Lecture Goals

- Students will be able to:
  - recognize types of shallow foundations,
  - examine the limits of foundation settlement,
  - estimate the ultimate bearing capacity of shallow foundations, and
  - estimate the influence of groundwater on the bearing capacity of shallow foundations.

Reading List

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Shallow Foundations

- **Purpose**
  - Redistribute structural loads over an area

- **Type**
  - Strip footing
  - Pad footing
  - Combined footing
  - Raft or mat foundation

Foundation Settlement

- **Limits on uniform displacement**
  - Concern for buried infrastructure and utilities

- **Limits on non-uniform displacement**
  - Structural serviceability concerns

- **Typically Controls Design**
  - Total settlement
  - 25mm to 50mm
  - Differential settlement
  - $\Delta / \text{span length} = 1/500$ to $1/150$

Foundation Settlement Calculations

- **Cohesionless Soil**
  - Elastic deformation
  - Pore pressures can dissipate
  - SPT

- **Cohesive Soil**
  - Elastic deformation
  - Pore pressure, deformation at constant volume
  - Consolidation methods

- **Settlement Analysis**
  - One-dimensional
  - Three-dimensional
Bearing Capacity

- Limit State
  - Capacity and stability

- Failure Mechanisms
  - General
    - Dense sand, stiff clay
    - UU & CU conditions
  - Local
    - Transitional mode
    - Punching
      - Compressible soil
      - Loose sand, sensitive clay
      - CD conditions

Bearing Capacity – Terzaghi

- Considerations
  - Strip Footing
    - Infinite soil layer depth
    - Uniform soil strength properties
  - Extended Applications
    - Square footing
      - \( q_u = c N_c + q N_q + 0.4 \gamma B N \gamma \)
    - Circular footing
      - \( q_u = 1.3 c N_c + q N_q + 0.3 \gamma B N \gamma \)

Bearing Capacity Factors

- Smooth Base
  - Cohesion
    - \( N_c = \left( N_q - 1 \right) \cot \phi' \)
  - Surcharge
    - Exact
      - \( N_q = e^{s u r f a c e} \tan i \left( 45 + \frac{\phi'}{2} \right) \)
  - Soil density
    - Vesic (1975)
      - \( N_q = 2 \left( N_q + 1 \right) \tan (\phi') \)
Bearing Capacity Factors

- Rough Base
  - Cohesion
  - Exact
    \[ N_c = \left( N_q - 1 \right) \cot \phi' \]
  - Surcharge
  - Exact
    \[ N_q = e^{1.5 \phi' - \phi' \tan \left( \frac{45 + \frac{\phi}{2}}{2} \right)} \]
  - Soil density
    Bowles (1968)
    \[ N_y = 1.1 \left( N_q - 1 \right) \tan (1.3 \phi') \]

Bearing Capacity Factors

- General shear failure

General Bearing Capacity – Meyerhof's Factors

- Additional Considerations
  - Footing shape
  - Footing depth
  - Footing inclination
  \[ q = \lambda \beta \lambda' \gamma' N_c + \lambda' \beta' \lambda'' N_q + \frac{1}{2} \beta' \lambda' \lambda'' N_y \]
Bearing Capacity – Undrained Conditions

- Terzaghi
  - $\phi' = 0^\circ$
  - $\tau = s_u$
  - $N_q = 0$
  - $N_c = 1$
  - $N_c = 5.70$

- Meyerhof
  - $\phi' = 0^\circ$
  - $\tau = s_u$
  - $N_q = 0$
  - $N_c = 1$
  - $N_c = 5.14$
  - $\lambda_{uu} = \lambda_{yd} = 1$

$q_u = c'N_c + qN_q + \frac{1}{2} \gamma B N_y$
$q_u = 5.70 s_u + q$

Factor of Safety – Bearing Capacity

- Gross Allowable Capacity
  - $FS = 2.5$ or $3.0$

- Net Allowable Capacity

- Design Capacity

$q_{net} = q_u - q = q_u - \gamma D$

Design Considerations

- Unequal Surcharge
  - Use lesser value

- High Water Table
  - More complex loading

$q_u = c'N_c + qN_q + \frac{1}{2} \gamma B N_y$

Handy and Spangler (2007)
### Design Considerations

- **Footing on a Slope**

- **Non-Uniform Soil Properties**
  - Strength variation with depth
  - Fissured clays
  - Layered soils

### References