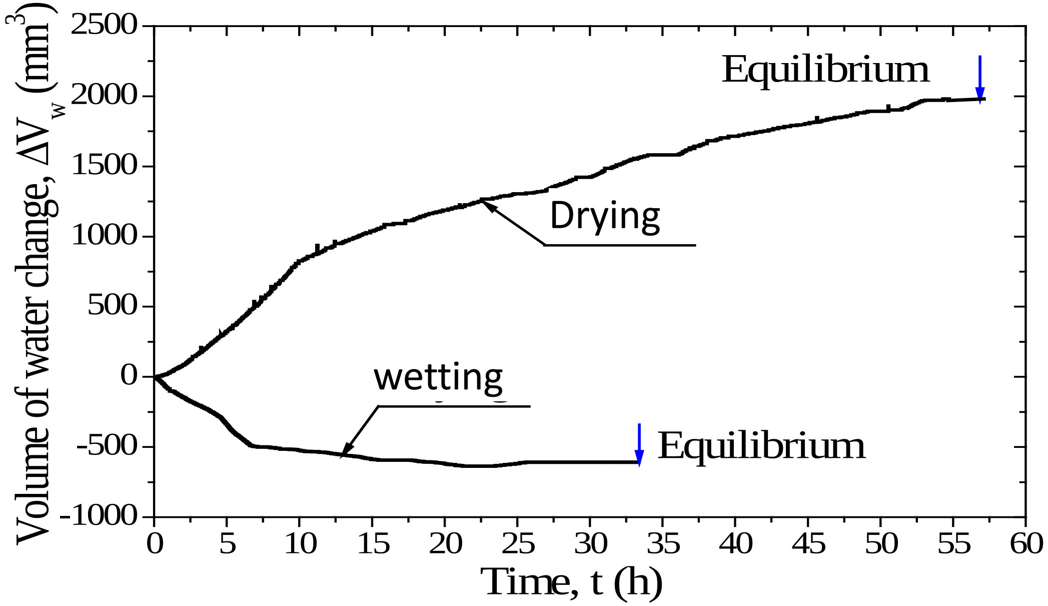


- BE Testing for every suction level at different frequencies (1.4, 2, 3, 5, 10, 20 and 50 kHz) = 230 signals

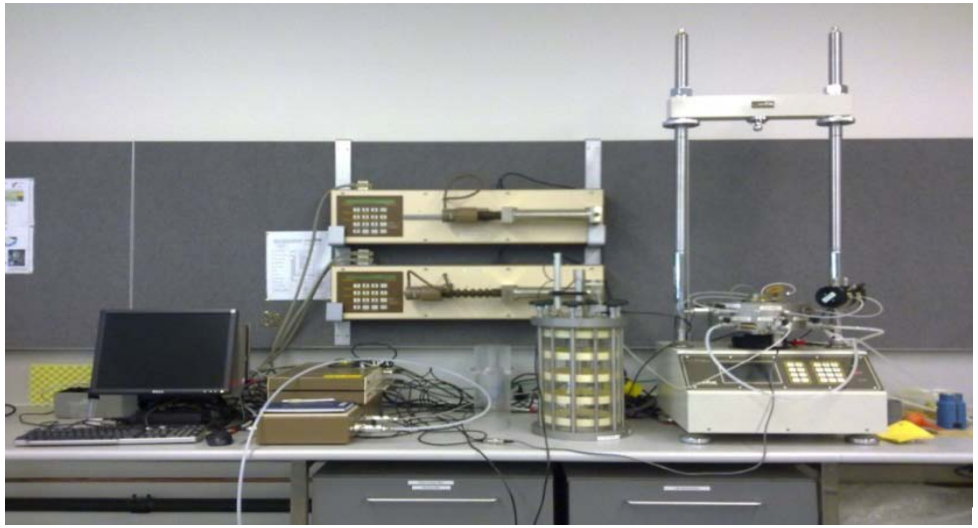
Control of suction : Axis translation technique

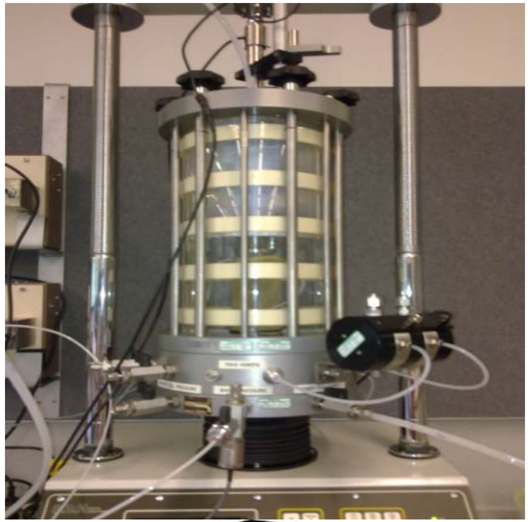
- Suction was incremented in 50kPa interval
- Rate of increase = 0.16kPa/min and kept constant until the end of the equilibration period

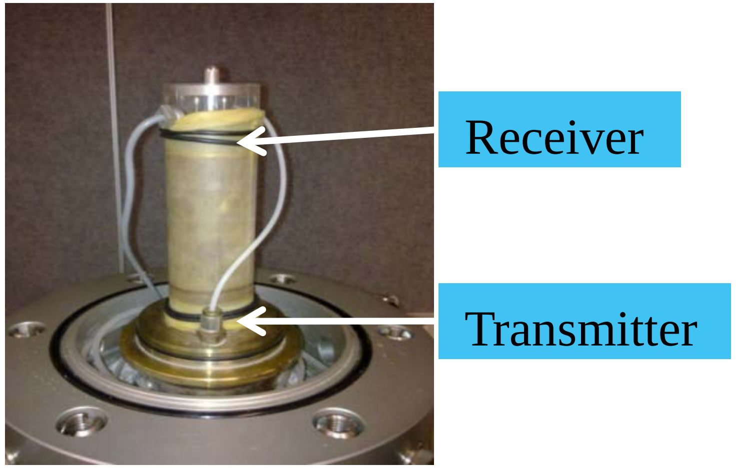


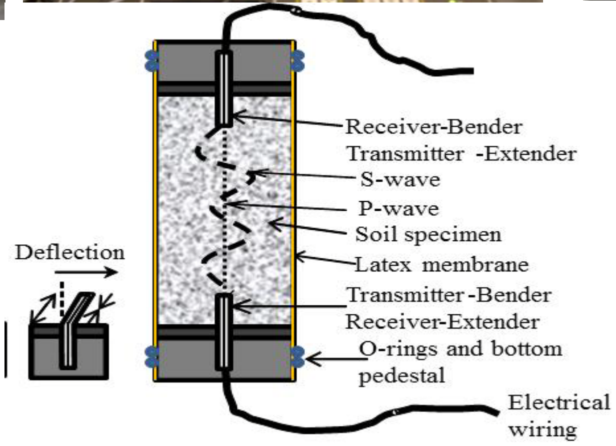


Determination of shear wave velocity : Bender elements









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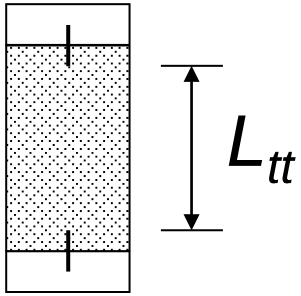
Wetting and Drying tests

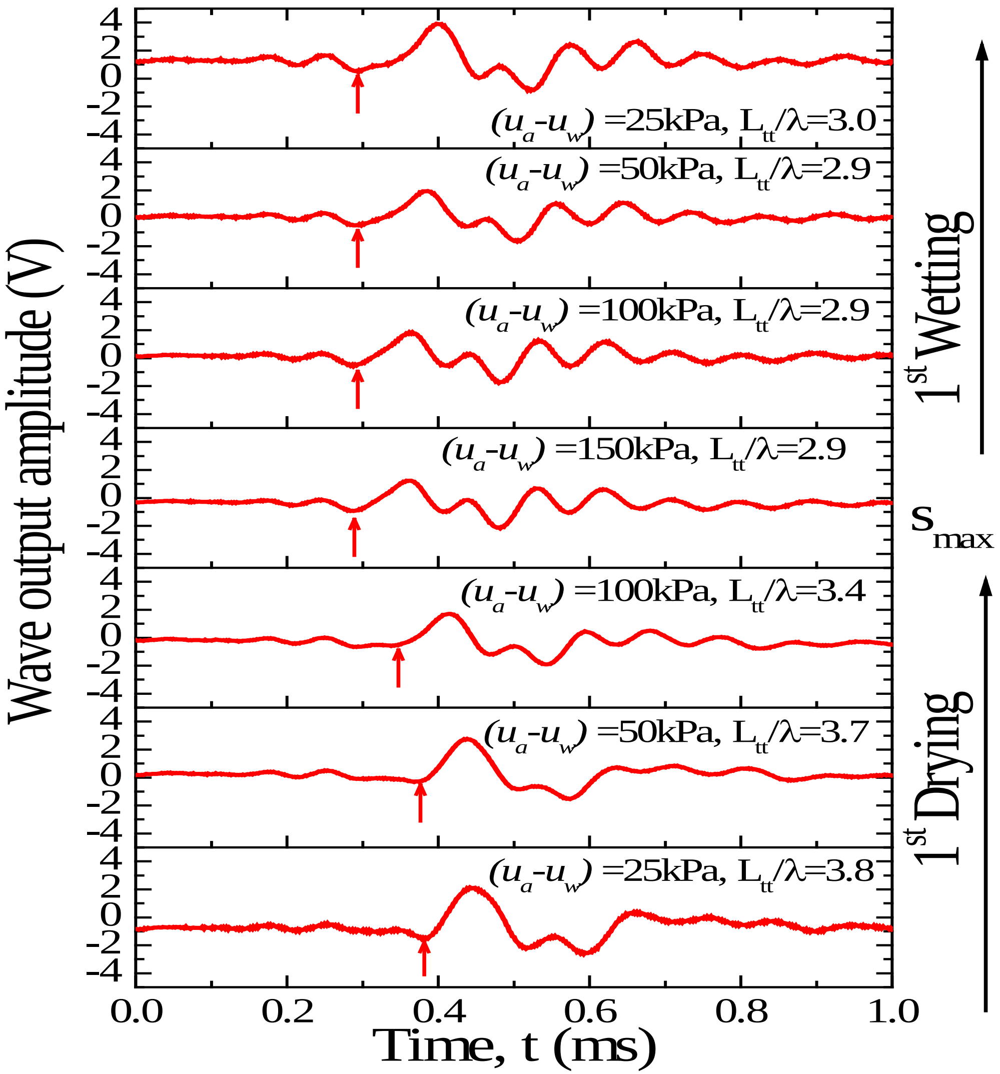
- Travel time evaluation methods:
  - **Time domain :** visual picking
    - 1st bump maximum ($L_{tt} / \lambda > 2$)
    - , 1st arrival, peaks, throughs, multiple reflections

    Frequency domain :
    - Cross-correlation
    - FFT
    - Wavelets
    - π points and phase delay



$$V_s = \frac{L_{tt}}{t}$$

Protruding 3mm



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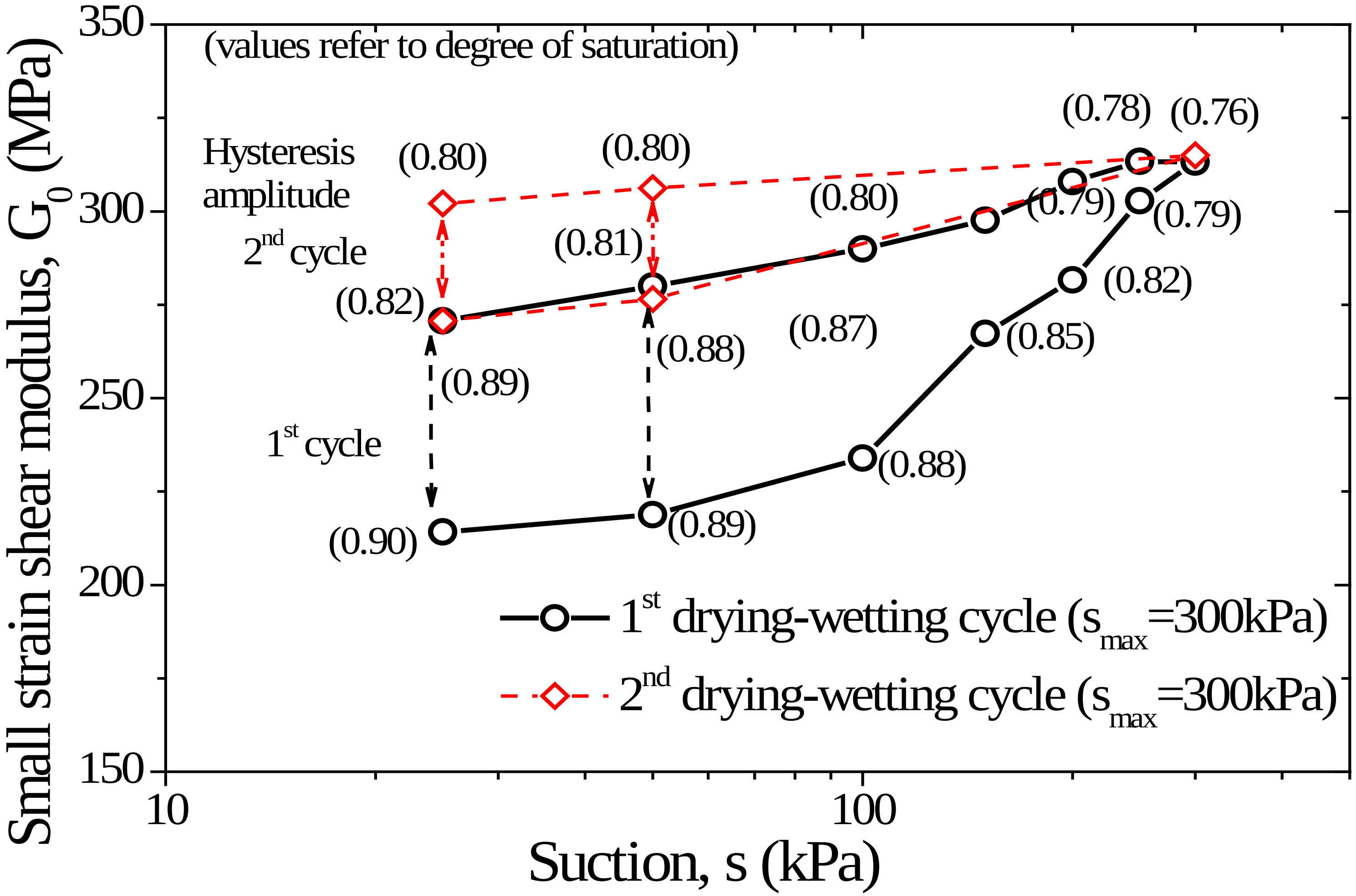
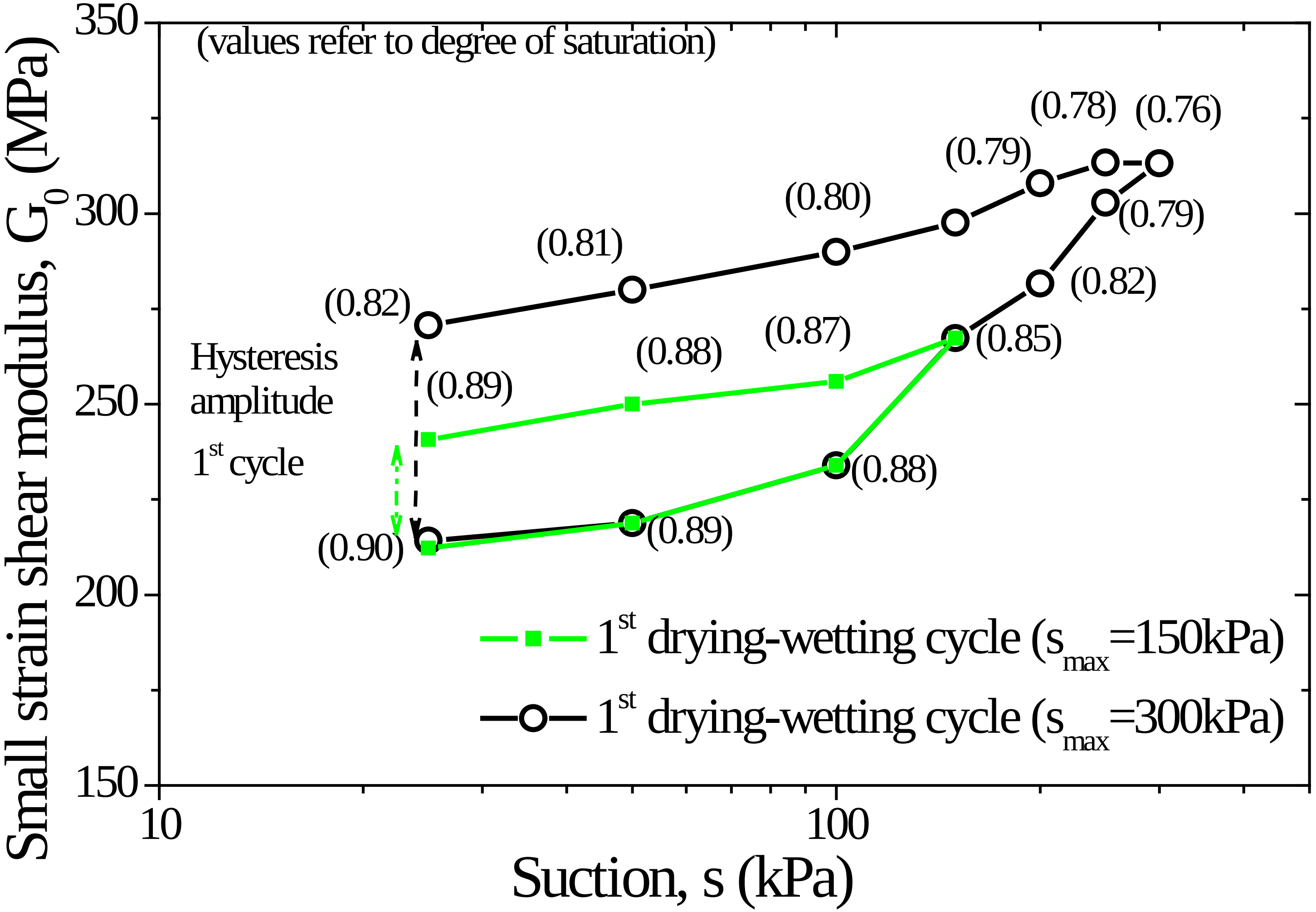
Hydraulic cycles



Recent suction history



Current stress ratio

- effect of suction stress history at the different CSR's on G_0 the data normalised by the current stress state (p')

$$\frac{G_0}{G_{ref}} = Af(e)\left[\underbrace{\frac{(p-u_a)+(u_a-u_w)S_r}{p_r}}_{p'}\right]$$

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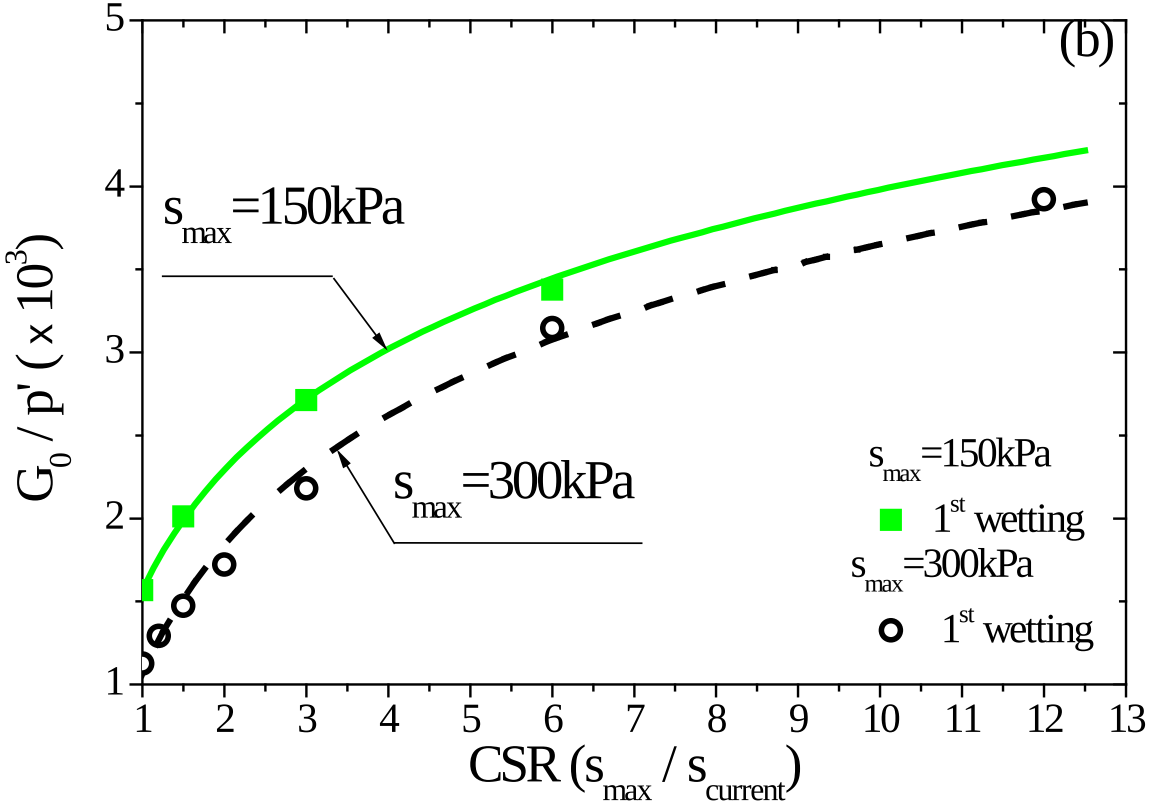
$$CSR = \frac{s_{\max}}{s_{current}}$$



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Conclusions

Larger values of G_0 correspond to the wetting paths and this difference was associated with the water retention properties and soil microstructure

The hydraulic cycles influence on the amplitude of the hysteretic response observed in a cycle of wetting and drying

The CSR influence however seems to be intimate related to the stress state represented by current suction and degree of saturation

CSR appears to control the G_0 to some extent but the number of hydraulic cycles contributes to an increase in G_0 for the same CSR

The geomechanical behaviour of earth structures exposed to changes in hydraulic regimes is dynamic and dependent on its suction history

References

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Acknowledgements

- Financial support from :
    - Australian Research Council (ARC) Linkage grant
    - Industry partners:

Australian Government
Australian Research Council

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PENRITH LAKES

- Laboratory assistance from technical Staff at UOW

Comments / Questions ?

Thank you.