University of Tennessee at Chattanooga

ENCE 461
Foundation Analysis and Design

Spring 2002

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http://www.vulcanhammer.net/utc/

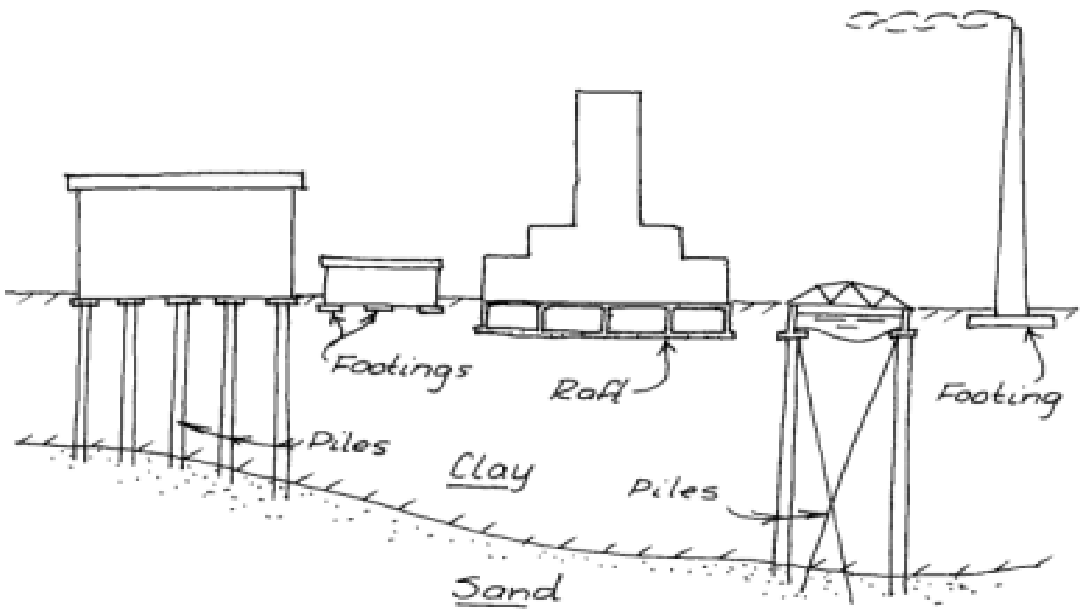
Catalog Description

- Fundamentals of soil mechanics as applied to the analysis and design of foundation systems
- Subsurface investigations
- Design of shallow and deep foundations
- Retaining structures and lateral earth pressures.

Textbook and Reference Books

- Required Textbook
  - McCarthy, D.F., *Essentials of Soil Mechanics*, 6th ed, 2002, Prentice Hall, Columbus, Ohio.
- Recommended Textbook
  - Coduto, D.P. *Foundation Design: Principles and Practices*, 2nd ed. Upper Saddle River, NJ: Prentice Hall, 2001.
- Reference Book
  - NAVFAC DM 7.02, *Foundations and Earth Structures*. Naval Facilities Engineering Command, Alexandria, Virginia, 1986.
  - Available from vulcanhammer.net website

Line Drawing Credit



Dr. Bengt Broms
Foundation Design
http://www.geoforum.com/

Evaluation

- Homework: 25%
  - Due date for homework assignments will be announced when assignment is given.
  - Homework turned in after due date will have 10% deducted from grade for each class period late.
  - Homework turned in after last class session will be given a grade of zero.
- Mid-Term Exam: 15%
- Final Exam: 19%
- Design Project: 25%
- Four (4) Unannounced Quizzes @ 4% each: 16%

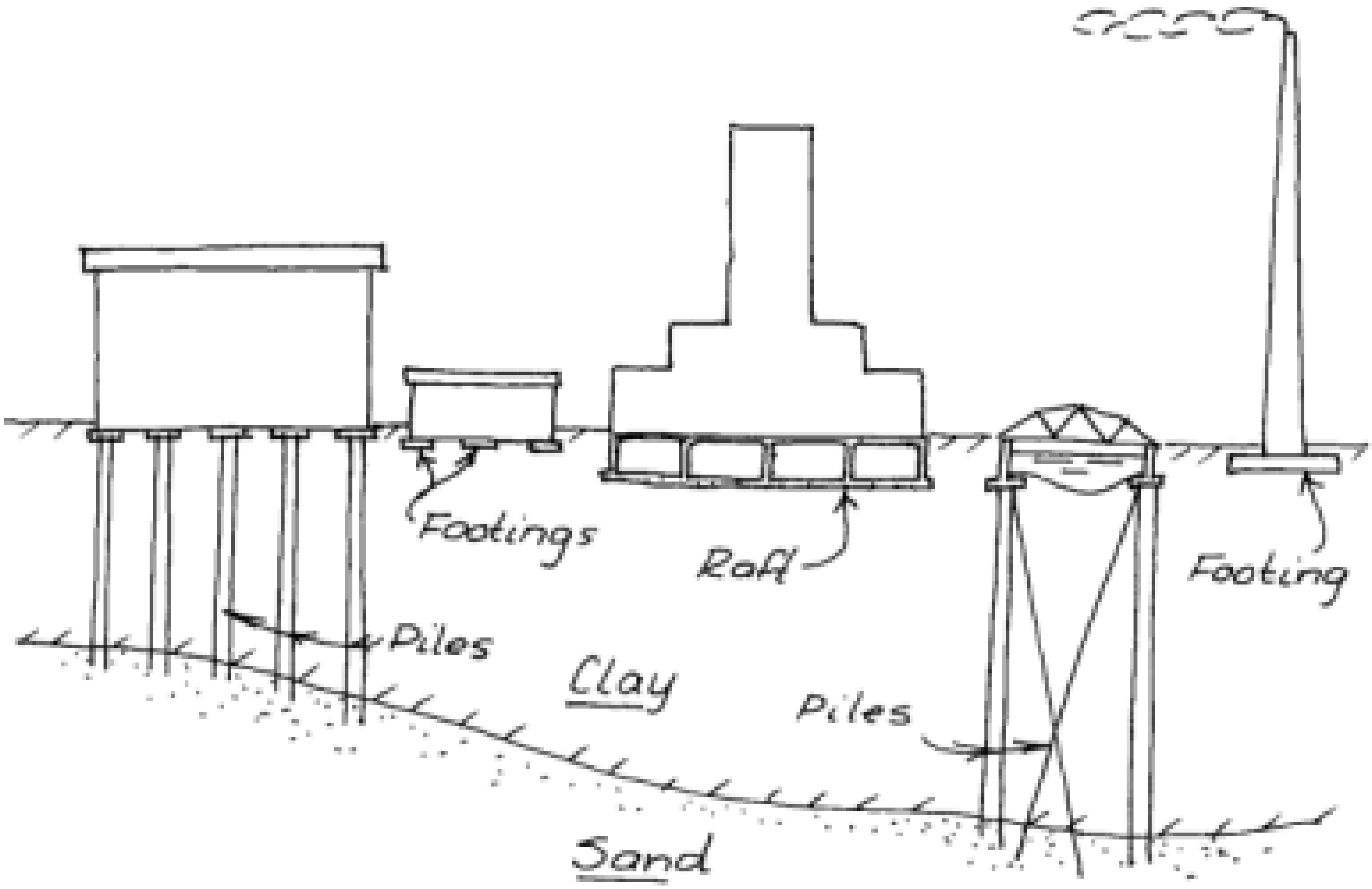
Appearance of Work

- All homework and tests must be on engineering paper.
- Homework and tests must conform to format given in syllabus. Failure to do so will result in reduced credit.
- Each time you use an equation, write down what it is: don't just put a bunch of numbers on the page and expect anyone to know what you did. This too will result in reduced credit.

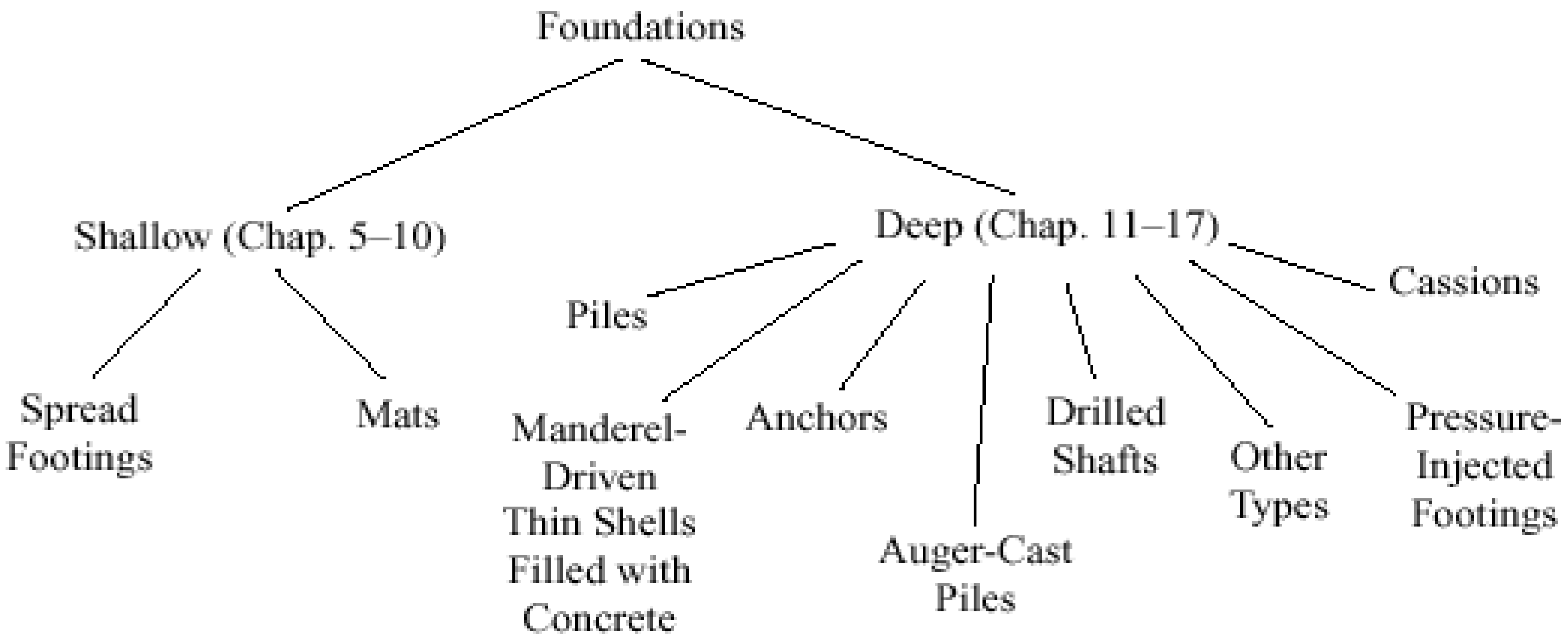
Honour System

- You are encouraged to work homework with someone but your turned in work must be your own work.
- You are studying now so that you may enter and practice the engineering profession later. The engineering profession is highly regarded by the public because those who practice it do so with ethical and social consciousness. The same is expected of students in this course. Any direct copying of homework, tests or exams will be considered a violation of the honour code and a course grade of “F” will be given.

Types of Foundations



Types of Foundations



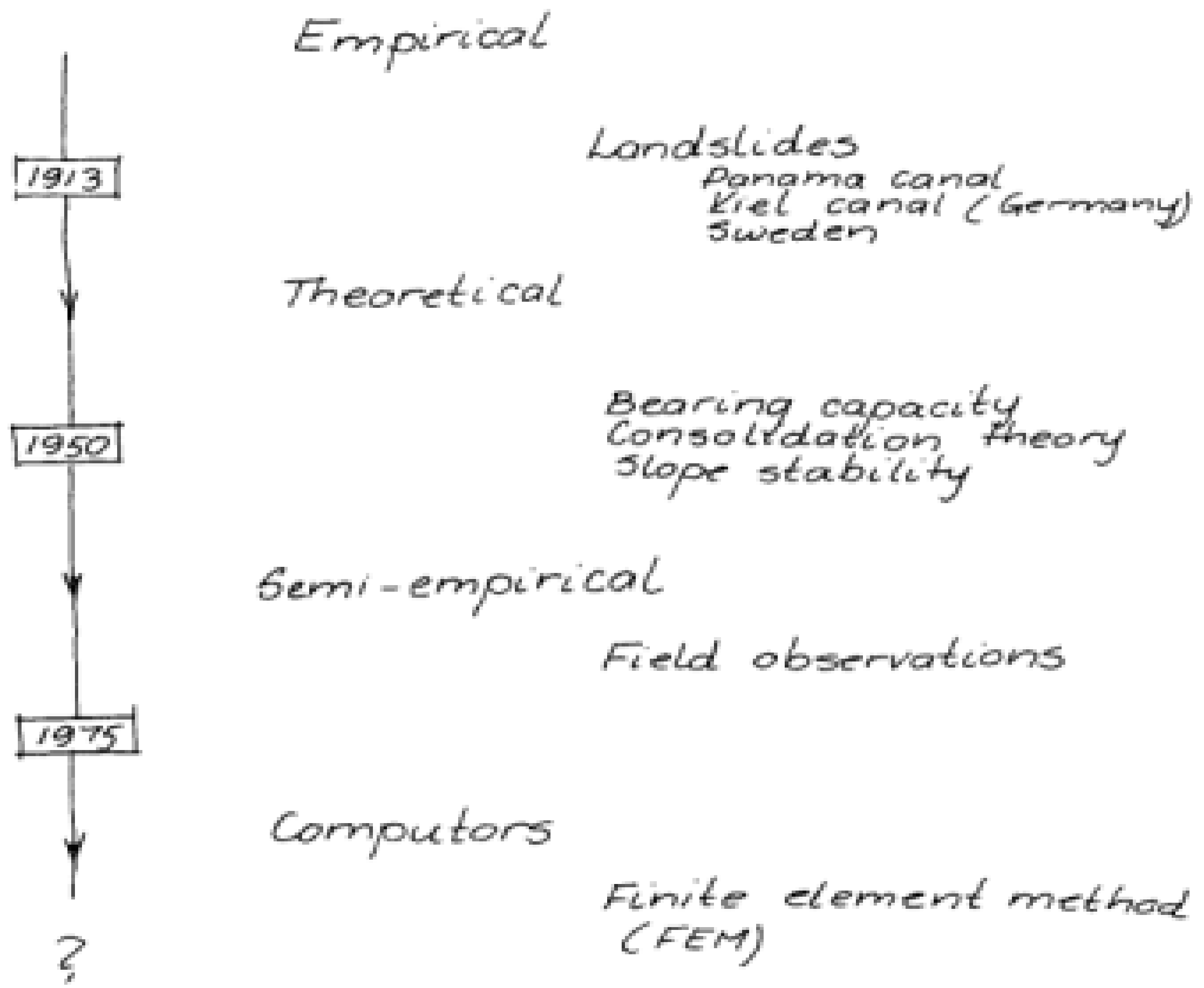
Types of Foundations

- Shallow Foundations
  - Spread Footings
  - Mat or Raft Foundations
  - Suitable when soil has sufficient bearing capacity at or near grade, either naturally or by soil improvement
- Deep Foundations
  - Driven Piles
  - Drilled Shafts
  - Caissons
  - Required when shallow foundations will not carry the load

Types of Foundations

- Floating Foundations
  - Used when displaced soil and groundwater weight is sufficiently large to « float » the foundation on the surface
- Lateral Earth Retaining Structures
  - Gravity Walls
  - Gabion Walls
  - Sheet Piling Walls
  - Reinforced Earth Walls
  - Slopes (supported and unsupported)
  - Used for necessary elevation changes of structure(s)

Methods of Foundation Analysis



Sources of Information for Solution of Foundation Problems

- Experience obtained by trial and error in the past; this developed into the empirical or "rule of thumb" procedures for today. The weakness of this approach is not recognizing differences in the engineering properties of soils. What works well at one location may not succeed with the same type of soil at another location.
- Information on the properties of soils; generally obtained by field explorations and laboratory tests. Subsequent, theoretical analysis results will only be as good as the soils data used as input.
- Scientific principles from various fields of engineering and science; used to explain or predict the behaviour of soils under various conditions.

Considerations for Foundation Design

1. Economical

2. Edequate safety (F_s)
   (Bearing capacity, sliding, overturning etc)

3. Small settlements
   (Total and differential settlements)

4. Small seasonal changes
   (drying, frost, heave)

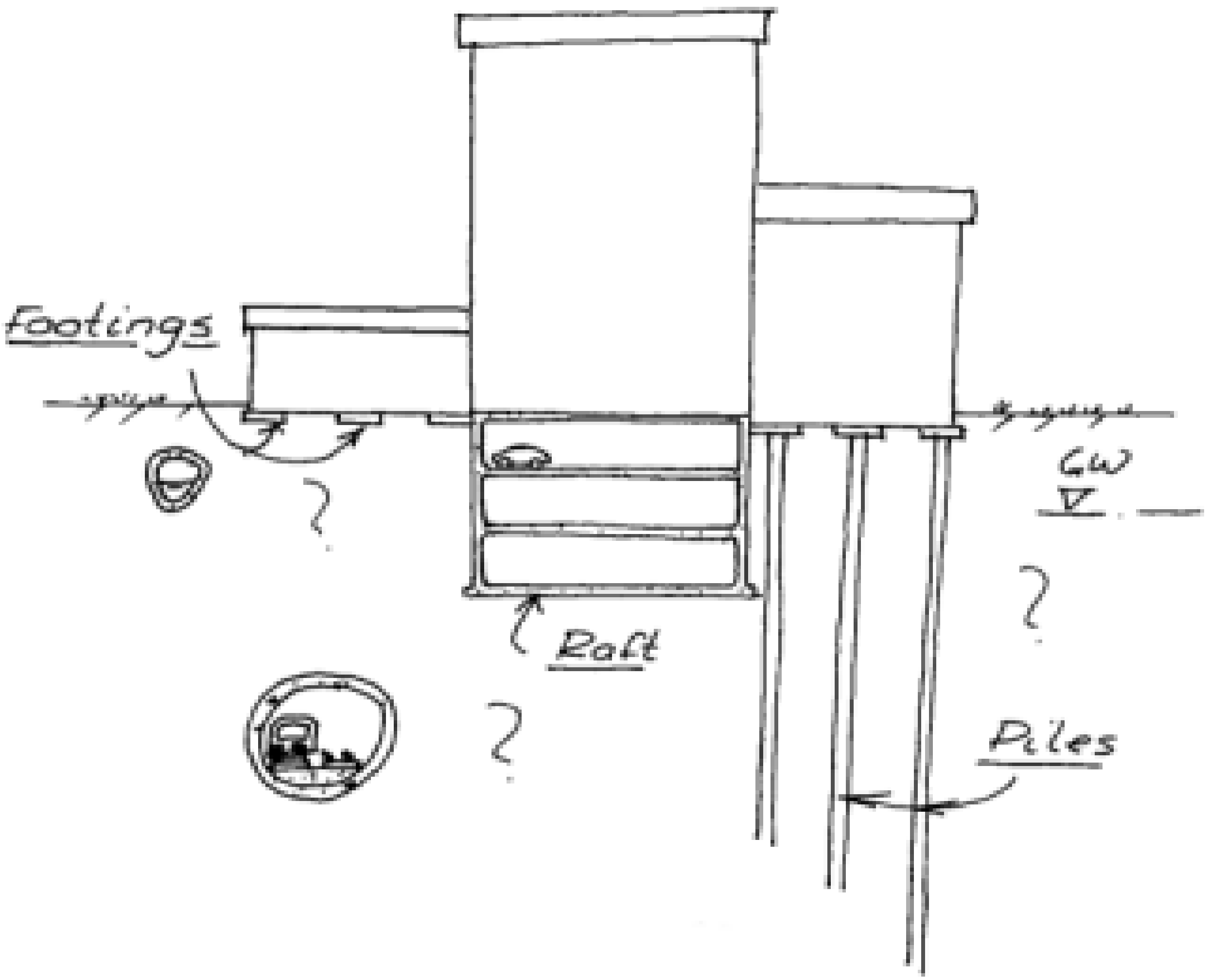
5. Construction problems (stability of excavation, bottom heave, ground water problems, vibrations, noise etc)

6. Environmental effects
   (E.g. permanent lowering of the ground water level)

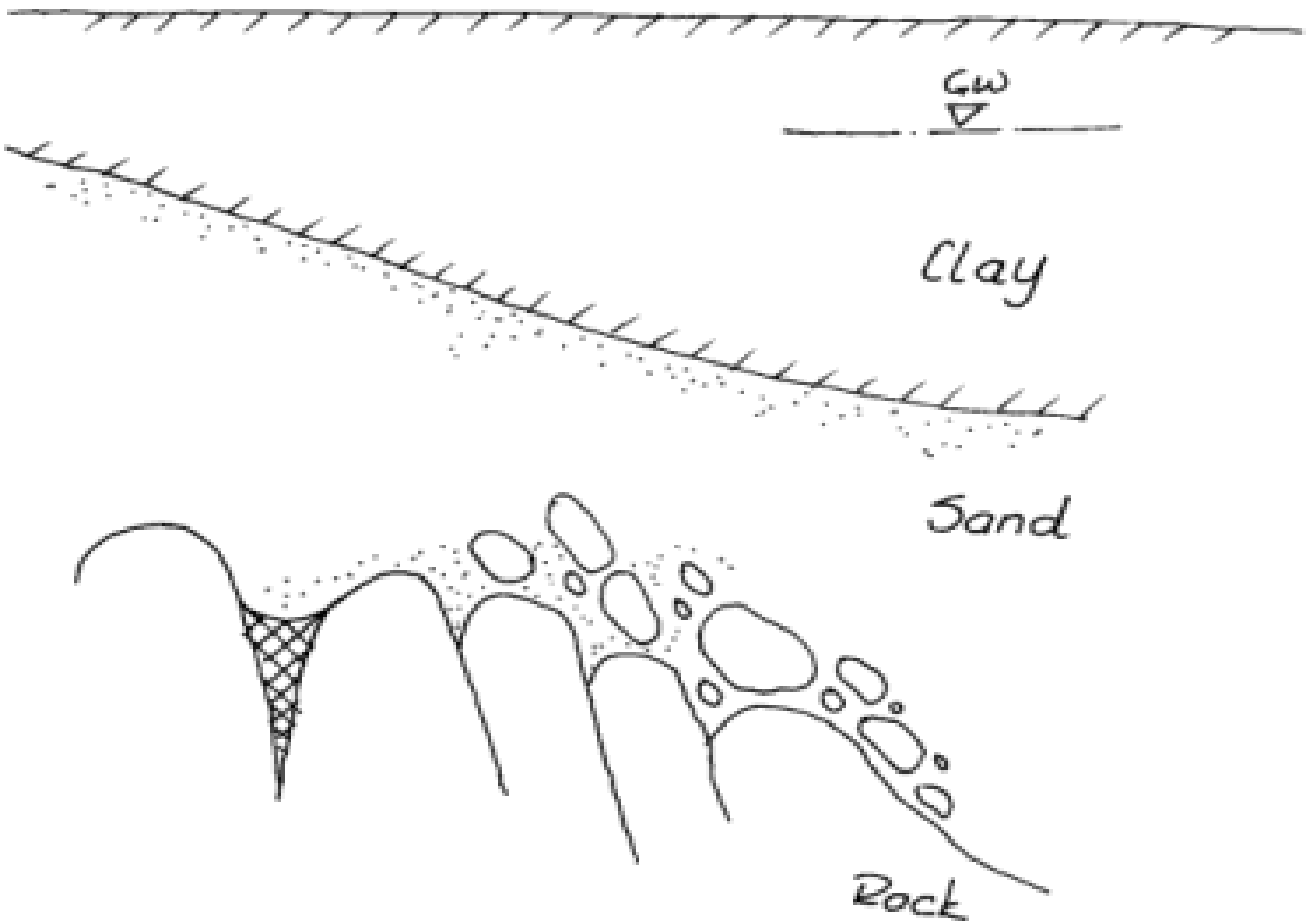
What to Analyse in Foundation Design

- Components of Foundation Design
  - Structural capacity of foundation materials and structures
  - Bearing or friction resistance of soils
- Modes of Failure
  - Bearing Failure (usually catastrophic)
  - Settlement Failure (usually not catastropic but damage to supported structure results)

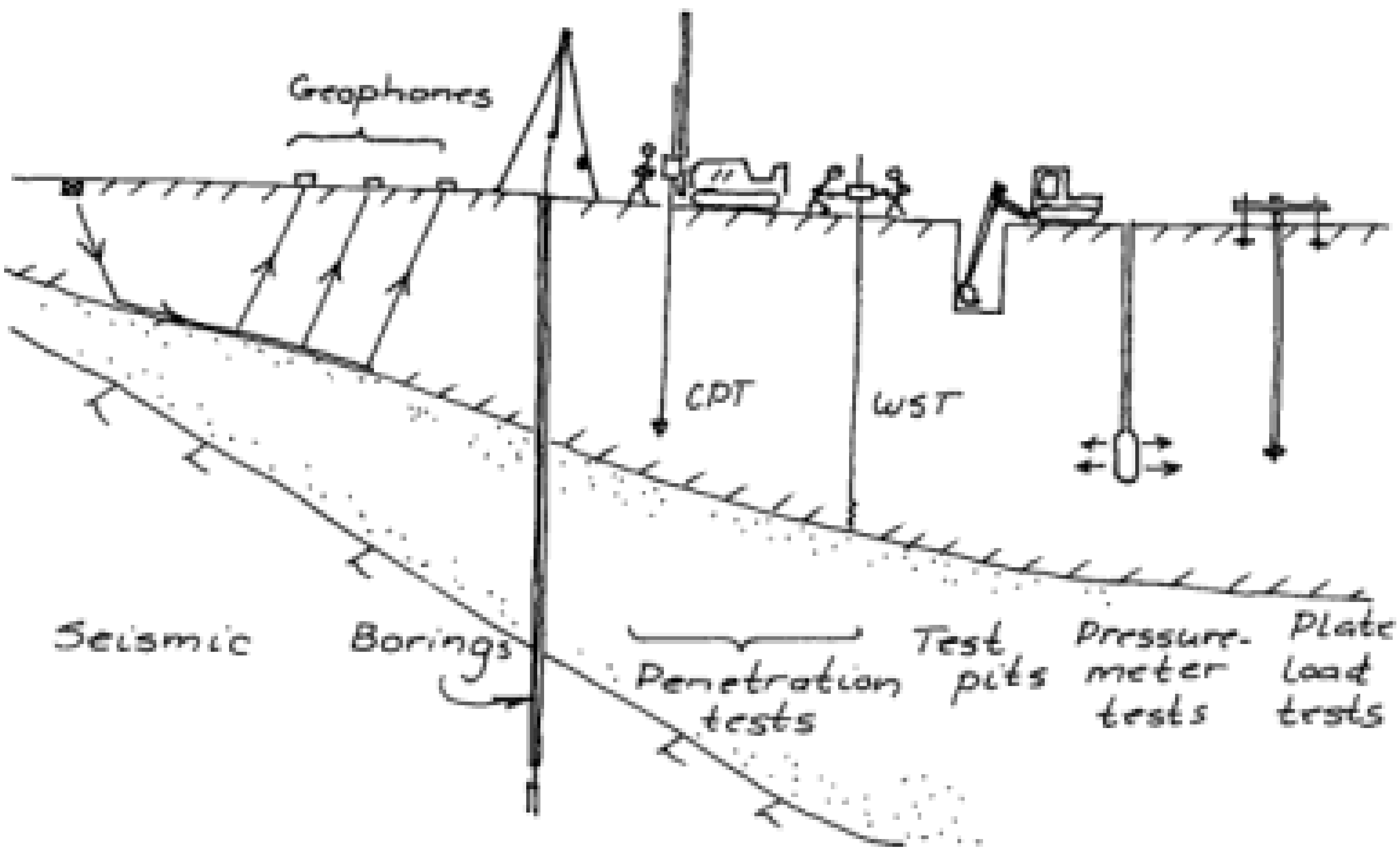
Selecting a Foundation Type



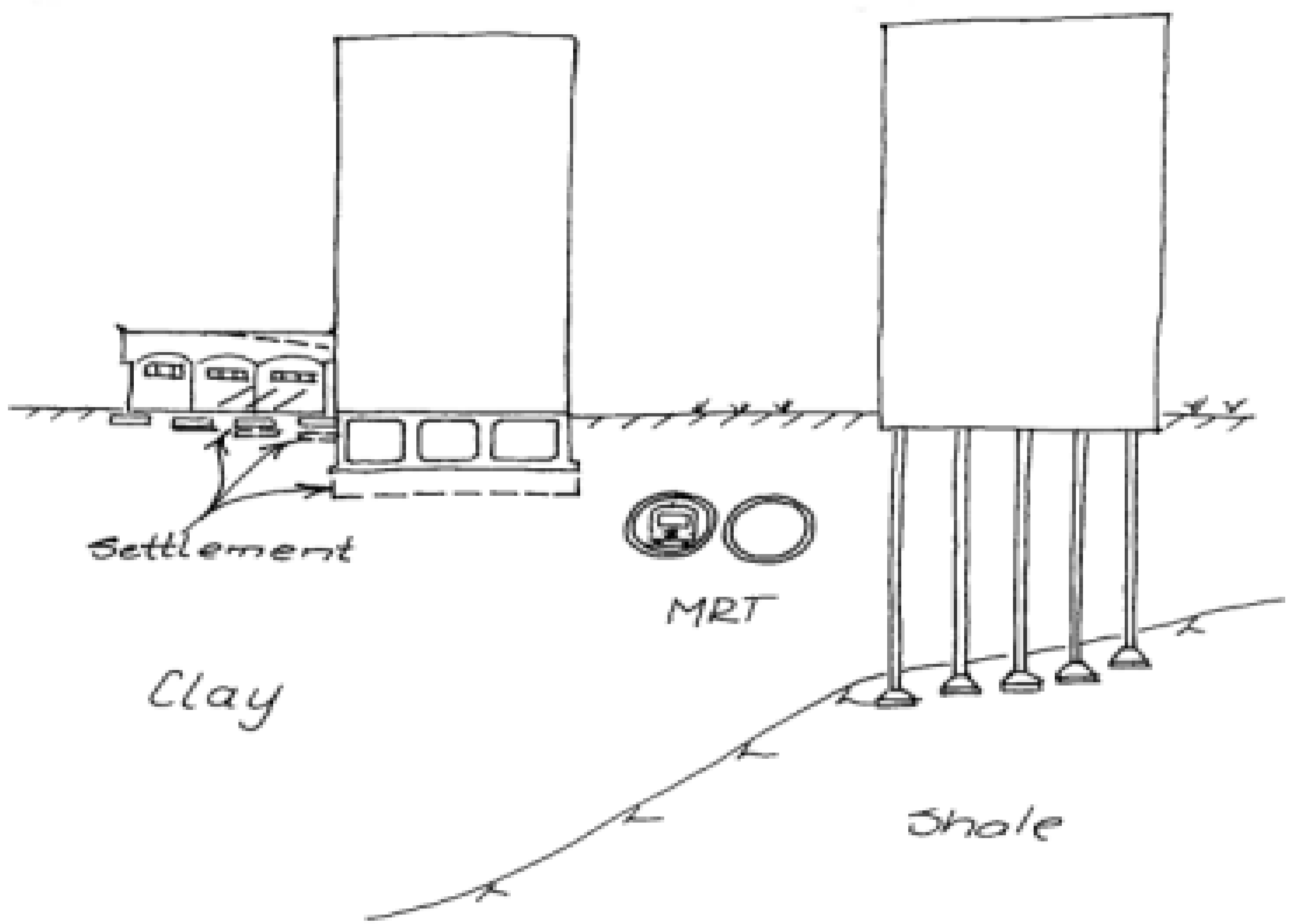
Typical Soil Profile



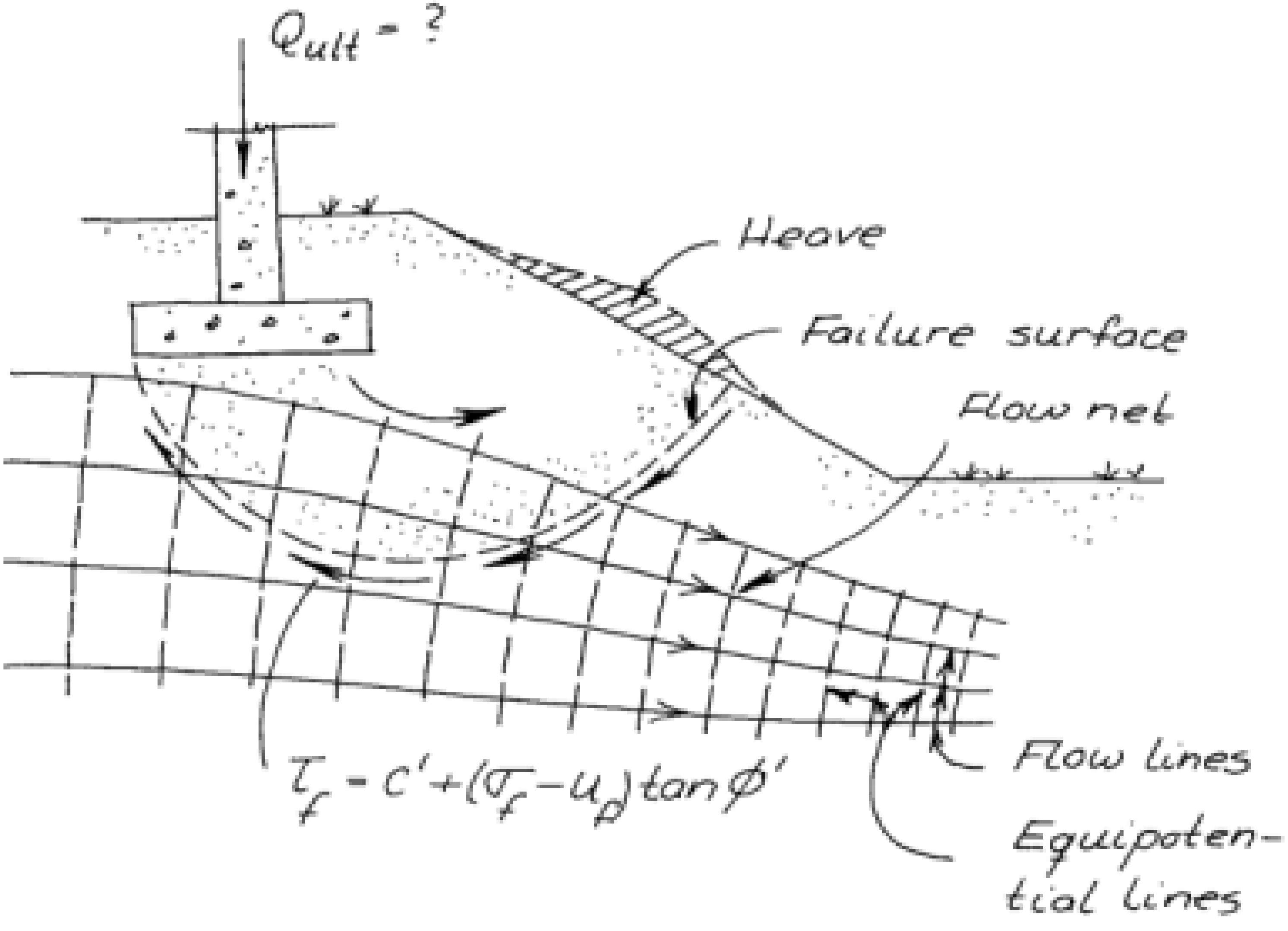
Methods of Analysis of Soil Properties



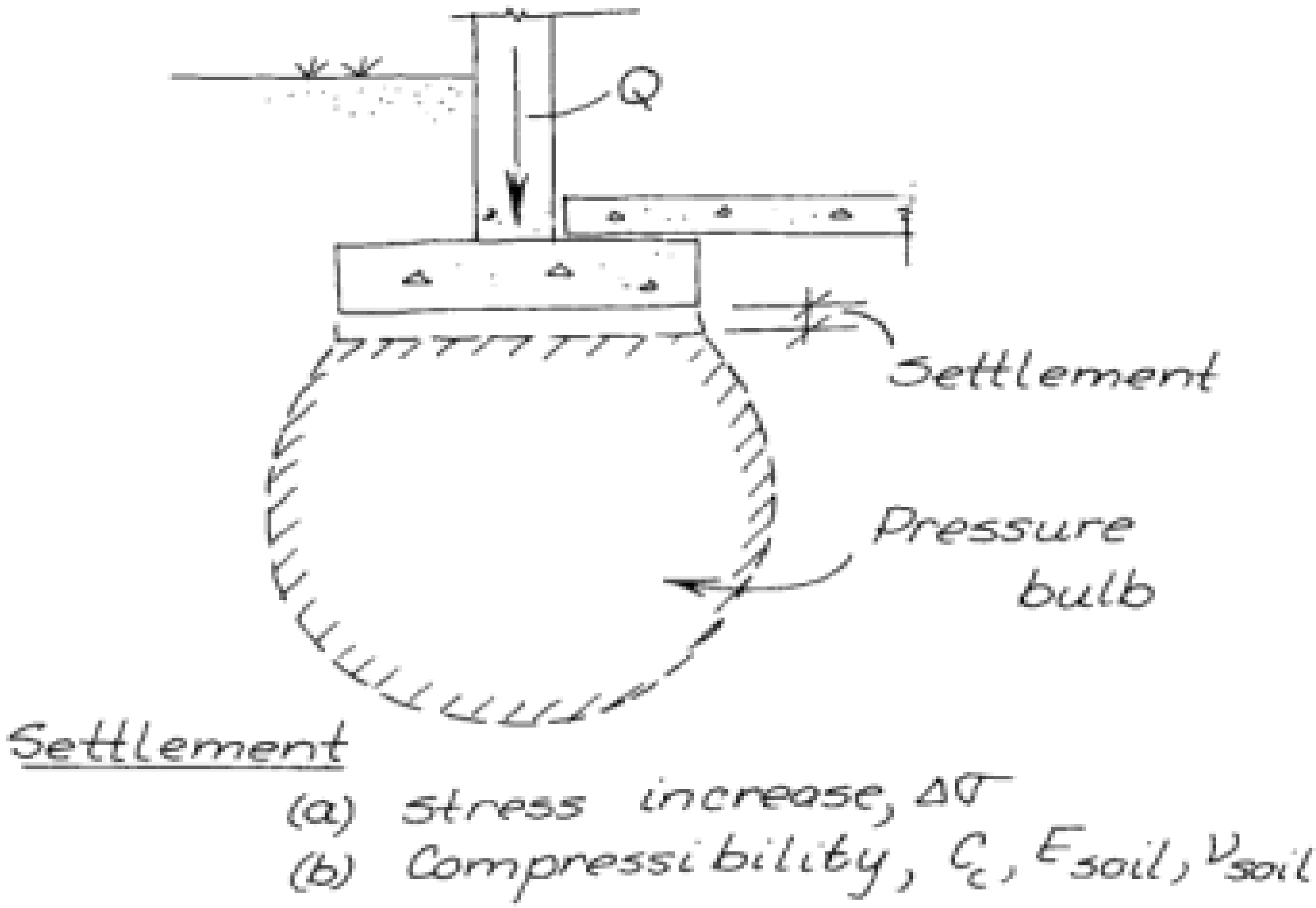
Consideration of Neighbouring Underground Structures



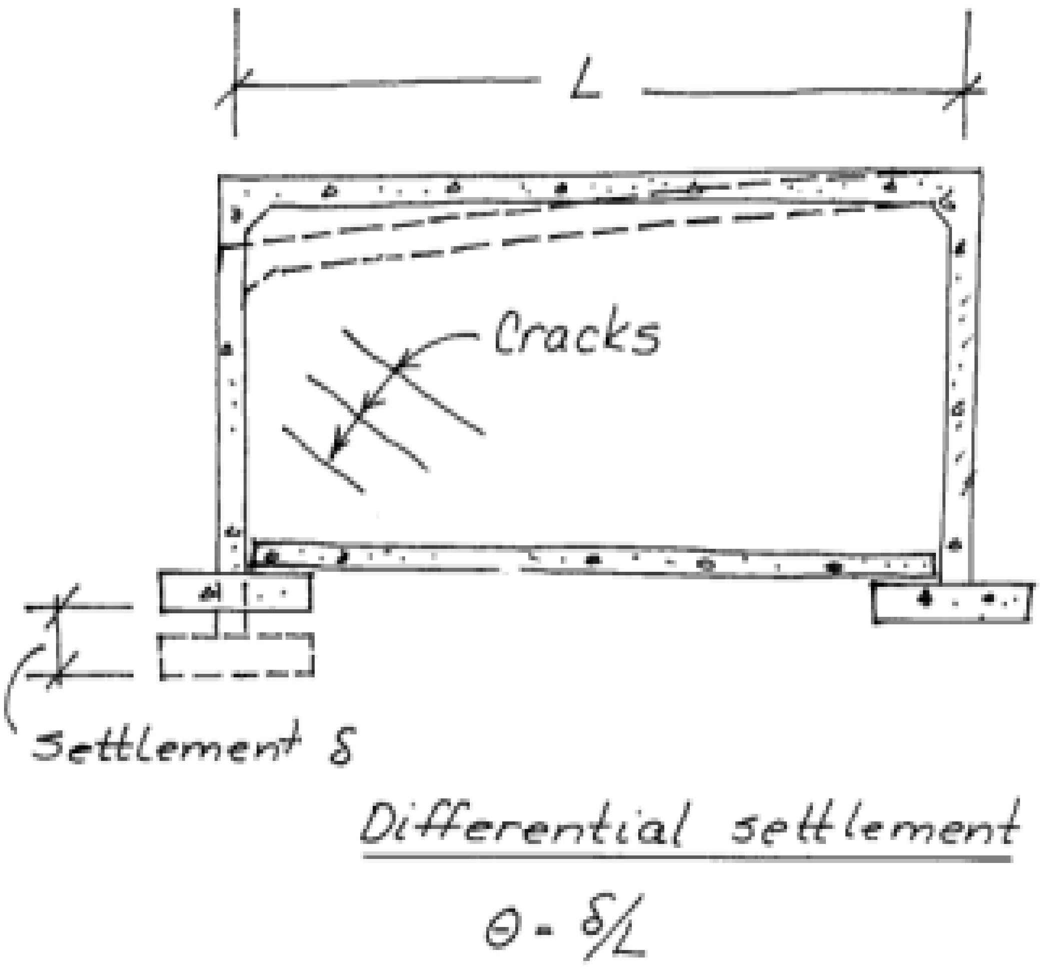
Foundations Around Slopes



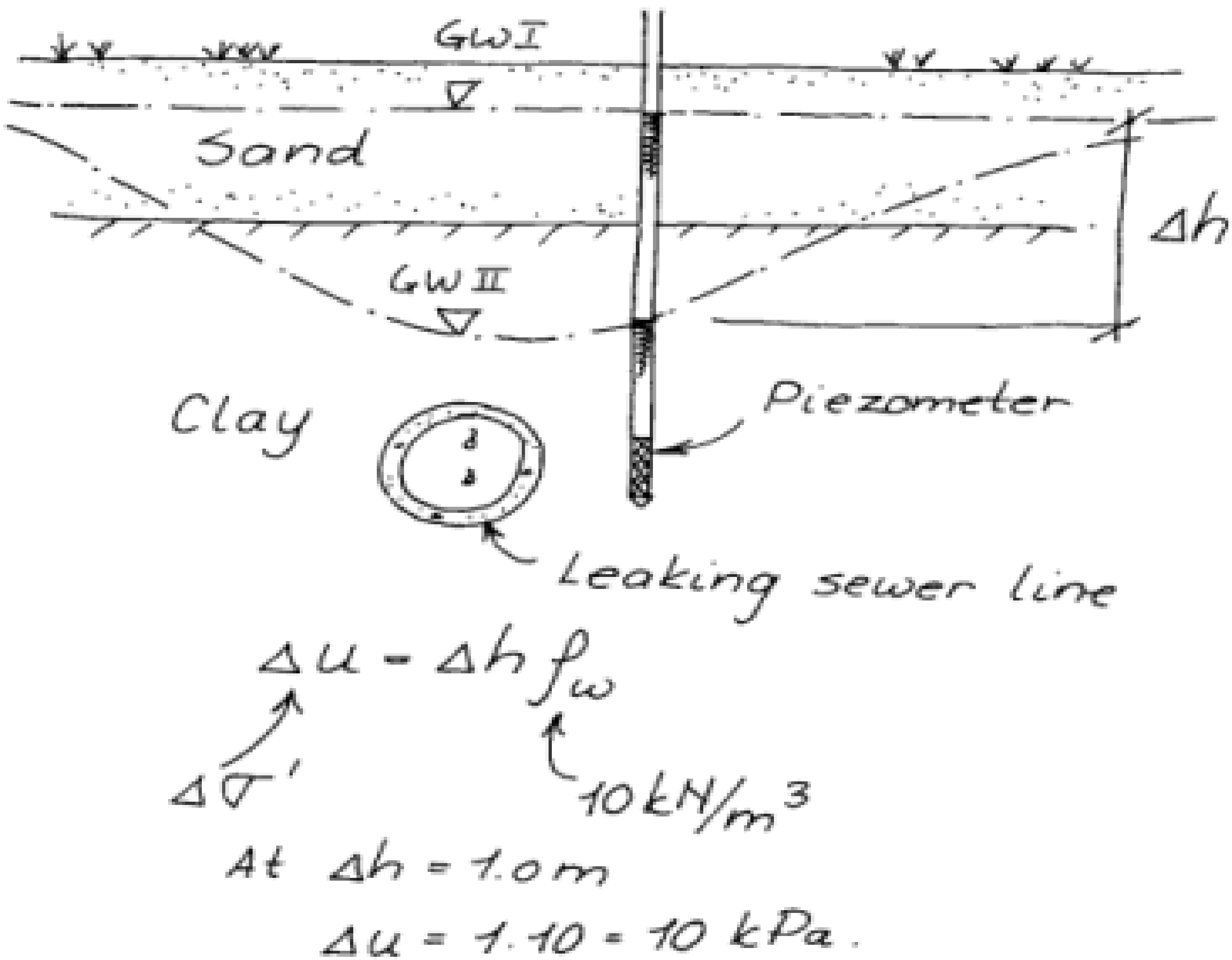
Failure by Soil Failure or Excessive Settlement?



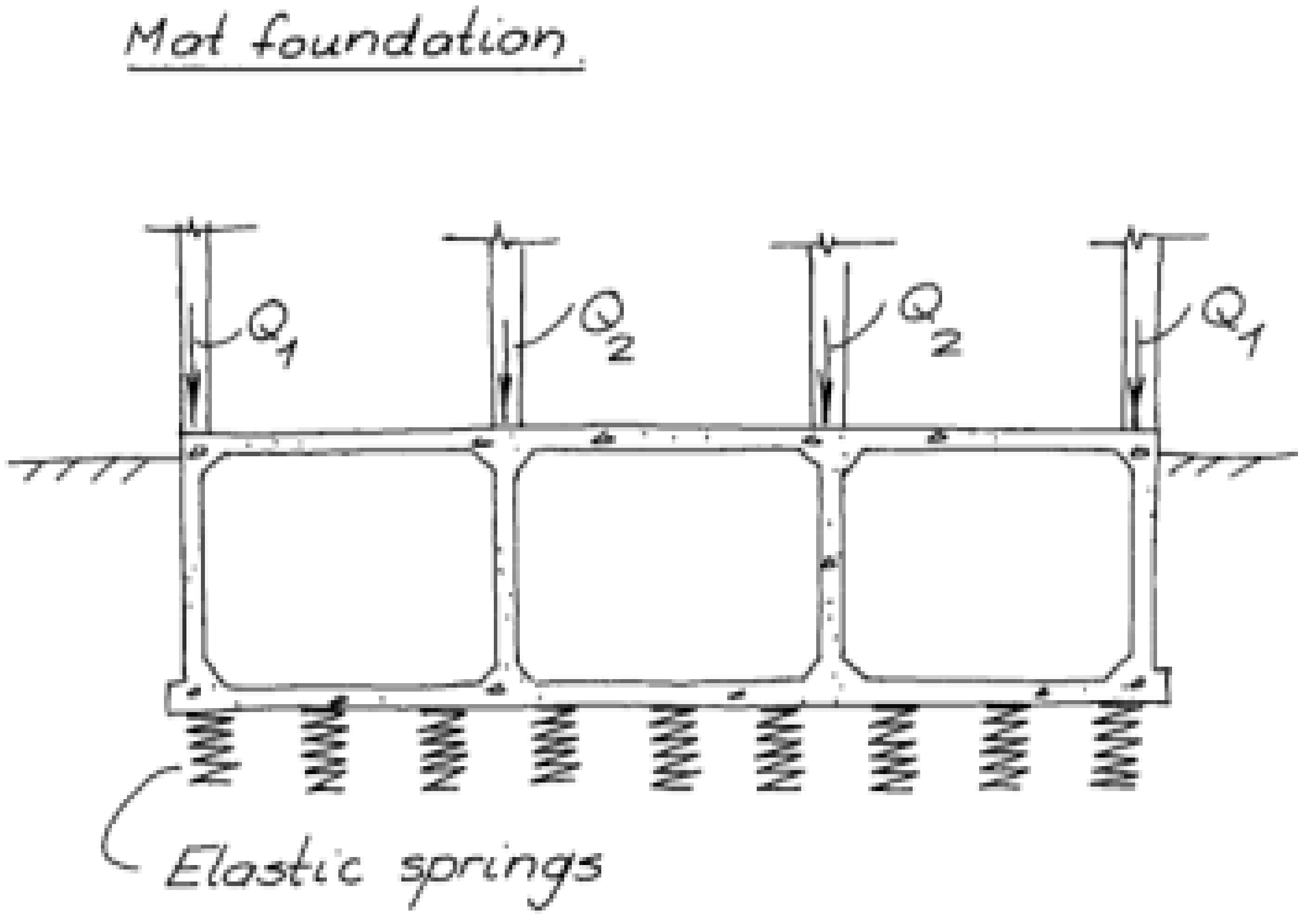
Differential Settlement



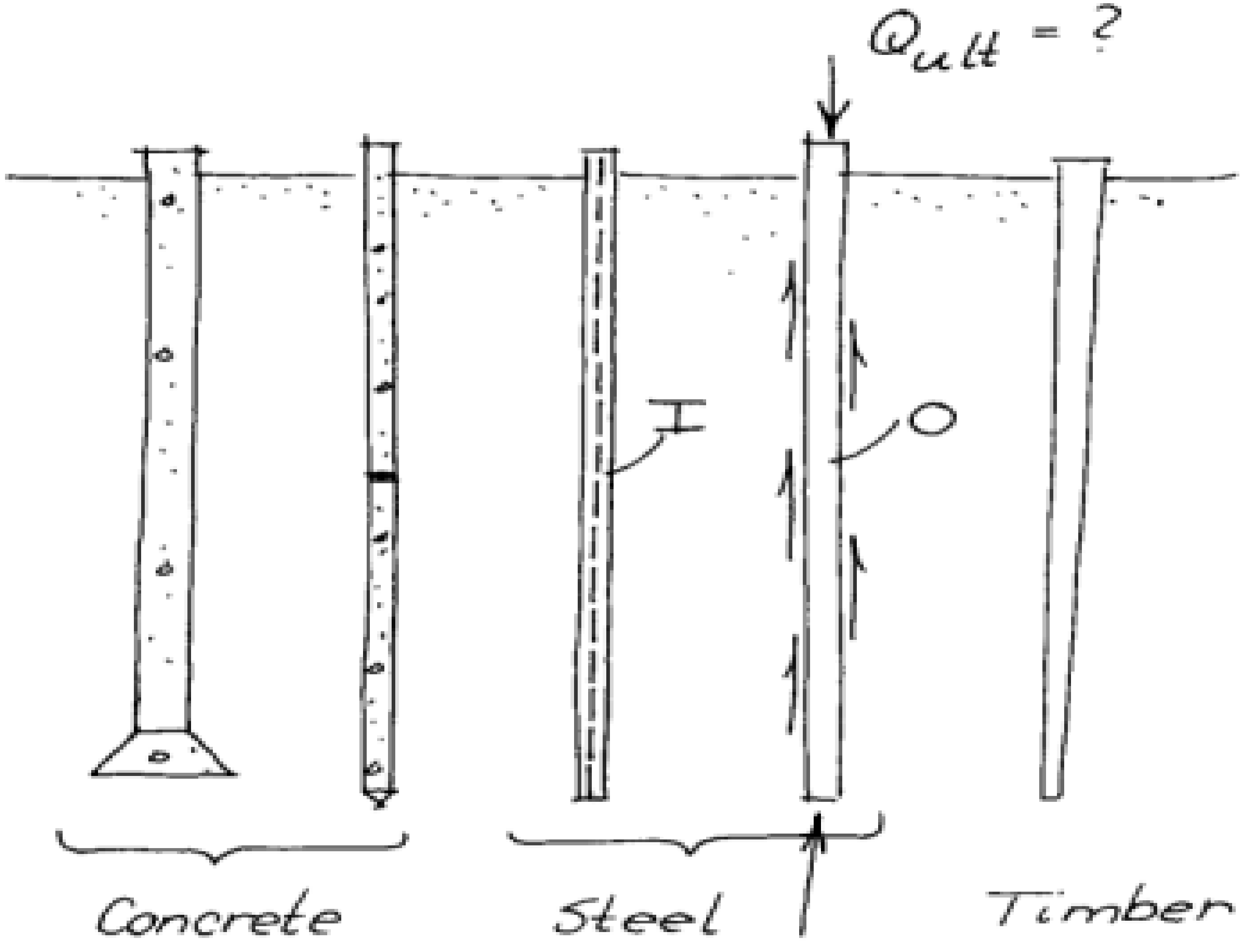
Groundwater Effects



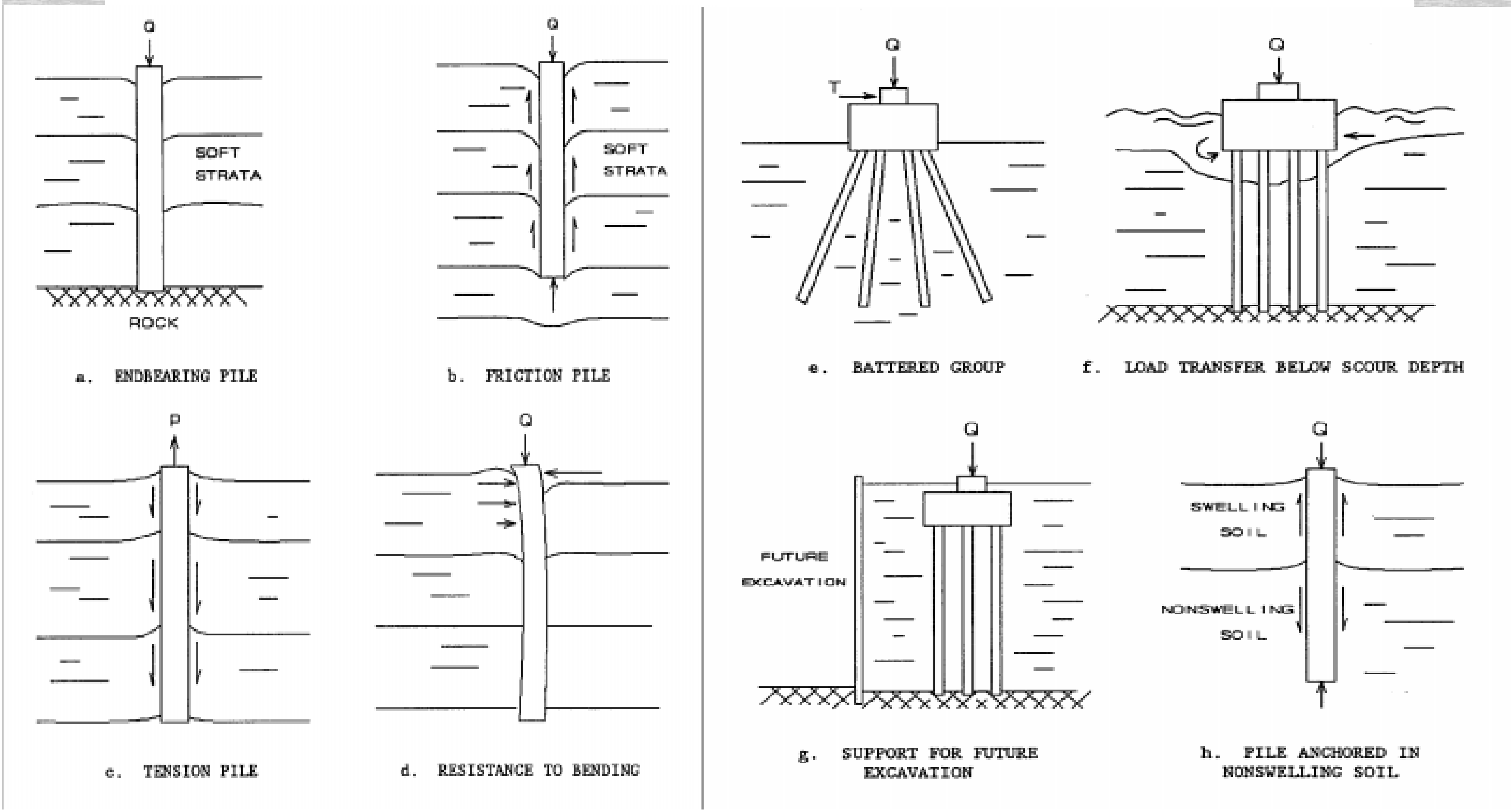
Mat Foundations: Elasticity of Soil and Foundation



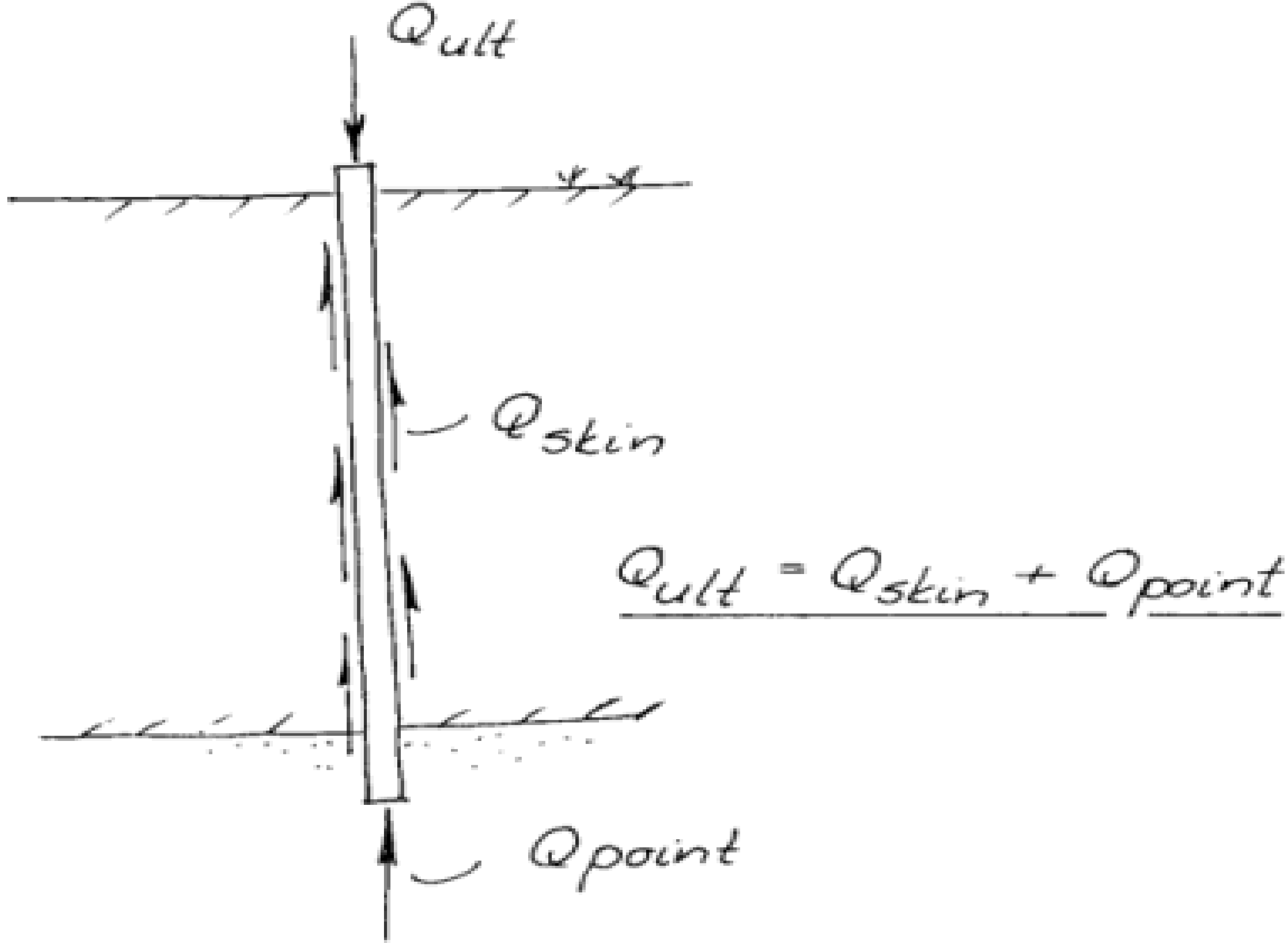
Deep Foundations



Loading Conditions for Deep Foundations



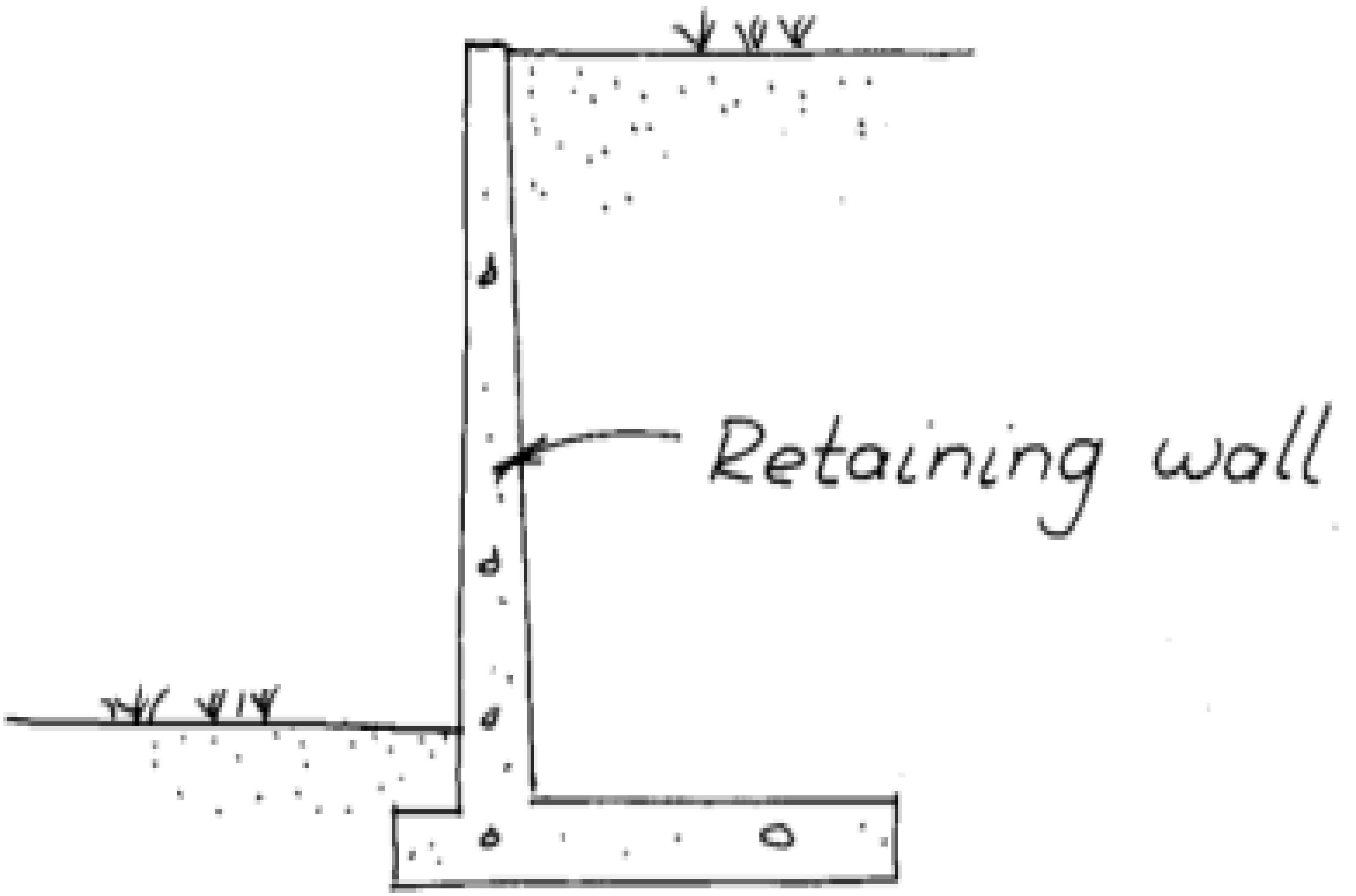
Load Transmission in Deep Foundations



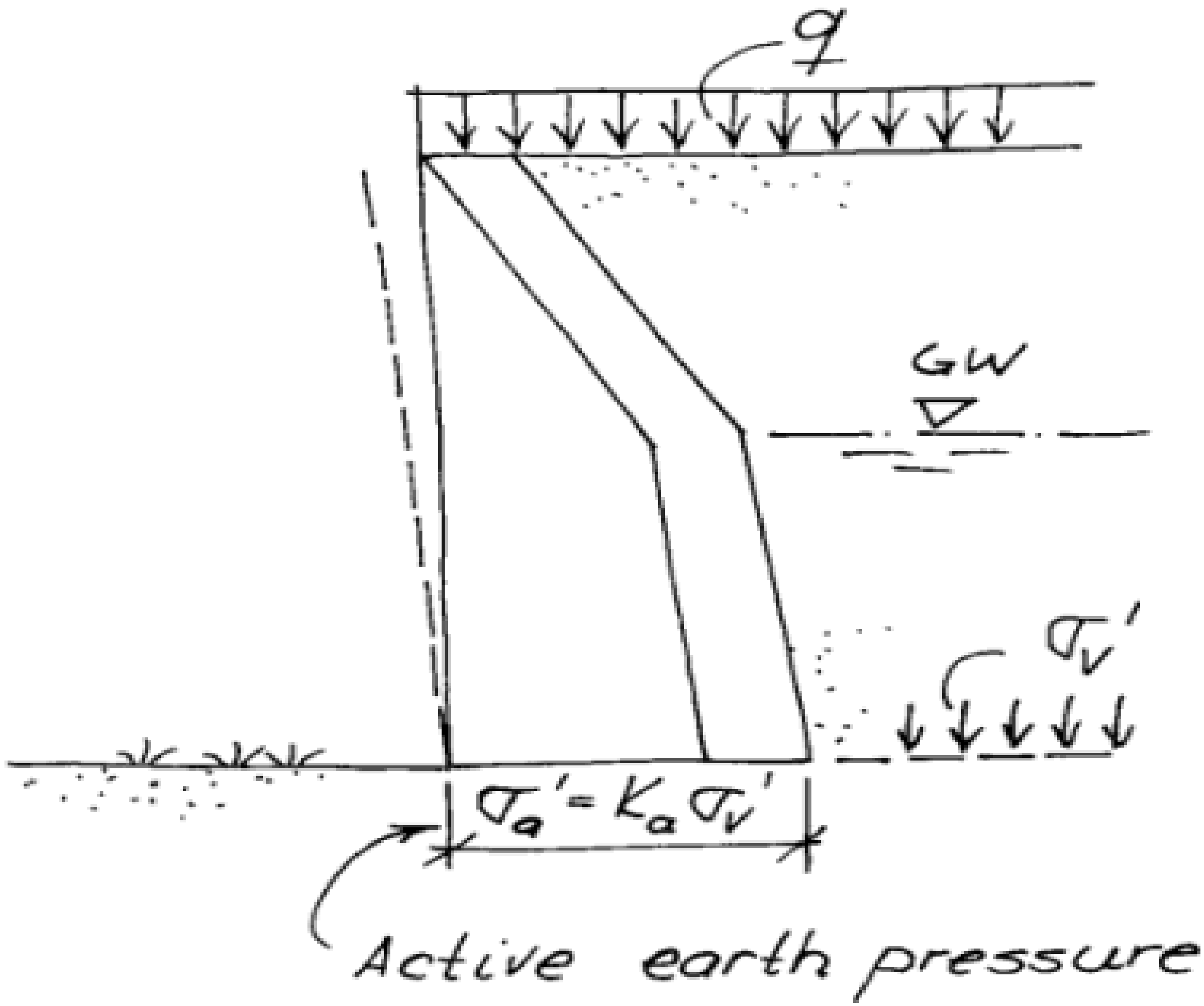
Uplift Loading

Lateral Loading

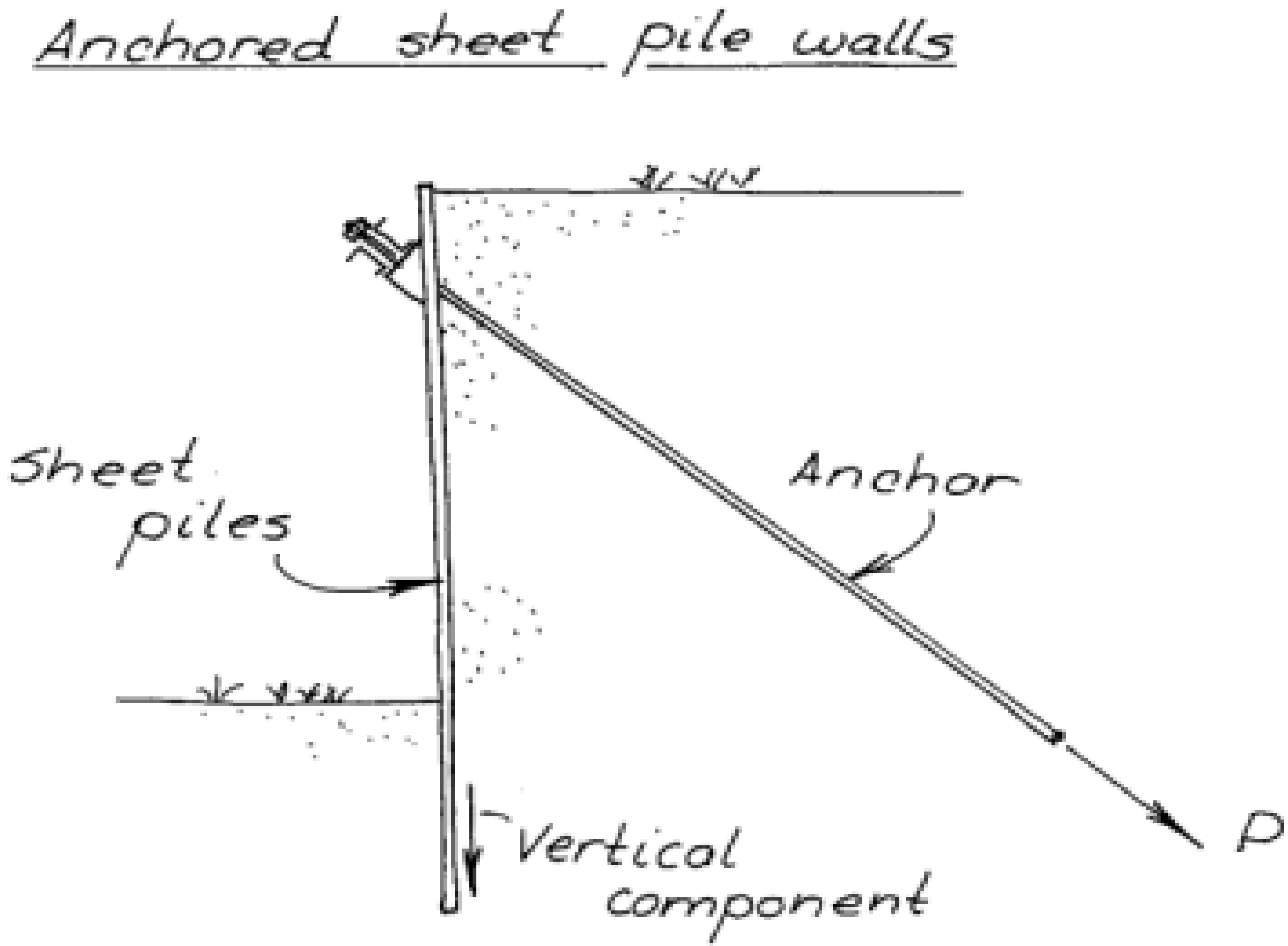
Retaining Walls



Retaining Walls: Active Earth Pressure

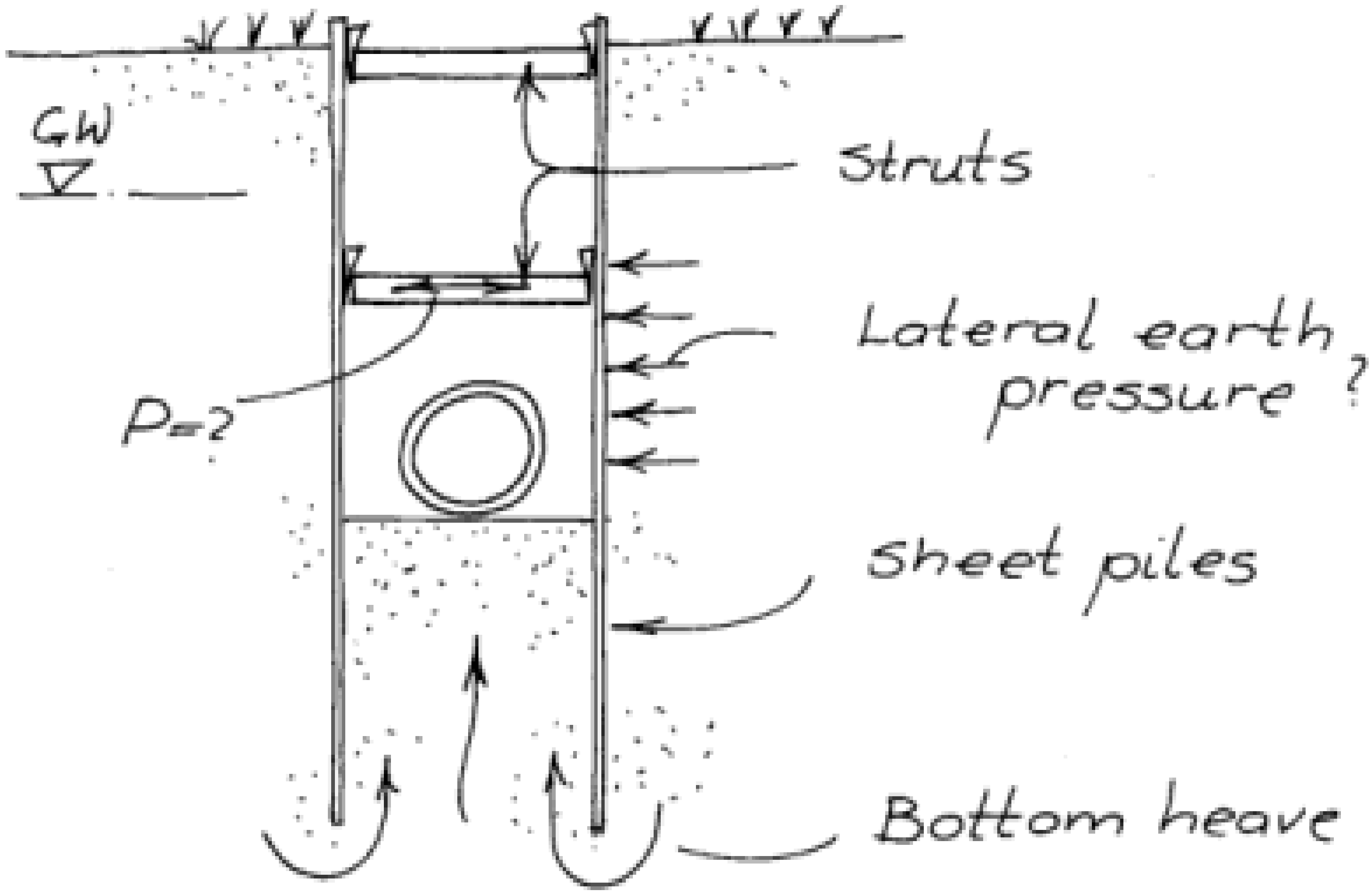


Anchored Sheet Piling Wall

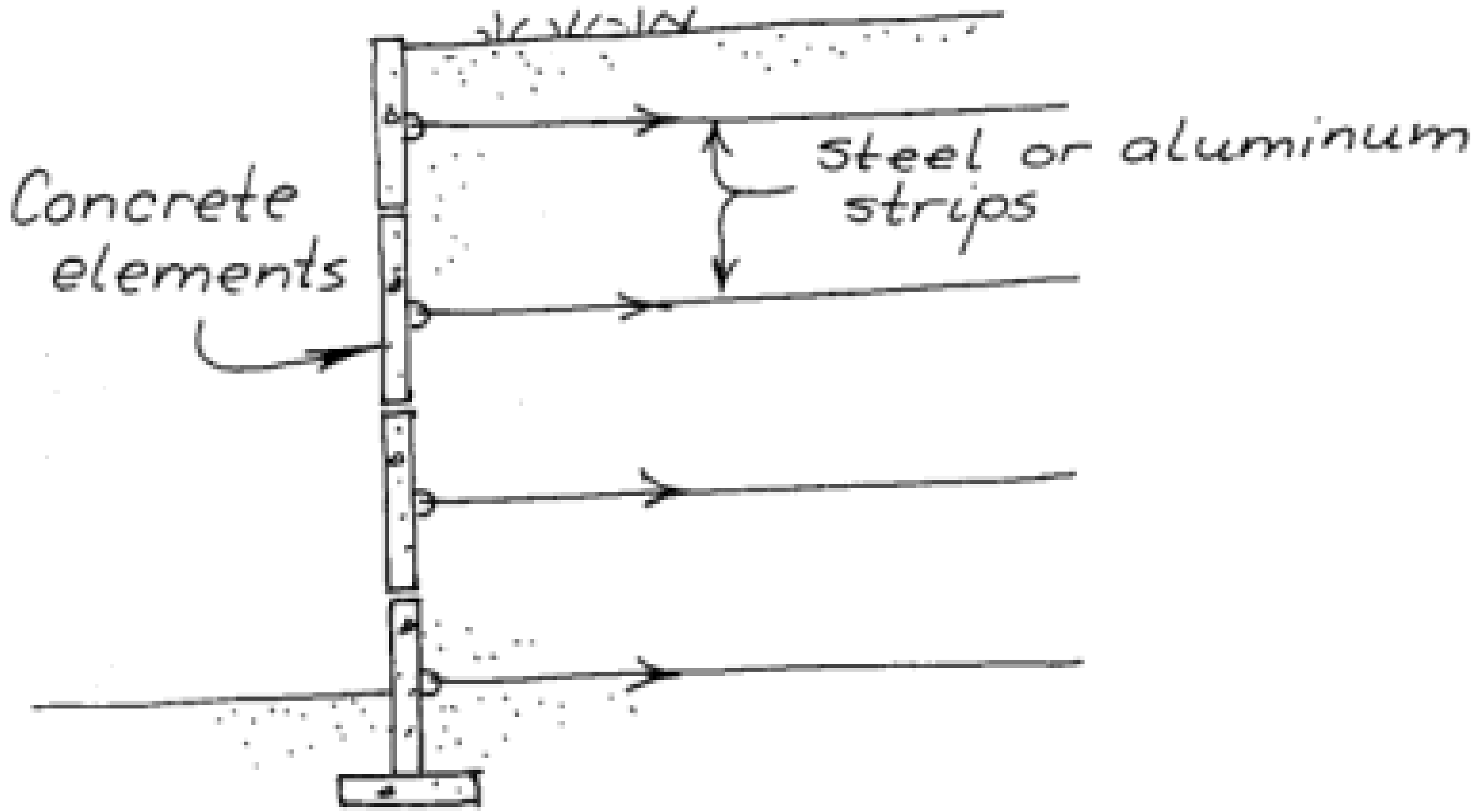


Sheet Piling Walls

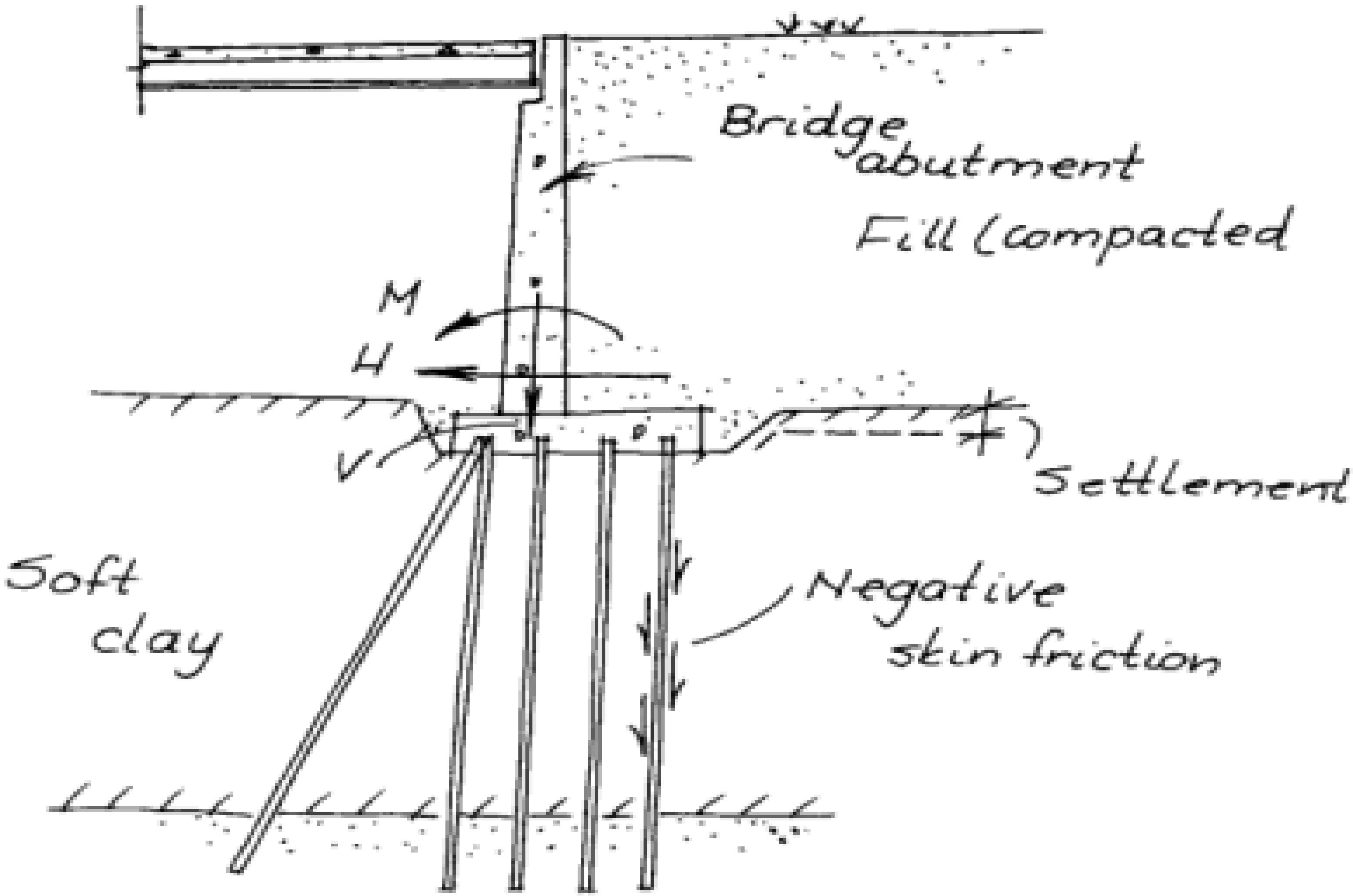
Braced Cuts


GW
Struts
Lateral earth pressure ?
P=?
Sheet piles
Bottom heave

Other Methods of Reinforcement



Combination of Foundation Types



The Problem of Constructibility

« The successful transfer of design objectives into construction is accomplished by consideration of construction operations during the design phase. In recent years the amount of coordination between design and construction has steadily decreased; primarily due to graduate engineers who specialize in design and who are never exposed to construction operations. In past years, engineers either began their careers in construction and advanced into design, or were assigned the design and construction responsibilities for projects. Present lack of coordination stemming from inexperience with field operations can result in a technically superior set of construction plans and specifications which cannot be built. Rational construction control is vital to assure a safe, cost-effective foundation and to avoid unnecessary court of claims actions.»

(Chaney & Chassie, *Soils and Foundations Workshop Manual*, FHWA HI-88-009)

Homework Set 1

- Textbook Reading:
  - McCarthy, Ch. 12, pp. 443-447, 463-466
  - McCarthy, Ch. 13, pp. 469-490
  - Coduto, Chs. 1, 2, 5 & 6 (optional)
- Problems
  - McCarthy: 12-9, 13-3, 13-14, 13-20
    - Problems need to be solved using either method shown in class (Vesić Method/Coduto) or in textbook (Design Method/McCarthy) but not a mixture of both
  - Other Problems which follow
- Due Date: 28 January 2002

Homework Set 1

- A proposed column has the following design loads:
  - Axial Load: P_D = 200 kips, P_L = 170 kips, P_E = 50 kips, P_W = 60 kips (all compression)
  - Shear Loads: V_D = V_L = 0, V_E = 40 kips, V_W = 48 kips
  - Compute the design axial and shear loads for foundation design using ASD
- Repeat the above problem using LRFD with the ACI load factors

Homework Set 1

- A two story steel reinforced concrete art museum is to be built using an unusual architectural design. It will include many tile murals and other sensitive wall finishes. The column spacing will vary between 5 and 8 m. Compute the allowable total and differential settlements for this building.
- The grandstands for a minor league baseball stadium are to be built of structural steel. The structural engineer plans to use a very wide column spacing (25 m) to provide the best spectator visibility. Compute the allowable total and differential settlements.

Homework Set 1

- A 400 kN vertical downward column load acts at the centroid of a 1.5 m square footing. The bottom of this footing is 0.4 m below the ground surface and the top is flush with the ground surface. The groundwater table is at a depth of 3 m below the ground surface. Compute the bearing pressure.

Homework Set 1

- A 5 ft. square, 2 ft. deep spread footing is subjected to a concentric vertical load of 60 kips and an overturning moment of 30 ft-kips. The overturning moment acts parallel to one of the side of the footing, the top of the footing is flush with the ground surface, and the groundwater table is at a depth of 20 ft. below the ground surface. Determine whether the resultant force acts within the middle third of the footing, compute the minimum and maximum bearing pressures, and show the distribution of bearing pressure in a sketch.

Questions