Geotechnical Engineering–I

BSc Civil Engineering – 4th Semester

Lecture # 17

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by

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Lecture Handouts: https://groups.google.com/d/forum/geotec-1

CONSOLIDATION OF SOIL

Load/stress application on soil

→ causes *soil compression*

Reasons for soil compression

- *Compression/expulsion of air* in soil voids
  - Soil *compaction* (already discussed)
- *Distortion/crushing* of soil grains
  - *Negligible* under normal structural loads
- *Expulsion/~~compression~~ of water* from the voids
  - Soil *consolidation*

CONSOLIDATION OF SOIL

Which soils have high water holding ability?

Phenomenon associated with *saturated fine grained soils* only.

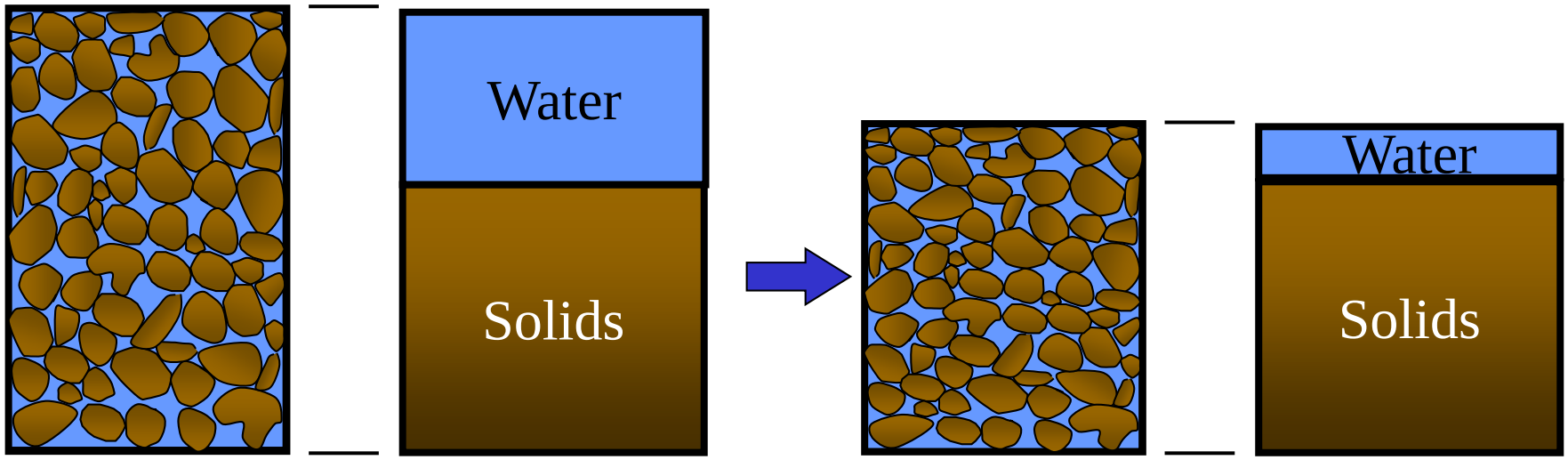
Consolidation → *compression/volume reduction* of soil mass due to *expulsion of water* when subjected to *external load/stress*.

CONSOLIDATION OF SOIL

Soil *volume reduction* due to *expulsion of water* upon application of *external load/stress.*

fully saturated soil, so all voids filled with water only *(no air)*

Before Consolidation ***After Consolidation***



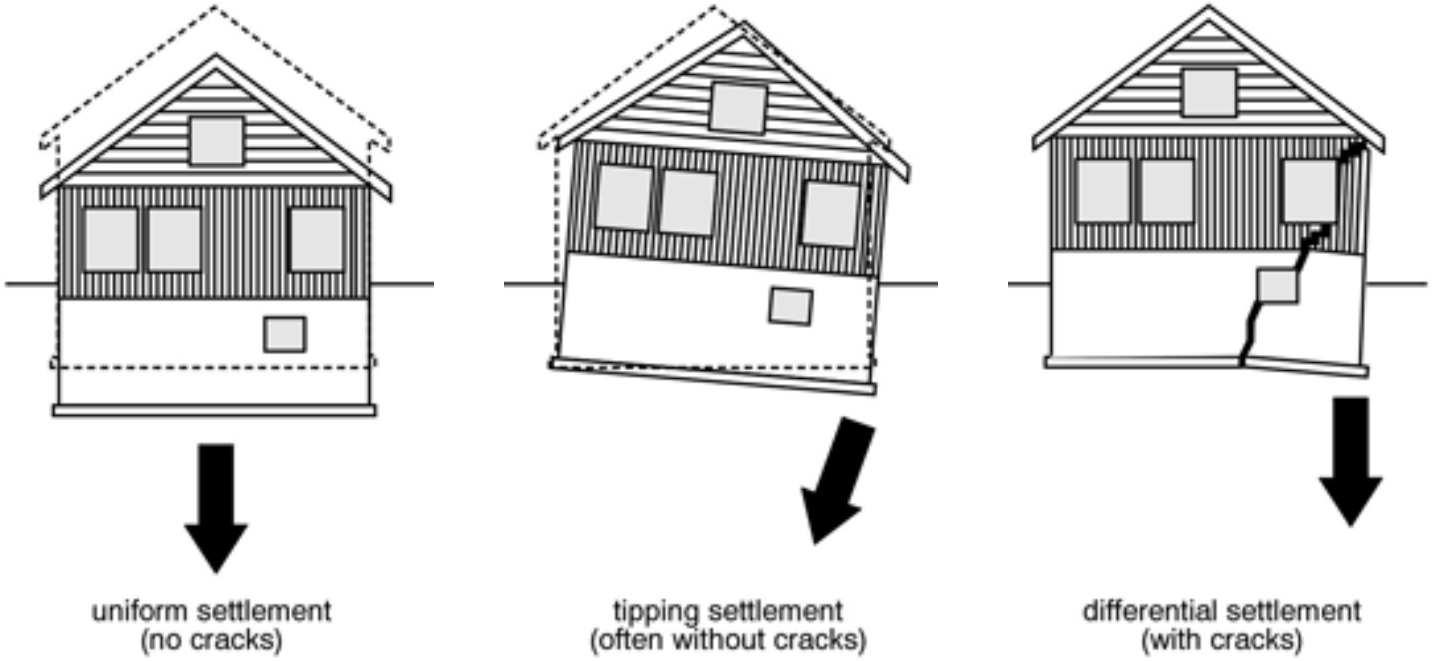
Saturated Fine-grained Soil

Consolidation Damages

Soil *volume reduction* due to *expulsion of water* upon application of *external load/stress.*

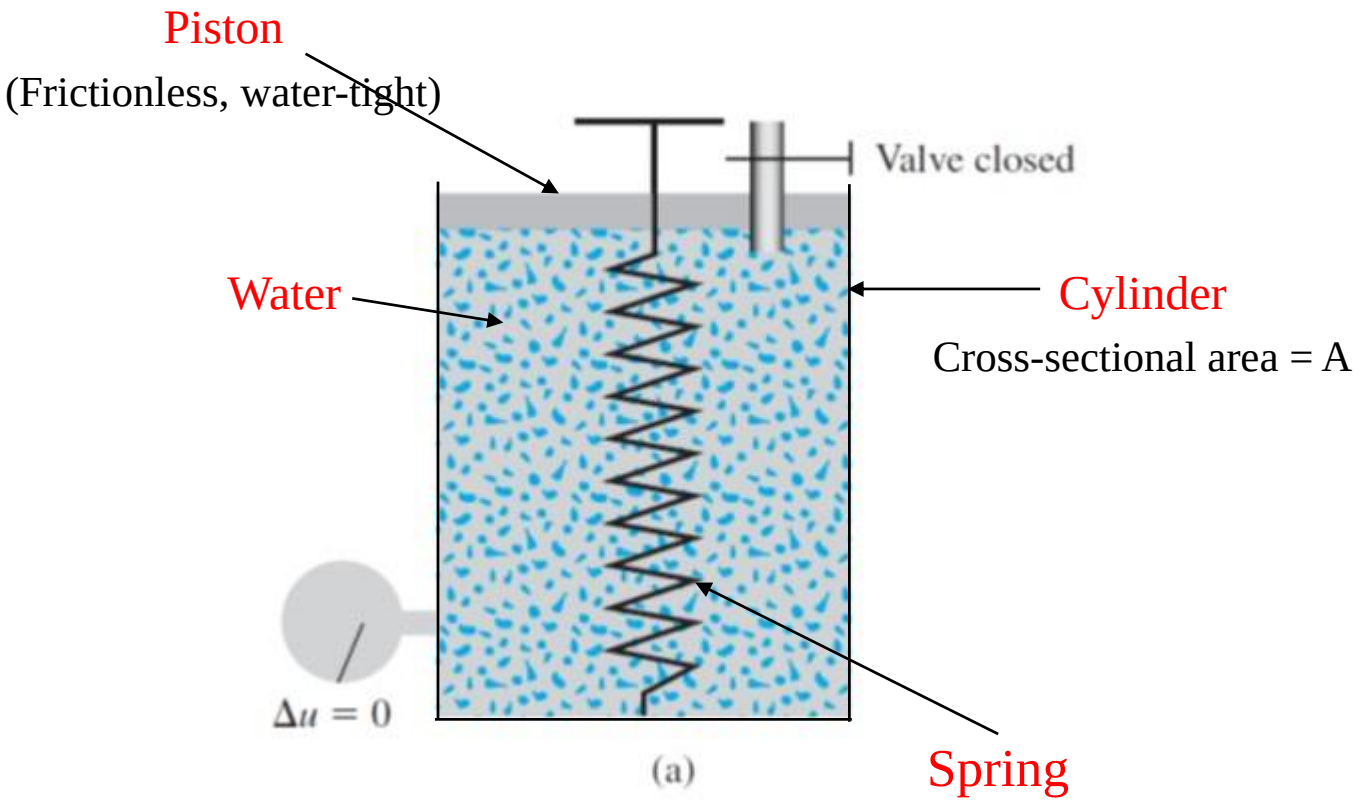
→ *Settlement* of structures

→ *Cracks* in walls, foundations, etc.



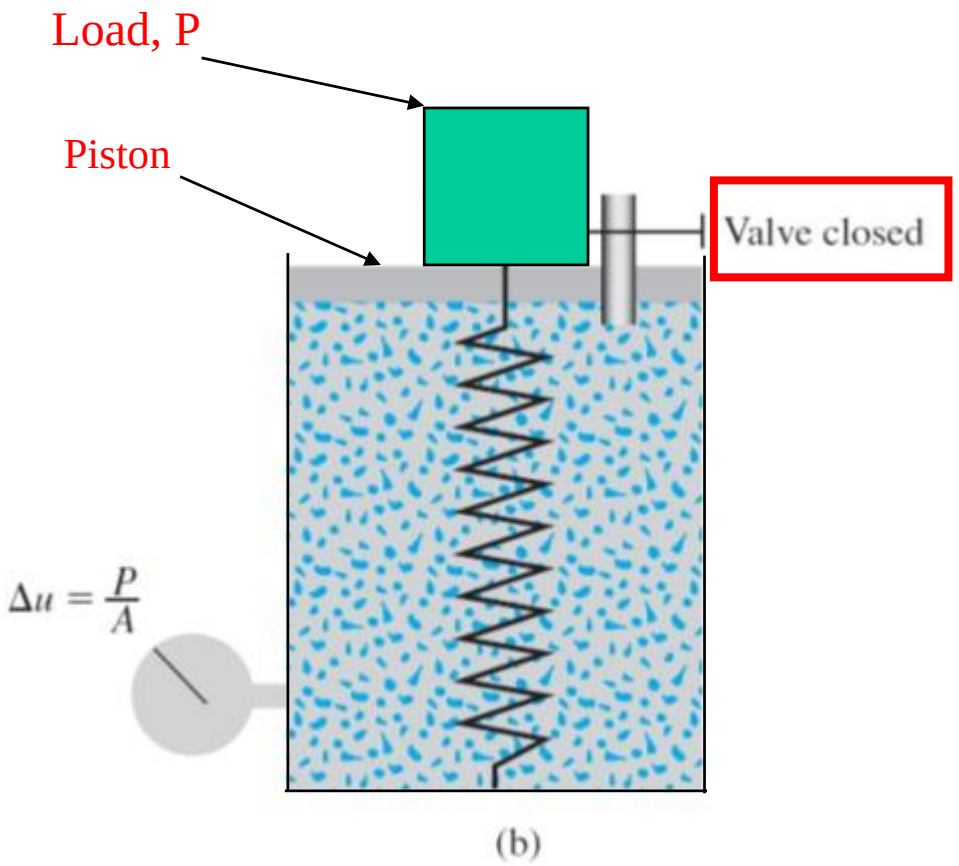
MECHANISM OF CONSOLIDATION

Spring-Cylinder Model



Consolidation Model (Spring-Cylinder Model)

Load (P) applied on the piston.



P_S = Load carried by the *spring*

P_W = Load carried by *water*

$$P = P_S + P_W$$

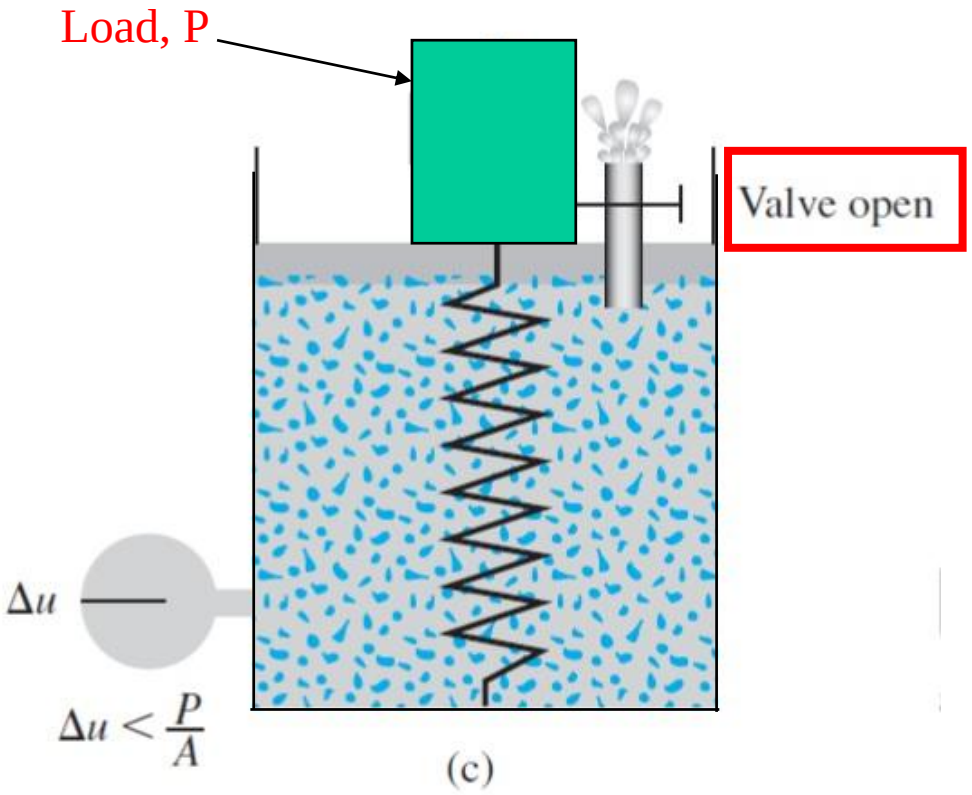
With the valve closed

$P_S = 0$, &

$P_W = P$

Consolidation Model (Spring-Cylinder Model)

- When the *valve is opened* → water flow outward
- Decrease in excess hydrostatic pressure
- Increase in compression of spring



P_S = Load carried by the spring

P_W = Load carried by water

$$P = P_S + P_W$$

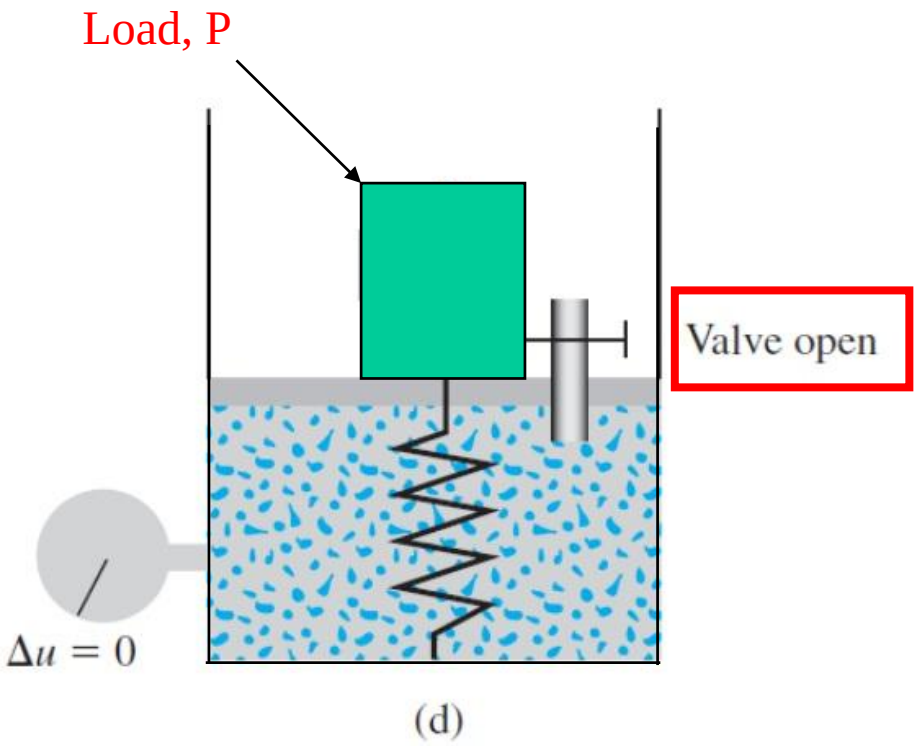
With the valve opened

$P_S > 0$, &

$P_W < P$

Consolidation Model (Spring-Cylinder Model)

After some time → *equilibrium* is reached



P_S = Load carried by the spring

P_W = Load carried by water

$$P = P_S + P_W$$

With the valve opened; after some time span.

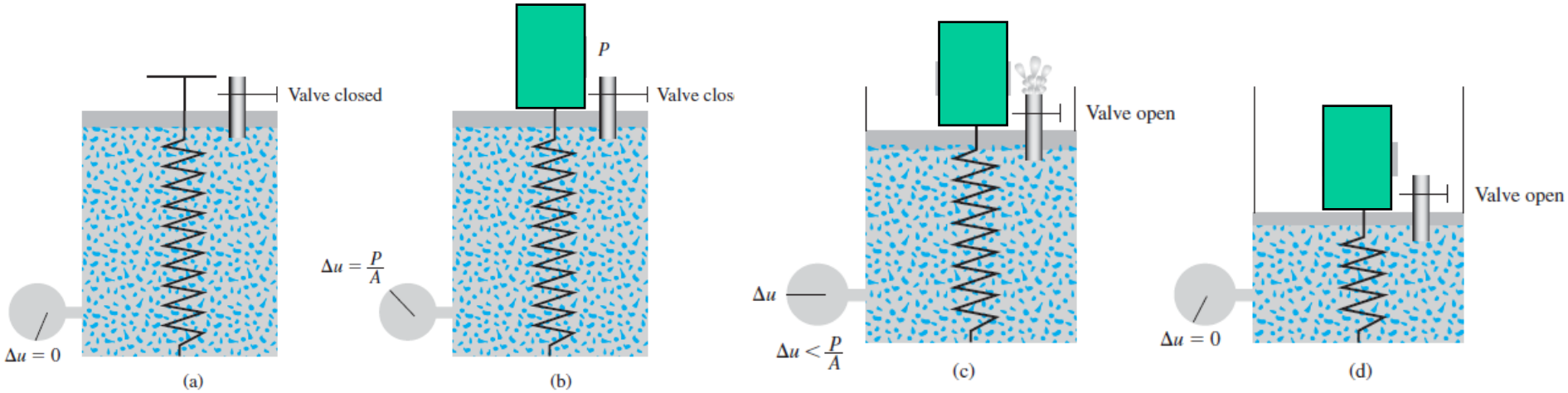
Excess hydrostatic pressure, $\Delta u = 0$

$P_W = 0$, &

$P_S = P$

Spring-Cylinder Model → Application to Soil

- Similar phenomenon occurs when load is applied on a *saturated clay deposit* (very low permeability).
  - Load is first taken by water only.
  - Pore water pressure slowly dissipates,
  - Soil particles start taking load gradually
  - After some time water completely escapes through voids, and the load is carried only by soil particles.



Spring-Cylinder Model → Application to Soil

Spring-cylinder assembly

Total load acting on the system = P

Load carried by water = P_W

Load carried by Spring = P_S

$$P = P_S + P_W$$

OR

$$P_S = P - P_W$$

In case of soil

Stress acting on soil mass → Total Stress = σ

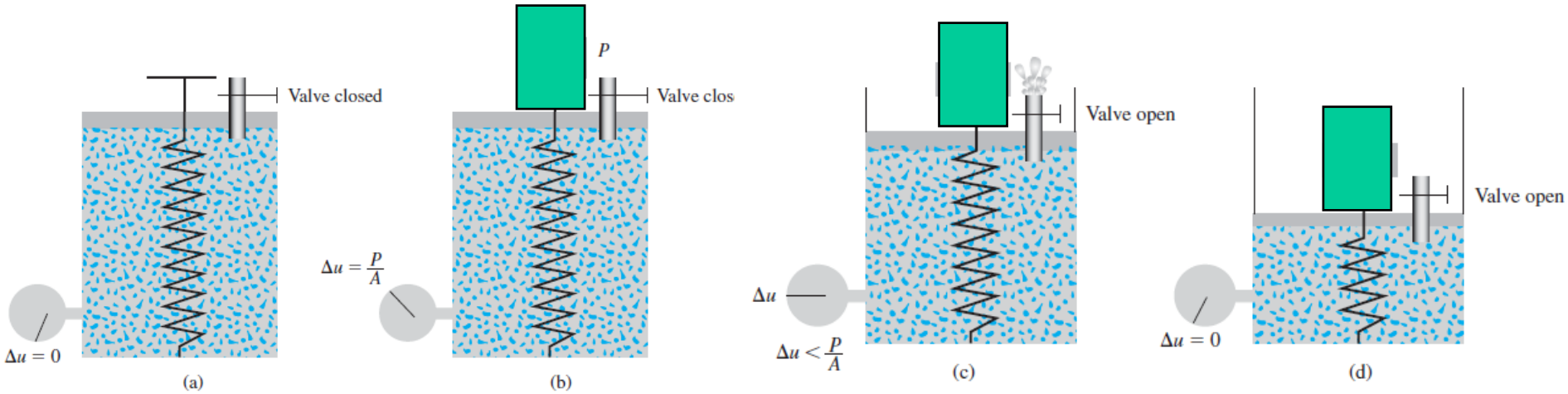
Stress carried by water → Pore water pressure = u

Stress carried by soil particles → Effective stress = σ'

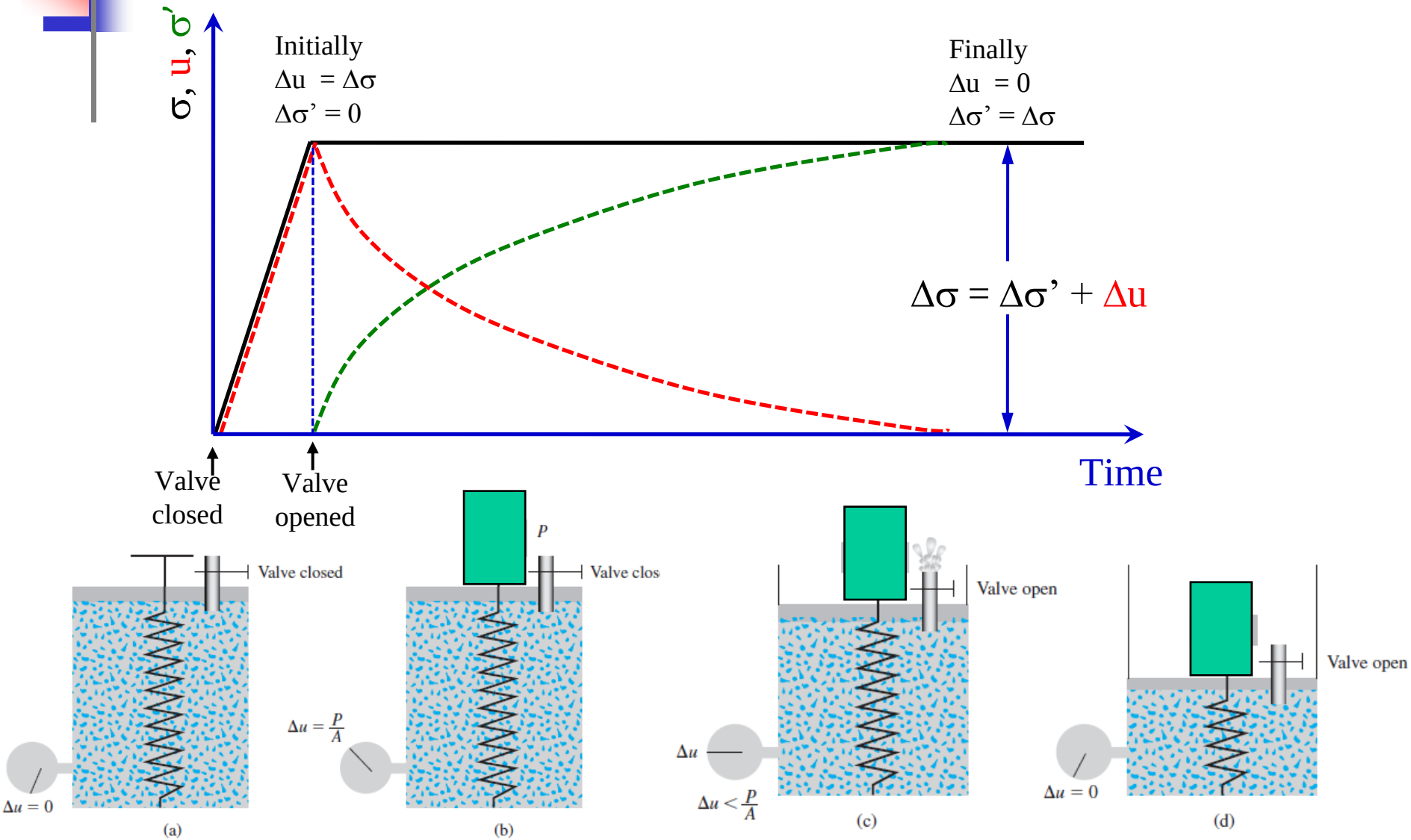
$$\sigma = \sigma' + u$$

OR

$$\sigma' = \sigma - u$$



Consolidation Model (Hydro-mechanical Analog)



Consolidation vs Compaction

Compaction	Consolidation
Applicable to *unsaturated soils*.	Applicable to *saturated soils*.
Decrease in *air voids* (not water voids)	Decrease in *water voids* (air voids do not exist).
Applicable for *both fine-grained and coarse-grained soils*	Only applicable for *fine-grained soils*
Instantaneous process	*Time-dependent* process Can occur over 100s of year.
May be accomplished by *rolling*, *tamping*, or *vibration*.	In general, caused by *static loading*.

CONCLUDED