

5. SOIL CLASSIFICATION

→ IS Particle Size Classification System

* Grain Size only - criteria

2 μ	75 μ	4.75mm	80mm	300 mm	
Clay	Silt.	Sand.	Gravel.	Cobble	Boule

The colloidal soil particle size is less than the clay size. However in our Indian code of practice, colloidal soil is not recognized.

But the Indian classification based on size alone is not always true. For eg:- Rock dusts or rock powder's particle size is less than 2 μ and hence belong to clay as per Indian system. But rock dust has no plasticity.

→ HRB Soil Classification System.

- HRB - Highway Research Board.

* Criteria: a) Grain size distribution.

b) Consistency or Atterberg limits.

- This system is more useful for pavement design.

- In this system, soils are given group numbers like

A₁, A₂, A₃ A₇, A₈.

- The smaller the group number, the better the soil for pavement purpose. i.e. A₁ is better than A₂. A₂ is better than A₃ and so on.

A₈ group - highly organic soil (worst soil for construction)

A₇ group - black cotton soil.

- Group Index, GI: an index value calculated by an empirical equation. GI value depends on -

- % of soil passing 75 μ sieve.
- w_L
- w_p or I_p

GI values ranges from 0 to 20

If GI value is found to be negative from equation, it is reported as 'zero'.

GI indicates quality of soil within its own group.

The smaller the GI value, the better the soil for pavement purpose.

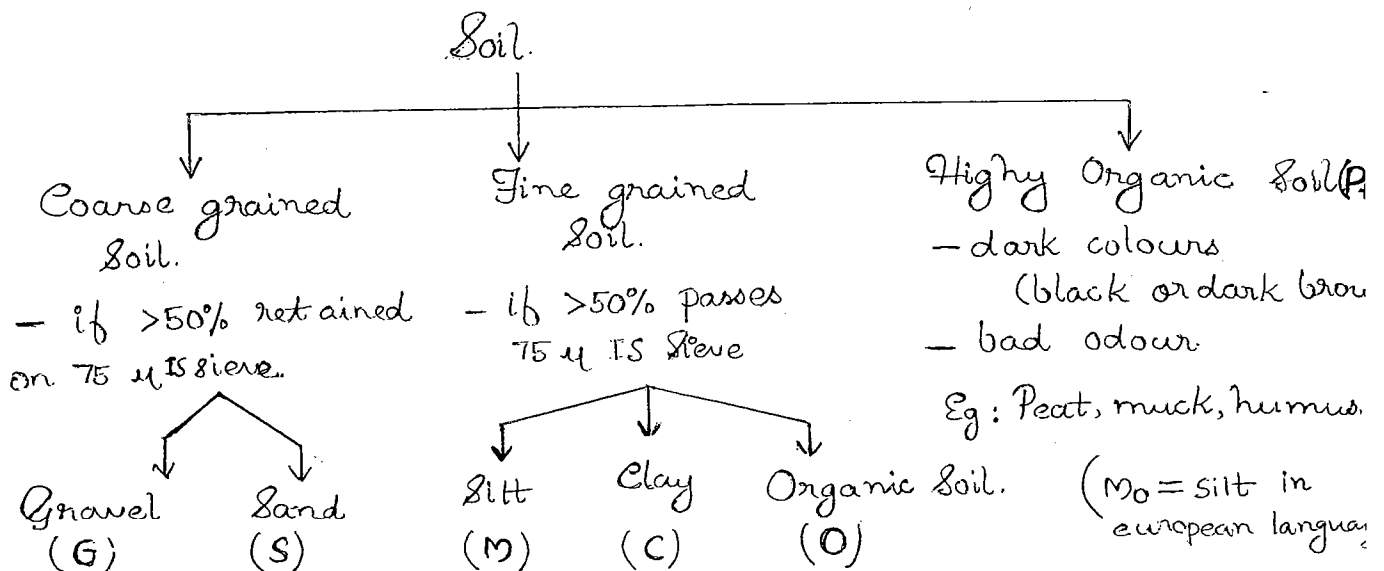
- Symbol: $A5(6)$
 $\downarrow$ GI
 $\uparrow$ Group no.

→ Unified Soil Classification System.

- most popular in European countries.
- criteria: a) grain size distribution data.
 b) consistency limits
 c) compressibility characteristics.

→ IS Soil Classification System.

- followed by all engineering departments in India.



Gravel - if more than 50% of coarse fraction retained on 4.75 mm sieve

Sand - if $> 50\%$ coarse fraction passes 4.75 mm sieve.

- Gravel:

- a) Well graded Gravel - GW
- b) Poorly graded Gravel - GP
- c) Silty gravel. - GM
- d) Clayey gravel. - GC

- Sand:-

- a) Well graded sand - SW
- b) Poorly graded sand - SP
- c) Silty gravel sand - SM
- d) Clayey gravel sand - SC

⊙ Clayey sand

$\Rightarrow$ clay qty $<$ sand qty

⊙ Silty Clayey gravel

$\Rightarrow$ silt qty $<$ clay qty $<$ gravel qty

⊙ Sandy clay.

$\Rightarrow$ sand qty $<$ clay qty.

- Silt:-

- a) Low compressible silt - ML
- b) Intermediate compressible silt. - MI
- c) Highly compressible silt. - MH

- Clay:-

- Organic Soil

- a) CL
- b) CI
- c) CH

- a) OL
- b) OI
- c) OH

- Total group symbols = 8 + 9 + 1 = 18 groups.
(coarse) (fine) (Pt)

- If $w_L < 35\%$ - Low compressible

$35\% < w_L < 50\%$ - Intermediate compressible.

$w_L > 50\%$ - Highly Compressible.

30th Aug,
SATURDAY → Plasticity Chart.

(21)

22

- to classify the fine grained soils.

* To identify Organic Soils:

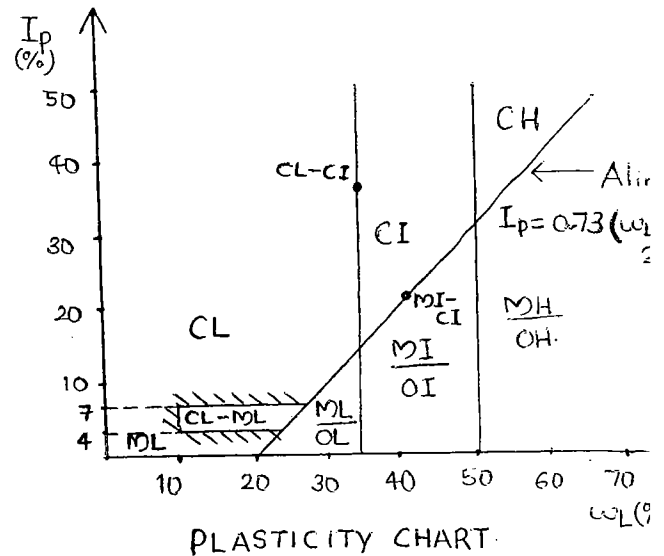
a) Colour test

Dark colours (black or dark brown)

b) Odour test.

Bad odour.

c) w_L test before and after oven drying.



For organic soils, w_L decreases (by more than one fourth of initial value) after oven drying.

* Boundary Classifications:

(i) CL-CI, CI-CH.

(ii) ML-MI, MI-MH.

(iii) OL-OI, OI-OH.

(iv) MI-CI, MH-CH. (coarser particle should be given preference
∴ MI-CI ✓
CI-MIX)

Q.1 Classify the fine grained soil with $w_L = 60\%$, $w_p = 20\%$.

$$I_p \text{ of soil} = 60 - 20 = 40\%$$

$$I_p \text{ of A-line} = 0.73(w_L - 20) = 29.2\%$$

Since I_p of soil is $> I_p$ of A line, the point plots above

A line $\Rightarrow$ clay.

$w_L > 50 \Rightarrow$ highly compressible.

∴ Soil is CH.

Q. $w_L = 20\%$, $w_p = 15\%$

$I_p = 5\%$ (blw 4 & 7)

$w_L = 20\%$

$\Rightarrow \underline{\underline{CL - ML}}$

— Equation of I_p vs w_L is called A-line because A is the surname of A. Casagrande.

$\rightarrow$ GW : (i) if fines $< 5\%$ (ii) $C_u > 4$ (iii) C_c lies blw 1 & 2

GP : if (i) fines $< 5\%$ (ii) not meeting above gradation requirements (C_c & C_u).

GM : if (i) fines $> 12\%$ (ii) I_p value $< 4\%$ or Atterberg limits fall below A-line.

GC : if (i) fines $> 12\%$ (ii) $I_p > 7\%$ with Atterberg limit fall above A-line.

If fines lies between 5% & 12%, it is a border line case requiring dual symbol.

For eg: GW-GC, GP-GM, GP-GC, GW-GM

If I_p lies blw 4 & 7%, it is a border line case requiring dual symbol. For eg:- GM-GC.

Q. Fines = 15%, $I_p = 6\%$

$\Rightarrow$ GM-GC.

Q. Fines = 3%, $C_u = 5$, $C_c = 2$

$\Rightarrow$ GW.

Q. Fines = 15%, $I_p = 2\% \Rightarrow$ GM.

Q. Fines = 10%, $C_u = 5$, $C_c = 2$, $I_p = 5\%$

$\Rightarrow$ GW-GM

In case of border line cases, the coarser one is to be favour (or) the coarser one is given priority.

- Between organic soil and clay, the organic one is coarser on

CI - OI ✗

OI - CI ✓

→ In the case of sand, all the conditions are same. except $C_u > 6$.

→ Single Clay Particle } not visible to
Single silt particle } naked eye

Size	% Retained	Cumulative %	% Finer
600 μ	$\frac{240}{600} \times 100 = 40\%$	40%	60%
500 μ	$\frac{300}{600} \times 100 = 50\%$	90%	10%
425 μ	10%	100%	0

D_{60} = diameter corresponding to 60% finer
= 600 μ .

D_{10} = 500 μ

$$C_u = \frac{D_{60}}{D_{10}} = \frac{600}{500} = \underline{\underline{1.2}}$$

3. $C_u < 6$
 $\Rightarrow \underline{\underline{SP}}$

4. $W_L = 42\%$ ie b/w 35% & 50% $\Rightarrow$ intermediate, I
MI

5. $Fines = \frac{250}{1000} \times 100 = 25\%$

Coarse fraction = $100 - 25 = 75\% \Rightarrow$ coarse grained soil.

$$I_p = 42 - 20 = 22\% > 18\%$$

$$I_p \text{ of A line} = 0.73(w_L - 20) = 16.06\%$$

$I_p > I_p \text{ of A line} \therefore \text{pt. lies above A line.}$

$\therefore \underline{\underline{SC}}$

6. $\text{Fines} = 30\%$ (silt + clay).

$$\therefore \text{Coarse fraction} = 100 - 30 = 70\% \text{ (gravel + sand).}$$

$\therefore$ It is coarse grained soil.

$$\text{Gravel fraction} = 100 - 60 = 40\% \text{ (more than 50\% of 70\%)}$$

$$\left\{ \begin{array}{l} \text{Gravel + sand} = 70\% \\ \therefore \text{Sand fraction} = 30\% \end{array} \right\}$$

$\therefore$ soil is gravel. ($\because$ gravel % > sand %)

$$I_p \text{ of soil} = 35 - 27 = 8\%$$

$$I_p \text{ of A line} = 0.73(w_L - 20) = 10.95\%$$

$\therefore$ point falls below A-line. $\Rightarrow \underline{\underline{GM}}$

7.
$$\left. \begin{array}{l} C_u = \frac{D_{60}}{D_{10}} = 1.78 \\ C_u = \frac{D_{30}^2}{D_{60} \cdot D_{10}} = 0.95 \end{array} \right\} \text{poorly graded.}$$

$$D_{60} = 0.41 \text{ mm.} \Rightarrow 60\% \text{ passing } 0.41 \text{ mm. (or } 4.75 \text{ mm)}$$

$\therefore \underline{\underline{\text{sand}}}$

$\underline{\underline{SP}}$