CE 353

Ch. 1: Soil Materials

1.0

Def.: Soil is the relatively loose materials, extending from ground surface down to solid rock (bed rock).

Soil formation: by weathering & disintegration from solid rock.

Differ → parent materials

→ weathering processes

→ transportation agents
- glaciers
- water
- wind

- Soil profile ⇒ land forms
  (topographic features)
- Soil is the oldest building material
- Soil supports all structures
- Detailed knowledge of soils at a site
  - physical properties
  - mechanical

- Geotechnical Engineering : application of CE technology to some aspect of the earth.

  - young discipline

    Soil mechanics – Eng. Mechanics & prop. of soil mat.

    Foundation Eng. - design of foundation (science) earth structures (art)

    - soil mechanics
    - str. eng.
    - geology
    - ……

- Ex.
  1. Frozen ground
  2. Soil erosion
  3. BH # 3 organic soil layer
  4. Pavement
  5.
  6.
  7.

1.4.1 Geotechnical properties of soils are required for the design of:

- Foundations
- Earth Dams
- Excavation
- Retaining Structures

Volume change = settlement

- Fill → increase load, water drains → soil compressed → settlement
    - void ratio (e)
    - prediction of settlement - setting a sample in the lab
    - permeability
    - rate of settlement (consolidation)
    - soil improvement - pre-loading

1.4.2 Stability of soil masses

- slope stability - highways cuts

    - soil tends to move downward & outward, under the influence of gravity

        - along some failure surface

    - initial movement - caused by external actions

    - shearing resistance (strength) vs. shear stress

1.4.3 Load transfer & bearing capacity

All structures - superstructures
- substructures (foundation)

interfaces with ground

- transferring load from superstructure to soil

- economical

- safe → tolerate settlement
→ sufficient bearing capacity
→ overturning
→ rotation
→ sliding
Depth → seasonal changes
→ corrosion
→ method of construction
→ adjacent buildings

Ex. - spread footings
- mat foundations (if > 50% of area)
- piles

1.4.4 Seepage, flow of water through soil

- move under influence of gravity

- degree of saturation
- groundwater table (GWT)
- Darcy's Law : $\frac{\text{velocity, hydraulic head gradient}}{\text{coefficient of permeability}}$
- Drainage

- Flow lines
- Discharge (quantity)

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1.1.1 Origin & Formation of Soils

- soil minerals : derived from rocks through weathering
- parent rocks
  - igneous
  - sedimentary (layers)
  - metamorphic

- Table 1.1

- Weathering process

  - Disintegration (physical)
    - temp. change
    - freezing & thawing
    - prying

  - Decomposition (chemical)
    - oxidation
    - hydration
    - carbonation
    - chemical effects of plants

- climate
- topography
- time
- geologic history
- rock type

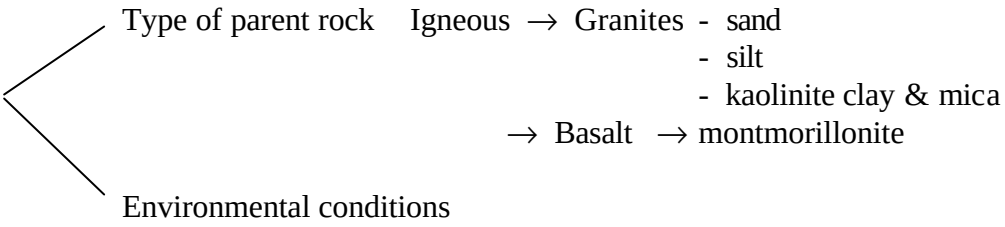
Table 1.2

1.2 Soil Deposits

- Geol. origin → physical characteristics

1.2.1 Residual Soils

- formed in-place (Not transported) No erosion



- Thickness up to 20m
- Degree of weathering

@ surface fedspar, mica, ferromagnesium → clays

- Joints, shear zones
- Depth of weathering - rock type (porous × impervious)
  - permeability
  - cementation

* sedimentary rocks - limestone (C_aCO_3)
- dissolved & removed by groundwater + CO_2
- cavities - caves
- collapse - sink holes filled with debris

* metamorphic rock - sand, silt, mica
gneiss & schist
marble – by solution

Transported Soils

1.2.2 Water - Transported Soils

- River deposits (alluvium)
- lake deposits (lacustrinc)
- sea deposits (marine)
- moving water
  - erode
  - transport
  - deposit
- rounded by abrasion
- alluvial fans : mountain streams enter flat country
- natural levees : rapid deposition along the riverbanks
- varved : uniform laminae of silt & clay
- peat $\rightarrow$ marsh or bog
- tidal lagoon
- swamps

1.2.3 Wind – Transported Soils

- dunes, ridges
- sort – uniform size
- loose
- continual migration in the direction of the prevailing wind

- Loess : - high vertical porosity
  - hard (dry)
  - soft (wet)

1.2.4 Soils of Glacial Origin

- continental glaciers North of 40^{th} parallel
- ice sheets - excavated
  - mixed
  - transported
  - deposited

  } loose rocks & soils
- <u>Till</u> : soil materials deposited directly by ice
- glacial till $\Rightarrow$ wide variation $\rightarrow$ Texture
  - size: boulder – clay
- meltwater deposits $\rightarrow$ outwash
  - * varved clay
- terminal or end moraines : accumulate ridge at face of the glacier
- eskers : sinuous ridges
- kames : conical hills

} remains of rivers flowed beneath or near the ice front

1.2.5 Special Soils

- Expansive soils
- Collapsing soils
- Limestone soils
- Quick clays
- Organic soils

} potential disasters

1. Expansive soils: potential for great volume increase, when exposed to water

   Ex. Montmorillonite clays & clay shales

2. Collapsing soils: potential for great volume decrease, upon increasing moisture content, without any change in the external loads.

   Ex. Loess, weakly <u>cemented</u> (soluble gypsum or halite) sand/silt.

   * Found in arid regions.

3. Limestone & related materials: solubility & potential for cavity development

4. Quick clays:
   - great sensitivity to disturbance
   - significant strength reduction upon remolding
   - marine origin <u>S > 15</u>. $S = \frac{s_{undis.}}{s_{dis.}}$

5. Organic Soils:

1.1.2 Assemblage of Particles

Assemblage of mineral particles + water + air
(solid) (liquid) (Air)

mineral particles — organic matters (diff. Sizes)

Fig. 1.4 Three phases of an element of natural soil

- Voids are continuous → water movement
- Water dissolved salts and carry solutions

Dry → No water → No pore fluid

Saturated → No air

- Compaction: reduces air by packing soil particles

* Porosity

* Void ratio

* Density

* Phase relationships

- Rock fragments > 1 mm
- Mineral glaciers (2 mm – 1 μm)

Ex. Sand - quartz mineral

* Organic matters - plant / animal remains

microbial activity

(humus) : mixture of organic compounds

peat: organic soil, prolonged periods of match development.

Thickness of single water layer = 2.9 A^o

Kaolinite	7.2 A^o		
Halloysite	10.1 A^o	head $\rightarrow$	7.2 A^o
Montmorillonite		9.6 A^o $\rightarrow$	∞
Illite	10 A^o		
Vermiculite	10 to 14 A^o		