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Impact of Pore Fluid Compressibility on Soil Cyclic Behavior

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Outline

- Introduction and motivation
  - ✓Cyclic behavior of loose material under cyclic loading - soil liquefaction
  - ✓Relationship between pore fluid compressibility and saturation degree
  - ✓Research motivation
- Material, apparatus, and test procedure
- Results
- Conclusions

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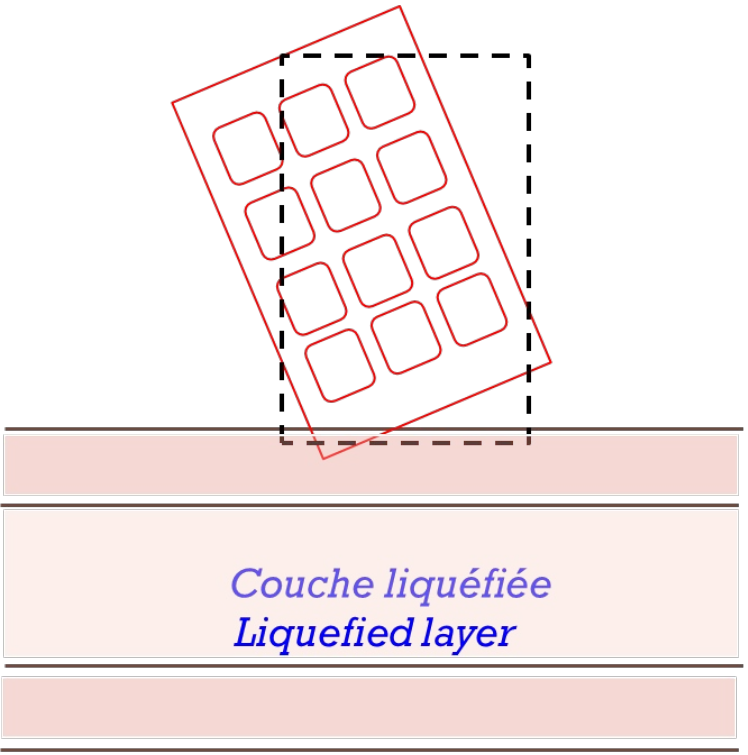
Rupture des fondations
Foundation failure



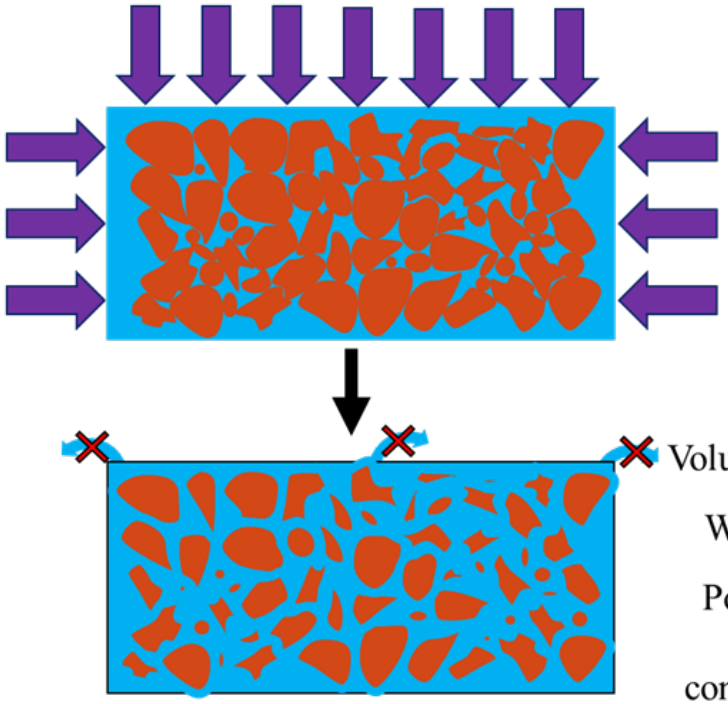
Niigata 1964

Izmit 1999

Yun Tsui building, Taiwan 2018

Liquefaction - Fully Saturated

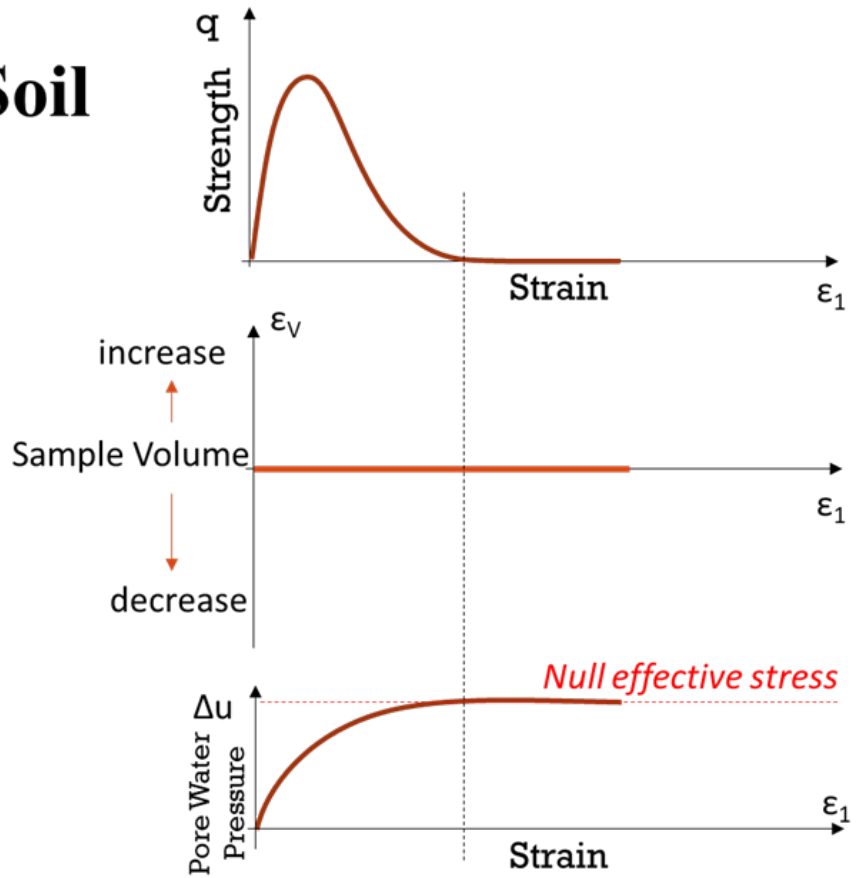
Undrained Loose Soil



Volume tries to decrease

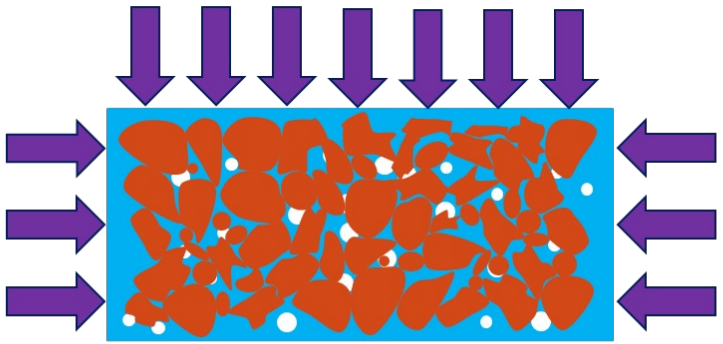
Water can not drain

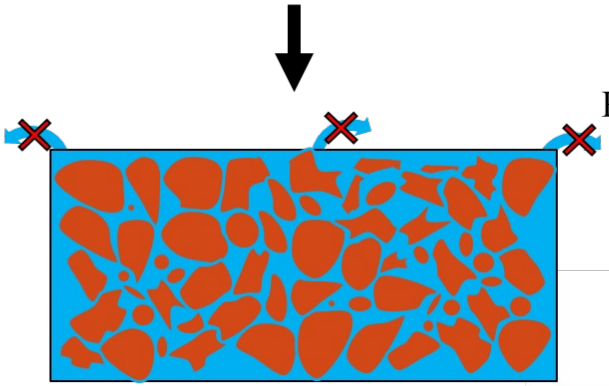
Pore water pressure increases due to contractancy blockage



Liquefaction - Unsaturation

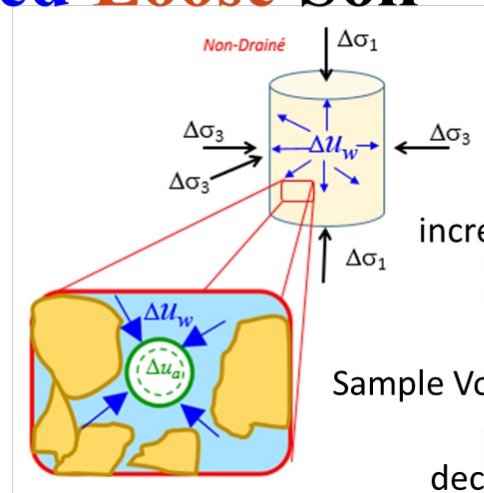
Undrained Unsaturated Loose Soil

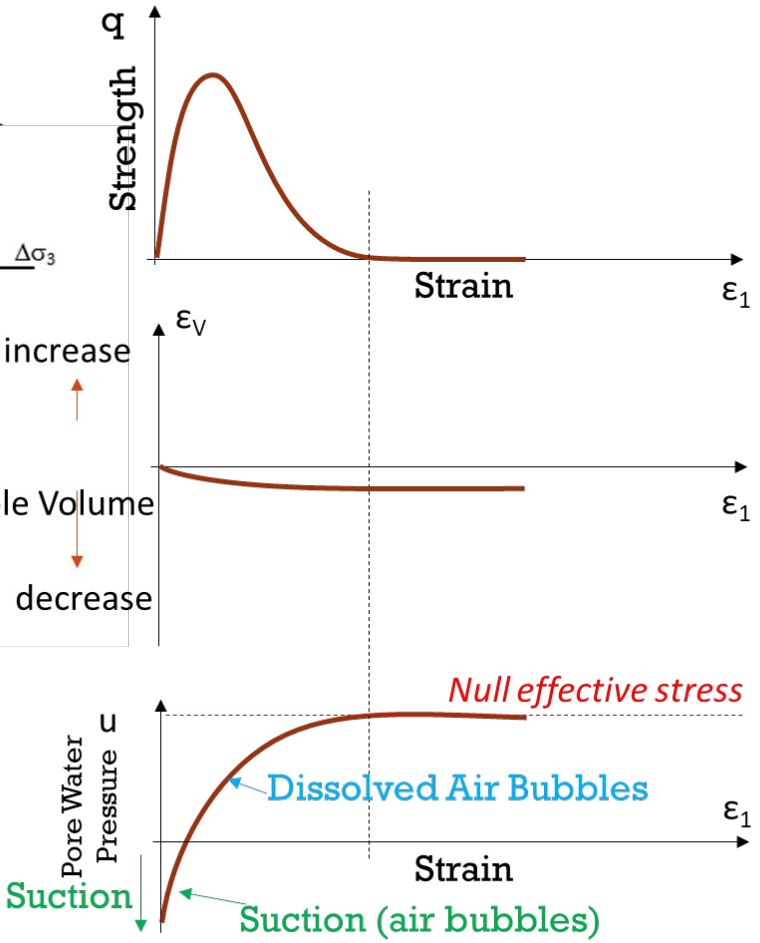




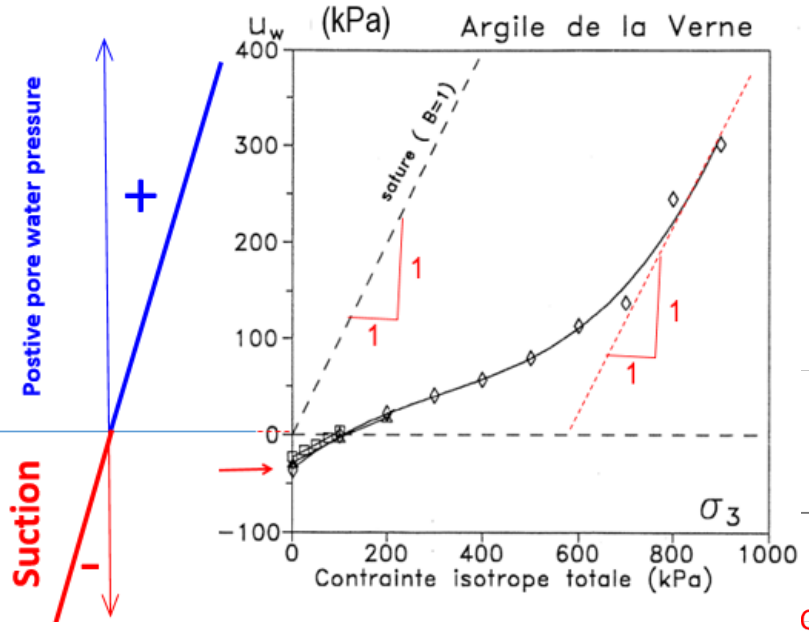
Pore water pressure increases but not significantly

Air takes some of the pressure and dissolve in water





Relationship between saturation degree and suction

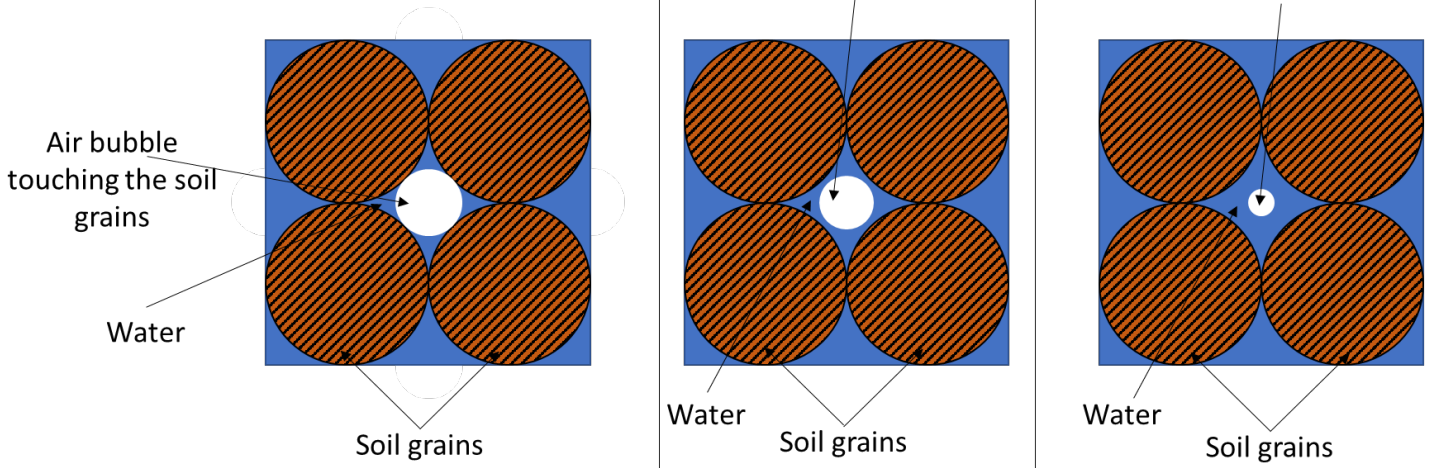


Tran et al. 2024

s_s=0 s_c =u_a-u_w≠0 Capillary Suction s_c ≠ 0	s_c= s_s=0 u_a=u_w	s_s=u_a-u_w≠0 Capillary Suction s_c=0
Effect of surface suction	No effect of capillary Suction and spherical suction	Effect of surface tention

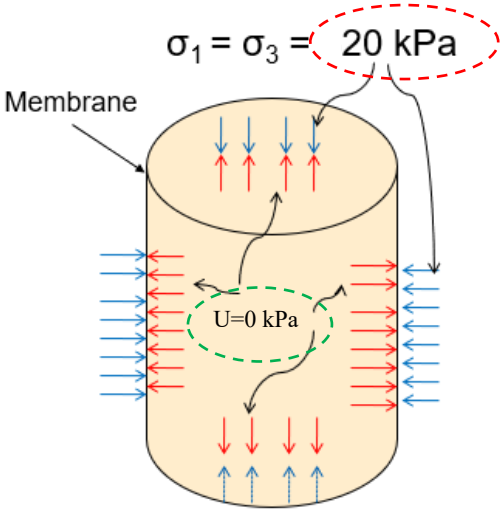
S_r≈80% S_r≈95% 100%

Capillary Suction s_c=T($\frac{1}{R_1}-\frac{1}{R_2}$)

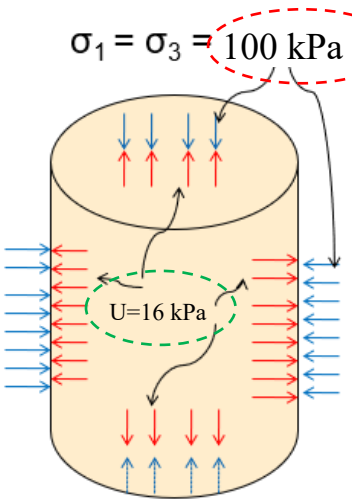


Pore pluid compressibility evaluation

B check test



State 1: before B check



State 2: after B check

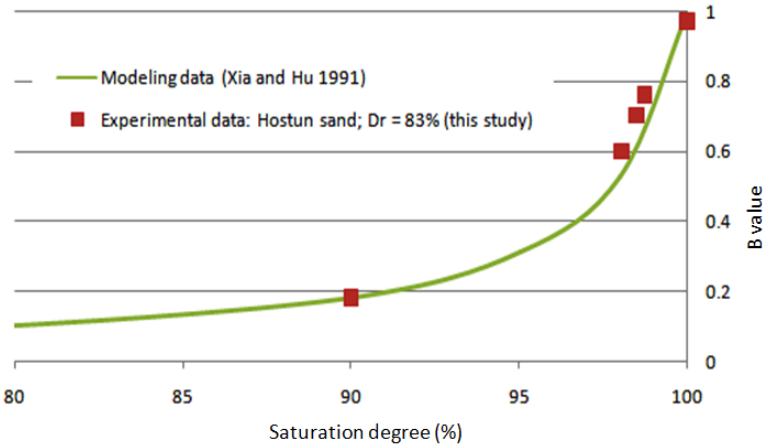
Skempton's parameter

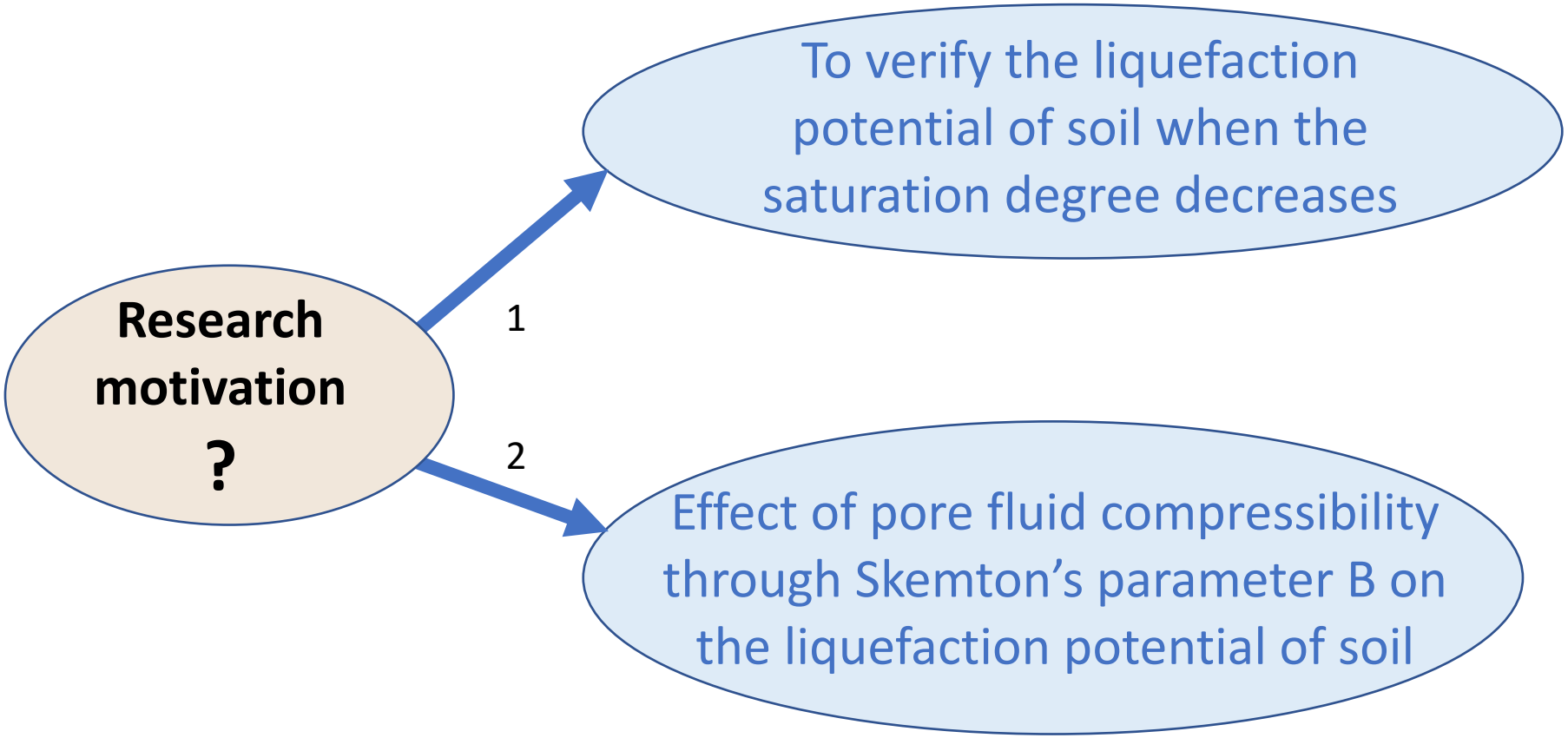
$$B = \frac{\Delta u_w}{\Delta \sigma_3} = \frac{1}{1 + n\frac{K_s}{K_{aw}}}$$

$$B = \frac{16\ \text{kPa}}{80\ \text{kPa}} = 0.2$$

Bulk modulus of Pore fluid

B – Sr relationship




Research motivation ?
1
2
To verify the liquefaction potential of soil when the saturation degree decreases
Effect of pore fluid compressibility through Skemton's parameter B on the liquefaction potential of soil

Outline

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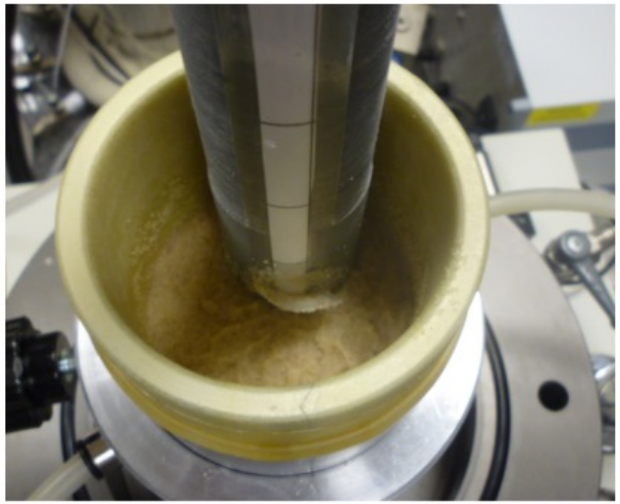
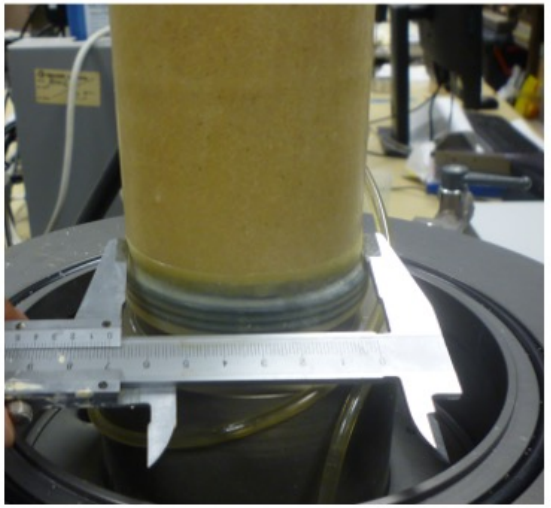
- Material, apparatus, and test procedure
- Results
- Conclusions

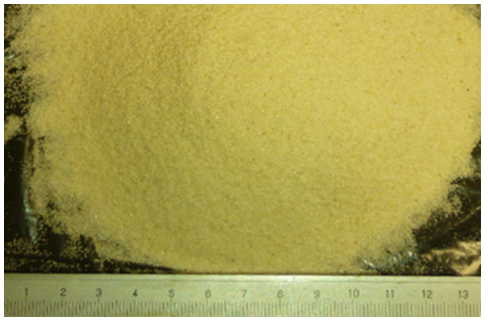
Material, apparatus, and test procedure.

- Material and sample preparation

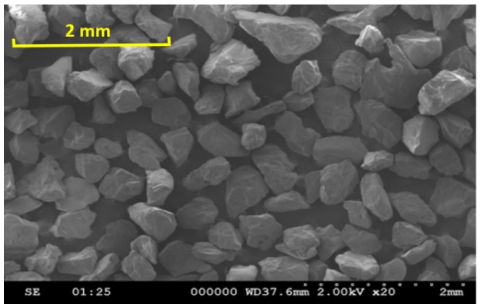




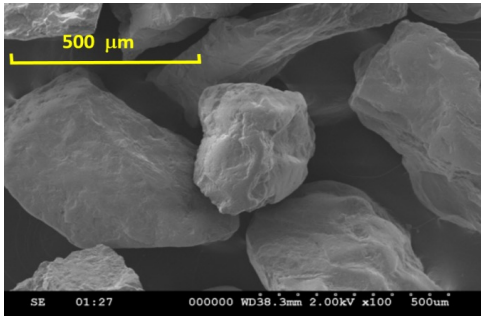
Fine clean sand



uniform grain size



Shape of edges



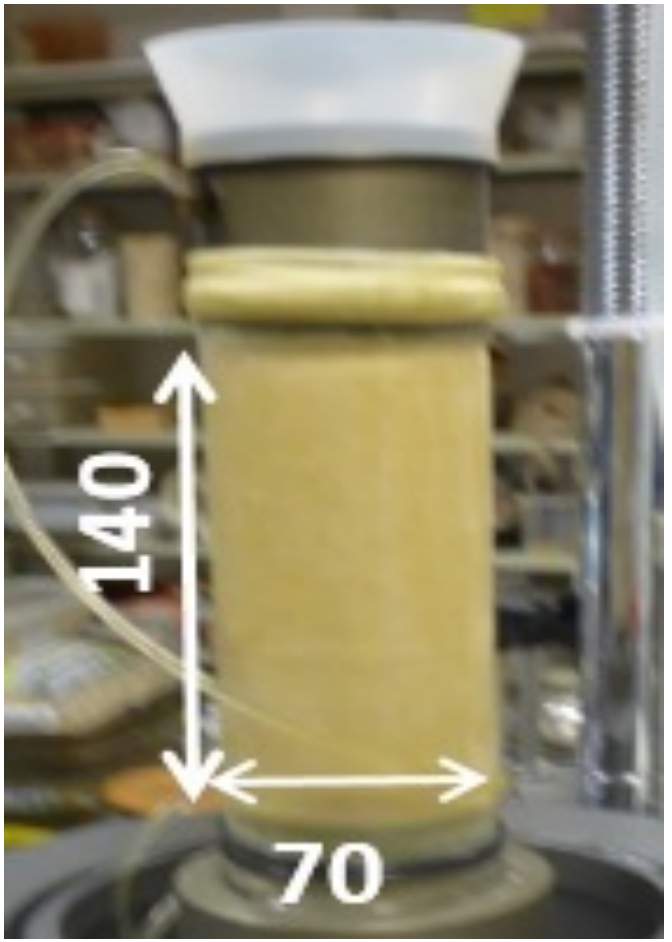
RF Hostun sand at different scales

Material, apparatus, and test procedure.

- Test procedure: sample preparation

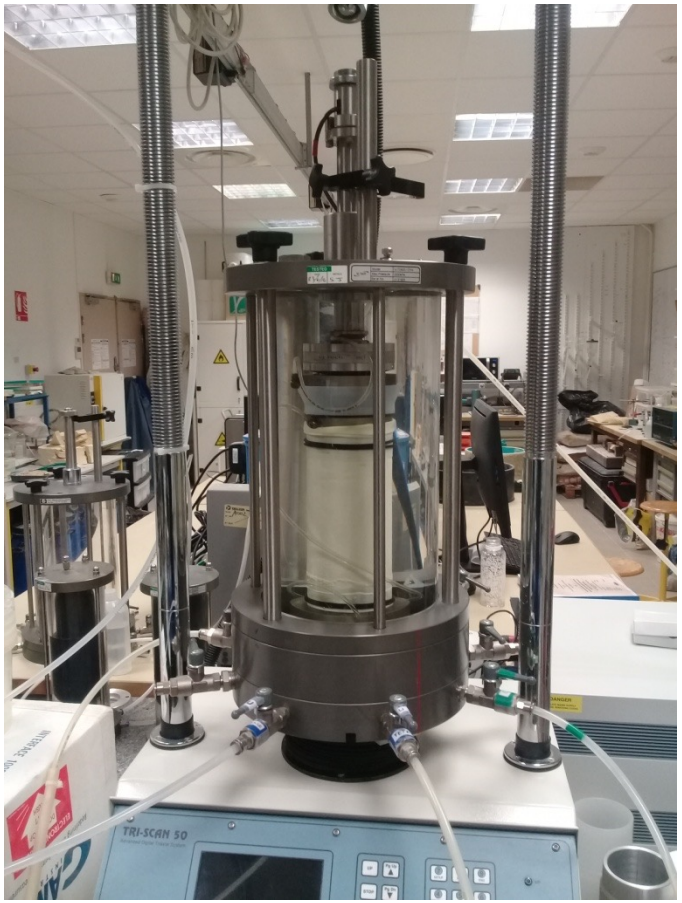
Diameter (mm)	**70**
Height (mm)	140
Initial Water Content W (%)	8
Initial degree of saturation Sr (%)	30%
Relative density Dr	80%

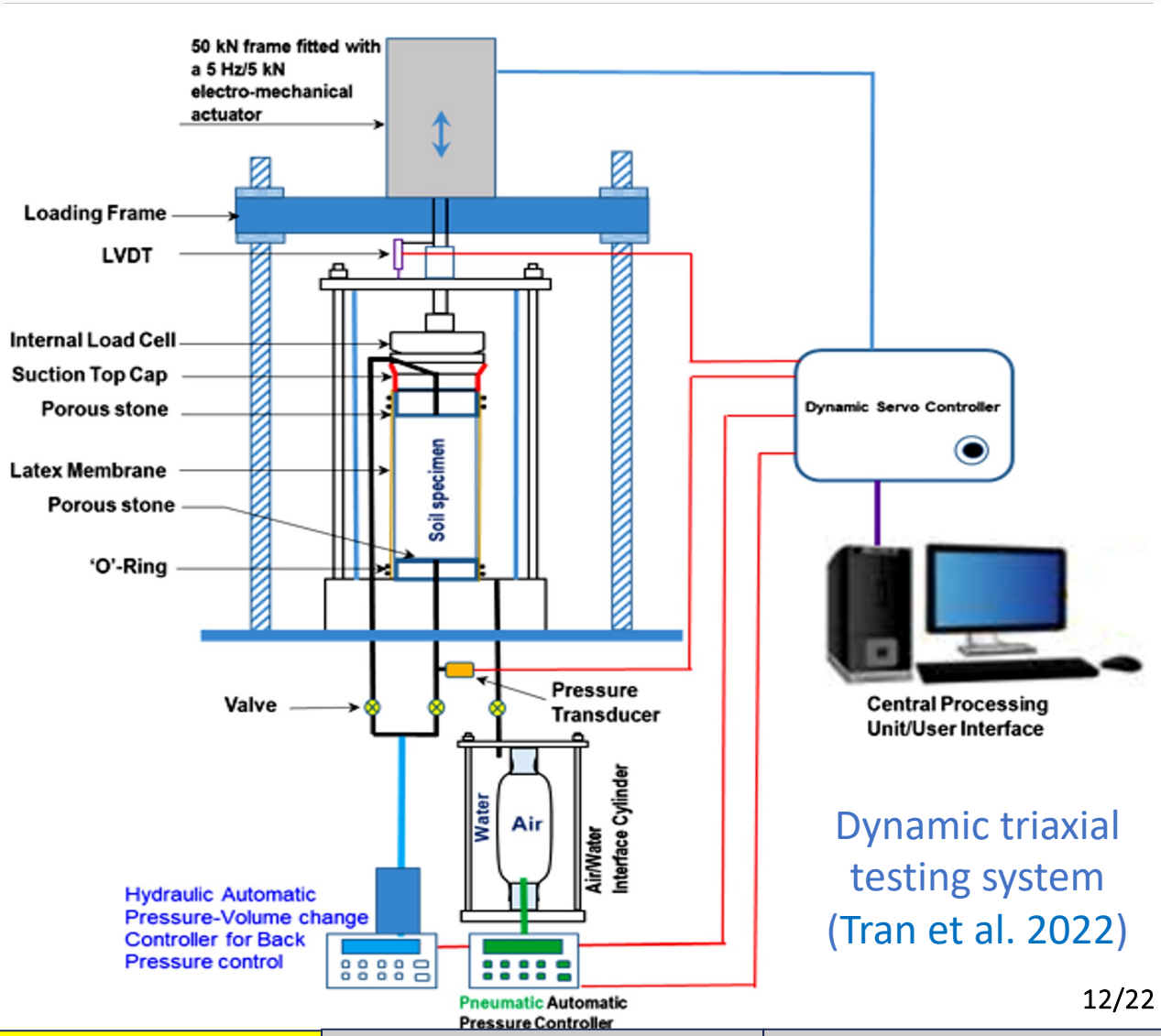
Test	B	Sr_0 (%)
1	0.97	100
2	0.22	95
3	0.056	86



Material, apparatus, and test procedure.

- Apparatus



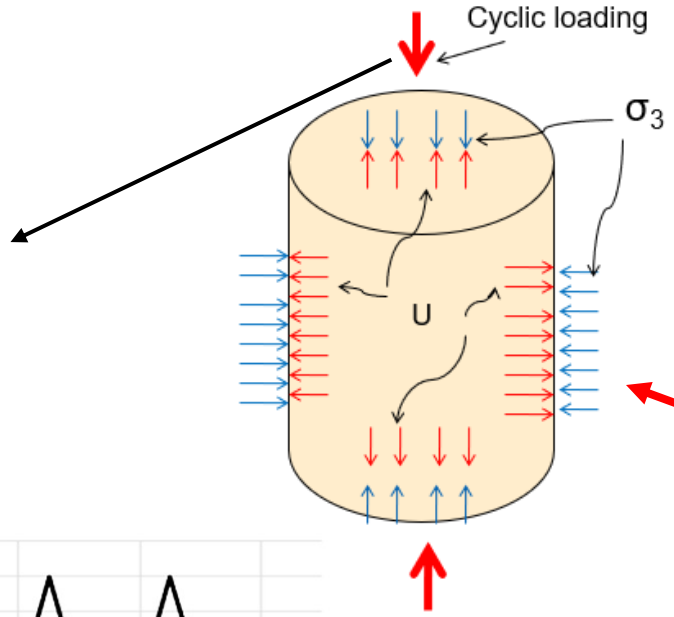


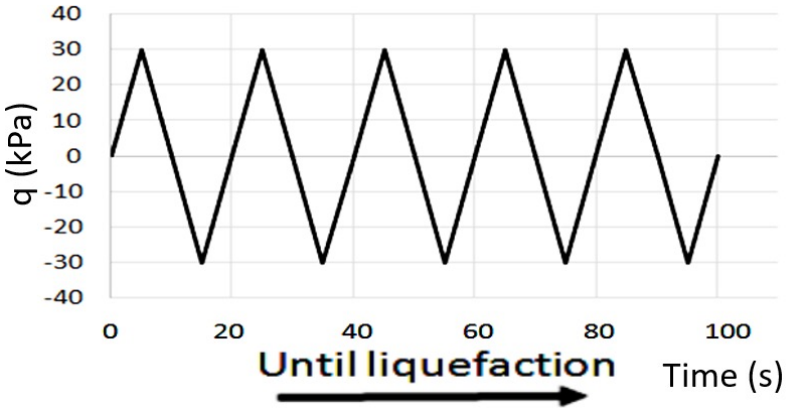
Dynamic triaxial testing system (Tran et al. 2022)

Material, apparatus, and test procedure.

- Test procedure: cyclic loading

Deviator load





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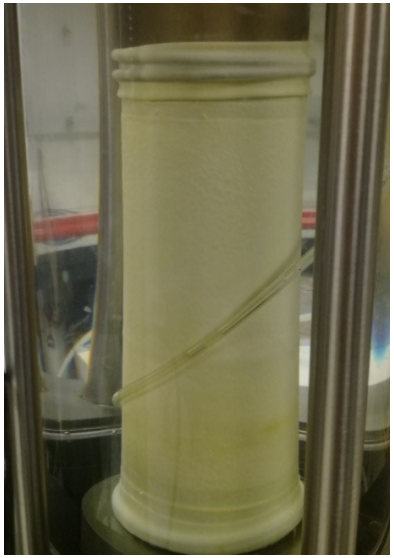
Unsaturated Sample

Initial state
Skempton's parameter
B = 0.2
-> The sample was
Unsaturated

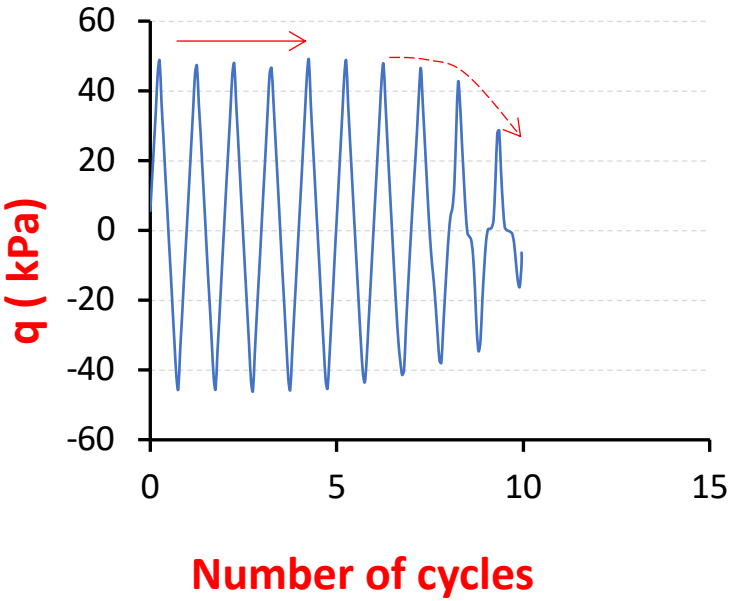


Final state
-> The sample was
Liquefied

The sample before and after liquefaction

Results

Saturated sample
B = 0.97



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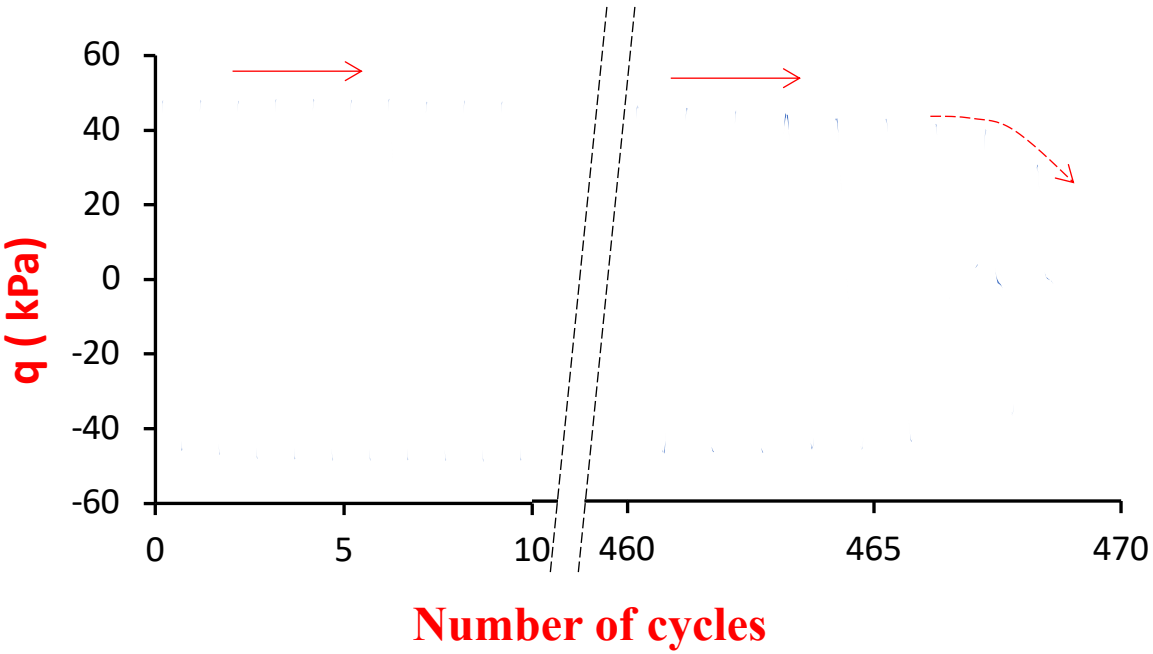

Results

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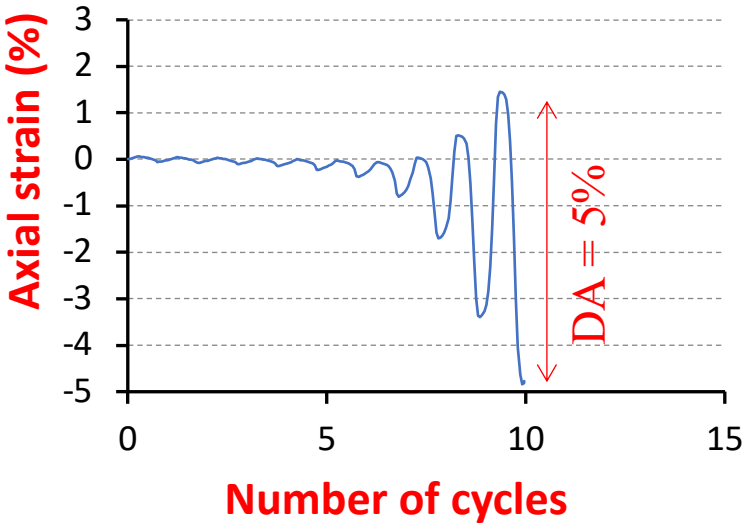

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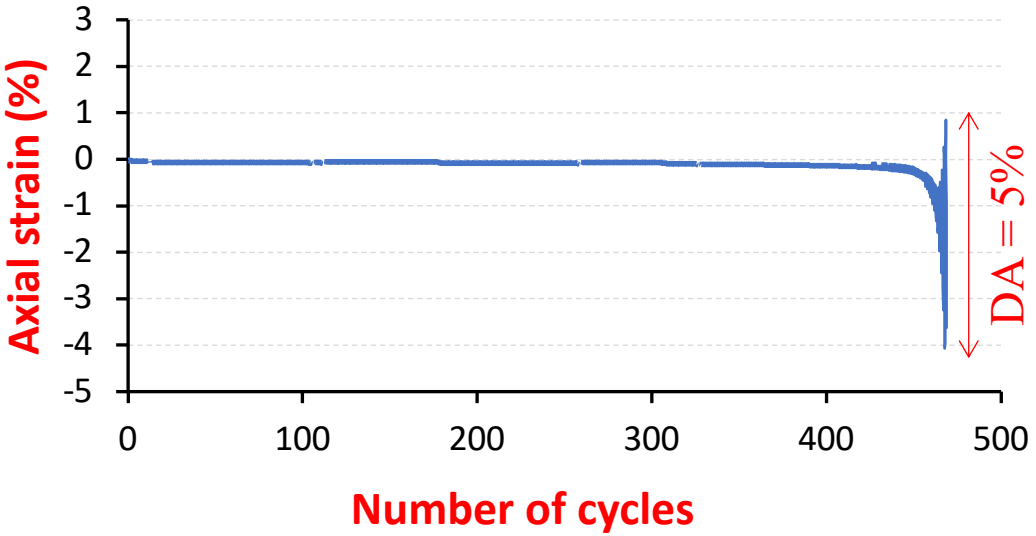

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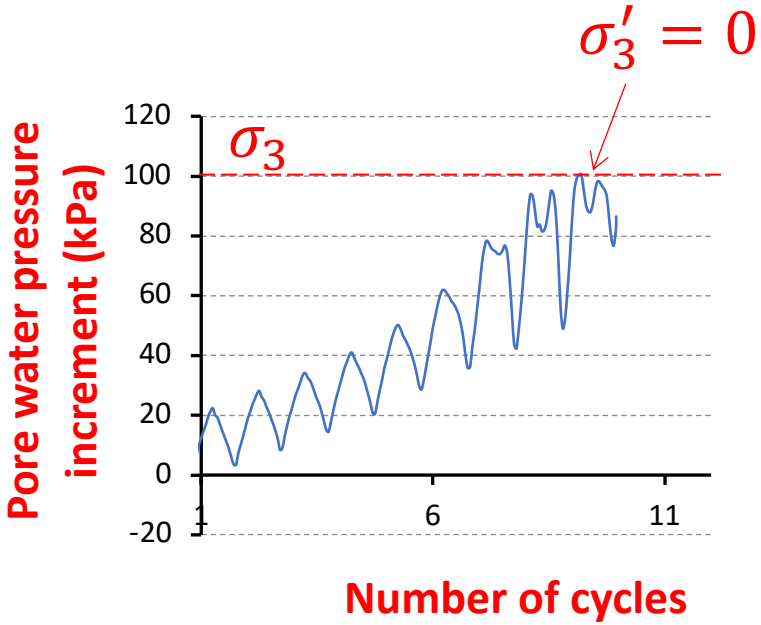
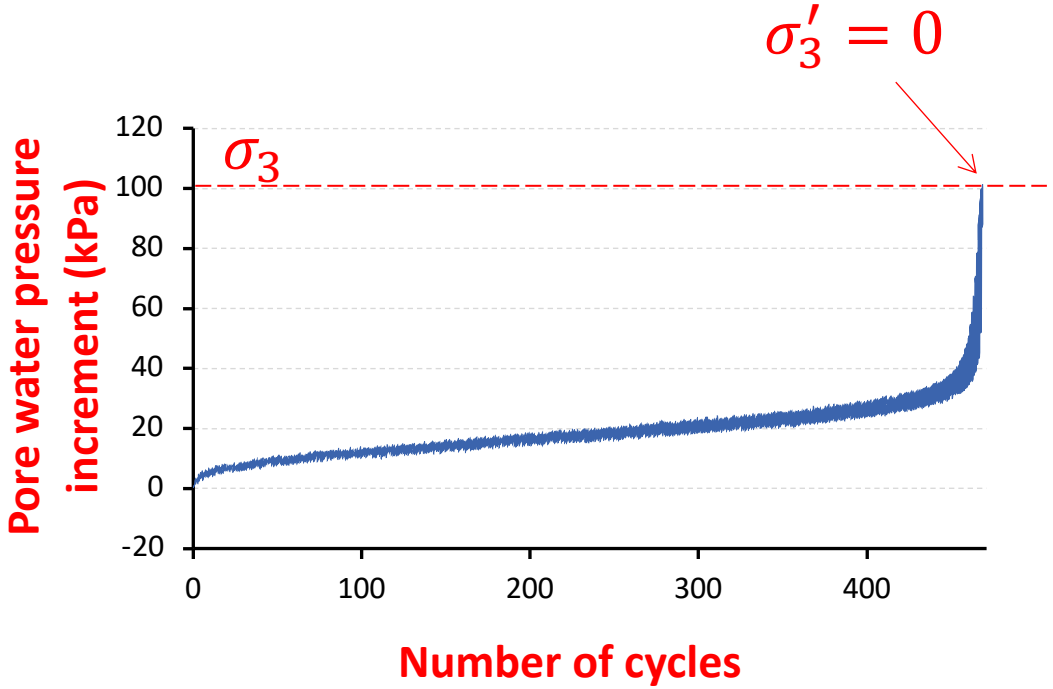


Unsaturated sample
B = 0.2



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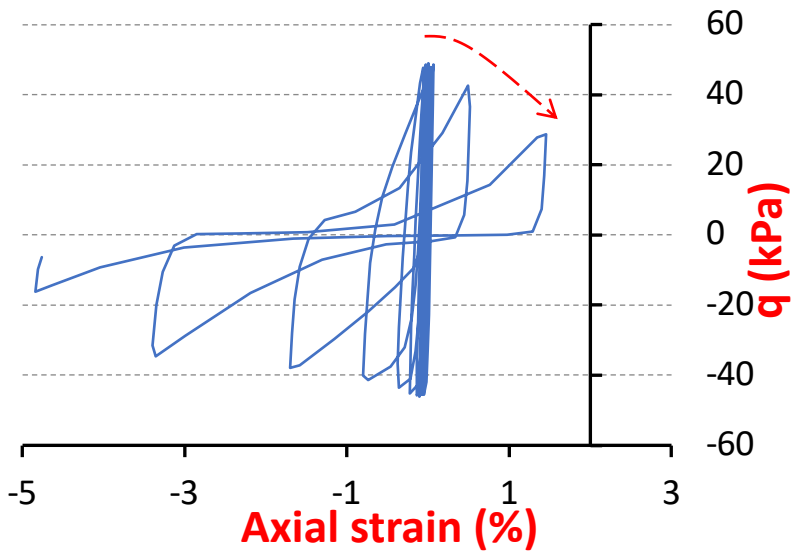

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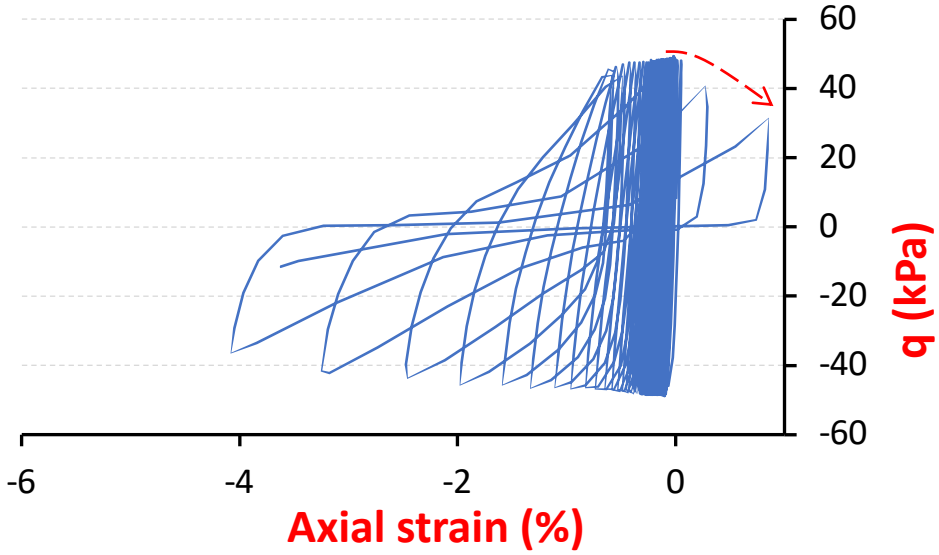

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Conclusions

- Although the sample was not well saturated, it has been liquefied.
- The increase of pore fluid compressibility represented by B value results in the increase of number of cycles to liquefy the sample.
- The saturation degree affects significantly the liquefaction potential of soil
- The results of this study suggest that desaturation can be used as a sustainable method to improve soil properties to mitigate the effect of liquefaction.

Thank you for your attention

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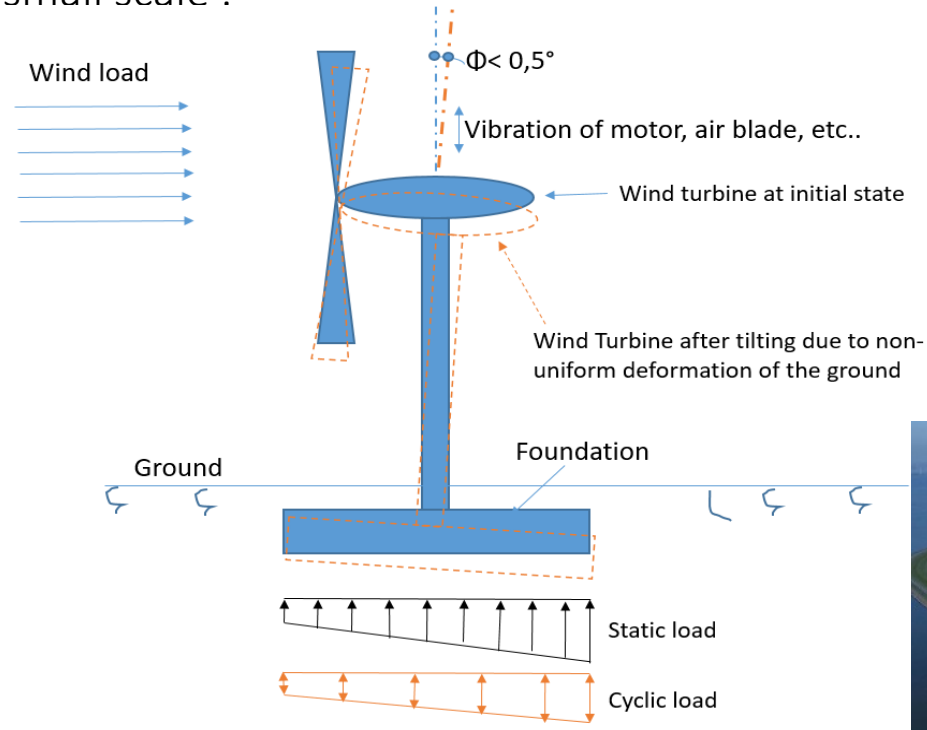
Experiences of liquefaction

- The sudden lost of soil strength
- Increase of pore water pressuse
- Damages significantly the site on large scale or on small scale .



Under wind turbine

Earthquake in Palu Indonesia 2018