Sand Equivalent Value of Soils and Fine Aggregate

- Categories of Soils based on Particle Size:
    - Coarse aggregate.
    - Fine aggregate.
    - Silt. (sieve #200, size 0.075)
    - Clay.

- Clay like material are small particles in the size of clay particles that are deleterious to asphalt concrete.

- The presence of clay in fine aggregate can have detrimental effect on water sensitivity of asphalt concrete mix.

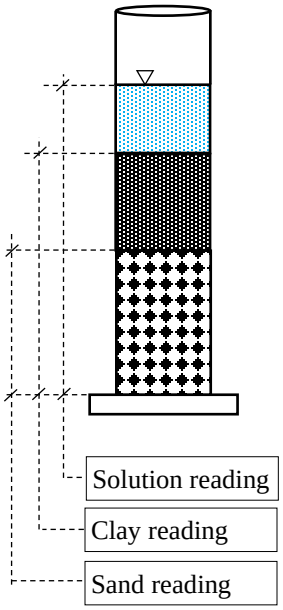
- Clay like materials have the tendency to form layers around the aggregate such that the asphalt binder sticks to this layer instead of the aggregate.

- These materials can coat aggregate particles and prevent proper asphalt binder-aggregate bonding.

- Problems Caused by clay like material:
    - Rutting.
    - Moisture damage.
    - Stripping in pavement.

- Sand Equivalent test is important because it is a simple test to determine whether a particular aggregate has enough dust or plastic fines to make a HMA mixture unstable or susceptible to stripping is valuable in preventing the manufacture of poor performing mixtures.

- In the sand equivalent test:
  - A sample of aggregate passing the No. 4 (4.75 mm) sieve and a small amount of flocculating solution are poured into a graduated cylinder and are agitated to loosen the clay-like coatings from the sand particles.
  - The sample is then irrigated with additional flocculation solution forcing the clay-like material into suspension above the sand.
  - After a prescribed sedimentation period, the height of flocculated clay and height of sand are determined.



- Clay Reading is usually clear to read; however, sand reading can be cloudy and difficult to read, thus we use the weighted foot assembly to find the sand reading.
  - The sand reading can be obtained by subtracting 10 from the weighted foot reading.
  - The sand equivalent is expressed as a ratio of the height of sand over the height of clay.

$$SE = \frac{\text{sand reading}}{\text{clay reading}}$$

- If the calculated sand equivalent is not a whole number, report it as the next higher whole number.

- Higher sand equivalent values indicate “cleaner” (less fine dust or clay-like materials) aggregate.

- Typical sand equivalent values range from less than 30% to more than 90%.

- If agg. #1 has SE = 70% and agg. #2 has SE = 40 % that means agg. #1 has more sand and less clay like material than agg. #2.

- The sand Equivalent in base material should be at least 45%.

Specific Gravity and Absorption of Aggregate

- Aggregate specific gravity is useful in
    - making weight-volume conversions
    - calculating the void content in compacted asphalt concrete.

- Specific gravity is the ratio of the mass of a unit volume of a material at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature.

    - Mass, m — kg
    - Weight, w — = m. g — kN
    - Volume, V — m^3
    - Density, ρ — = m/V — kg/m^3
    - Unit weight, γ — = *w*/V — kN/m^3

    - *w* = m. g ➔ γ = m. g/V = (m/V). g ➔ γ = ρ. G

    - Specific gravity, $G = \gamma/\gamma_w$ ➔

$$G = \frac{\frac{m.g}{V}}{\frac{m_w.g}{V_w}} = \frac{\frac{m}{V}}{\frac{m_w}{V_w}} = \frac{\rho}{\rho_w}$$

    - where γ_w is unit weight of water at 23.7° i.e. $\rho_w = 1\ g/c^3$

- since $\rho_w = 1$ g/c3, them the specific gravity of any material should equal its density dimensionless.

- Apparent Specific Gravity, G_{sa}:
  - The volume measurement only includes the volume of the aggregate particle; it does not include the volume of any water permeable voids.
  - The mass measurement only includes the aggregate particle.
  - Apparent specific gravity is intended to only measure the specific gravity of the solid volume,
  - Therefore, it is the highest of the aggregate specific gravities.

$$G_{sa} = \frac{m \quad (No\ Voids)}{V \quad (No\ Voids)}$$

- Bulk Specific Gravity (Bulk Dry Specific Gravity), G_{sb}:
  - The volume measurement includes the overall volume of the aggregate particle as well as the volume of the water permeable voids.
  - The mass measurement only includes the aggregate particle.
  - Since it includes the water permeable void volume, bulk specific gravity is less than apparent specific gravity.

$$G_{sb} = \frac{m \quad (No\ Voids)}{V \quad (With\ Voids)}$$

- Bulk Saturated Surface Dry (SSD) Specific Gravity.
  - Volume measurement includes the overall volume of the aggregate particle as well as the volume of the water permeable voids.
  - The mass measurement includes the aggregate particle as well as the water within the water permeable voids.

$$G_{SSD} = \frac{m \quad (with\ Voids)}{V \quad (with\ Voids)}$$

- Effective Specific Gravity, G_{se}.
  - Volume measurement includes the volume of the aggregate particle plus the void volume that becomes filled with water during the test soak period minus the volume of the voids that absorb asphalt.
  - Effective specific gravity lies between apparent and bulk specific gravity.

$$G_{se} = \frac{m \quad (No\ Voids)}{V \quad (partially\ with\ Voids)}$$

- $G_{sa} \geq G_{se} \geq G_{sb}$
- Bulk (SSD) specific gravity $\geq G_{sb}$

Calculations for Coarse Aggregate:

Obtain:

A = weight of oven-dry test sample in air, g
B = weight of saturated-surface-dry test sample in air, g., and
C = weight of saturated test sample in water, g.

Bulk Specific Gravity (Bulk Dry Specific Gravity):	$G_{sb} = A / (B - C)$
Bulk Specific Gravity (Saturated-Surface-Dry):	$SSD = B / (B - C)$
Apparent Specific Gravity:	$G_{sa} = A / (A - C)$
Absorption %:	$\% = [(B - A) / A] \times 100$

Calculations for Fine Aggregate:

Obtain:

A = weight of oven-dry specimen in air, g.
B = weight of pycnometer filled with water, g.
S = weight of the saturated surface-dry specimen, g.
C = weight of pycnometer with specimen and water to calibration mark, g.

Bulk Specific Gravity (Bulk Dry Specific Gravity):	$G_{sb} = A / (B + S - C)$
Bulk Specific Gravity (Saturated-Surface-Dry):	$SSD = S / (B + S - C)$
Apparent Specific Gravity:	$G_{sa} = A / (B + A - C)$
Absorption %:	$\% = [(S - A) / A] \times 100$

- Procedure for determining combined specific gravities for different sources of material.

  When the total aggregate consists of separate fractions of coarse aggregate, fine aggregate, and mineral filler, all having different specific gravities

$$G_{sb} = \frac{P_1 + P_2 + \cdots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \cdots + \frac{P_n}{G_n}}$$

Where:
G_{sb} = bulk specific gravity for the total aggregate
P_1, P_2, P_n = percentages by weight of aggregates 1, 2, ... n
G_1, G_2, G_n = bulk specific gravities of aggregate 1, 2, ... n