INFRASTAR

Innovation and Networking for Fatigue and Reliability Analysis of Structures – Training for Assessment of Risk

Lifetime Cyclic Behavior of Offshore Wind Turbine Foundations

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Background

PhD Researcher at GuD Geotechnik und Dynamik Consult, *Berlin, Germany*

- Thesis: *Lifetime cyclic behavior of offshore wind turbine foundations*

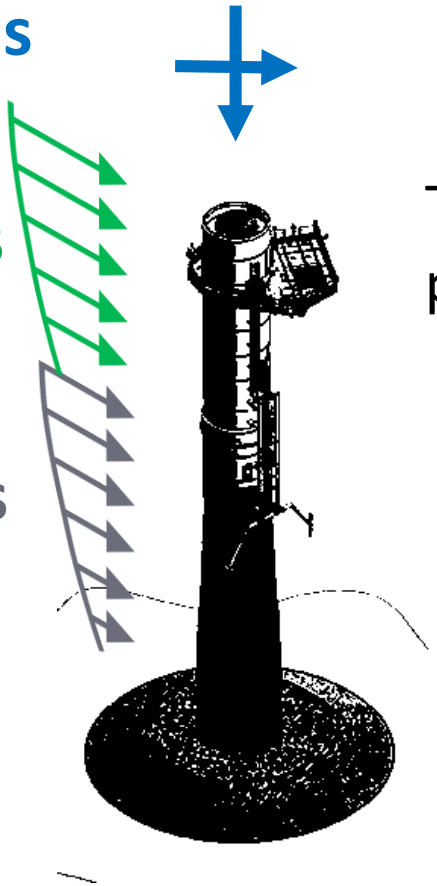
International Master Course in Civil Engineering University of Bologna, Italy

- Thesis: *Numerical and experimental long term cyclic behavior of soil*

BSc at University of Padova

- Thesis: *Cyclic behavior of granular material*

Wind turbine foundation



- Slender and Dynamic structure
- Vulnerable to cyclic loading
- Change in Soil-structure-interaction

Geotechnical Design of offshore structures

Static design (time 0):

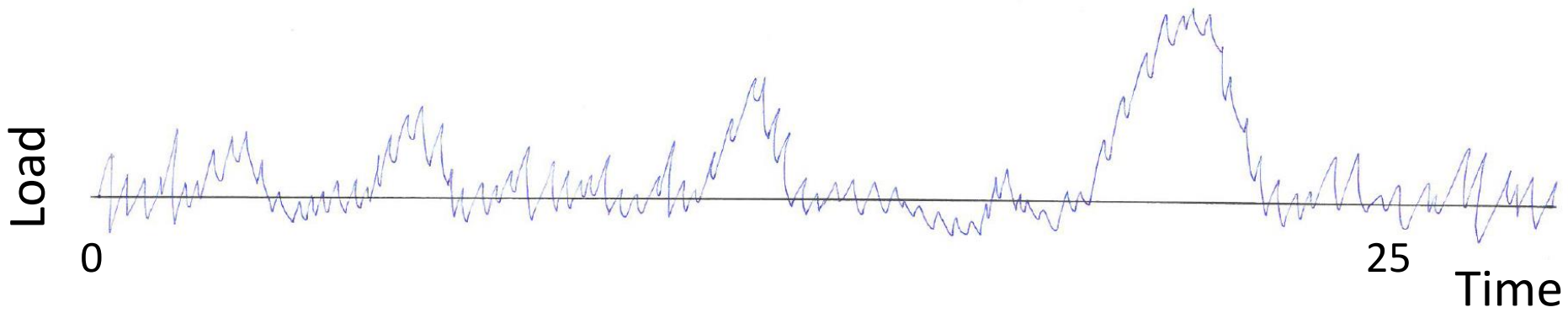
- Bearing capacity
  - Axial and lateral loads
- Stiffness
- Damping

Dynamic design (0 to 25 years +) : performance under cyclic loading

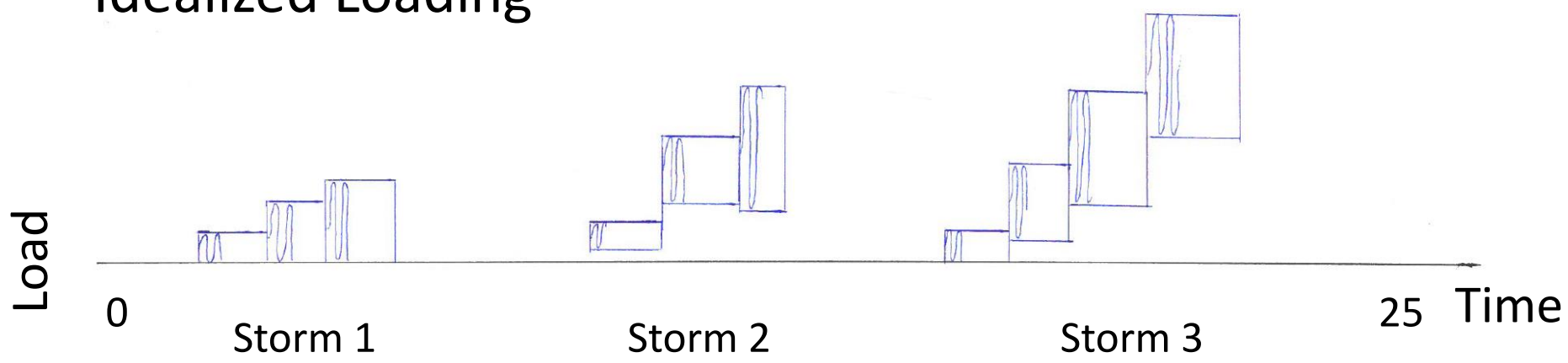
- Accumulated rotations? → Serviceability Analysis
- Decrease in bearing capacity? → Stability Analysis
- Change in Soil Stiffness? → Fatigue Analysis
- Change in Soil damping? → Fatigue Analysis

Design conditions
Lifetime

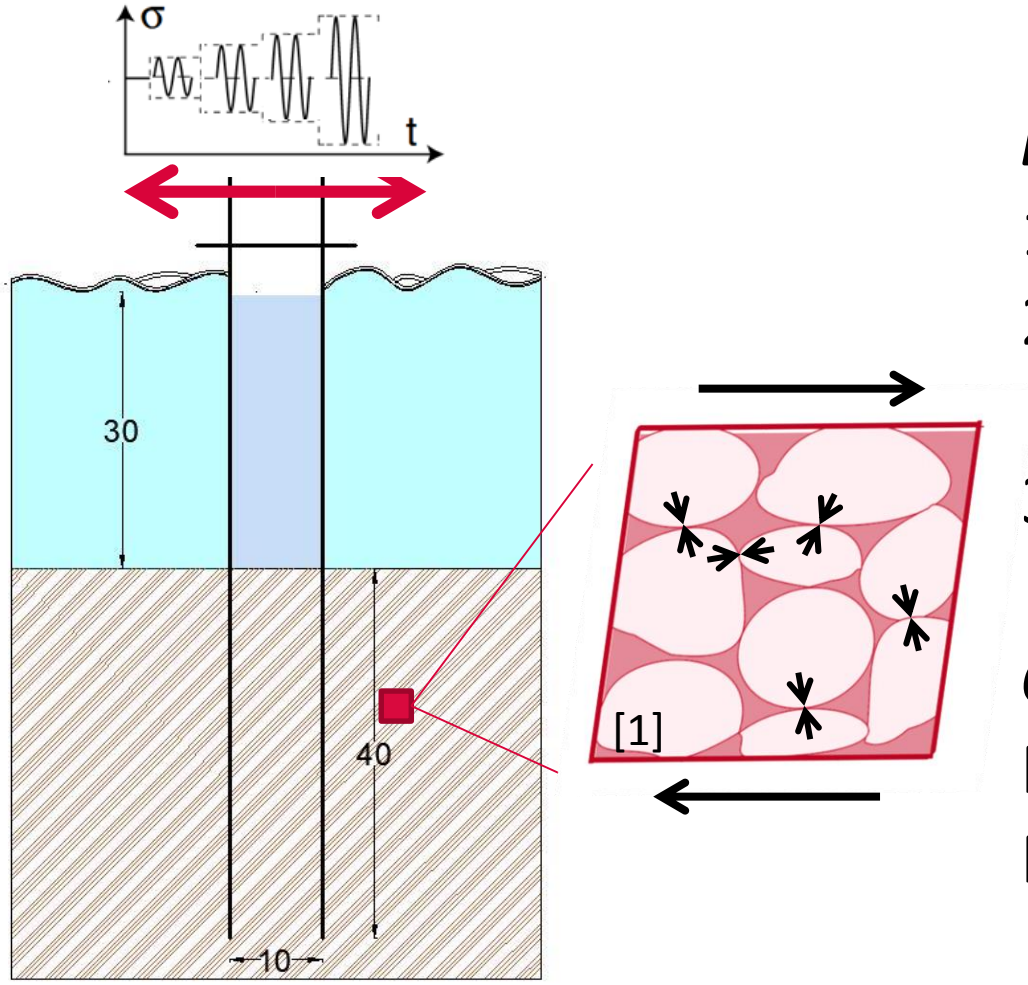
Real Loading



Idealized Loading



Cyclic behaviour of soil



Basic knowledge

1. Grains + Water
2. Strength=force between the grain
3. Soil is not linear

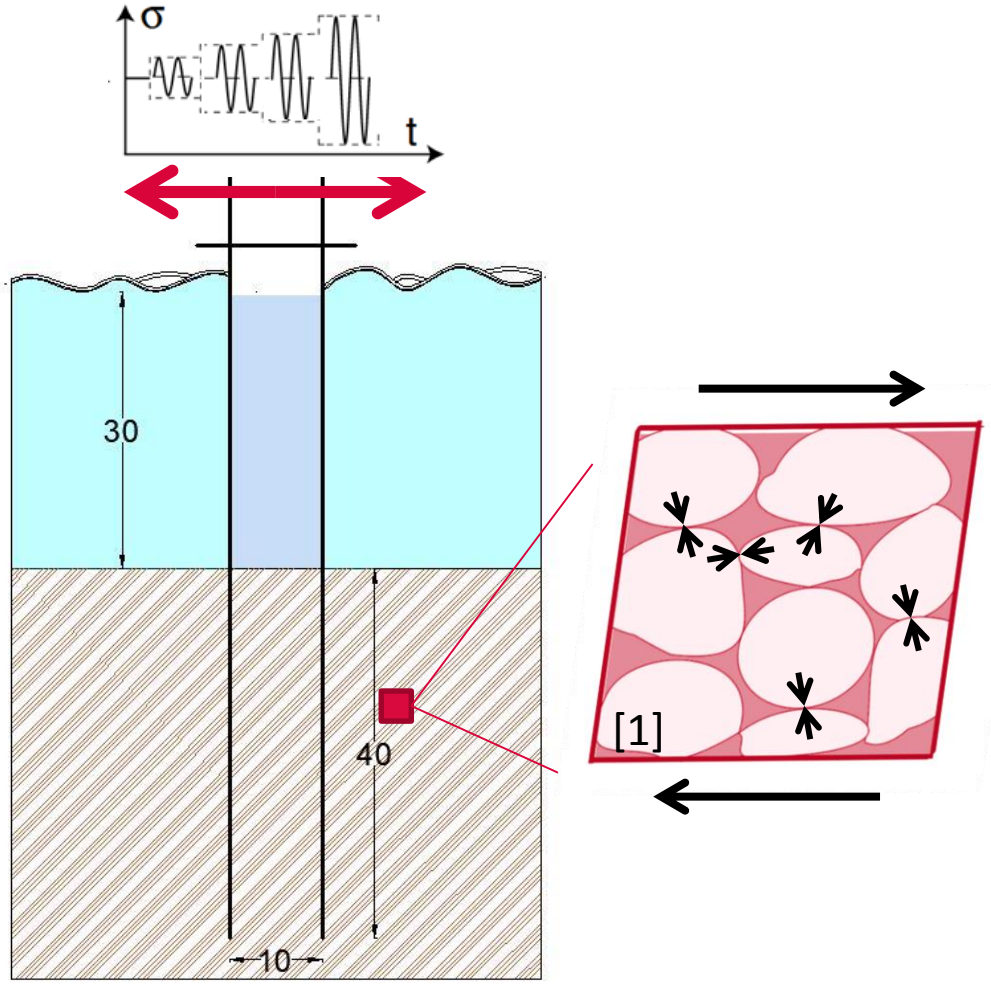
Cyclic behavior of soil

Phase 1. During storm event

Phase 2. After the storm event

[1] https://www.geological-digressions.com/liquefaction-more-than-an-interesting-phenomenon/

Cyclic behaviour of soil

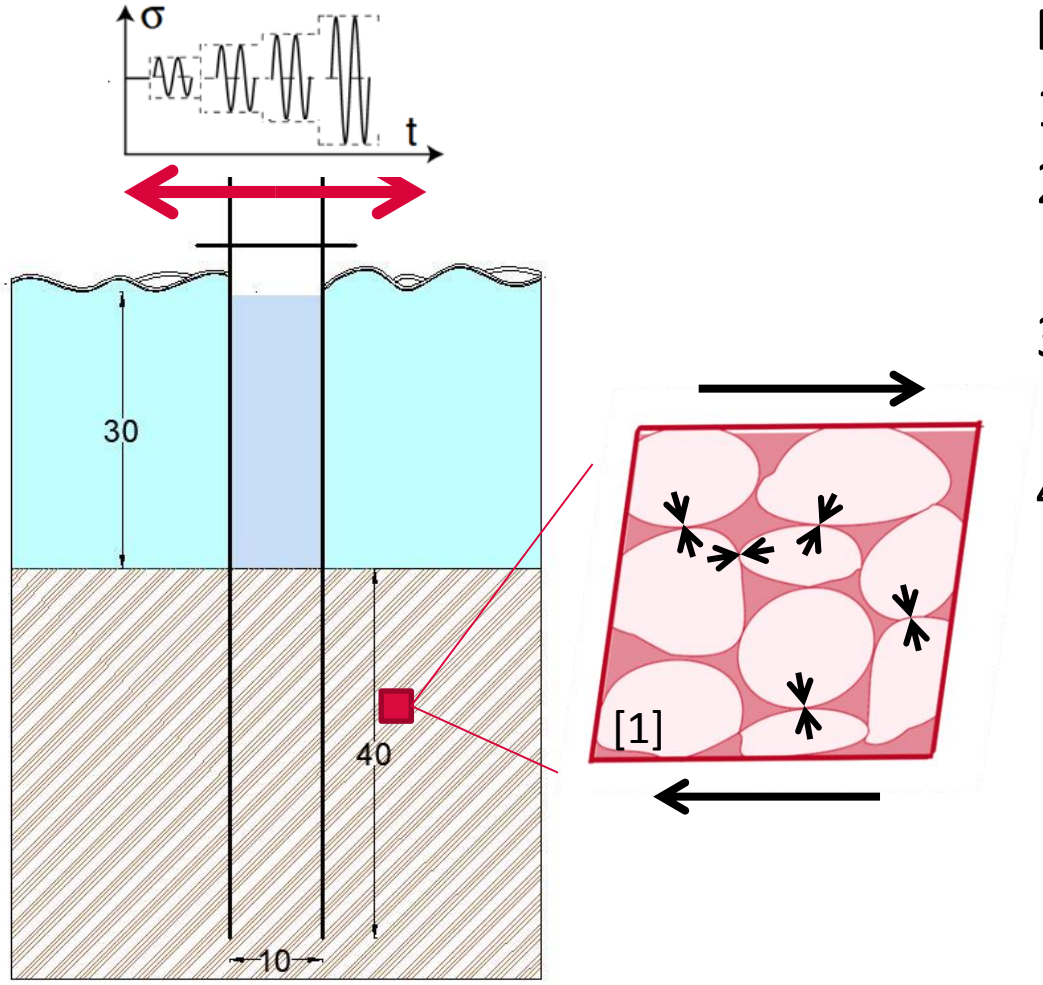


Phase 1:

1. Undrained conditions
2. Increase in water pressure
3. Loosing strength and stiffness
4. Accumulation of deformations

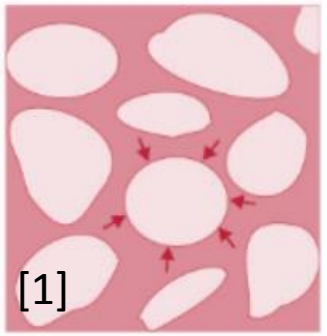
Phase 1 = Softening (Soil degradation)

Cyclic behaviour of soil



Phase 2

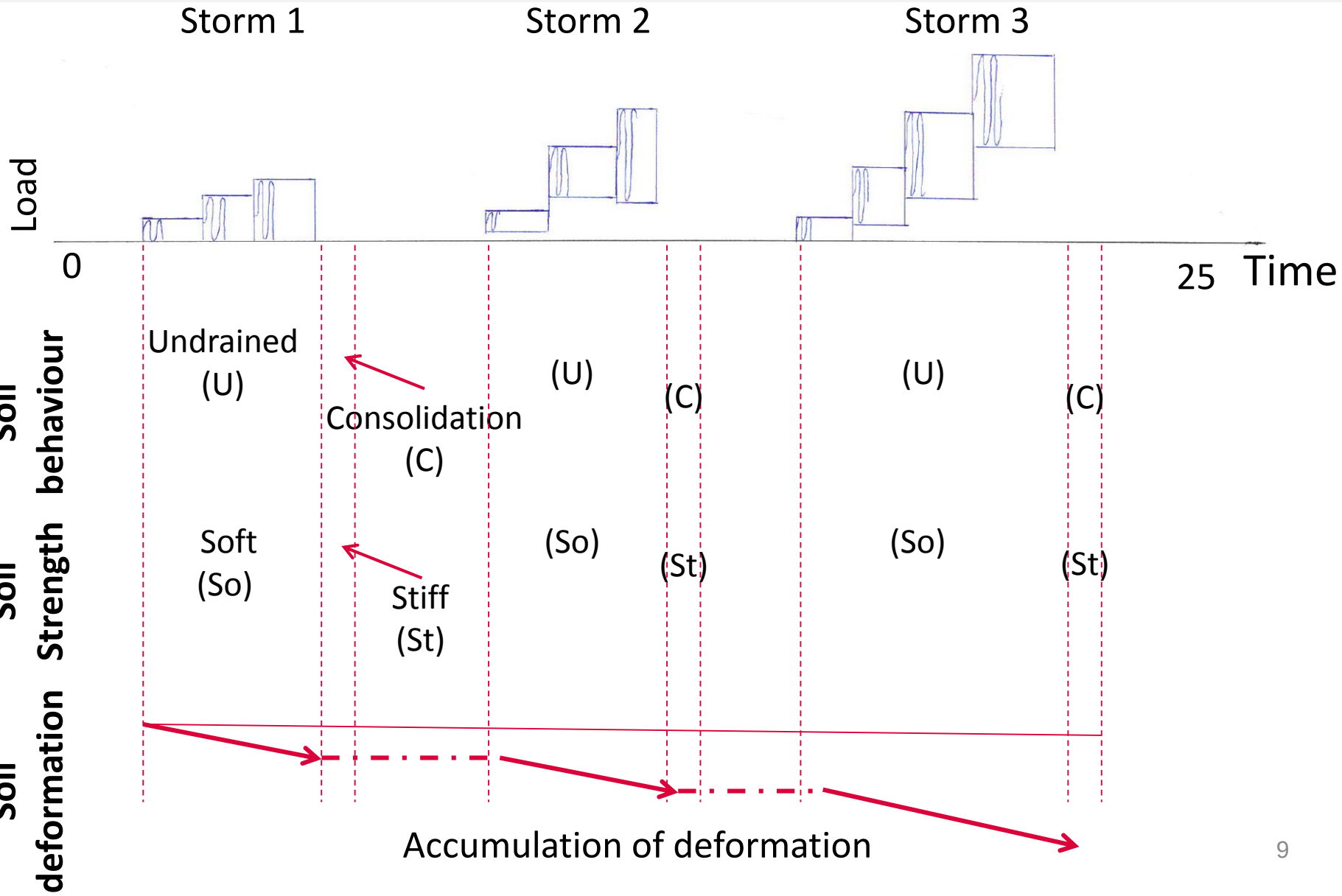
1. Consolidation
2. Dissipation of pore pressure
3. Better locking between the grains
4. Increasing in strength and stiffness
   - Not for liquefaction



Phase 2 = Stiffening (Soil hardening)

Cyclic behaviour of soil

Idealized Loading



Conclusion

- Cyclic behavior of soil is challenging:
  - Softening, stiffening, the micromechanical behavior is very important!!
- The methods to predict the cyclic loading is just based on lab tests and theories:
  - Need of monitoring data focusing on soil behavior
  - To enable a better understanding of the foundation performance
  - To understand the limitations
  - To reduce conservatism

Thank you for your attention

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