EWCE 341

Principles of Soil Mechanics

EWCE 341

Stresses in Soils

EWCE 341

Stresses in soils

What we are going to discuss today?

- What is stress in soils?
- Stresses on a plane
- Types of stresses
- What is shear failure in soils?
- Types of shear failures
- Computation of vertical stress
- Problem

What is stress in soils ?

Stress:

- All civil Engineering projects **impart** loads on the ground that supports them.
- Loads produces **stresses in soils** ie **compressive stress**, **shear stress** and **even tensile stress**.
- A **stress** on the **soil** depends on the **load per unit area**.
- Construction of a foundation mainly increases the **stresses** on the **soil**.
- As the **stress** increases in the **soil**, the **soil** can be deformed by the **stress**. There are two **stresses** can acts on a plane: normal **stress** (σ) and shear **stress**(τ) .

Why stresses in soils are important to the Geotechnical Engineers?

Stresses in Soils

Induce Stresses:

- When a building is constructed, its weight is transmitted to the ground through the foundation and thus **induces stresses** in the under lying strata.

Additional Stresses:

- **Additional stresses** exist in the ground due to the weight of the overlying soils.

Importance of stresses to Geotechnical Engineers:

- **Induce stresses** might cause problems such as **shear failures** or **excessive settlement**.
- **Additional stresses** might cause problems such as **land slide**, **stability of slopes**.
- Both **depends on the differences** between these **stresses and the strength of soils.**

Shear Failure in Soils

- A shear failure is **defined as a foundation failure** that occurs when the **shear stresses in the soil exceed the shear strength of the soil.**

- When the **ultimate bearing capacity** of the soil is reached, it may fail in one of the following **three failure mode** depending upon the **type of soil** and **depth to width ratio** of the footing (i.e. D/B):

  -General Shear Failure
  -Local Shear Failure
  -Punching Shear Failure

General Shear Failure:

A slight downward movement of the footing **develops fully plastic zones** and a **sudden failure takes place** with a **considerable bulging** of the ground surface adjacent to the footing.

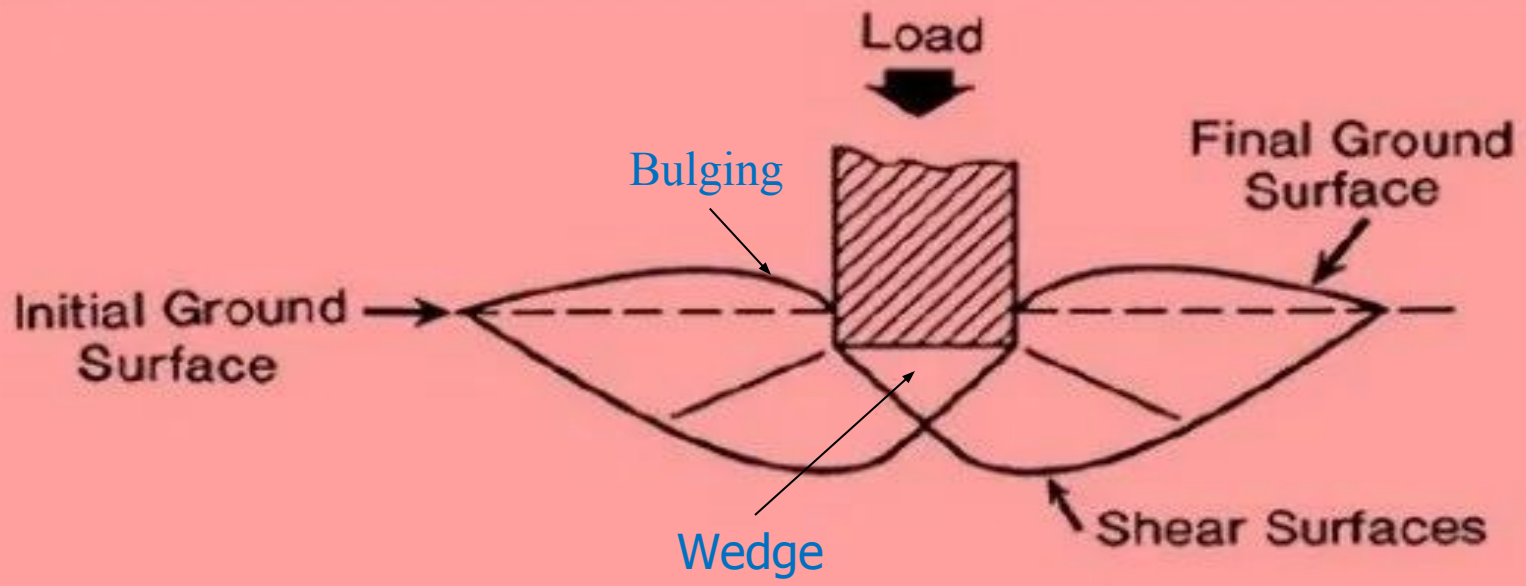
Characteristics of General Shear failure:

- **Well defined failure pattern**, consisting of a **wedge** and **slip surface** and **bulging (heaving) of soil** surface adjacent to the footing.

- **Sudden collapse occurs**, accompanied by tilting of the footing.

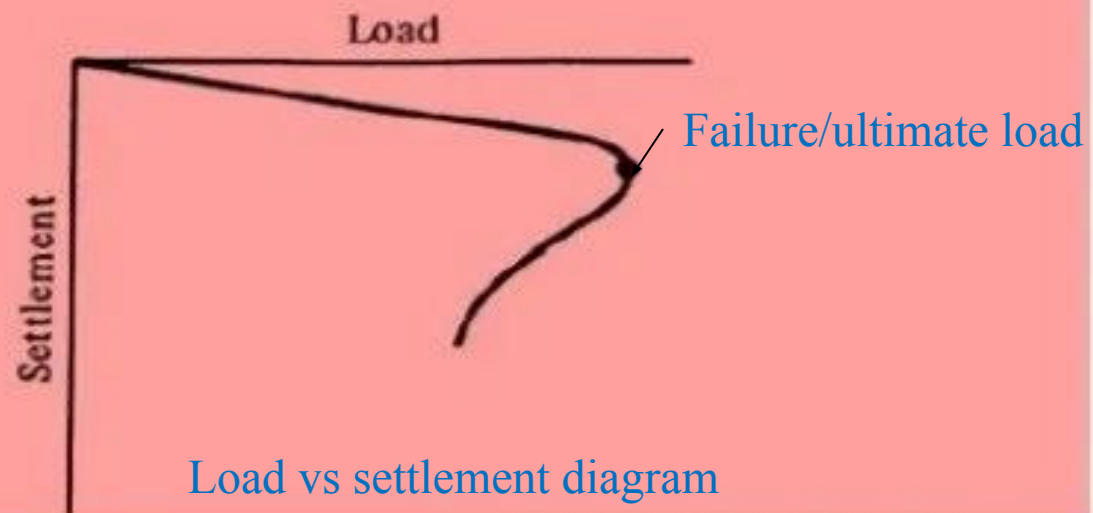
- Occurs in case of **dense sand or stiff cohesive soil** supporting the footing.
- **Failure load is well defined** in this case.
- **Load-settlement diagram** is similar to stress-strain for dense sand or over-consolidated clay as shown.
- **Ultimate load is well defined**.

General Shear Failure



Dense sand or stiff cohesive soils

/Slip surface



Load vs settlement diagram



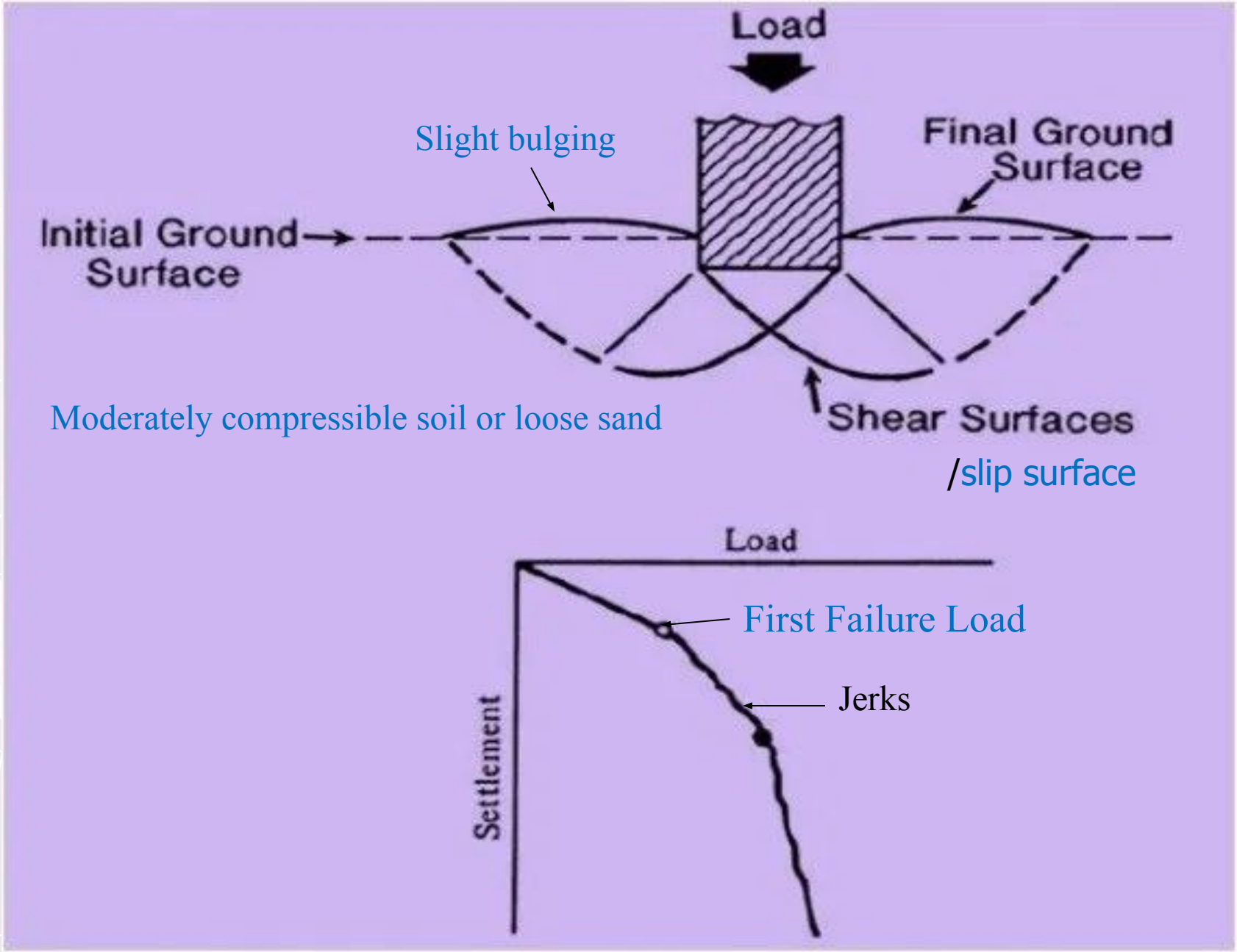
Local Shear Failure:

- Failure pattern consists of **wedge** and **slip surface** but is **well defined only under the footing**.
- **Slight bulging** of soil surface occurs:
- A **large deformation takes place under the footing** before the development of failure zones, i.e. large vertical settlement takes place before slight bulging of the ground surface.

Characteristics of Local Shear Failure:

- **Ultimate load is not well defined.**
- Occurs in **moderately compressible soils or loose sand**.
- **Yielding takes place** close to the lower edges of the footing.
- **Several yield developments may occur** accompanied by settlement in a series of **jerks**.
- Bearing pressure at which the first yield takes place is referred to as the **first-failure pressure or first failure load**.

Local Shear Failure







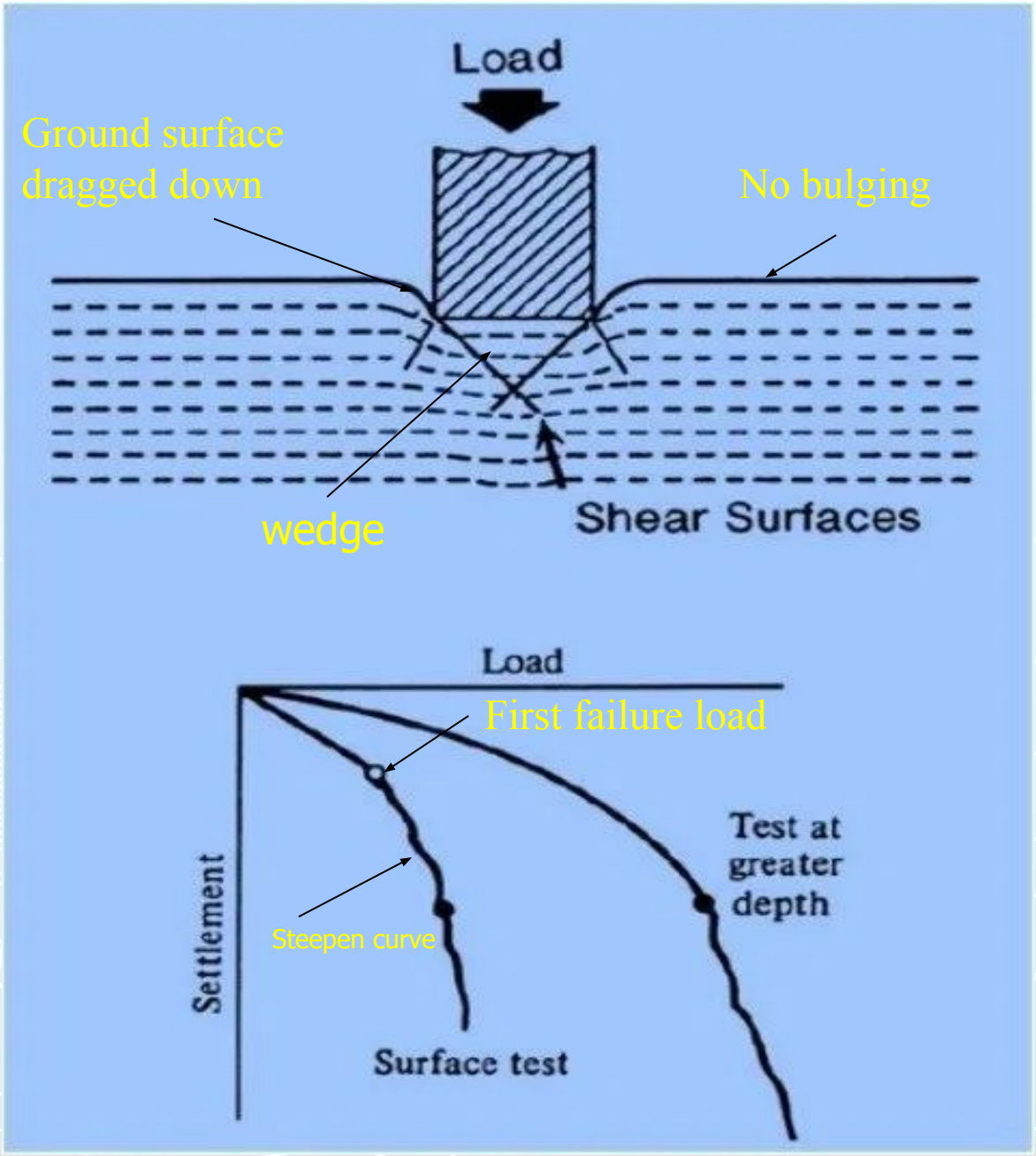
Punching Shear Failure:

- **Failure pattern is not well defined** in punching shear failure of soil.
- Failure takes place in weak compressible soils with considerable vertical settlement.

Characteristics of Punching Shear Failure:

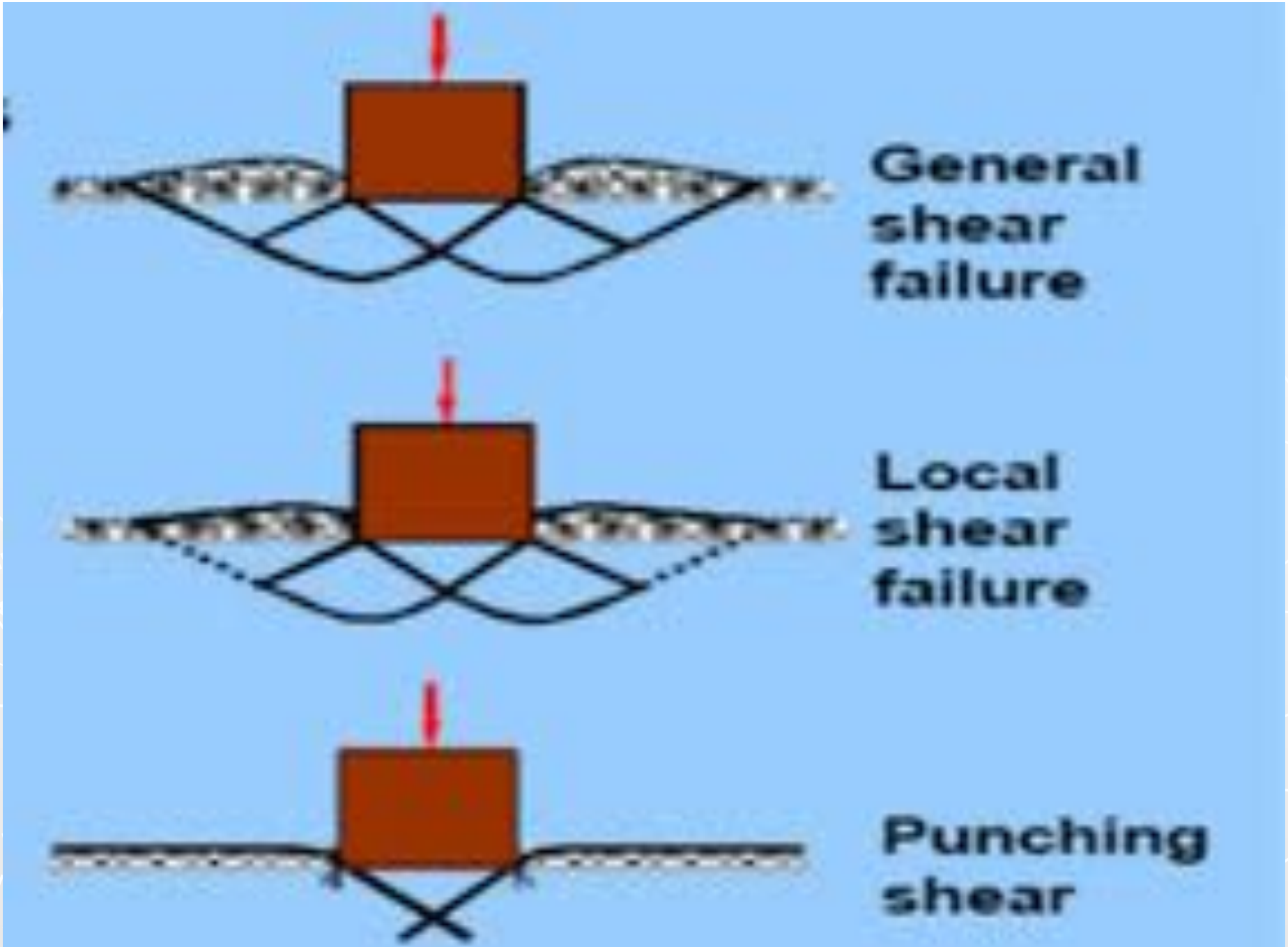
- **Yield surfaces are** adjacent to the sides of the foundation.
- **Failure take place immediately below footing** and surrounding soil remains relatively unaffected
- **Ground surface may be dragged down** thus, **no bulging** of the surface takes place.
- **Large settlements-ultimate load is not well defined**.
- After the first yield the **load-settlement curve** will steepen slightly.

Punching Shear Failure



Punching Shear Failure




General shear failure
Local shear failure
Punching shear

Land slide



Slope Stability



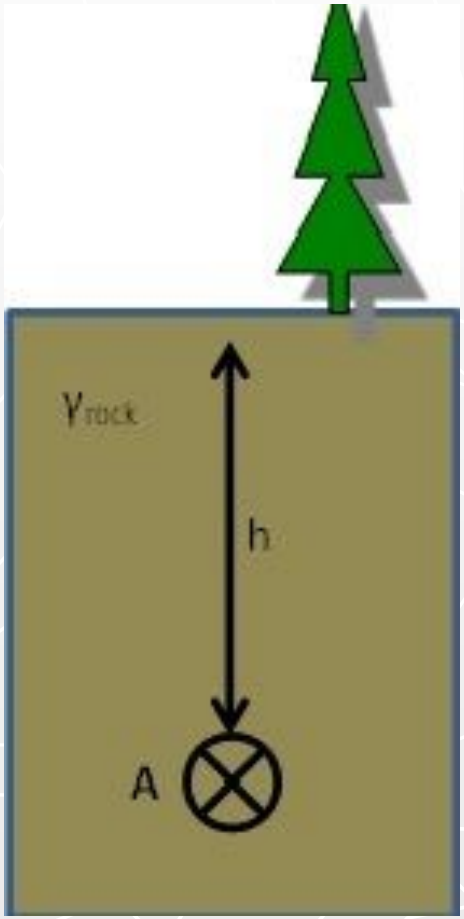
Describe the different sources of stresses in the ground.

Sources of Stresses in the Ground: Two broad categories:

Geostatic Stresses:

- Sometimes called **body stresses.**

- Occur due to the **weight of soil** above the point of being evaluated.



- **Naturally present** in the ground.

- Ac**tivity**, like placing of fills or making an excavation can cause them change.

- **Induced Stresses:**

  -Caused by the **external loads**.

  -Example: Structural foundation, vehicles etc.

  -**Usually caused by human activity**.

Only consider static stresses.

What are the geostatic stresses? Why these are important to geotechnical engineers?

Geostatic Stresses:

- **Caused by the gravity**, acting on the soils or rocks, so the **direct result** in a vertical stresses.
- Has **significant impact** on the engineering behavior of soils and frequently need to be computed.
- **Vertical normal stress** indirectly produces horizontal normal stress and shear stress.
- **Normal stress and shearing stress** are important to geotechnical engineers.

Geostatic stresses may be:

- Vertical stresses
- Horizontal Stresses
- Shear stresses.

How do you compute the geostatic vertical stress at a particular point in the ground?

Computation of Vertical Geostatic Stresses:

- Compute geostatic vertical stress at point P.
- Consider a column of soil that extends from the ground surface down to the point P.
- Column intercepts soil strata with unit weight $\gamma_1, \gamma_2, \gamma_3$

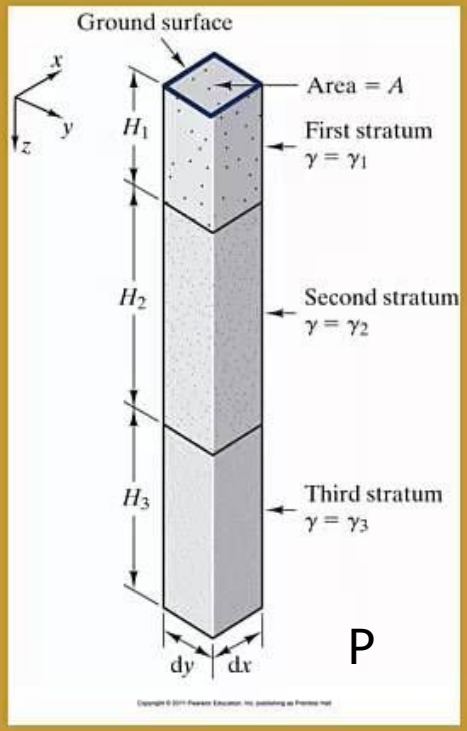
so weight of the soil column:

$$W = dxdy \sum \gamma H = A \sum \gamma H$$

- Geostatic vertical stress at bottom of the soil column,

$$\sigma_z = \frac{W}{A} = \frac{A \sum \gamma H}{A} = \sum \gamma H$$

Computing vertical geostatic stress



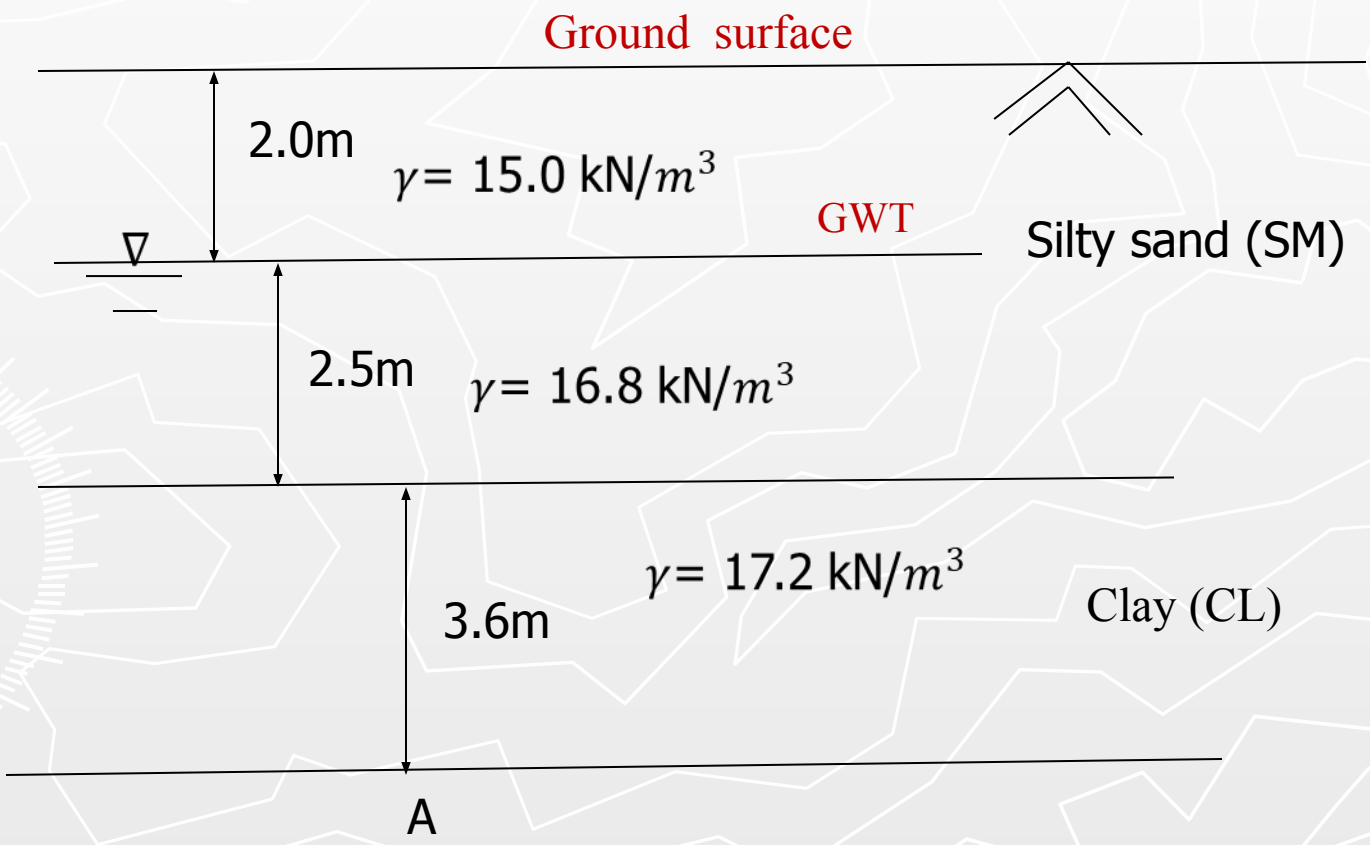
- Total weight of soil column, W

$$W = \sum V_i \gamma_i$$

$$V_i = H_i dx dy$$

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Compute vertical normal stress at point A, shown in the following figure (soil profile).



Solution:

$$\sigma_z = \sum \gamma H = 15.0 \times 2.0 + 16.8 \times 2.5 + 17.2 \times 3.6$$

$$= 133.92 \approx 134 \text{ kN/}m^2\text{(kPa)}$$

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Thank you