



# Geotechnical Engineering–I

## *BSc Civil Engineering – 4<sup>th</sup> Semester*

Lecture # 9

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*by*

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*Lecture Handouts: <https://groups.google.com/d/forum/geotec-1>*

# SOIL CLASSIFICATION

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Two commonly classification system used are:

1. **Unified Soil Classification System (USCS)**
  - preferred by *Geotechnical engineers*
2. **American Association of State Highway and Transportation Officials (AASHTO) System**
  - preferred by *Transportation engineers*

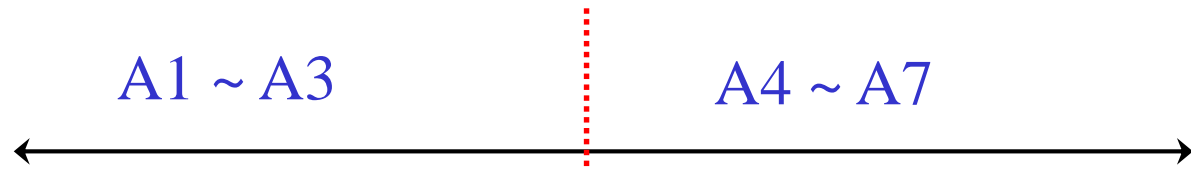
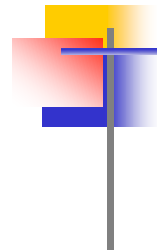
# AASHTO Soil Classification

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- Classification procedure standardized by *ASTM D3282* and *AASHTO M145*.
- *Soil rating* for *subgrade* construction.
- Soils classified into *8 groups (+ several subgroups)*;  
**A-1** (*best*) to **A-8** (*worst*).
- *Organic soils* (peat and muck) assigned group *A-8*.
- Required tests are *sieve analysis* and *Atterberg limits*.

# AASHTO Soil Classification

(ASTM D3282; AASHTO M145)



Granular Materials

$\leq 35\%$  pass No. 200 sieve

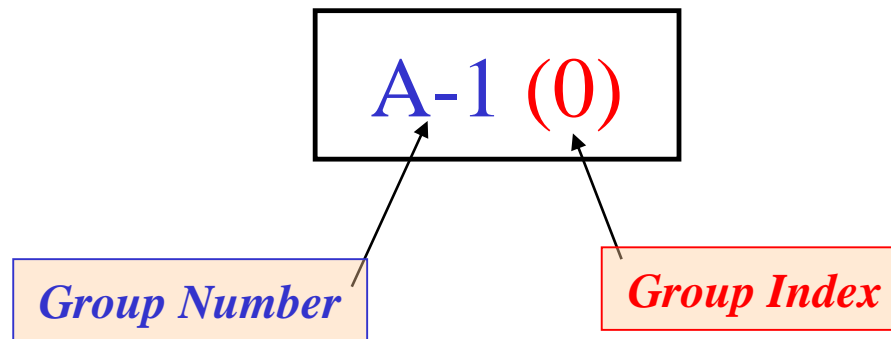
Silt-clay Materials

$> 35\%$  pass No. 200 sieve

Using LL and PI separates silty materials from clayey materials (only for A2 group)

Using LL and PI separates silty materials from clayey materials

## Example



# GROUP INDEX (*GI*)

**GI** → *Empirical formula* used to further evaluate soils within a group (*subgroups*)

$$GI = (F_{200} - 35)[0.2 + 0.005(LL - 40)] + 0.01(F_{200} - 15)(PI - 10)$$



Partial GI determined from *LL*



Partial GI determined from *PI*

where

$F_{200}$  = percentage passing through the No. 200 sieve

$LL$  = Liquid limit, and  $PI$  = Plasticity index

- **GI** is *rounded off* to nearest whole number  
(e.g.,  $GI = 3.4$  is rounded off to 3;  $GI = 3.5$  is rounded off to 4)
- **GI** = 0, if the equation yields *negative value*.

# GROUP INDEX (*GI*)

*Smaller* the *GI*, *better* is the soil.

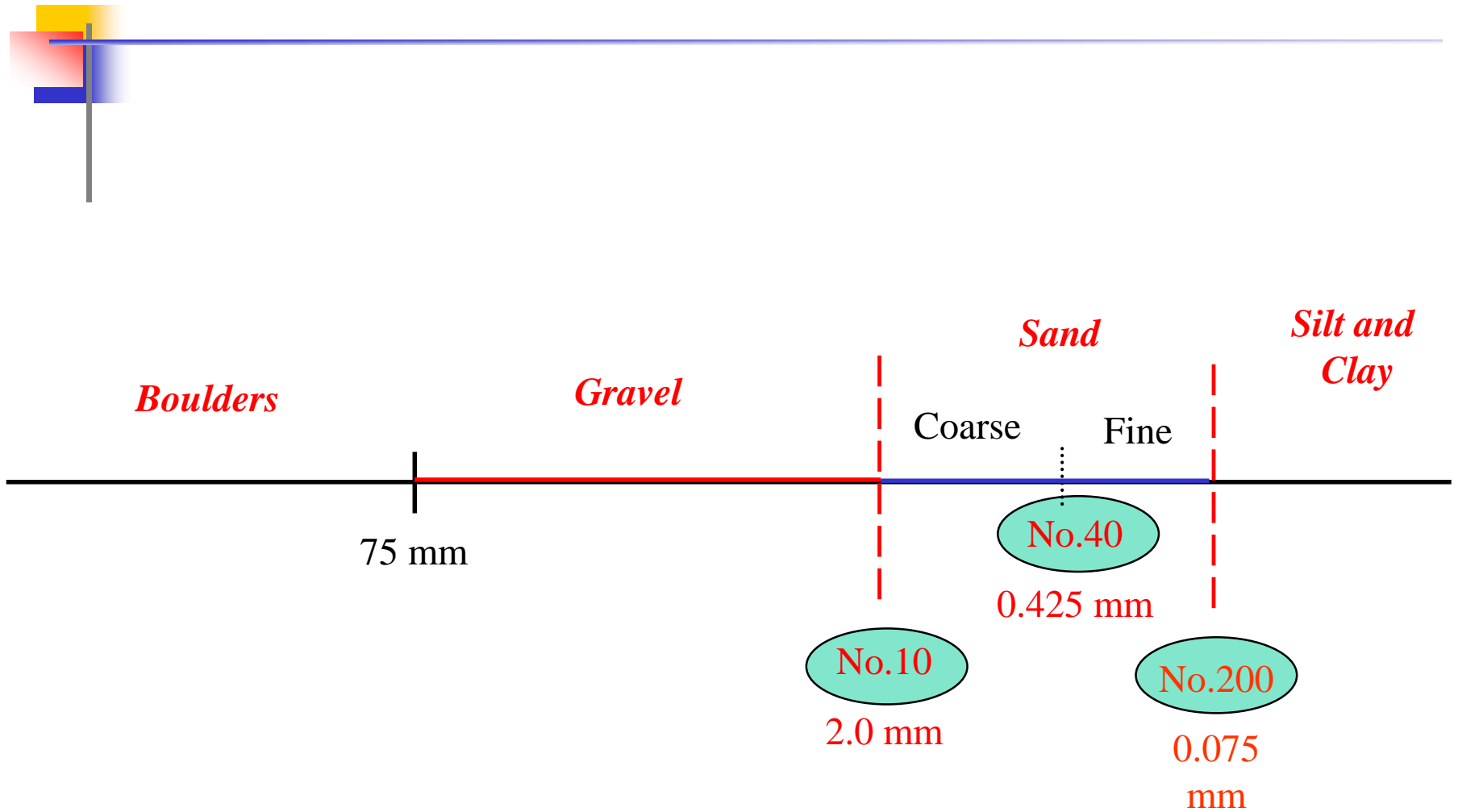
GI of soils belonging to groups A-1-a, A-1-b, A-2-4, A-2-5, and A-3 is always *zero*.

GI for soils belonging to groups A-2-6 and A-2-7 is computed by using the partial formula.

$$GI = 0.01(F_{200} - 15)(PI - 10)$$

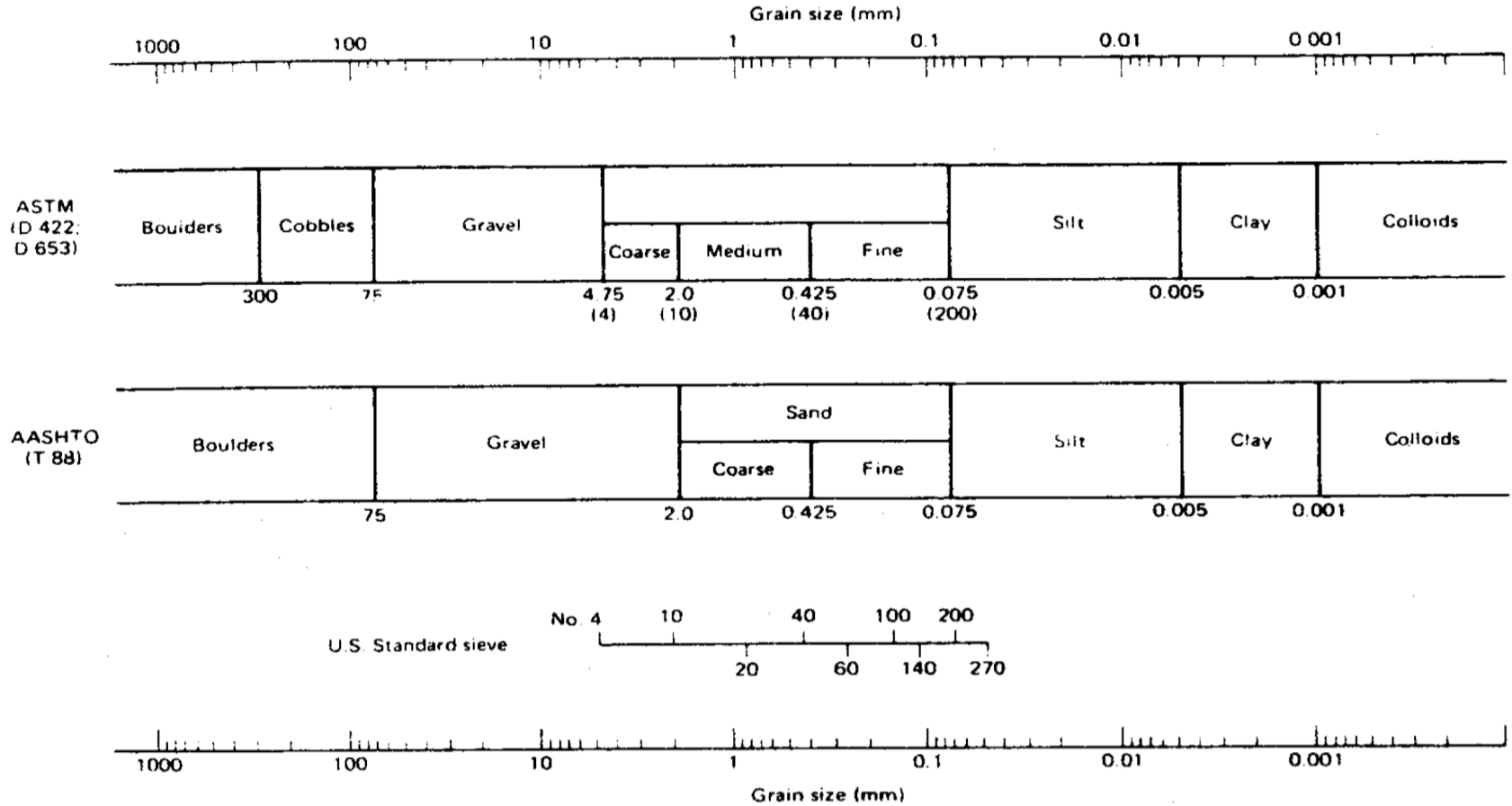
- GI is *shown in parentheses* after the group symbol, e.g. A-2-6(3), A-6(12), A-7-5(17)

# AASHTO Particle Size



# AASHTO vs USCS

## Particle Size Comparison

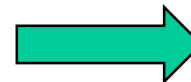




# AASHTO Classification Chart

(Coarse-grained Soils)

General classification	Granular materials (35% or less of total sample passing No. 200)							
	A-1			A-3	A-2			
Group classification	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							



Note:

First group from the left to fit test data is the correct AASHTO classification.

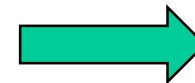
# AASHTO Classification Chart

(Fine-grained Soils)

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 <sup>a</sup> A-7-6 <sup>b</sup>
Sieve analysis (percentage passing)					
No. 10					
No. 40					
No. 200	36 min.	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40					
Liquid limit	40 max.	41 min.	40 max.	41 min.	41 min.
Plasticity index	10 max.	10 max.	11 min.	11 min.	11 min.
Usual types of significant constituent materials	Silty soils			Clayey soils	
General subgrade rating			Fair to poor		

<sup>a</sup>For A-7-5,  $PI \leq LL - 30$

<sup>b</sup>For A-7-6,  $PI > LL - 30$

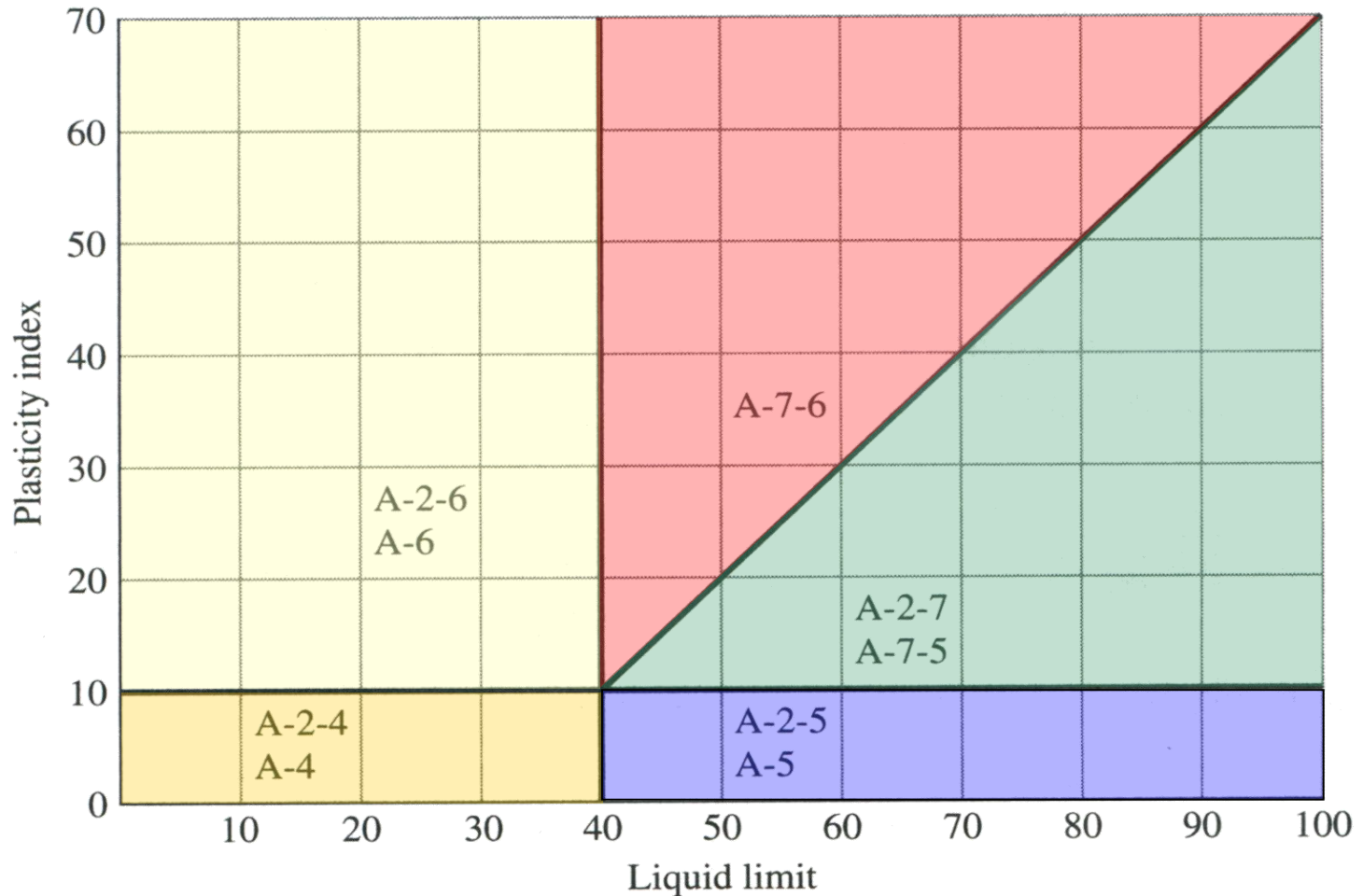


Note:

First group from the left to fit test data is the correct AASHTO classification.

# AASHTO Plasticity Chart

Range of *LL* and *PI* for soils in groups *A-2*, *A-4*, *A-5*, *A-6*, and *A-7*.



# Practice Problem #1

$$P_{10} = 80\%$$

$$P_{40} = 52\%$$

$$P_{200} = 20\%$$

$$LL = 35 \quad PL = 20 \quad PI = 15$$

## Given data

Obtained from  
*gradation curve &  
Atterberg Limit tests*

General classification	Granular materials (35% or less of total sample passing No. 200)						
	A-1		A-3	A-2			
Group classification	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						

# Practice Problem #1

$$P_{10} = 80\% \quad P_{40} = 52\% \quad P_{200} = 20\%$$
$$LL = 35 \quad PL = 20 \quad PI = 15$$

**Given data**  
Obtained from  
*gradation curve &  
Atterberg Limit tests*

Since,  $P_{200} < 35\%$ , coarse grained soil

Since,  $P_{10} > 50$ , not A-1-a

Since,  $P_{40} > 50$ , not A-1-b

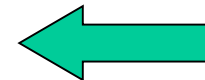
Since,  $P_{200} > 10$ , not A-3

So must be **A-2 soil**, use plasticity chart

**A-2-6** soil

$$GI = 0.01(F_{200} - 15)(PI - 10)$$

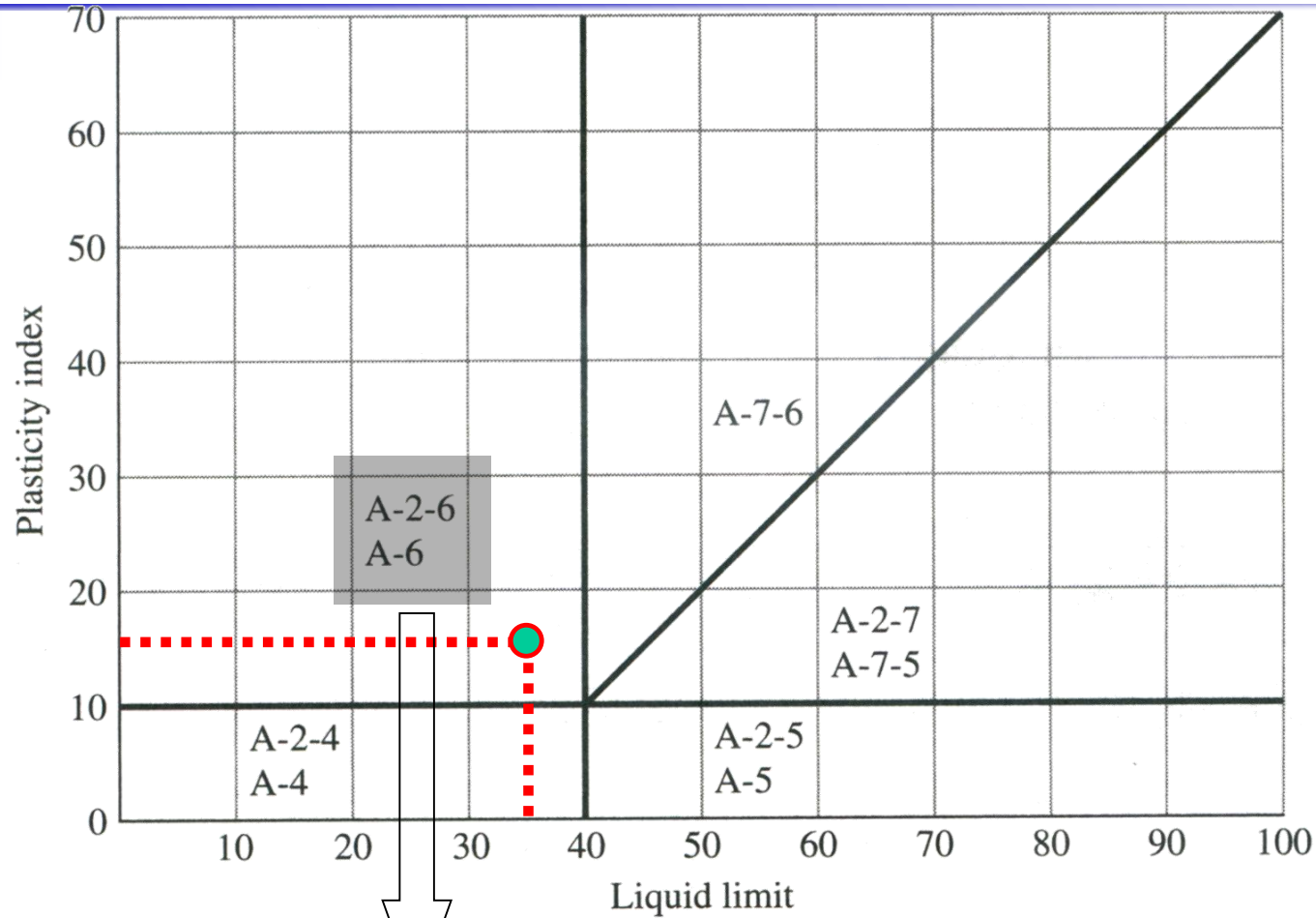
$$GI = 0.01(20 - 15)(15 - 10) = 0.25 = 0$$



Use this formula for  
A-2-6 and A-2-7

Therefore, soil is **A-2-6 (0)**

# Practice Problem #1



A-2-6 soil

# Practice Problem #2

Classify the following soils by the AASHTO classification system.

Description	Soil				
	A	B	C	D	E
Percent finer than No. 10 sieve	83	100	48	90	100
Percent finer than No. 40 sieve	48	92	28	76	82
Percent finer than No. 200 sieve	20	86	6	31	38
Liquid limit <sup>a</sup>	20	70	—	37	42
Plasticity index <sup>b</sup>	5	32	Nonplastic	12	23

# Practice Problem #2

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 <sup>a</sup> A-7-6 <sup>b</sup>
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			

<sup>a</sup>For A-7-5,  $PI \leq LL - 30$

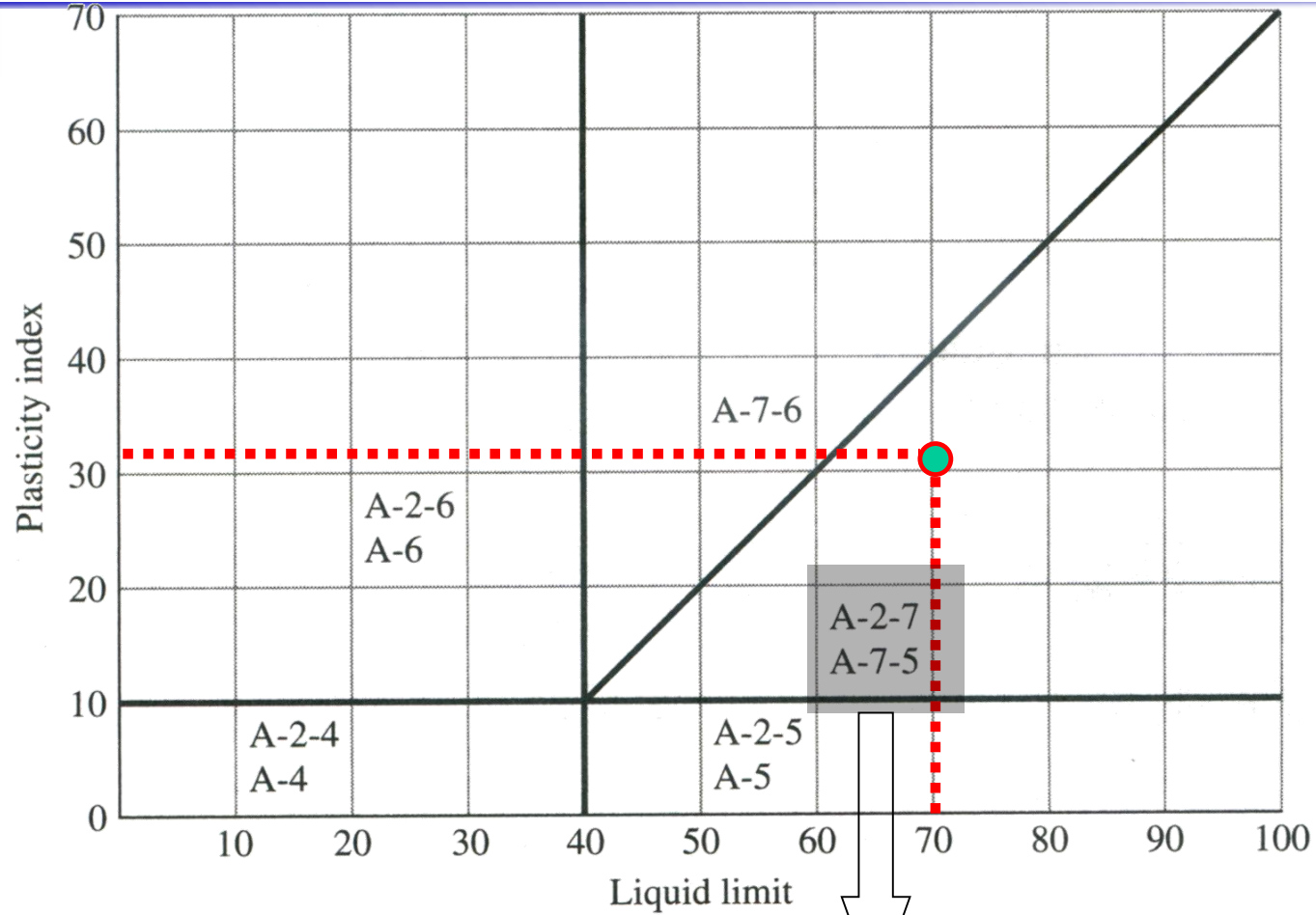
<sup>b</sup>For A-7-6,  $PI > LL - 30$



Note:  
First group from the left to fit test data is the correct AASHTO classification.

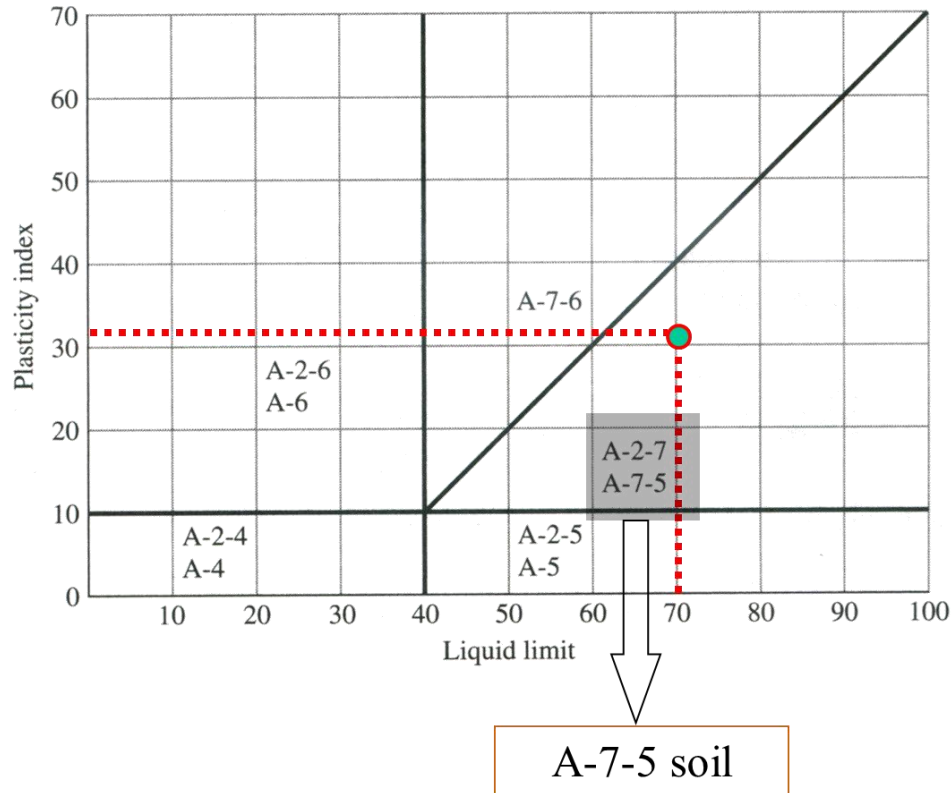


# Practice Problem #2



A-7-5 soil

# Practice Problem #2



Passing No.200 86%  
 LL=70, PI=32  
 LL-30=40 > PI=32

$$\begin{aligned}
 GI &= (F_{200} - 35)[0.2 + 0.005(LL - 40)] \\
 &\quad + 0.01(F_{200} - 15)(PI - 10) \\
 &= 33.47 \approx 33 \quad \text{Round off}
 \end{aligned}$$

**A-7-5(33)**

# Practice Problem #3

Classify the following soil Using AASHTO System. Given:

% passing No. 10 = 100;

% passing No. 40 = 80;

% passing No.200 = 58

LL = 30; PI = 10

GI=3

**A-4(3)**

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<sup>a</sup>  
A-7-6<sup>b</sup>

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

Plasticity index

40 max.

41 min.

40 max.

41 min.

10 max.

10 max.

11 min.

11 min.

Usual types of significant constituent materials

Silty soils

Clayey soils

General subgrade rating

Fair to poor

<sup>a</sup>For A-7-5,  $PI \leq LL - 30$

<sup>b</sup>For A-7-6,  $PI > LL - 30$



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**CONCLUDED**