# Geotechnical Engineering–I

*BSc Civil Engineering – 4th Semester*

Lecture # 8

20-Feb-2015

*by*

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# SOIL CLASSIFICATION

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*

# UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) (ASTM D 2487)

→ Developed by Casagrande in 1942 for US Army

→ System based on particles < 3 in

→ Uses *grain size distribution* and *plasticity of fines*

Three major categories:

- coarse-grained soils
- fine-grained soils
- organic soils

P200 < 50% → Coarse grained soil

P200 ≥ 50% → Fine grained soil

# USCS – Naming Convention

**Soil symbols:**

G: Gravel

S: Sand

M: Silt

C: Clay

O: Organic

Pt: Peat

**Liquid limit symbols:**

H: High LL (LL>50)

L: Low LL (LL<50)

**Gradation symbols:**

W: Well-graded

P: Poorly-graded

Well – graded soil

$1 < C_c < 3$ and $C_u \geq 4$ (for gravels)

$1 < C_c < 3$ and $C_u \geq 6$ (for sands)

*Group Symbol* → SM

Silty sand ← *Group Name*

| | |
|---|---|
| SW | Well-graded sand |
| SC | Clayey sand |
| CL | Low plasticity Clay |
| MH | High Plastic silt |

# USCS – Terminology

**Clay (C)**: Soil *passing No. 200* (0.075 mm) sieve that *exhibits plasticity*. It has *PI ≥ 4* and plot of PI and LL falls on or *above "A" line*.

**Silt (M)**: Soil *passing No. 200* (0.075 mm) sieve that is *non-plastic* or *very slightly plastic* and that exhibits *little or no strength* when air dry. It has *PI < 4* or the plot of PI versus LL falls *below "A" line*.

**Sand (S)**: Particles of rock that will *pass No. 4* (4.75 mm) sieve and *retained on No. 200* (0.075 mm) sieve.

**Gravel (G)**: Particles of rock that will *pass 3 in.* (76.2 mm) sieve and *retained on No. 4* (4.75 mm) sieve.

# USCS – Terminology

**Organic Clay**: A *clay* with *sufficient organic content* to influence the soil properties.

(*LL after over drying*) < 75% (*LL before oven drying*)

**Organic Silt**: A *silt* with *sufficient organic content* to influence the soil properties.

(*LL after over drying*) < 75% (*LL before oven drying*)

**Peat (Pt)**: A soil composed of *vegetable/animal tissue* in various stages of decomposition usually with an *organic odor*, a *dark-brown to black color*, a *spongy consistency*, and a texture ranging from *fibrous to amorphous*.

# USCS – Terminology

**W – Well Graded**: Good *representation of all particle sizes* from largest to smallest.

**P – Poorly Graded**:

Uniform, most particles about the *same size*;

Skip (or gap) gradation, *absence* of one or more intermediate sizes.

**Coefficient of uniformity** ***($C_u$)*** and **Coefficient of curvature** ***($C_c$)*** are defined as below:

$$C_u = \frac{D_{60}}{D_{10}} \quad , \quad C_c = \frac{D_{30}^2}{(D_{60} \times D_{10})}$$

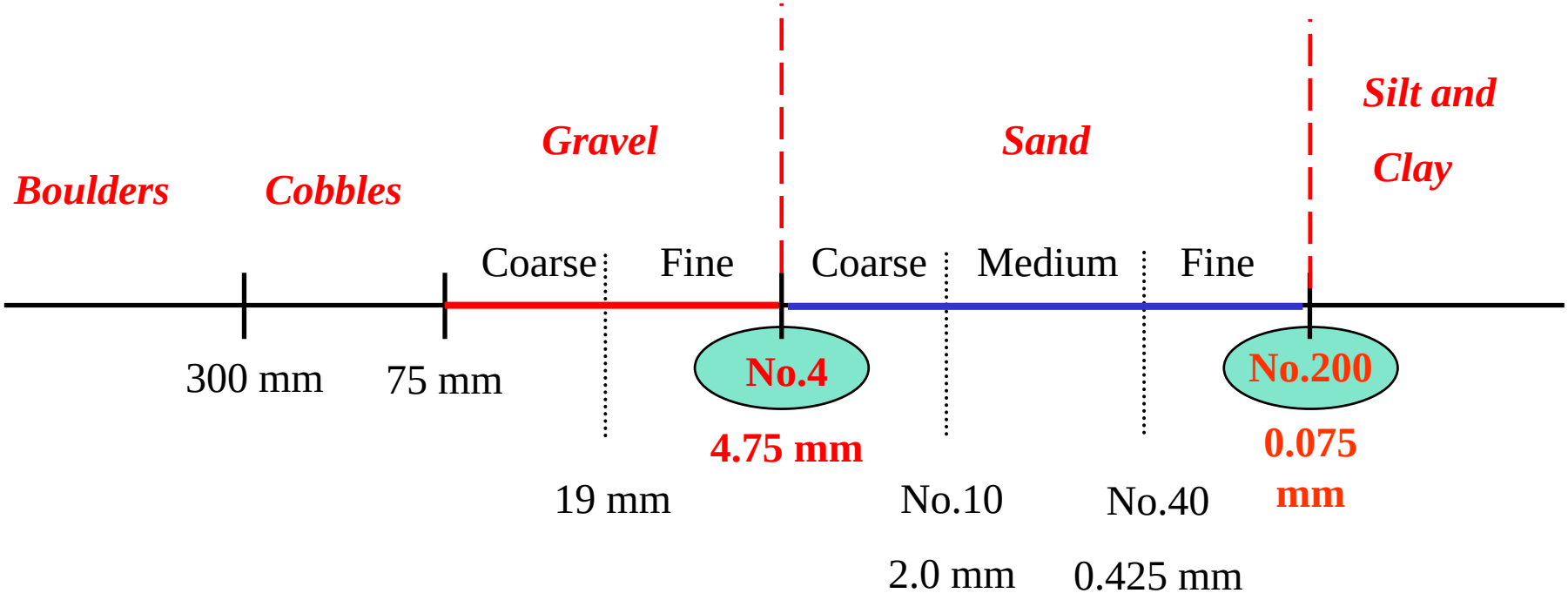
where $D_{60}$, $D_{30}$, $D_{10}$ are diameter of 60%, 30% and 10% passing on gradation curve, respectively.

# UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

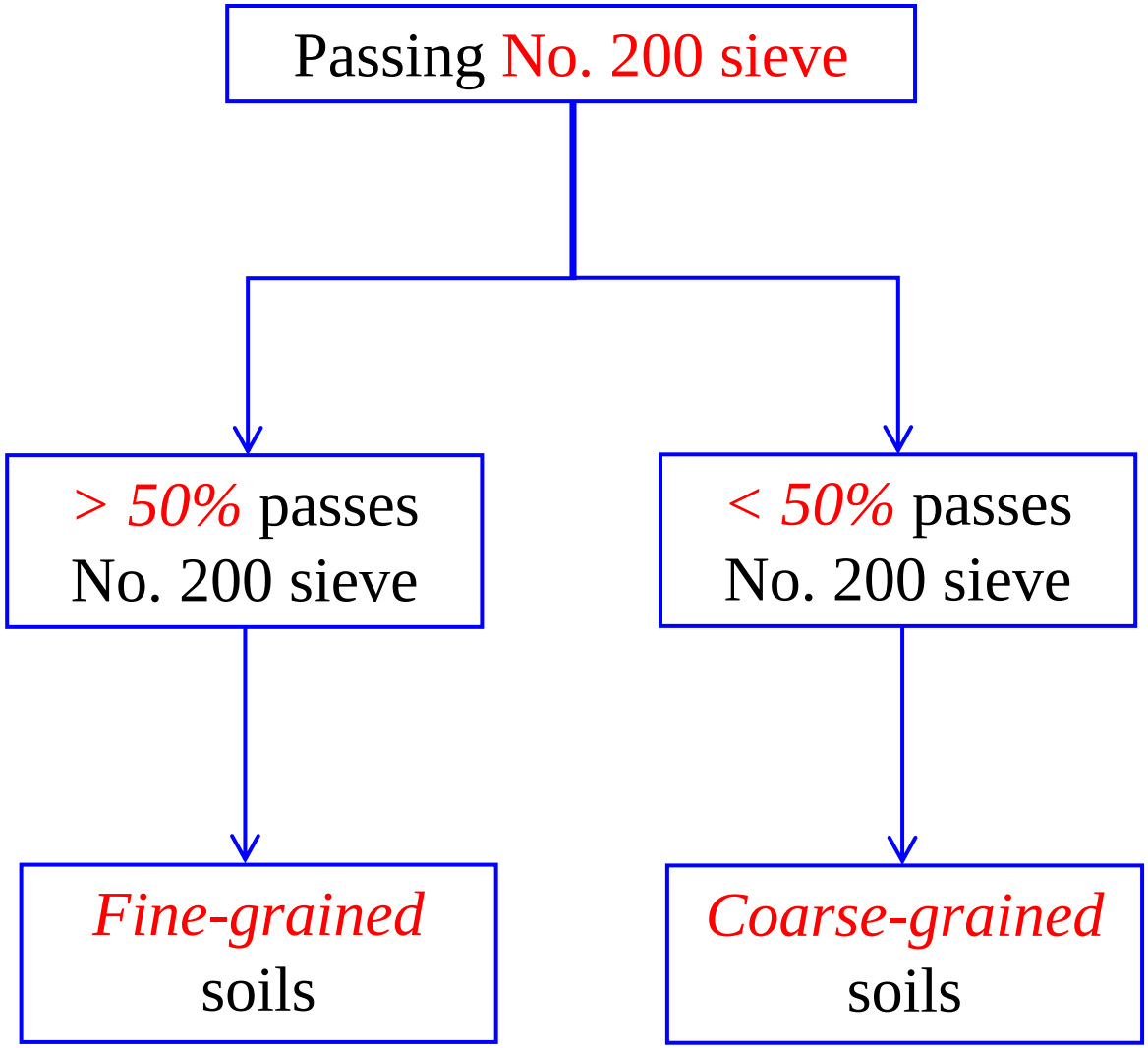
## Definition of Grain Size

Use

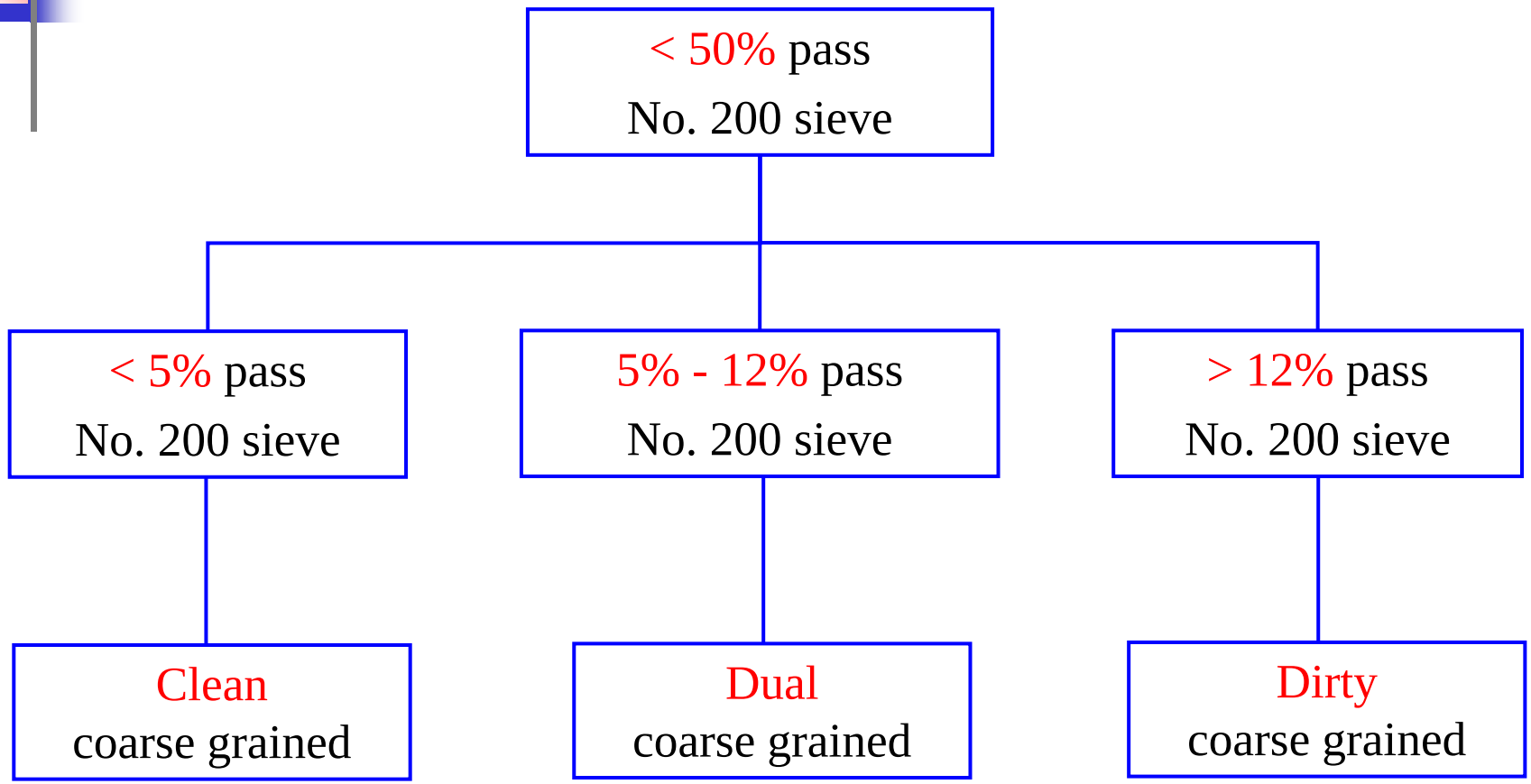
Atterberg limits



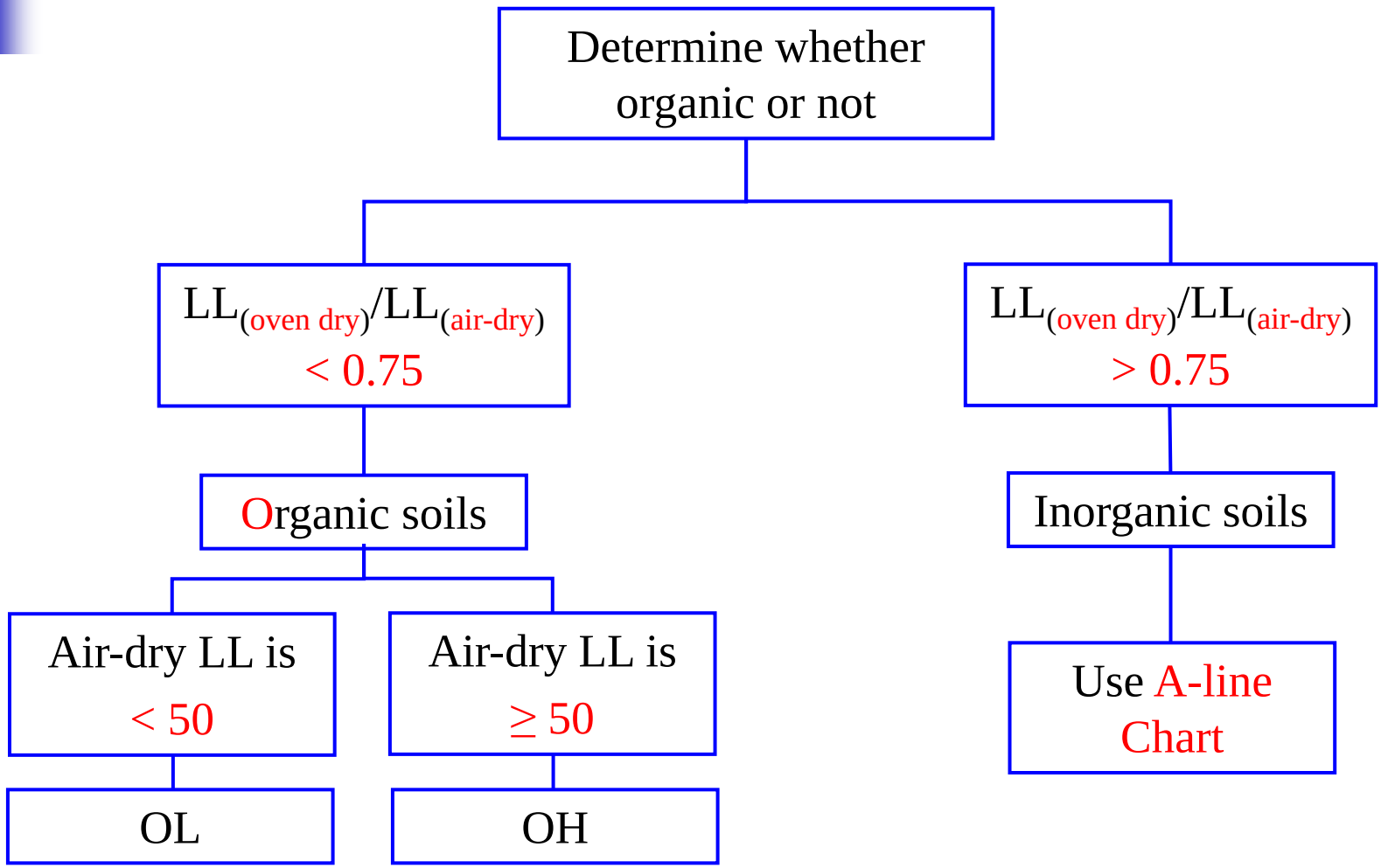
# FLOW CHART – Coarse and Fine Grained



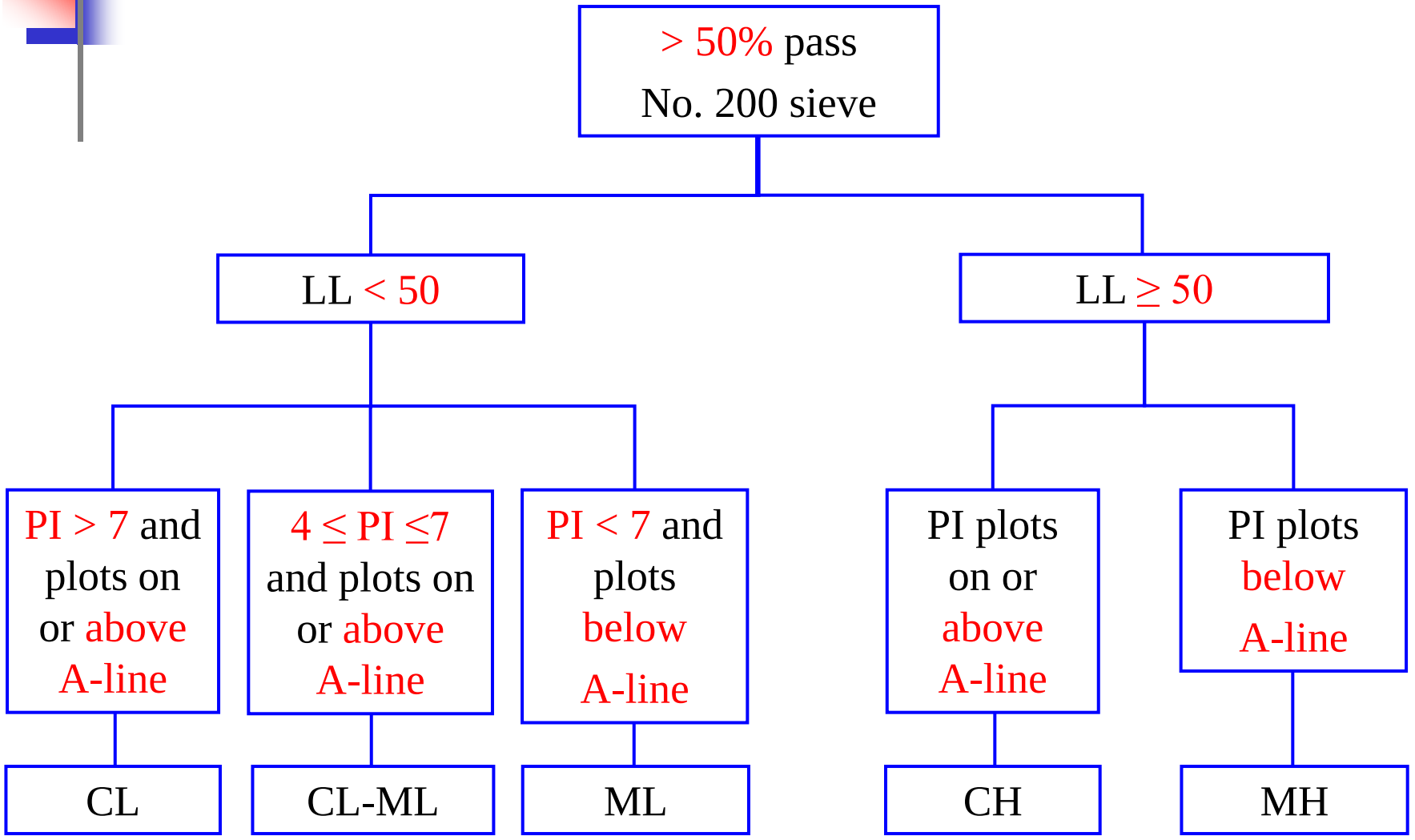
# FLOW CHART – Coarse Grained



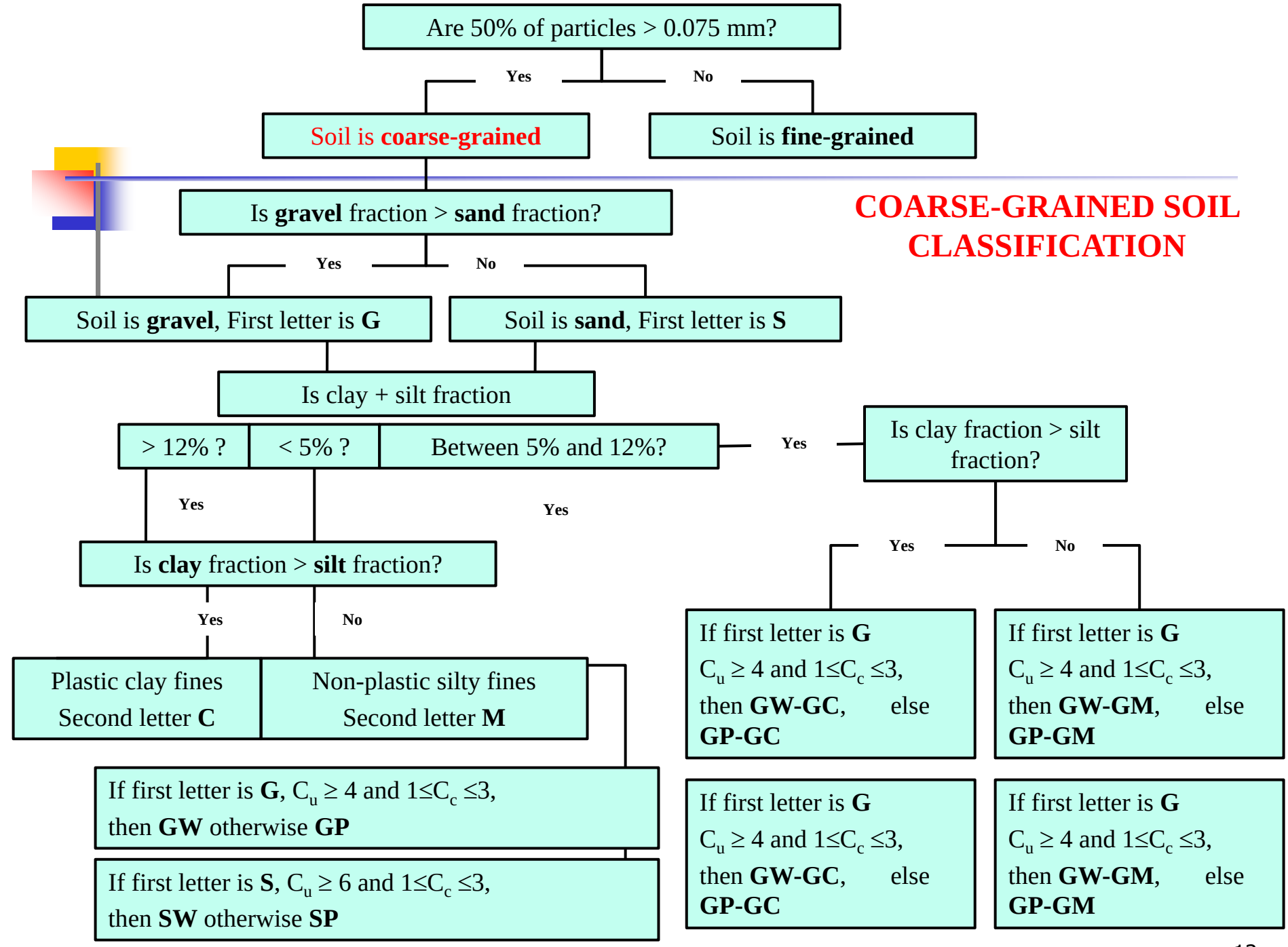
# FLOW CHART – Organic Soils



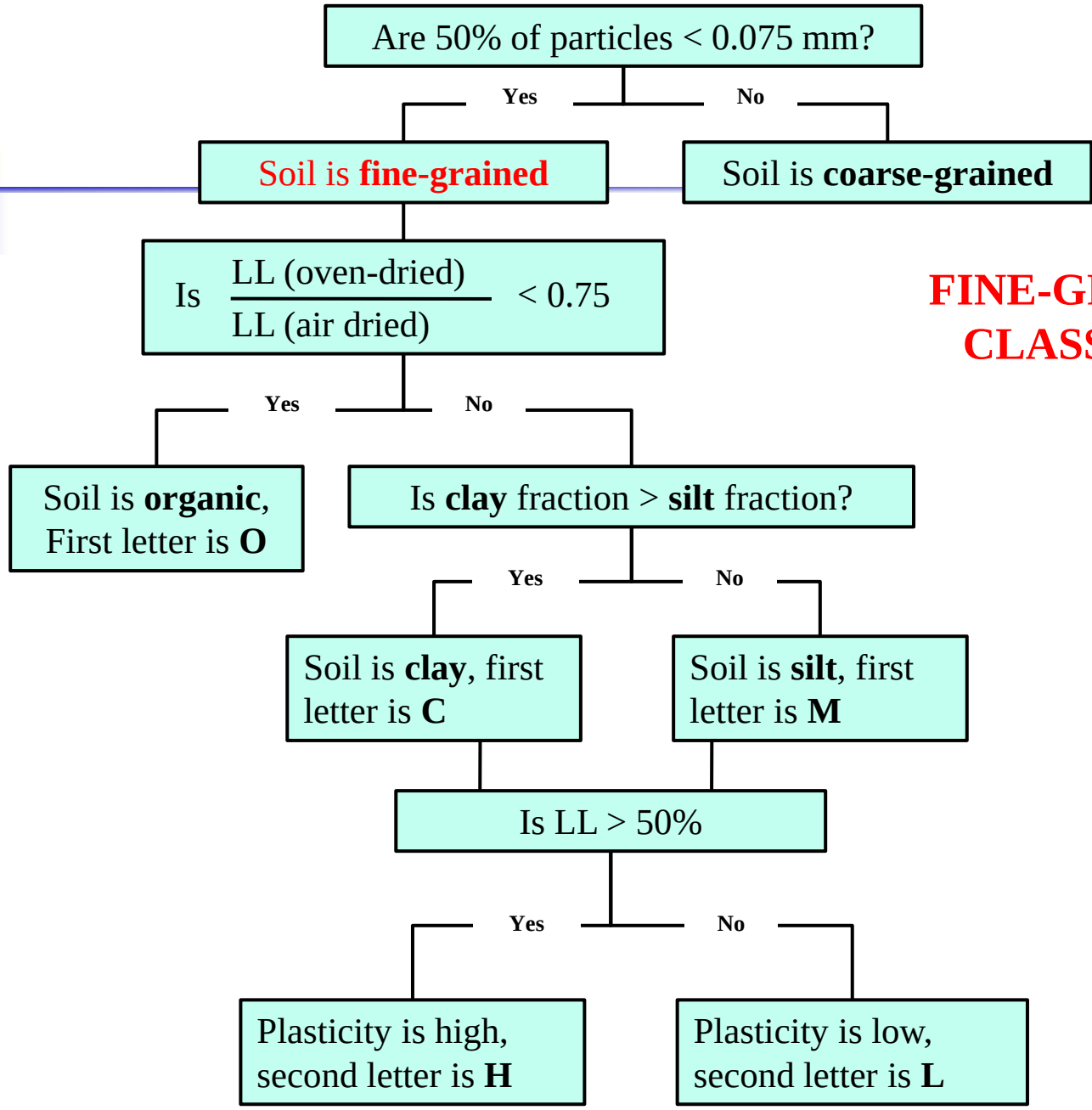
# FLOW CHART – Fine Grained



# COARSE-GRAINED SOIL CLASSIFICATION



# FINE-GRAINED SOIL CLASSIFICATION



# Designation of Organic Soils

A liquid limit test is performed on:

- One sample that is only *air-dried*.
- On another that is *oven-dried* prior to testing.
- The *liquid limit values are compared* by computing the ratio of the 2 values.

$LL_{(oven\ dried)}/LL_{(air\ dried)} < 0.75 \rightarrow$ Organic

$LL_{(oven\ dried)}/LL_{(air\ dried)} > 0.75 \rightarrow$ Inorganic

## ADDITIONAL EVALUATION PROCEDURES

**Ignition Test (ASTM D2974)**

- Soil sample heated in muffle furnace set at either 440 $^{o}$C or 750 $^{o}$C and weight loss measured.

**Peat Classification (ASTM D4427)**

# Fine Grained Soils

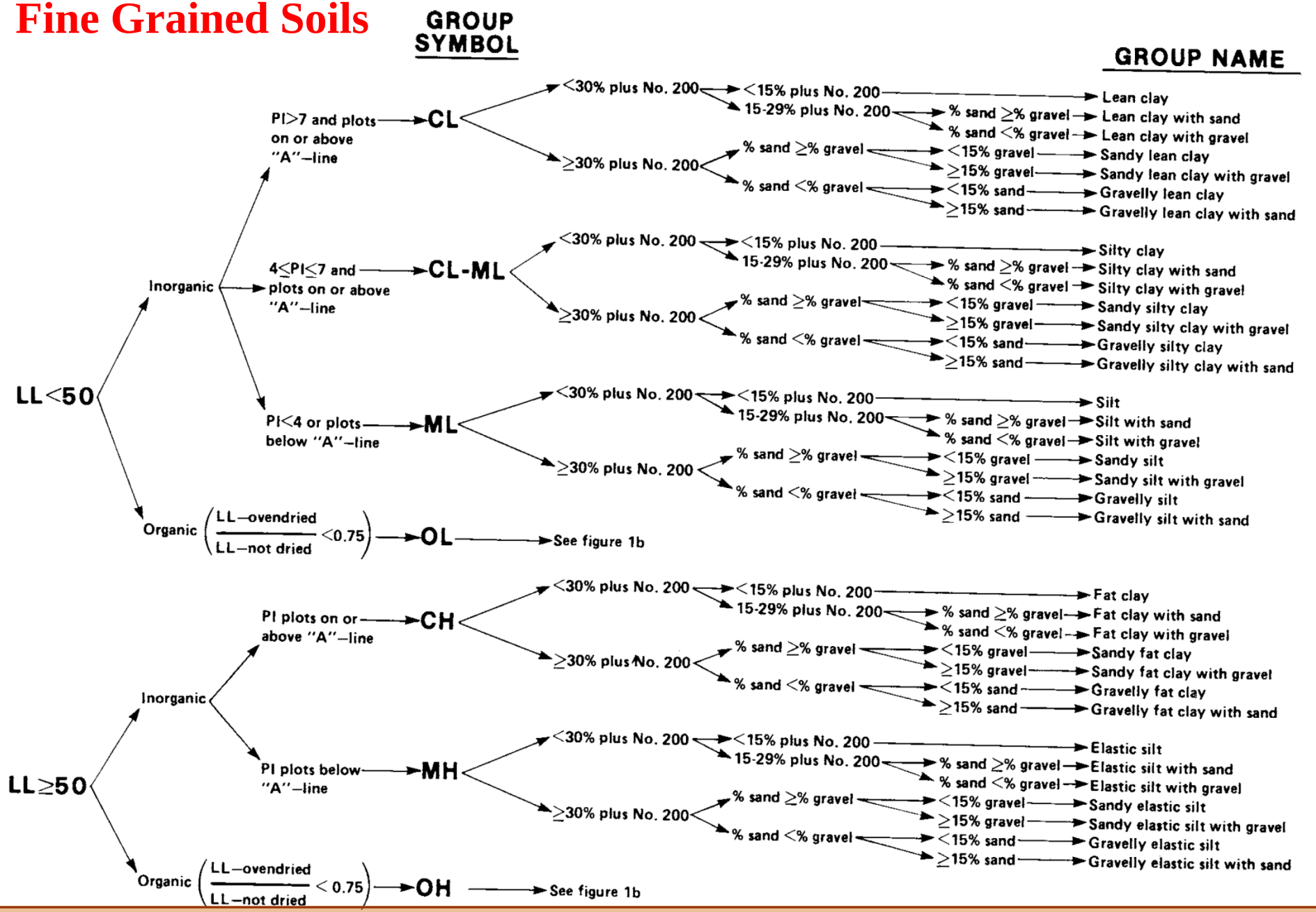



**FIG. 1 Flow chart for Classifying Fine-Grained Soil (50% or More Passes No. 200 Sieve)**

# Fine Grained Organic Soils

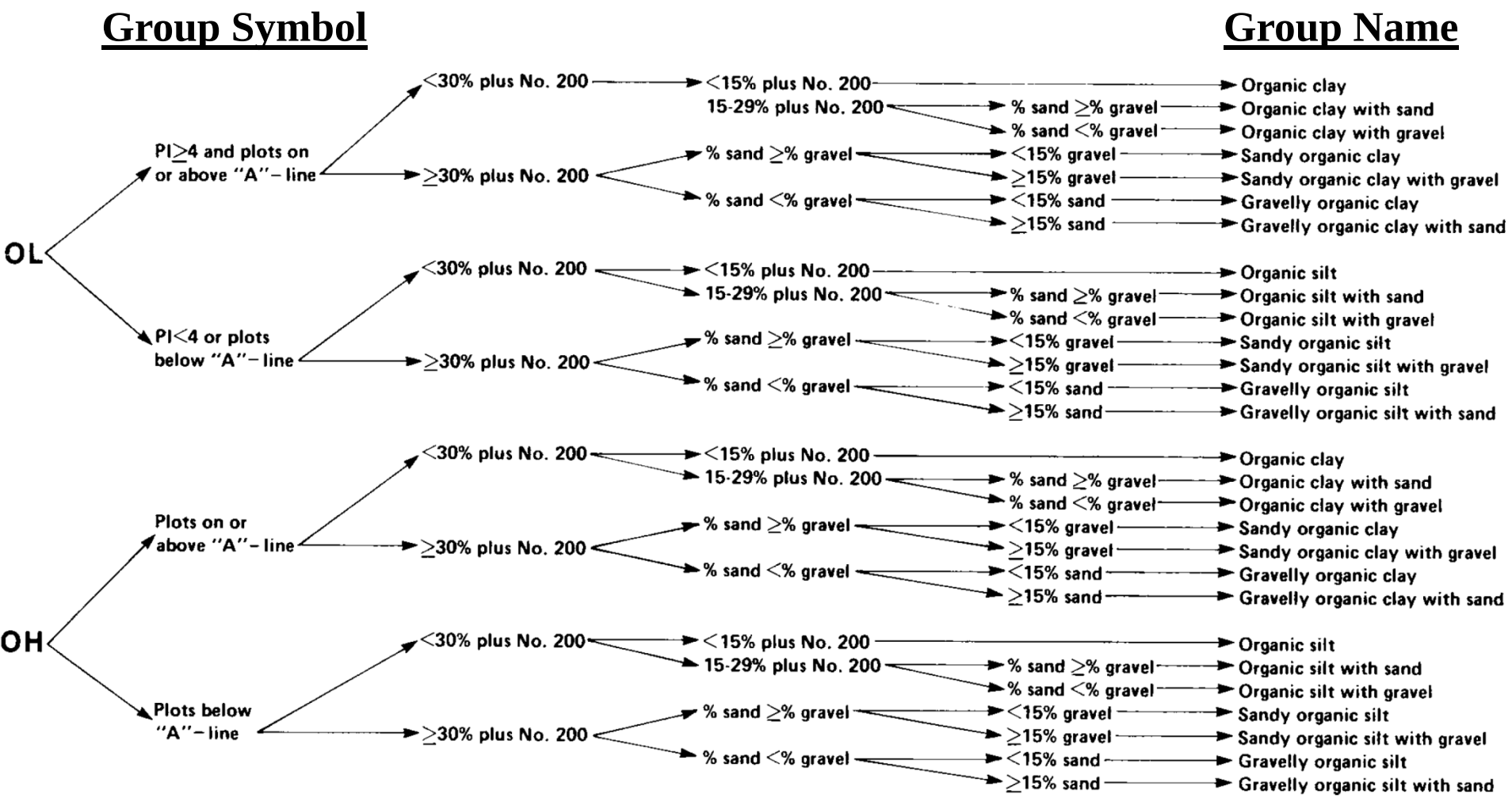



**FIG. 2 Flow chart for Classifying Organic Fine-Grained Soil (50% or More Passes No. 200 Sieve)**

# Coarse Grained Soils

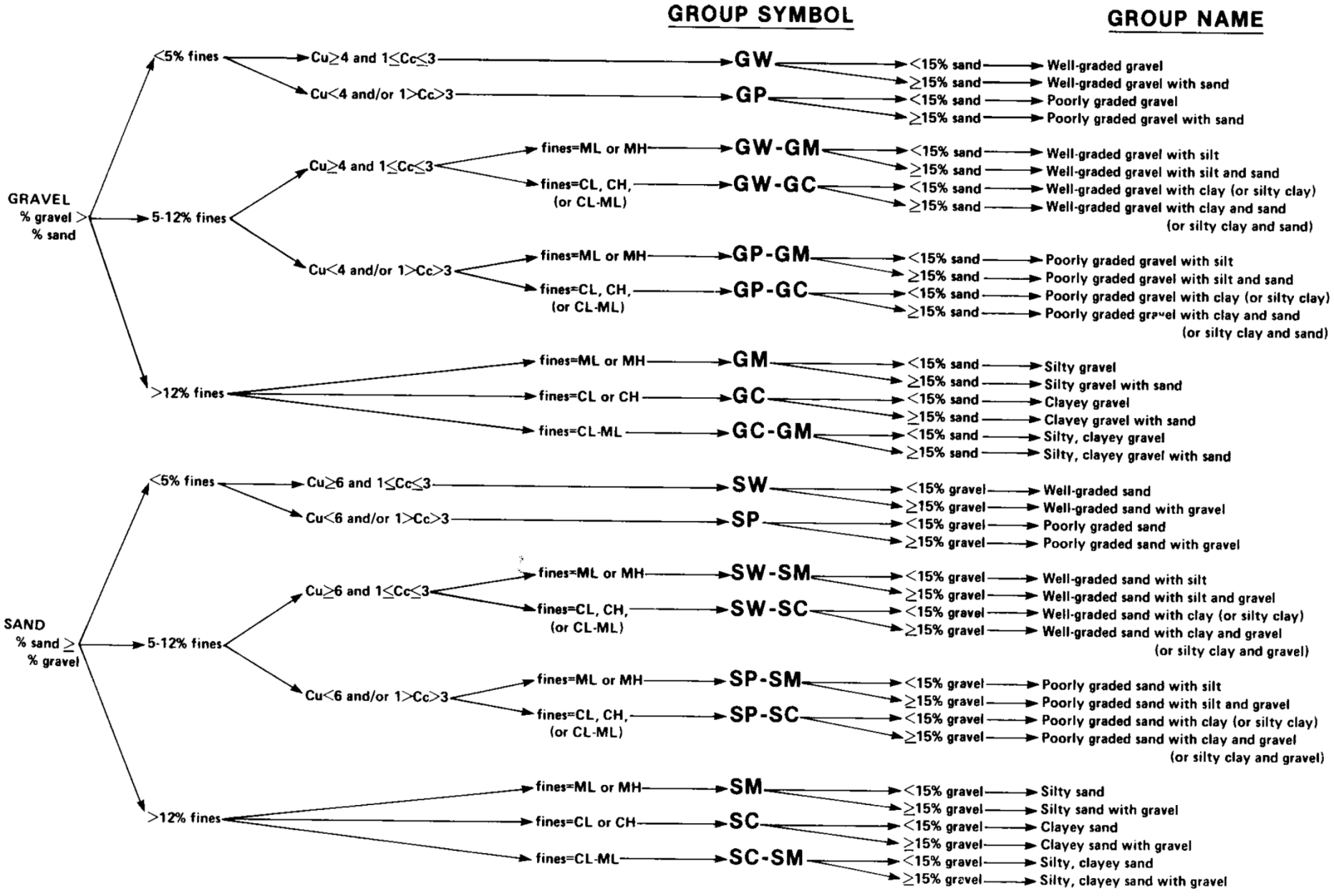
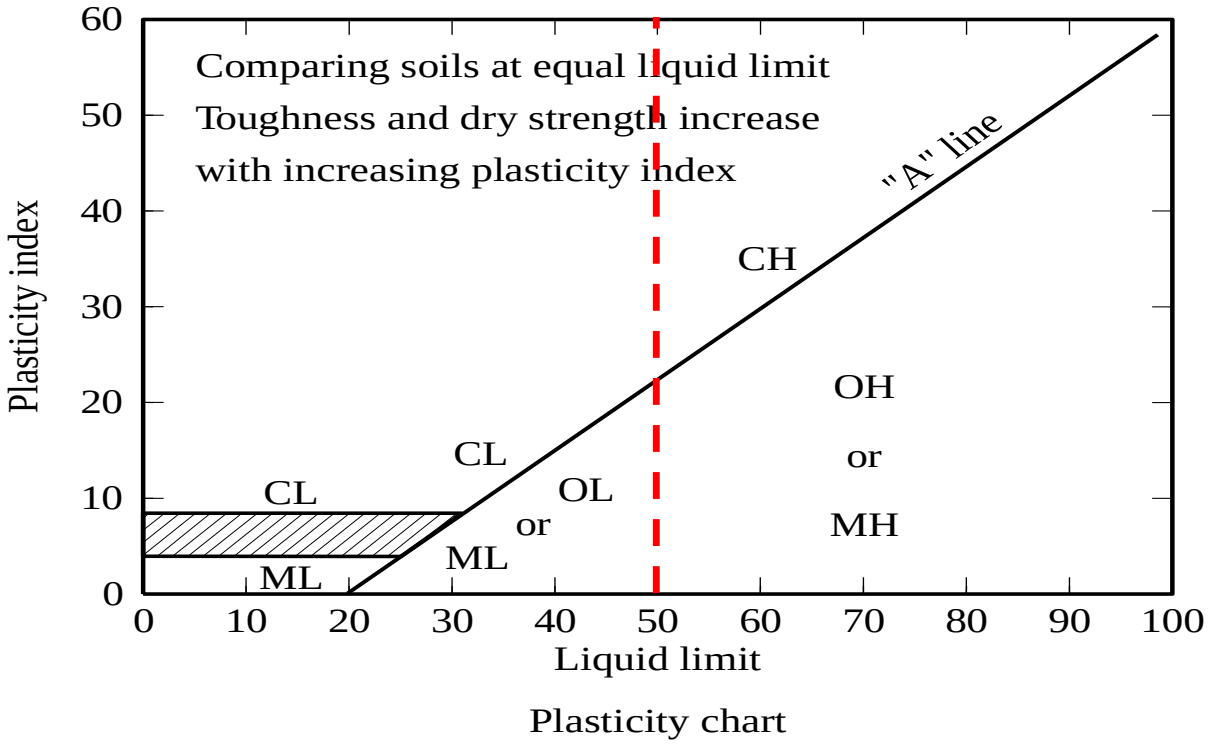



**FIG. 3 Flow chart for Classifying Coarse-Grained Soils (50% or More Retained on No. 200 Sieve)**

# PLASTICITY/A-LINE CHART

Used for *fine grained* soils to determine whether *silt (M)* or *clay (C)*




Plasticity chart

Below A-line is silt – use symbol M

Above A-line is clay – use symbol C

LL > 50 → High plasticity

LL< 50 → low plasticity



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# PRACTICE PROBLEM #1

Classify the following soils Using Unified Classification System.

| Soil | No. 4 Sieve | No. 200 Sieve | LL | PI |
|---|---|---|---|---|
| | (cumulative % passing) | | | |
| A | 92 | 48 | 30 | 10 |
| B | 99 | 76 | 60 | 32 |
| C | 80 | 35 | 24 | 2 |

# PRACTICE PROBLEM #1

**Soil A**

Coarse = 100-48 = 52% (retained on N o. 2 0 0), so COARSE-GRAINED SOIL
8% retained on No. 4, vs. 52% coarse,
8/52 = 15% (<50%), so SAND
Using the LL and PL values in the USAC
Atterberg limits above line A, so Clay
Classification SC, clayey sand

**Soil B**

Coarse = 100 - 76 = 24%, so FINE-GRAINED SOIL
LL = 60, and P I = 32 Using Casagrandi Chart
Classification CH, inorganic clay with high plasticity

**Soil C**

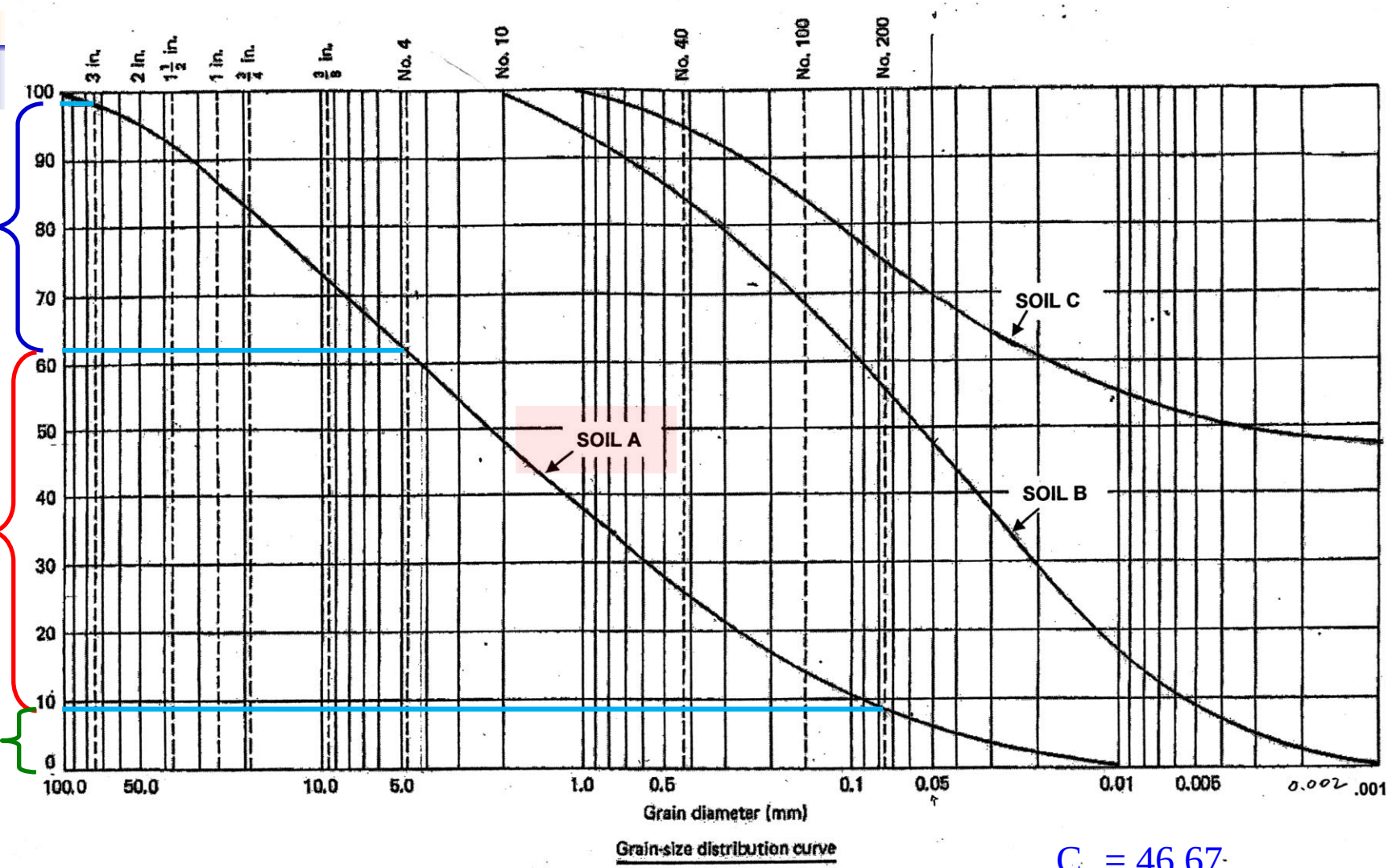
Coarse = 100 - 35 = 65%, so COARSE-GRAINED SOIL
20% retained on No. 4, vs. 65%
coarse, 20/65 = 31% (<50%), so SAND
Using Casagrandi Chart
Classification SM, Silty sand

# PRACTICE PROBLEM #2

Gravel
= 98-62
= 36%

Sand
= 62-8
= 54%

Fines
= 8%

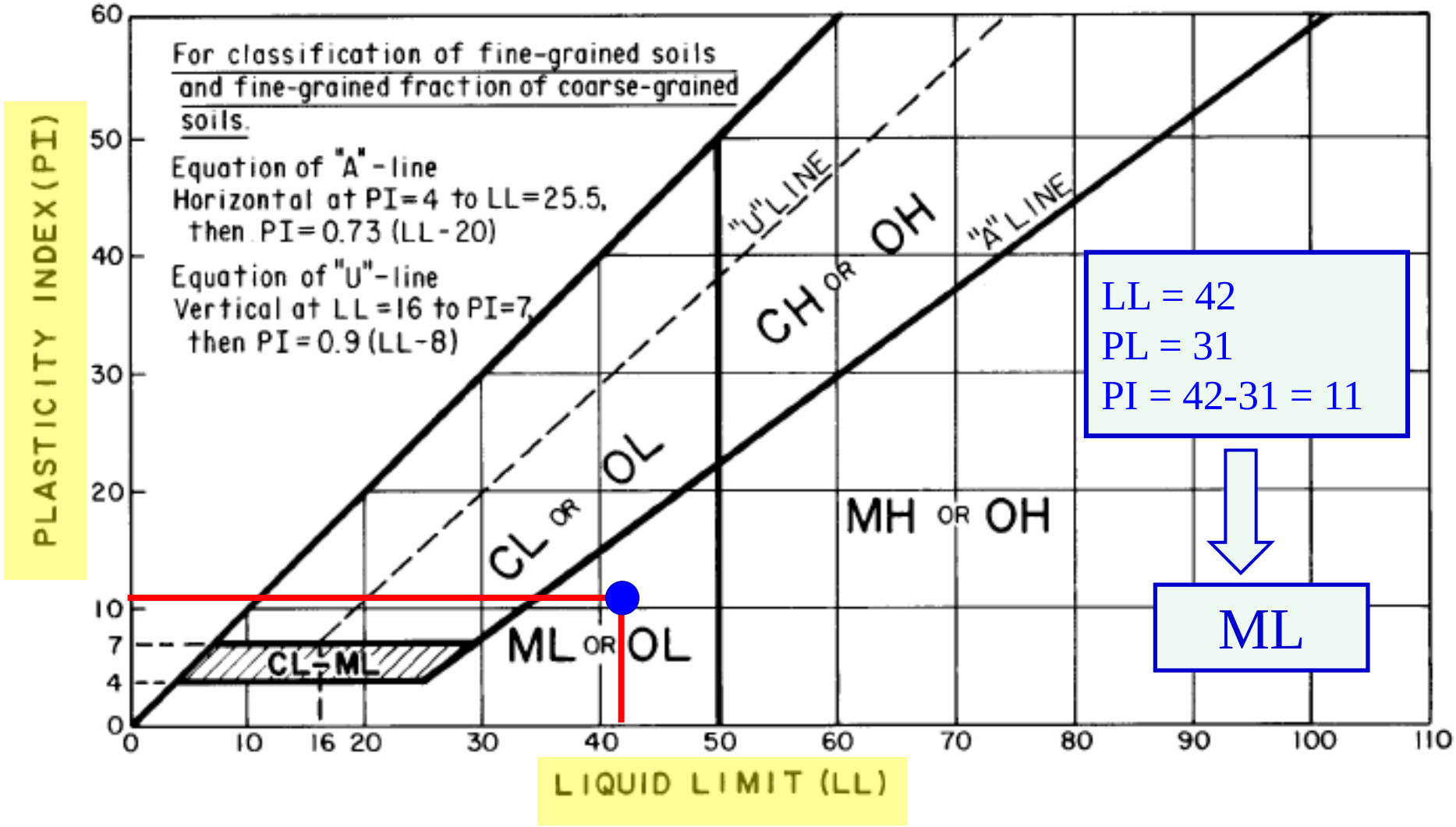



Grain-size distribution curve

Soil A: $D_{60}$ = 4.2 mm , $D_{30}$ = 0.6 mm, $D_{10}$ = 0.09 mm

$C_u$ = 46.67
$C_c$ = 0.95

# PRACTICE PROBLEM #2



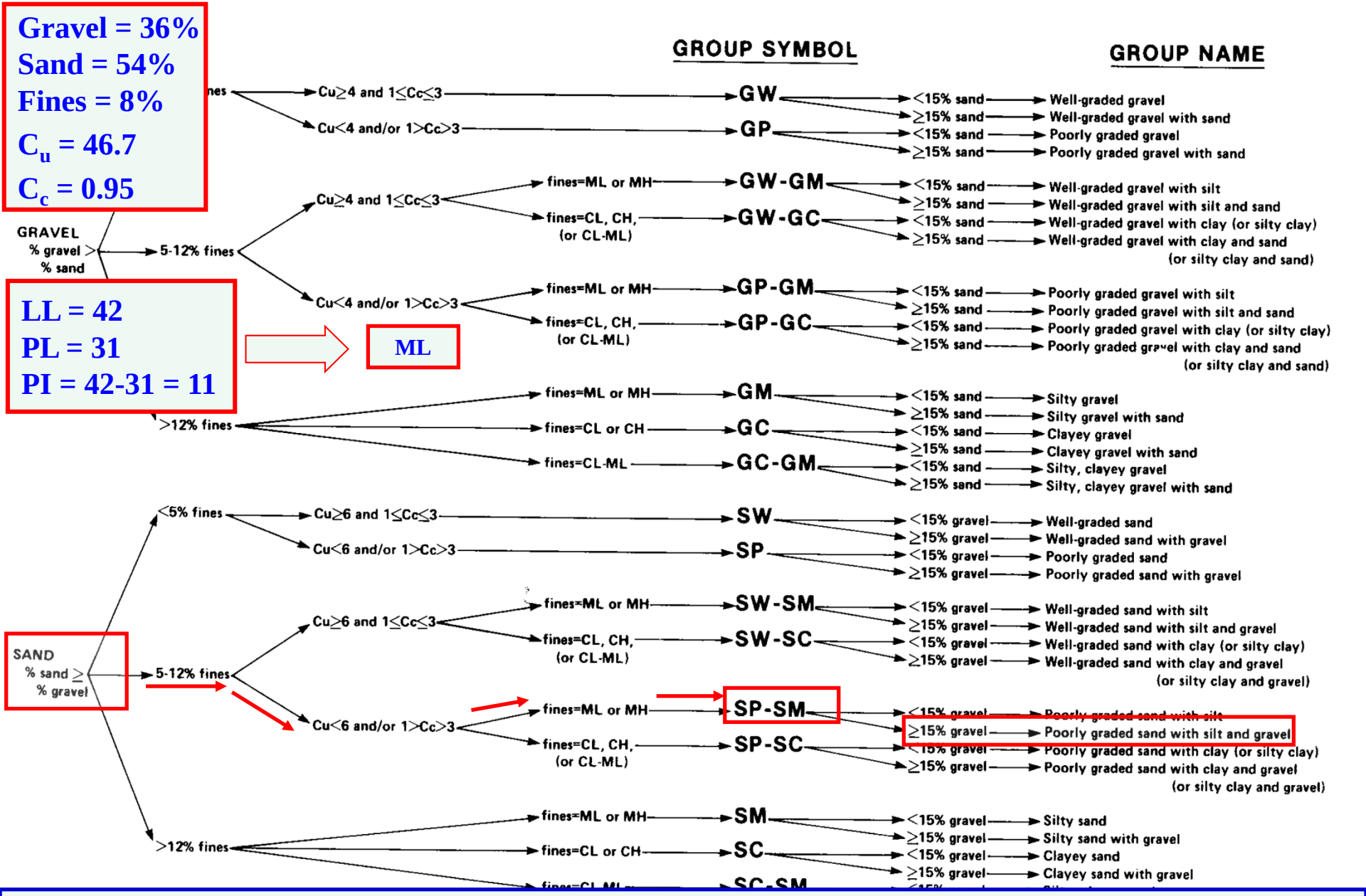

LL = 42
PL = 31
PI = 42-31 = 11

ML

Gravel = 36%
Sand = 54%
Fines = 8%
$C_u$ = 46.7
$C_c$ = 0.95

LL = 42
PL = 31
PI = 42-31 = 11

ML




**Soil A is classified as [SP-SM: Poorly-graded sand with silt and gravel]**

FIG. 3 Flow chart for Classifying Coarse-Grained Soils (50% or More Retained on No. 200 Sieve)

# PRACTICE PROBLEM #3

| Soil | Sieve analysis, % finer | | Liquid limit | Plasticity index |
|---|---|---|---|---|
| | No. 4 | No. 200 | | |
| A | 80 | 52 | 30 | 8 |
| B | 79 | 45 | 26 | 4 |
| C | 91 | 80 | 60 | 32 |
| D | 95 | 75 | 41 | 12 |
| E | 82 | 41 | 24 | 2 |

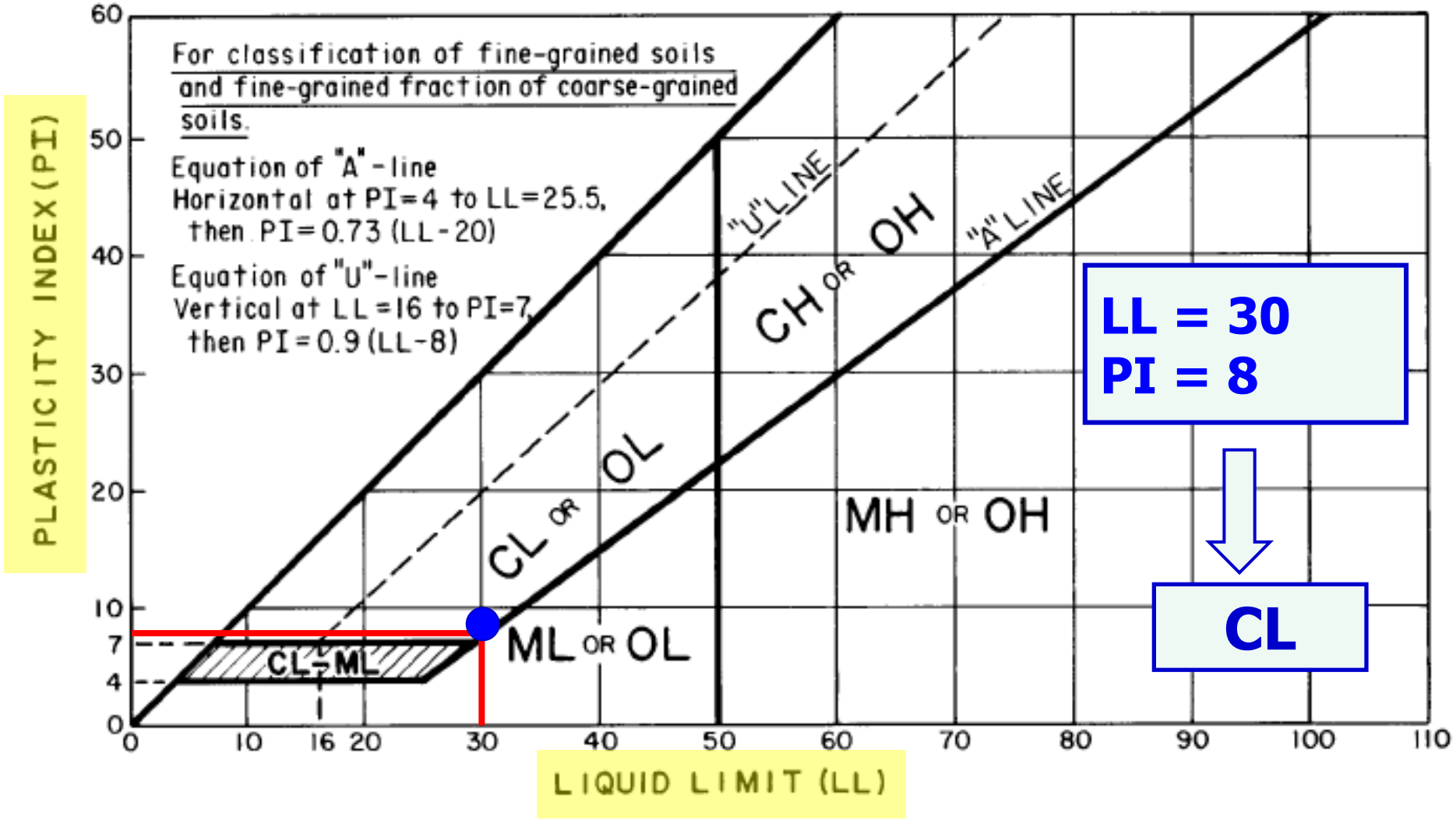
**Soil A**

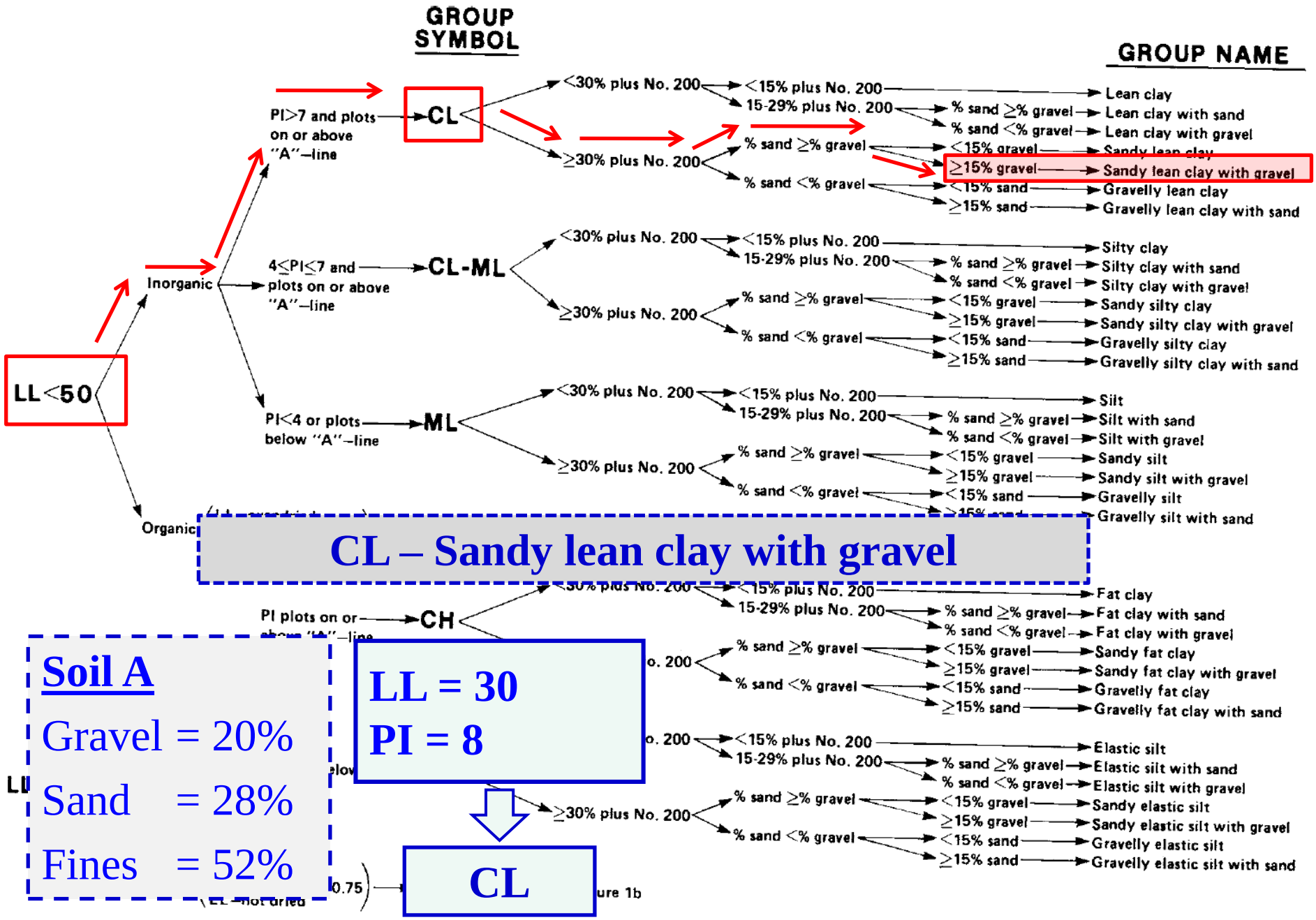
Gravel = 100 – 80 = 20%

Sand = 80 – 52 = 28%

Fines = 52% > 50% => Fine-grained soil

# PRACTICE PROBLEM #3






**CL – Sandy lean clay with gravel**

**Soil A**

Gravel = 20%

Sand = 28%

Fines = 52%

**LL = 30**

**PI = 8**

**CL**

FIG. 1 Flow Chart for Classifying Fine-Grained Soil (50 % or More Passes No. 200 Sieve)

# CONCLUDED