CASE-1 : When fineness is less than 5% by weight.

Gravels: more than 50% of coarse fraction retained on 4.75 mm sieve

(i) GW ⇒ well graded gravel.

$C_u > 4$, $1 \le C_c \le 3$ and fineness < 5%

(ii) GP ⇒ poorly graded gravel.

Above values of C_u and C_c are not satisfied.

Sand: more than 50% of coarse fraction pass through 4.75 mm sieve

(i) SW ⇒ well graded sand.

$C_u > 6$, $1 \le C_c \le 3$ and fineness < 5%

(ii) SP ⇒ poorly graded sand.

Above values of C_u and C_c are not satisfied

CASE-2 : When fineness is between 5-12%

This is known as borderline case and dual symbols are used. First part of dual symbol represent gradation and second part represents nature of fines i.e. clay or silt.

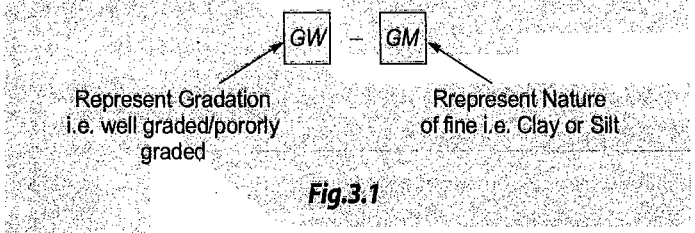

Fig.3.1

Gravel:

(i) GW – GC ⇒ well graded gravel containing clay as fine

$C_u > 4$, $1 \le C_c \le 3$

clay fraction > silt fraction

(ii) GP – GC ⇒ poorly graded gravel containing clay as fine

Above values of C_u and C_c are not satisfied

clay fraction > silt fraction

(iii) GW – GM ⇒ well graded gravel containing silt as fine

$C_u > 4$, $1 \le C_c \le 3$

silt fraction > clay fraction

(iii) GP – GM ⇒ poorly graded gravel containing silt as fine

above values of C_u and C_u are not satisfied

silt fraction > clay fraction

Sand: more than 50% of coarse fraction pass through 4.75 mm sieve

(i) SW – SC ⇒ well graded sand containing clay as fine

$C_u > 6$, $1 \le C_c \le 3$

clay fraction > silt fraction

(ii) SP – SC ⇒ poorly graded sand containing clay as fine

values of C_u and C_c are not satisfied

clay fraction > silt fraction

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(iii) SW – SM ⇒ well graded sand containing silt as fine

$C_u > 6$, $1 \le C_c \le 3$

silt fraction > clay fraction

(iii) SP – SM ⇒ poorly graded sand containing silt as fine

values of C_u and C_u are not satisfied

silt fraction > clay fraction

CASE-3 : When fineness is more than 12%

In this case soil is classified according to I.S. plasticity chart (%I_P)

Gravel:

(i) GC ⇒ clayey gravel

% fineness > 12 and $I_P > 7\%$

clay fraction > silt fraction [$\because I_P > 7\%$]

(ii) GM ⇒ Silty gravel

% fineness > 12 and $I_P < 4\%$

silt fraction > clay fraction [$\because I_P > 4\%$]

Sand:

(i) SC ⇒ clayey sand

% fineness > 12 and $I_P > 7\%$

clay fraction > silt fraction [$\because I_P > 7\%$]

(ii) SM ⇒ Silty sand

% fineness > 12 and $I_P < 4\%$

silt fraction > clay fraction

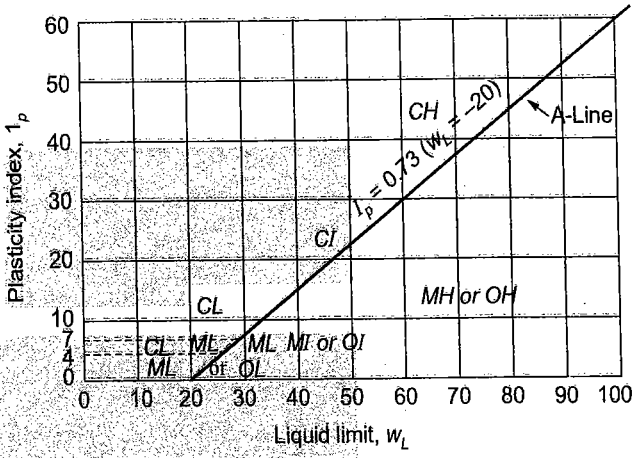

Fig.3.2

NOTE: If plasticity index is between 4% - 7% then dual symbols are used.

Example 3.1 From a particle-size distribution curve of a sandy soil, the following data is obtained:

Determine the uniformity coefficient and coefficient of curvature. Is this soil is well graded or poorly graded?

Size of particle (mm)	Percentage finer
0.48	60
0.33	30
0.21	10

Solution:

Given $D_{60} = 0.48$ mm, $D_{30} = 0.33$ mm and $D_{10} = 0.21$ mm

Coefficient of curvature, $C_u = \dfrac{D_{60}}{D_{10}}$

$\Rightarrow$ $C_u = \dfrac{0.48}{0.21} = 2.28$

and coefficient of curvature, $C_c = \dfrac{(D_{30})^2}{D_{60} \times D_{10}}$

$C_c = \dfrac{(0.33)^2}{0.48 \times 0.21} = 1.08$

For well graded sand, $C_u > 6$ and $1 \le C_c \le 3$

So it is a poorly graded sand.

$$\Rightarrow \quad C_u = \frac{600\ \mu}{500\ \mu} = 1.2$$

More than 50% of the soil pass through 600 μ sieve, it means that greater percentage of the soil will pass through 4.75 mm sieve. Hence the soil is definitely sandy soil.

For well graded sand

$C_u > 6$ and $1 \le C_c \le 3$

Here, $C_u = 1.2$ thus the soil is poorly graded sand.

Example 3.4 Classify the soil for date given:

Sieve size (mm)	Weight retained (g)
4.75	20
0.075	730

1000 g of soil was used.
Liquid Limit = 40%
Plastic Limit = 18%
The soil classification is
(a) GM (B) SM
(c) GC (D) ML-MI
Ans. (a)

S.N.	Sieve size (mm)	Weight retained (g)	Cum-weight retained (g)	Cum. % retained	% Finer % N
1	4.75	20	20	2	98
2	0.075	730	750	75	25

Since 98% of soil pass through 4.75 mm IS sieve, and 75% are retained on 75 μ, given soil is sand.
Also, 25% soil is pass through 0.75 mm sieve.

$\therefore$ fineness = 25%

$W_L = 40\%$, $W_P = 18\%$

$\therefore \quad I_P = 22\% > 7\%$

here fineness > 12% and $I_P > 7\%$

$\therefore$ soil is clayey sand (SC)

3.5 Classification of Fine Grained Soil

- In ISSCS, fine grained soils are classified on the basic of plasticity chart (I_P) and compressibility (W_L)
- Generally soils are considered as fine soils, when 50% or more of the total material by weight pass 75 μ sieve.
- LL (W_L) and PL (W_P) are determined for 425 μ sieve fraction and corresponding plasticity index is fine out.

$$I_P = W_L - W_P$$

CASE-1: Low Plastic Soil (Low Compressibility) (LL < 3.5%)

$CL \rightarrow$ Low plastic inorganic clay
$ML \rightarrow$ Low plastic silt
$OL \rightarrow$ Low plastic organic clay

CASE-2: Medium Plastic Soil (Medium Compressibility) (35% < LL< 50%)

CI → Medium plastic inorganic clay

MI → Medium plastic silt

OI → Medium plastic organic clay

CASE-3: Highly Plastic Soils (High compressibility)

$LL > 50\%$

CH → High plastic inorganic clay

MH → High plastic silt

OH → High plastic organic

NOTE

Organic and inorganic soils are plotted in same zone in plasticity chart which are distinguished by odour and colour or liquid limit test on oven dry sample. If LL of oven dry is sample less than the three fourth of in-situ soil sample then soil is organic otherwise Inorganic.

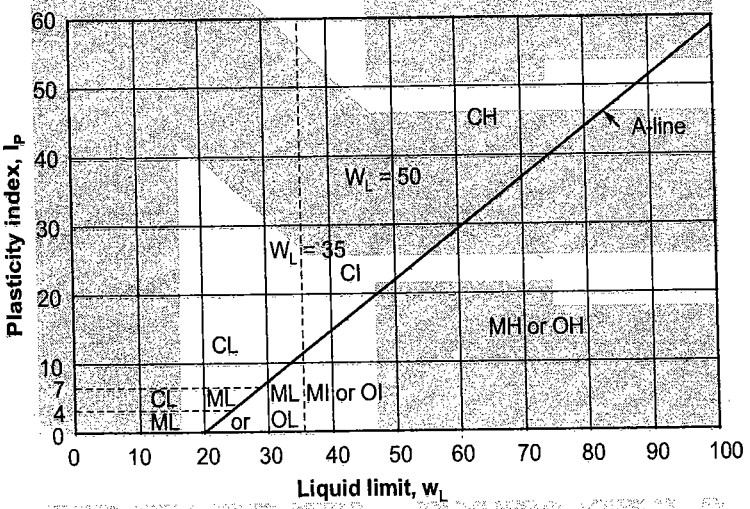

Fig.3.3 Plasticity chart as per Indian Standard Soil Classification System

The above soil classification is based on a line called A-line, which is a boundary representing relationship between plasticity index (I_P) and *LL* (W_L).

- If I_P of soil > I_P of *A*-line
  the soil will lie above *A*-line and it will be Inorganic clay(*C*)
- If I_P of soil < I_P of *A*-line
  the soil will lie below *A*-line and it may be either silt (*M*) or organic clay (*O*)
- The I_P of *A*-line is given by
  $$I_P = 0.73\,(W_L - 20)$$
  where W_L = liquid limit
- *U*-line represent upper boundary beyond which no soil lie. If results are found above U-line then test must be repeated.
  $$I_P \text{ of } U\text{-line} = 0.9\,(W_L - 8)$$
  where W_L = liquid limit
- Highly organic soils (eg. Peat) are classified as *Pt.*

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