Soil Formation

Das Chapter 2

Rock and Soil

- Rock - mineral aggregate that is strongly bonded
- Soil - mineral aggregate that is weakly or loosely held together

When Does Rock Become Soil?

- Dividing line can be arbitrary
- Contractors and engineers can have different definitions
  - Poor definition can result in contractor going out of business and significant project delays
- For geotechnical applications:
  - If you can sample it with a split spoon sampler then it is soil. If not then it is rock
  - Very soft rock ⟹ analyze as hard or stiff soil

Standard Split-Spoon Sampler

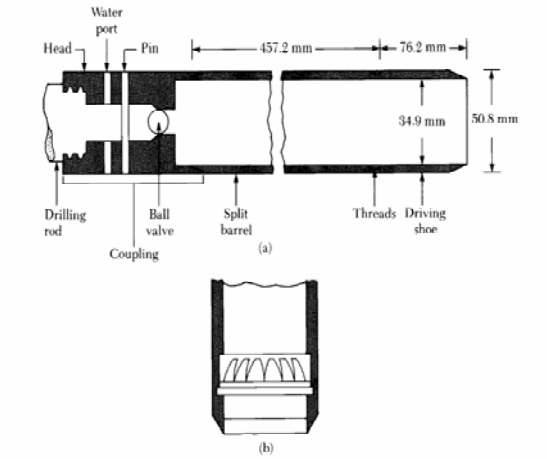
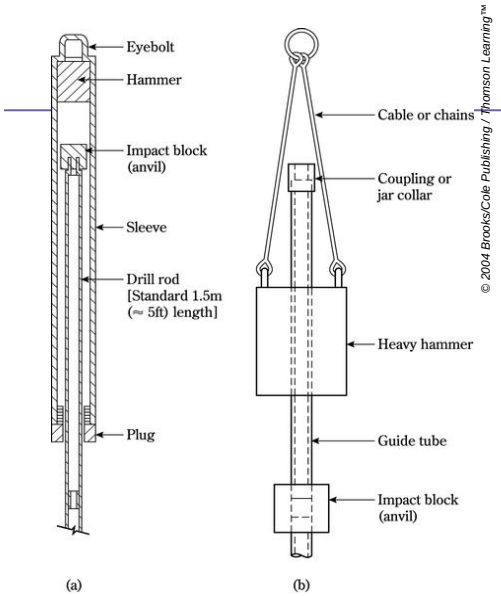


Figure 10.6 (a) Standard split-spoon sampler; (b) spring core catcher



Configuration of Standard Penetration Test (SPT) hammers
(a) safety hammer;
(b) donut hammer
(after Seed et al., 1985)

N_{value} = number of blows (hits) it takes to drive a standard split spoon 300mm with a 623N hammer dropped a distance of 762mm

(ASTM D1586)

How are Soils Formed?

- Degradation of rock into small pieces or weakly bonded mineral aggregates
- The process that forms or deposits soil will influence the soil mass engineering properties
  - Compressibility, strength, ability to conduct fluid flow (permeability)

Soil Formation Process

Weathering
- Chemical
- Physical

Vegetation growth

Chemical Weathering

- Results from reaction of mineral aggregates with oxygen, water, acids, salts, etc
- Causes chemical decomposition of rock that can drastically change its physical and chemical properties
- Decompose rock minerals by:
  - Oxidation, reduction, carbonation, & other chemical process

Physical Weathering

Includes mechanical weathering

- Freezing and thawing
- Temperature changes (expansion-contraction)
- Erosion
  - Activity by plants, animals (people)
  - Glaciers
  - Water transport

Types of Soil Deposits

Organic - vegetation growth and decay

- Very soft deposits
- High organic content due to decaying vegetation
- Peat or muck

Residual - remain in place of origin (weathered)

Transported soils - transported from place of origin and deposited else where

Transported Soils

Common transporting agents:

- Gravity
- Water
- Air (wind)
- Glaciers

Gravity Transported Soils

Colluvium - gravity soil deposits

- Develop from mud or land slides and debris flows - short transportation distance

Characteristics:

- Mixture of particle sizes
- Loosely compacted
- Angular particles

Water Transported Soils

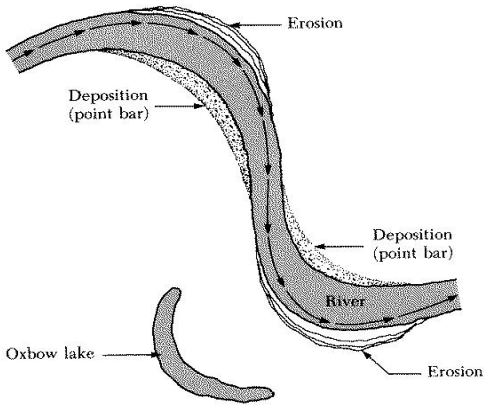
- Alluvial
- Lacustrine
- Marine

Water Transported Soils

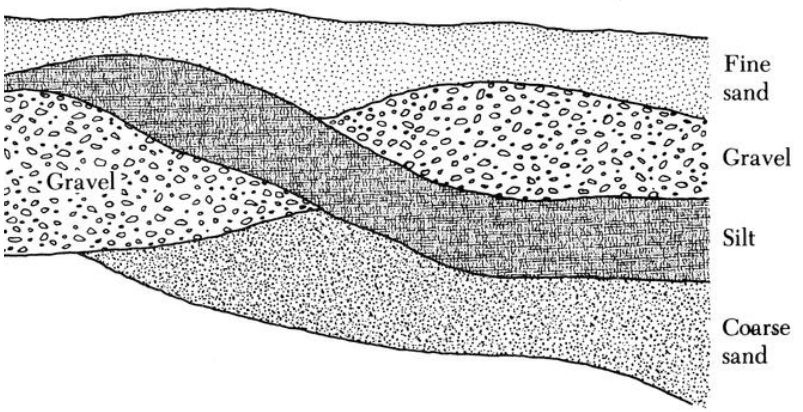
Alluvial soil - developed on flood plain and delta

- Transported by moving water
- Particles can be transported large distances
- Size of particles carried depends on water velocity: velocity ⇧ particle size carried⇧
  - Slow moving = silt and clay
  - Fast moving = sand and gravel

Formation of point bar deposits and oxbow lake in a meandering stream



Cross section of a braided-stream deposit



Water Transported Soils (con't)

Alluvial soil characteristics:

- Sub-rounded to rounded particles
- Layered deposits - seasonal changes
  - Spring fast moving water
    - Sand and gravel
  - Summer slow moving water
    - Clay and silt

Water Transported Soils (con't)

Alluvial fans

- River deposits where water velocity suddenly decreases: (river widening)
- Coarse soils, flat triangular deposits

Deltas

- Sediment deposited at mouth of creeks, rivers, lakes, bays, or seas
- Loose deposits (compressible)
  - may contain organics

Water Transported Soils (con't)

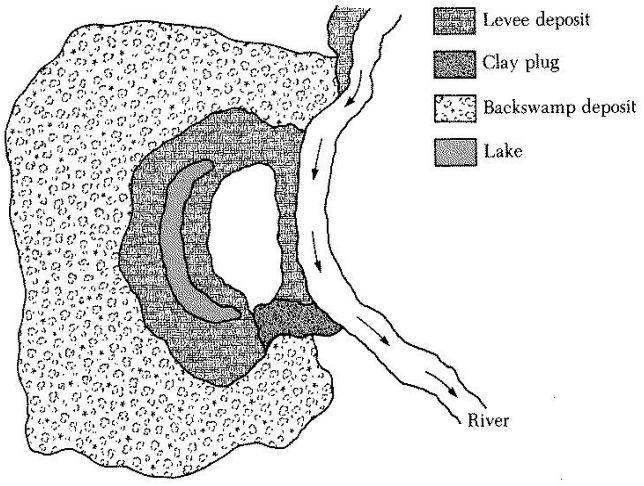
Lacustrine soil

- Belonging to or produced by lakes or other bodies of water

Characteristics

- Fine grained soils (silt and clay)
- varved - contains thin horizontal layers

Levee and backswamp deposit



Water Transported Soils (con't)

Marine soils – salt water deposits

- Formed in the sea
- Varying particle sizes

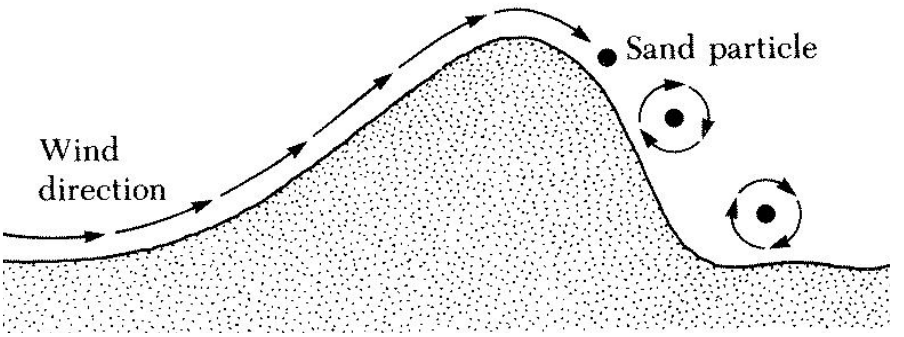
Beach deposits - (high energy)

- Loose and one particle size

Bay and inlets - (low energy)

- Fine grained, may contain organics & shells

Air Transported Soils



Air Transported Soils

Aeolin soil

- Formed by wind
  - Dunes, loess, volcanic dust (ash)

Characteristics:

- Well rounded
- One particle size - silt or sand
- High dry strength, low wet strength

Glacial Deposited Soils

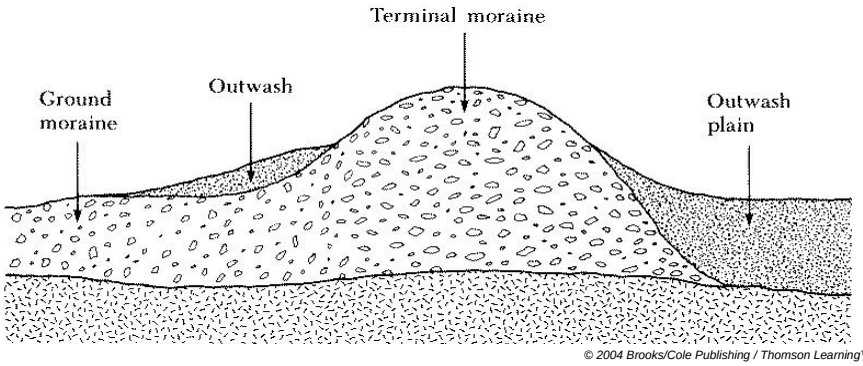
Result from the action of glaciers

- Erosion from ice sheet
  - Till: mixture of particle sizes (clay to cobbles)
    - Well compacted
    - Angular fragments
- Soil deposits formed on ice sheet
  - Moraine: mixture of particle sizes

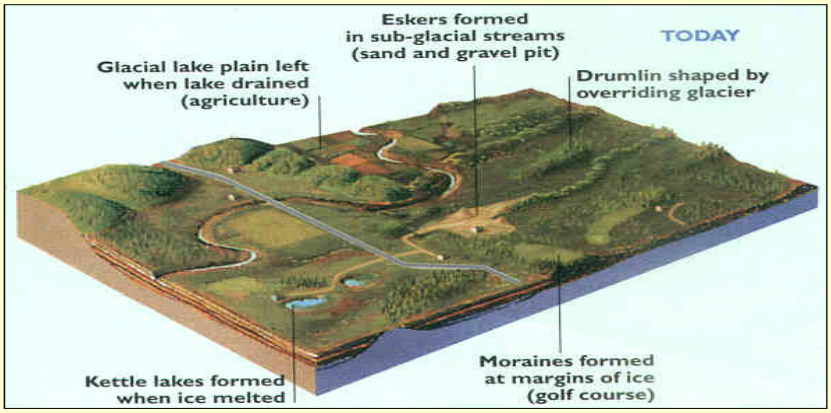
Glacial Deposited Soils

- Melting of an ice sheet
  - Outwash deposits, kame and kame terraces, kettle, drumlin, esker

Glacial Deposited Soils



Expect the Unexpected



Peck, Hanson and Thornburn

Foundation Engineering
(Second Edition)
1974 Wiley & Son

Expect the Unexpected

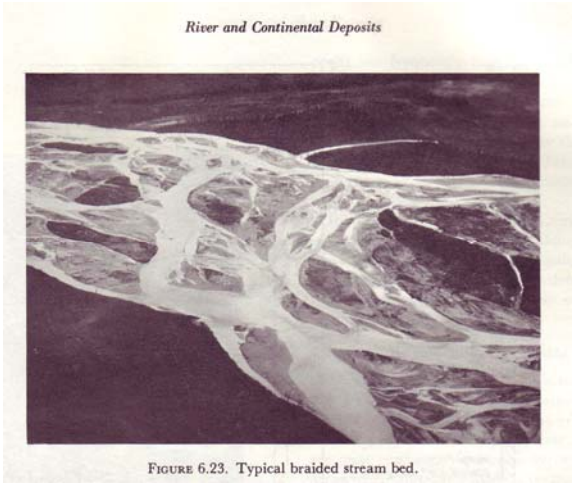


FIGURE 6.23. Typical braided stream bed.

Expect the Unexpected

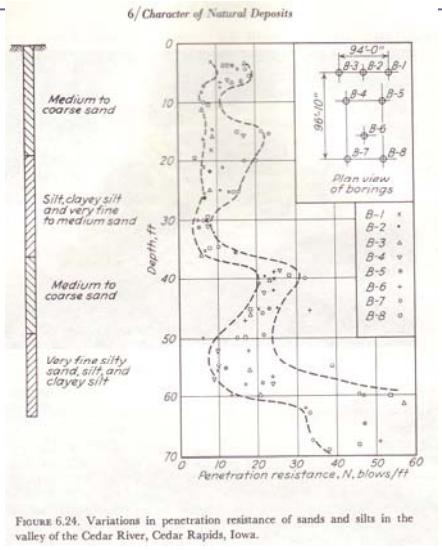
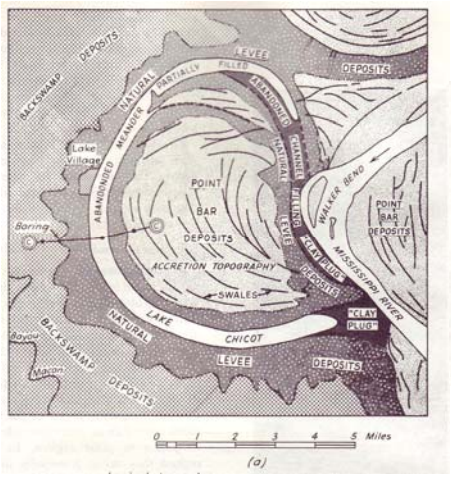


FIGURE 6.24. Variations in penetration resistance of sands and silts in the valley of the Cedar River, Cedar Rapids, Iowa.

Expect the Unexpected



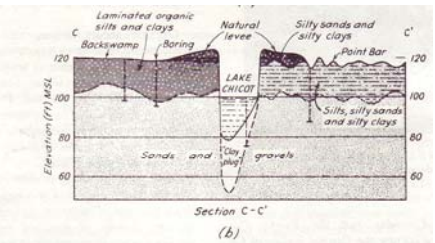


FIGURE 6.26. Portion of meander belt in lower Mississippi Valley (Lake Chicot) showing (*a*) distribution of deposits at the surface; (*b*) section through portion of the deposit (after Fisk, 1947).

Expect the Unexpected

FIGURE 6.25. Two-inch tube sample from flood-plain deposit of Mississippi River near Baton Rouge, La.

Expect the Unexpected

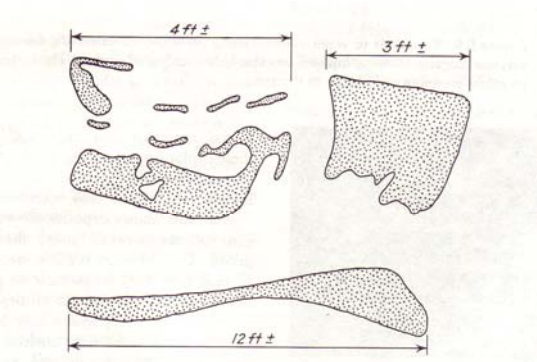
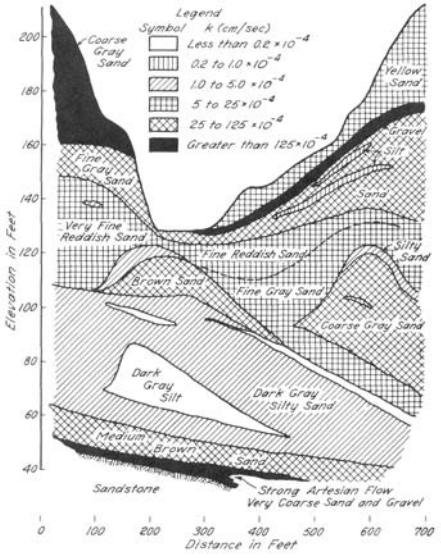


FIGURE 6.8. Sketches of coarse sand inclusions encountered during tunneling operations in ground moraine consisting of soft clay.

- Sand deposits discovered during hand carving slabs of clay during construction of Chicago subway system
- Origin of formation unknown

Expect the Unexpected

- Permeability profile glacial deposit Chicopee, Mass USA (Terzaghi, 1929)
- Similar problem Oakridge moraine Markham, ON



Expect the Unexpected

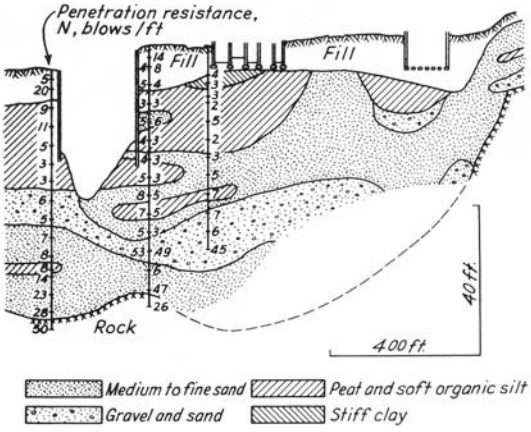


FIGURE 6.29. Cross section through composite shore deposit near mouth of Milwaukee River, Wis.

Expect the Unexpected

FIGURE 6.36. Exposures of residual soil showing effects of spheroidal weathering.

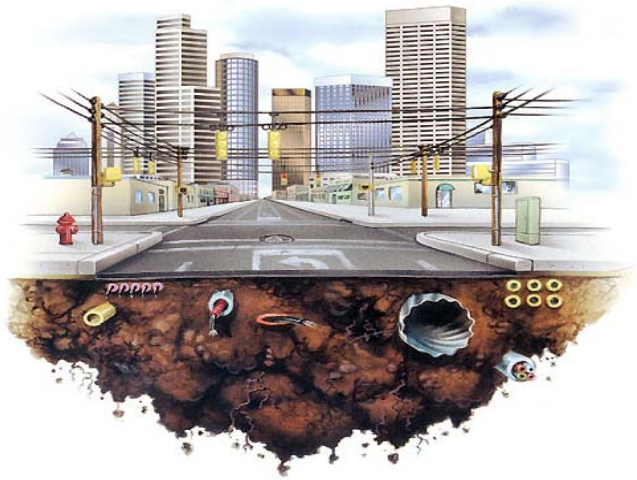
FIGURE 6.34. Road cut through dikes in volcanic rock on island of Oahu, Hawaii.

Expect the Unexpected

- Waste fill
- Clay
- Sand
- Gravel/cobble seams
- Boulders
- Changing ground conditions
- Organics

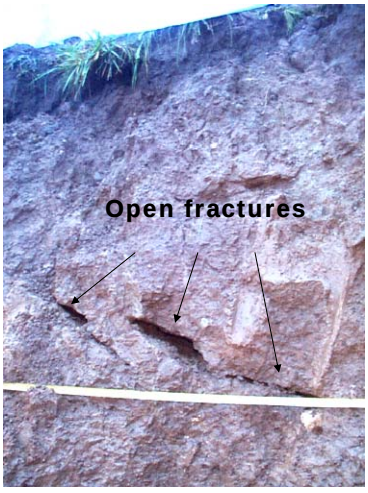
DESIGN BASED ON
LIMITED BOREHOLE DATA

Expect the Unexpected

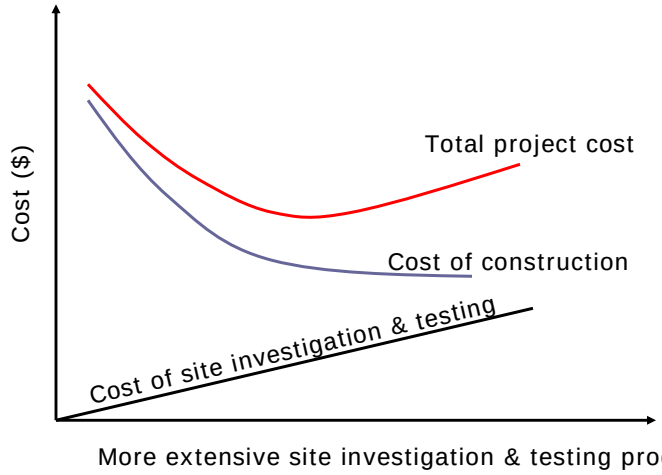


New York City

Expect the Unexpected



How Much Site Investigation?



How Much Site Investigation?