



INS 3121

SOIL MECHANICS

Examples:

Classification of Soils

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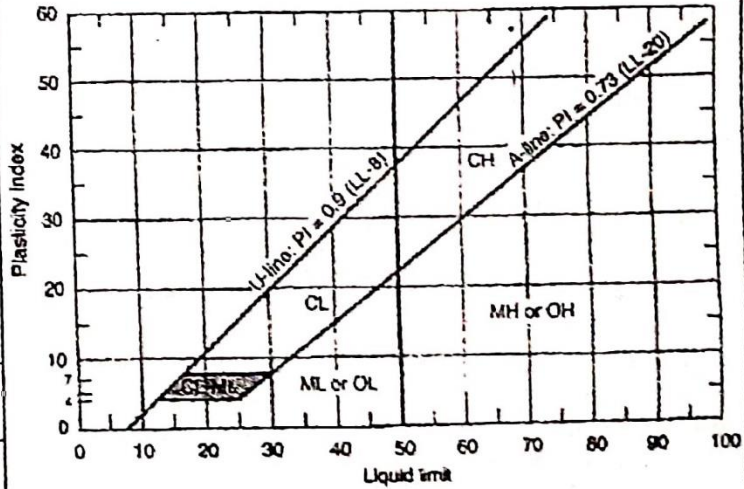
Basic Groups			Group Symbol	Soil Type	Laboratory Classification Criteria						
Coarse Grained Soils (Finer Percent No:200 < 50%)	Gravels More than 50% of coarse fraction larger than No: 4 sieve size	Clean Gravels (Passing the sieve No:200 <5%)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Passing the sieve No:200 <5% GW,GP,SW,SP >12% GM,GC,SM,SC 5%-12% Borderline cases requiring dual symbols.	$C_u = D_{60}/D_{10} > 4$ and $C_c = D_{30}^2 / (D_{10} * D_{60}) = 1-3$					
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines		$C_u \leq 4$ or $C_c \neq 1-3$					
		Gravel with Fines (Passing the sieve No:200 >12%)	GM	Silty gravels, gravel-sand-silt mixtures		Attenberg limits below A line or $I_p < 4\%$	Above A line and $4 < \% < 7$ dual symbols				
			GC	Clayey gravels, gravel-sand-clay mixtures		Attenberg limits above A line and $I_p > 7\%$					
	Sands 50% or more of coarse fraction smaller than No: 4 sieve size	Clean Sands (Passing the sieve No:200 <5%)	SW	Well-graded sands, gravelly sands, little or no fines		$C_u = D_{60}/D_{10} > 6$ and $C_c = D_{30}^2 / (D_{10} * D_{60}) = 1-3$					
			SP	Poor-graded sands, gravelly sands, little or no fines		$C_u \leq 6$ or $C_c \neq 1-3$					
		Sands with Fines (Passing the sieve No:200 >12%)	SM	Silty sands, sand-silt mixtures		Attenberg limits below A line or $I_p < 4\%$	Above A line and $4 < \% < 7$ dual symbols				
			SC	Clayey sands, sand-clay mixtures		Attenberg limits above A line and $I_p > 7\%$					
			Fine Grained Soils (Finer Percent No:200 > 50%)	Sils and Clays		Low Plasticity Silts and Clays ($w_L < 50\%$)		ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity		
								CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
OL	Organic silts and organic silty clays of low plasticity										
High Plasticity Silts and Clays ($w_L > 50\%$)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts									
	CH	Inorganic clays of high plasticity, fat clays									
	OH	Organic clays of medium to high plasticity, organic silts									
Organic Soils				Pt	Peat and other highly organic soils						

Table 5.1 Classification of Highway Subgrade Materials

General classification		Granular materials (35% or less of total sample passing No. 200)					
Group classification	A-1		A-3	A-2			
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7
Sieve analysis (percentage passing)							
No. 10	50 max.						
No. 40	30 max.	50 max.	51 min.				
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.
Characteristics of fraction passing No. 40							
Liquid limit				40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Stone fragments, gravel, and sand		Fine sand	Silty or clayey gravel and sand			
General subgrade rating			Excellent to good				
General classification		Silt-clay materials (more than 35% of total sample passing No. 200)					
Group classification				A-4	A-5	A-6	A-7 A-7-5 ^a A-7-6 ^b
Sieve analysis (percentage passing)							
No. 10							
No. 40							
No. 200				36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40							
Liquid limit				40 max.	41 min.	40 max.	41 min.
Plasticity index				10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials				Silty soils		Clayey soils	
General subgrade rating					Fair to poor		

^aFor A-7-5, $PI \leq LL - 30$

Example 1

Classify the soil using the AASHTO and USCS classification system.

Sieve Analysis Result		
Sieve No	Sieve Diameter (mm)	Percent Passing
4	4.75	58
10	2.00	41
40	0.425	29
200	0.075	21
Atterberg Limits		
w_L	39%	
w_p	20%	

Solution 1

USCS

Sieve no: 200 -> percent passing -> %21, so coarse grained soil (gravels or sands)

Gravels -> more than 50% of coarse fraction retained on No: 4 sieve

Sands -> 50% or more of coarse fraction passes No:4 sieve

Sieve no: 4 -> percent passing of coarse grained soils -> $58 - 21 = 37\%$

$37\% < 50\%$ so, -> Gravels

Clean gravels Gravels with fines

(sieve no 200 < 5%) (sieve no 200 > 5%)

GC

PI > 7 and above A line

Solution 1

AASHTO

Sieve no: 200 -> percent passing -> 21%, so coarse grained soil (gravels or sands)

Sieve no: 40 -> percent passing -> 29%

Sieve no: 10 -> percent passing -> 41% < 50%

Sieve no: 200 -> percent passing -> 21% > 10%, so coarse grained soils

$I_p = 19$ -> A-2-6, A-2-7

$LL = 39 < 40$
 $PI = 19 > 10$ } **A-2-6** → **Gravels with fines and sands**

Example 2

Classify the soil using USCS classification system

Sieve No	Soil A	Soil B	LL	PL
4	100	100	30	26
200	8	61	22	20
C _u	1.59			
C _c	1.25			

Solution 2

Soil A

Above No. 200 = 92 > 50% -> coarse grain

Sand = 92%
Gravel = 10% } S_{-}

Below No. 200 = 8 -> 5% < 8 < 12%

Dual Symbols

$C_u = 1.59 \leq 6$
 $C_c = 1.25$ } SP $LL - PL = 30 - 22 = 8\%$
 $I_p > 7\%$ } SC

$SP-SC$

Solution 2

Soil B

Above No. 200 = $39 < 50\%$ -> fine grained soil

In plasticity chart.

CL-ML

Example 3

Classify the soils using AASHTO and USCS

Sieve No	Percent Passing		
	Soil A	Soil B	Soil C
No.4	40	100	100
No.10	33	88	100
No.40	21	53	
No.200	3	37	66
LL	45	68	46
PL	18	25	24
Cu	5.3	4.9	2.8
Cc	6.0	2.5	5.1

Solution 3

USCS

For soil A -> percent passing of sieve 200 equal 3% -> **coarse soils**

percent passing of sieve 4 equal 40% -> coarse (37%) + fine (3%)

37% < 50% -> **gravel**

percent passing of sieve 200 = 3% < 5% -> GW or GP

$$\left. \begin{array}{l} Cu = 5.3 \leq 4 \quad \otimes \\ Cc = 6.0 \neq 1 - 3 \quad \checkmark \end{array} \right\} \boxed{\text{GP}}$$

Solution 3

USCS

For soil B -> percent passing of sieve 200 equal 37% -> **coarse soils**

percent passing of sieve 4 equal 100% -> coarse (63%) + fine (37%)

63% > 50% -> **sand**

percent passing of sieve 200 = 37% > 12% so, SM or SC

$I_p = LL - PL = 68 - 25 = 43 > 7$ -> **SC**

Solution 3

USCS

For soil C -> percent passing of sieve 200 equal 66% -> fine soils

$\omega_l = 46\% < 50\%$ -> ML, CL or OL

with plasticity card -> $\omega_l = 46$
 $I_p = 22$ } CL

Solution 3

AASHTO

For soil A -> percent passing of sieve 200 equal 3% < 35% so **coarse soils**

A-1-a -> No. 10 passing 33% ≤ 50% ✓

No. 40 passing 21% ≤ 30% ✓

No. 200 passing 3% ≤ 15% ✓

$$I_p = 27 \leq 6 \quad \otimes$$

A-1-b -> No. 40 passing 21% ≤ 50% ✓

No. 200 passing 3% ≤ 25% ✓

$$I_p = 27 \leq 6 \quad \otimes$$

Solution 3

AASHTO

For soil A -> percent passing of sieve 200 equal 3% < 35% so **coarse soils**

A-3 -> No. 40 passing 21% > 50% ⊗

A-2-4 -> No.200 passing 3% < 35% ✓

A-2-5 -> No. 200 passing 3% ≤ 35% ✓

$$\omega_l = 45 > 40 \quad \checkmark$$

$$I_p = 27 \leq 10 \quad \otimes$$

A-2-6 -> No. 200 passing 3% ≤ 35% ✓

$$LL = 45 \leq 40 \quad \otimes$$

A-2-7 -> No. 200 passing 3% ≤ 35% ✓

$$LL = 45 > 40 \quad \checkmark$$

$$I_p = 27 > 10 \quad \checkmark$$

} ✓ **A-2-7**