Soil Classification Systems

- Soil classification systems are used to class soils into groups and subgroups based on their engineering behavior
- Systems use common language to concisely express general characteristics without detailed descriptions

Soils Classification Systems

- USDA
- AASHTO
- USCS

USDA Classification

- Developed by United States Department of Agriculture to provide indication of soils ability to support plant/crop growth
- Textural classification system
- Based on relative proportions of Sand, Silt and Clay

USDA Classification

- Complete a grain size analysis of soil
- Determine %G, S, M, C
- Adjust %S, M, C based on gravel content
- Use textural triangle to classify soil
- Use name modifier to account for gravel content

USDA Example
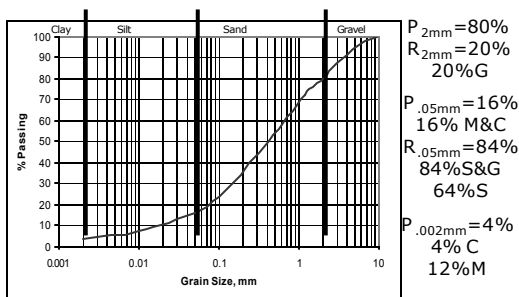

$P_{2mm} = 80\%$
$R_{2mm} = 20\%$
  20%G

$P_{.05mm} = 16\%$
  16% M&C
$R_{.05mm} = 84\%$
  84%S&G
  64%S

$P_{.002mm} = 4\%$
  4% C
  12%M

USDA Example

- 20%G, 64%S, 12%M, 4%C
- 80% S,M,C
- Modified S,M,C contents
- %S' = 64%/.8 = 80% S
- %M' = 15% M
- %C' = 5% C

USDA Textural Triangle

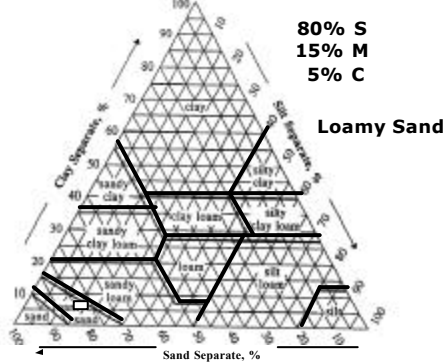
80% S
15% M
5% C

Loamy Sand

Sand Separate, %

Gravel Modifier

- If %G<15%, no modifier
- If 15%$\leq$%G$\leq$50%, add gravelly
- If %G>50%, add very gravelly

- In example, %G=20%; therefore, soil is classed as
    Gravelly Loamy Sand

AASHTO Classification

- Developed in 1929 by the Bureau of Public Roads
- Currently uses seven major groups of soils, A1 to A7
- Provides a general rating of the soil as a subgrade for road construction
- Considers grain size distribution and plasticity of fines (P_{40})

AASHTO Classification

- Coarse grained, granular soils have $P_{200} \leq 35\%$ (A1 to A3 soils)
- Fine grained silty and clayey soils have $P_{200} > 35\%$ (A4 to A7 soils)
- Soils classes based on elimination using Table 2.4 in text or with plasticity chart
- Group Index also calculated as a relative within group indicator

AASHTO Group Index

- $GI = (F-35)[0.2+0.005(LL-40)] + 0.01(F-15)(PI-10)$
- $F = P_{200}$
- For A-2-6 and A-2-7, use $GI = 0.01(F-15)(PI-10)$
- GI reported in parenthesis as integer
- If GI < 0, use 0

AASHTO Plasticity Chart
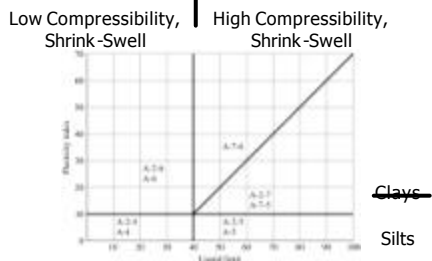
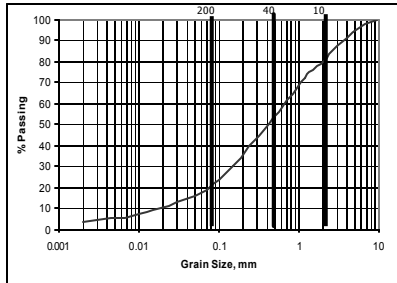Low Compressibility, Shrink-Swell | High Compressibility, Shrink-Swell

Clays

Silts

AASHTO Example

$P_{10}=80\%$

$P_{40}=52\%$

$P_{200} = 20\%$

AASHTO Example

- $P_{10}=80\%$ $P_{40}=52\%$ $P_{200}=20\%$
- LL = 35 PL = 20 PI = 15
- Because $P_{200}\leq35\%$, Coarse Soil
- Because $P_{10}>50\%$, not A-1-a
- Because $P_{40}>50\%$, not A-1-b
- Because $P_{200}>10\%$, not A-3
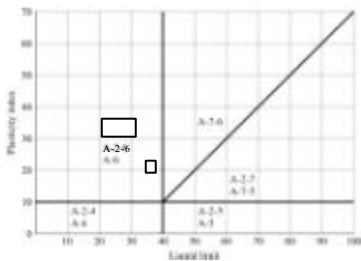- So must be A-2 soil, use plasticity chart

AASHTO Plasticity Chart

LL = 35, PI = 15

5

AASHTO Classification

- A-2-6 Soil
- GI=0.01(20-15)(15-10)=0.25=1
- So soil is A-2-6 (1)
- Clayey Sand & Gravel

Unified Soil Classification

- Developed by Casagrande in 1942
- Widely used by geotechnical engineers
- Considers grain size distribution and plasticity of fines (P_{40})
- Coarse Grained: $P_{200} < 50\%$
- Fine Grained: $P_{200} \geq 50\%$

USCS Symbols

- G – gravel   S - sand
- M – silt   C – clay
- O - organic
- W – well graded
- P – poorly graded
- L – low plasticity (LL < 50)
- H – high plasticity (LL $\geq$ 50)

USCS Process

- If $P_{200} < 50$; Coarse Grained
- G or S based on which proportion is greatest
- If $P_{200} < 5$, consider only gradation parameters C_u, C_z
- If $P_{200} > 12$, consider only plasticity
- If $5 \leq P_{200} \leq 12$, consider both

USCS Process

- If $P_{200} \geq 50$ – Fine Grained
- M or C based on plasticity
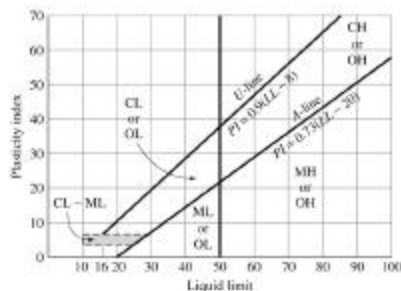- O based on LL before and after oven drying

USCS Plasticity Chart

USCS Process

- Group Symbol determined as outlined previously
- Group Name determined based on percentages of other soil components using decision tree process shown in Figures 2.13 and 2.14
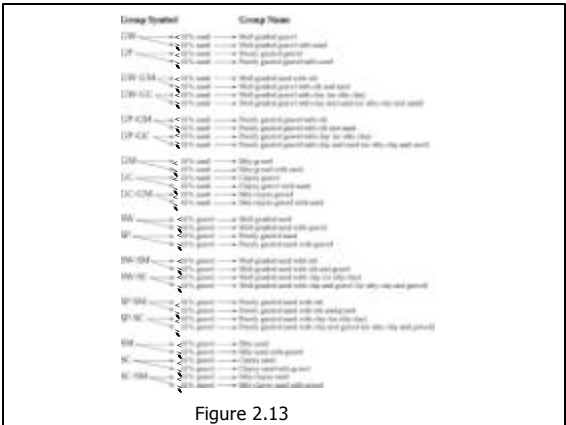
Figure 2.13
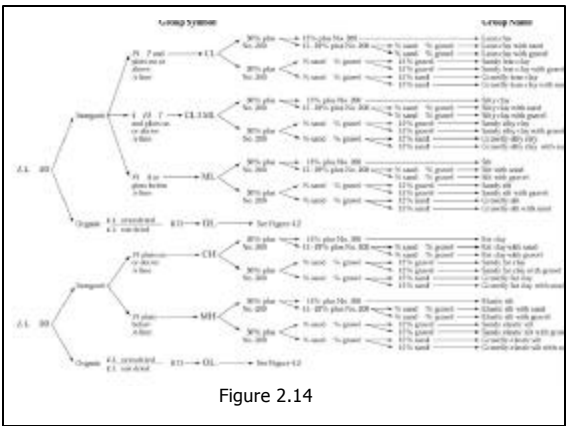
Figure 2.14

USCS Example
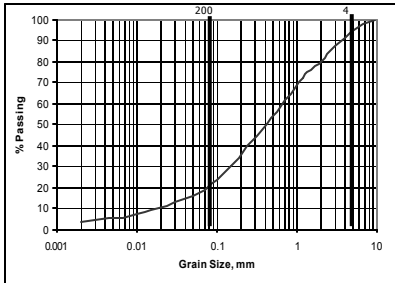
P_4=93%
%G=7

P_{200} = 20%
%S&G=80
%S=73

USCS Example

- P_4=93%, P_{200}=20%, %G=7, %S=73
- LL = 35 PL = 20 PI = 15
- Because $P_{200} \leq$ 50%, Coarse Soil
- Because %S>%G, Sand
- Because P_{200}>12%, use plasticity chart

USCS Plasticity Chart

LL = 35, PI = 15
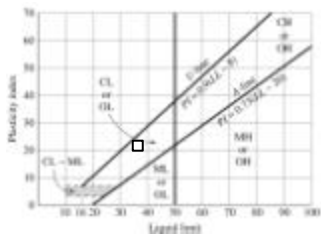
Soil fines are Clay

USCS Example

- Group Symbol is SC
- Because %G<15, Group Name is Clayey Sand