SOIL CLASSIFICATION

Application

A classification scheme provides a method of identifying soils in a particular group that would likely exhibit similar characteristics. Soil classification is used to specify a certain soil type that is best suitable for a given application. There are several classification schemes available. Each was devised for a specific use. For example, the American Association of State Highway and Transportation Officials (AASHTO) developed one scheme that classifies the soil according to their usefulness in roads and highways. However, the Unified Soil Classification System (USCS) was originally developed for use in airfield construction, but was later modified for general purpose. AASHTO and USCS are two major classification systems in use.

Information needed

- Grain size distribution curve
- Plasticity information of the soil - LL, PL, and PI
- ASTM D 2487
- AASHTO M 145

Procedure

USCS Classification

1. Determine the % of soil retained on #200 sieve (R200).
2. If R200 is greater than 50%, it is a coarse grained soil otherwise it is a fine grained soil.
3. For fine grained soil:
   a. Find whether the soil is organic, by comparing the liquid limit of oven dried specimen with that of the original specimen. If the LL of oven dried specimen is less than 75% of that of the non oven dried specimen, the soil is organic. Otherwise, the soil is inorganic.
   b. Plot the LL and PI values on the plasticity chart, and find the group symbol for the soil.
   c. Determine % of soil retained on the US #4 sieve (R4). This is the % of gravel fraction (GF) in the soil.
   d. Determine the % of sand fraction (SF) in the soil by, SF = R200 - GF.
   e. Use the ASTM table to classify the fine grained soil.
4. For coarse grained soil,
   a. If % of gravel is more than % of sand, it is gravelly soil otherwise sandy.
   b. Using the grain size distribution curve, calculate Cc, and Cu.
   c. Using the ASTM chart for the coarse grained soil, classify the soil. Be careful to check whether they fall under dual classification or not.

AASHTO Classification

1. Determine the % of soil passing through #200 sieve (F200). If F200 is more than 35% soil is fine grained otherwise coarse grained.
2. For coarse grained soil:
   a. Determine $F_{10}$, $F_{40}$, $F_{200}$, LL, and PI.
   b. Match the soil group based on the AASHTO Classification.
3. For fine grained soil:
   a. Determine LL, and PI.
   b. Group soil according to the AASHTO classification.
4. Determine Group Index (GI) of the soil as:
   \[
   \text{Group Index : GI} = (F-35)(0.2+0.005(LL-40)) + 0.01(F-15)(PI-10)
   \]
5. Express GI in whole number.
6. Express the classification first by soil classification and then GI in parenthesis.

Calculations

1. Calculate the % of soil retained on the #200 sieve
   \[
   R_{200} = (100 - F_{200})
   \]
2. Calculate the % of soil retained on the #4 sieve
   \[
   R_4 = (100 - F_4)
   \]
3. Calculate uniformity coefficient ($Cu$) and coefficient of gradation ($Cc$) using the following equations.
   \[
   Cu = \frac{D_{60}}{D_{10}}
   \]
   \[
   Cc = \frac{D_{30}^2}{D_{60} \times D_{10}}
   \]
4. Calculate Group Index (GI)
   \[
   GI = (F-35) \times (0.2+0.005(LL-40)) + 0.01(F-15)(PI-10)
   \]
Classification of Soil

A classification scheme provides a method of identifying soils in a particular group that would likely exhibit similar characteristics. Soil classification is used to specify a certain soil type that is best suitable for a given application. There are several classification schemes available. Each was devised for a specific use. For example American Association of State Highway and Transportation Officials (AASHTO) developed one scheme that classifies the soil according to their usefulness in roads and highways. However, Unified Soil Classification System (USCS) was originally developed for use in airfield construction, but was later modified for general purpose.

USCS

The USCS uses symbols for the particular size group:

- **G** - Gravel particles retained on #4 sieve (4.75 mm)
- **S** - Sand particles passing #4 sieve, but retained on # 200 sieve (0.075 mm)
- **M** - Silt particles passing # 200 sieve
- **C** - Clay particles passing # 200 sieve

These are combined with other symbols with expressing gradation characteristics

- **W** - Well graded
- **P** - Poorly graded

And, plasticity characteristics (figure 1)

- **H** - High plasticity
- **L** - Low plasticity
- **O** - Organic matter

![Plasticity Chart](image)

Figure 1 Plasticity chart for the USCS classification of fines (Source: Das, 2006)
Unified Soil Classification System

<table>
<thead>
<tr>
<th>COARSE-GRAINED SOILS</th>
<th>Group Symbols and Group Names Using Laboratory Tests</th>
<th>Soil Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 50% retained on No. 200 sieve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravels</td>
<td>More than 50% of coarse fraction retained on No. 4 sieve</td>
<td>Clean Gravels Less than 5% fines Gravels with Fines More than 12% fines</td>
</tr>
<tr>
<td>Sands</td>
<td>50% or more of coarse fraction passes No. 4 sieve</td>
<td>Clean Sands Less than 5% fines Sands with Fines More than 12% fines</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FINE-GRAINED SOILS</th>
<th>Group Symbols and Group Names Using Laboratory Tests</th>
<th>Soil Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% or more passes the No. 200 sieve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silt and Clay</td>
<td>Liquid limit less than 50</td>
<td>inorganic</td>
</tr>
<tr>
<td>Silt and Clay</td>
<td>Liquid limit = oven dried Liquid limit = not dried &lt; 0.75</td>
<td>organic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HIGHLY ORGANIC SOILS</th>
<th>Group Symbols and Group Names Using Laboratory Tests</th>
<th>Soil Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on the material passing the 3-in. (75-mm) sieve.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If field sample contains cobbles or boulders, or both, add &quot;with cobbles or boulders, or both&quot; to group name.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gravels with 5 to 12% fines require dual symbols:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GW-GM well-graded gravel with silt</td>
<td>GM OR SC-GM</td>
<td>( \text{Cv} = \frac{(\text{D}<em>{10})^{2}}{\text{D}</em>{95} \times \text{D}_{60}} )</td>
</tr>
<tr>
<td>GW-GC well-graded gravel with clay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP-GM poorly graded gravel with silt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GP-GC poorly graded gravel with clay</td>
<td></td>
<td>( \text{Cv} \text{ or } \text{Cf} \text{ for } \text{CL-ML} \text{ silty clay} )</td>
</tr>
</tbody>
</table>

**Figure 2 USCS Classification Chart (Source: Das, 2006)**

**AASHTO Soil Classification System**

The AASHTO soil classification is used to determine the suitability of soils for earthworks, embankments, and road bed materials (sub base and sub grade). According to AASHTO classification,

- **Gravel**: 75 mm - 2 mm (#10 sieve)
- **Sand**: 2 mm - 0.075 mm (#200 sieve)
- **Silt and Clay**: <0.075 mm
  - Silty: PI <10%
  - Clayey: PI >11

AASHTO classification classifies soil into 7 major groups: A-1 through A-7.

- **A-1 - A-3**: Granular or coarse grained soil
- **A-4 - A-7**: Silty clay or fine grained soil
Silty and clayey soils can be located in a plasticity chart as shown in the figure below.

Figure 3 AASHTO soil classification chart (Source: Das, 2006)

Figure 4 Plasticity chart for the AASHTO classification system (Source: Das, 2006)

Silty and clayey soils can be located in a plasticity chart as shown in the figure below.
A group index value (GI) is appended in parentheses to the main group to provide a measure of quality of a soil as highway sub grade material. The group index is given as:

\[
G I = (F - 35) (0.2 + 0.005 (LL - 40)) + 0.01 (F - 15) (PI - 10)
\]

Where,
\[F = \%\text{ finer than } \#200\text{ sieve size.}\]

GI is expressed in a nearest whole number. If GI is less than 0, set it to 0. If any terms in the above equation are less than 0, set them to 0. For them partial group index is used. The higher the group index, the lower the quality of soil as sub grade material. GI should not exceed 20 for any of group A-4 through A-7.