Geotechnical Engineering–I

BSc Civil Engineering – 4th Semester

Lecture # 5

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by

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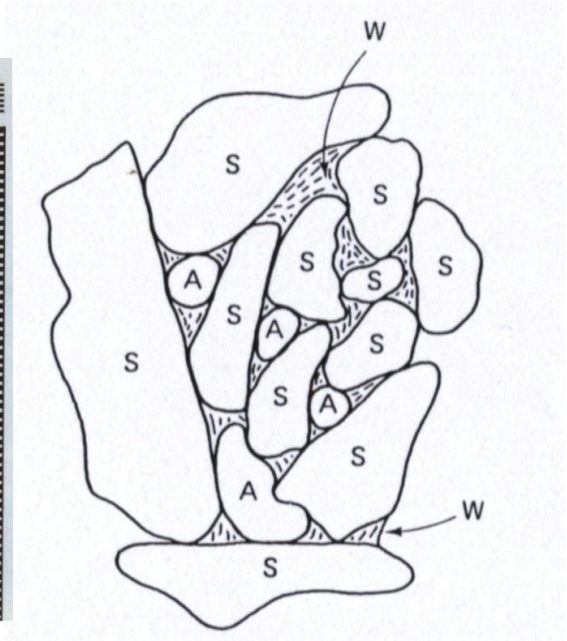
Lecture Handouts: https://groups.google.com/d/forum/geotec-1

MECHANICAL ANALYSIS OF SOIL

S:	Solid	Soil particle
W:	Liquid	Water
A:	Air	Air

Mechanical Analysis
OR
Particle Size Analysis
OR
Grain Size Distribution *(GSD)*



Why?

- To group soils with similar engineering properties.
- To predict soil behavior.

MECHANICAL ANALYSIS OF SOIL

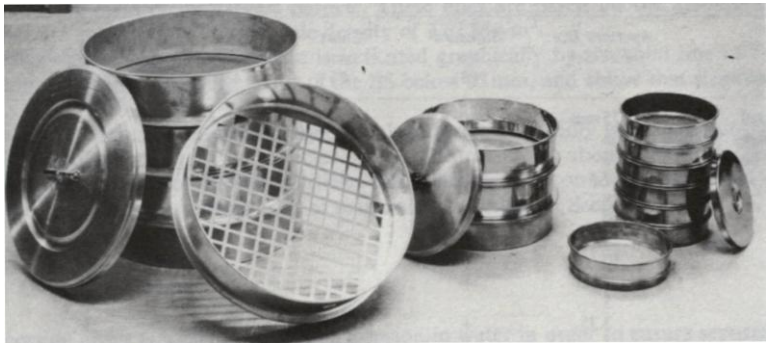
Mechanical analysis is the determination of the size range of particles present in a soil, expressed as a percentage of the total dry weight.

Coarse-grained soils: Fine-grained soils:

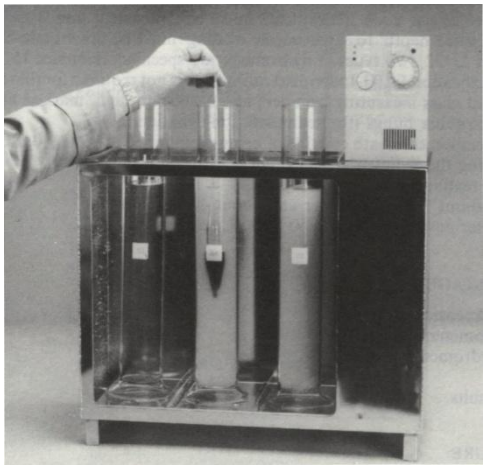
Gravel Sand Silt Clay

0.075 mm (USCS)

0.06 mm (BS)

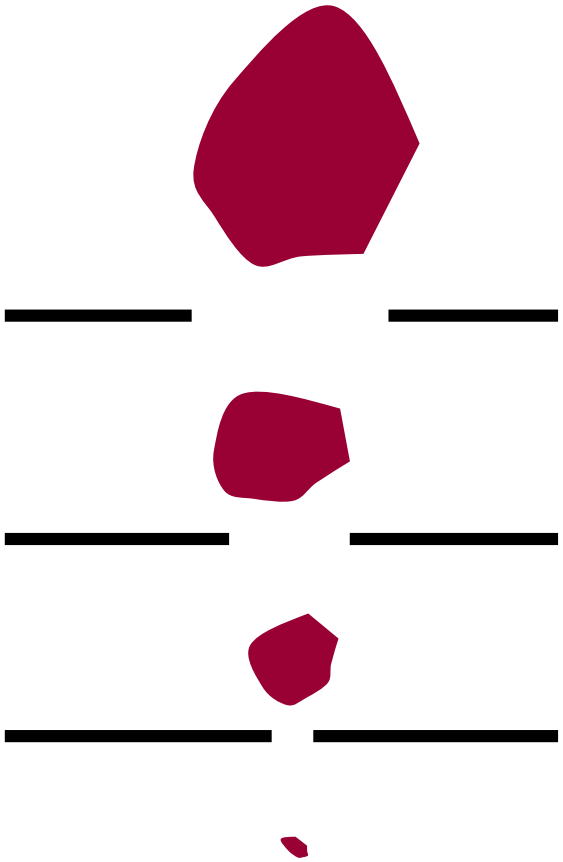


Sieve Analysis

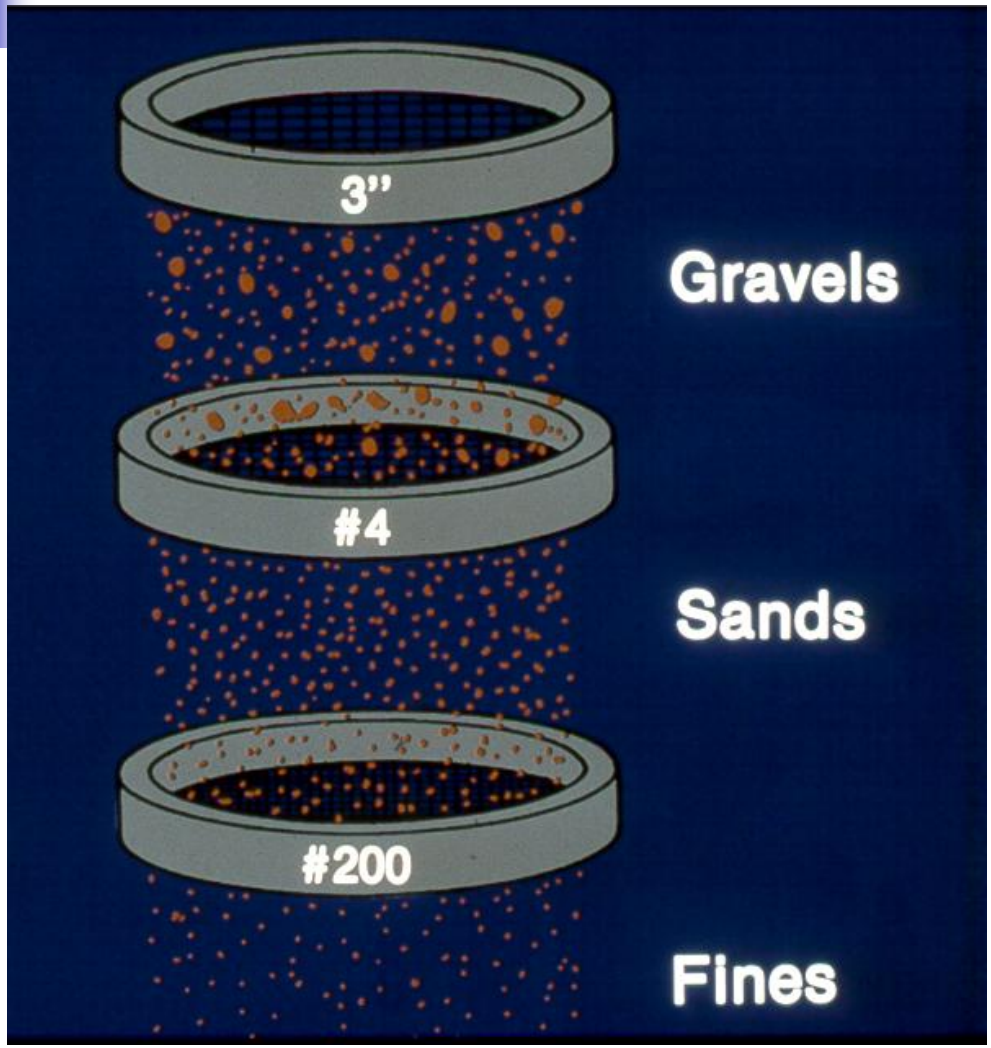


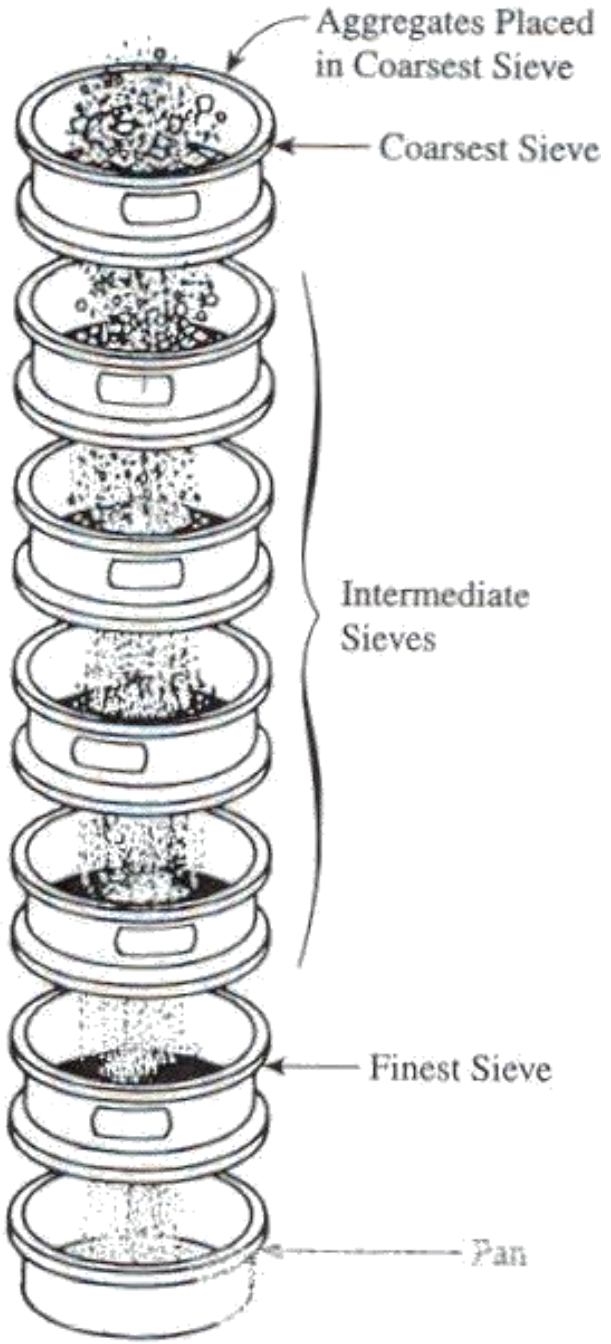
Hydrometer Analysis

SIEVE ANALYSIS



SIEVE ANALYSIS





SIEVE ANALYSIS

76.2 mm

Gravel

4.75 mm

Sand

0.075 mm

Silt and Clay

Pan

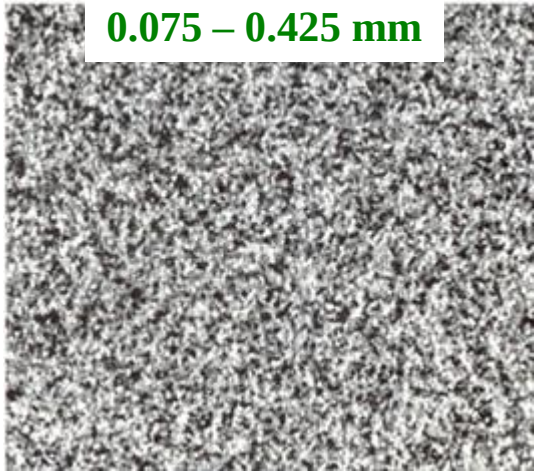
	Gravel	Sand	Silt	Clay
USCS	4.75	0.075		
BS	2.0	0.06	0.002	

USCS: Unified Soil Classification

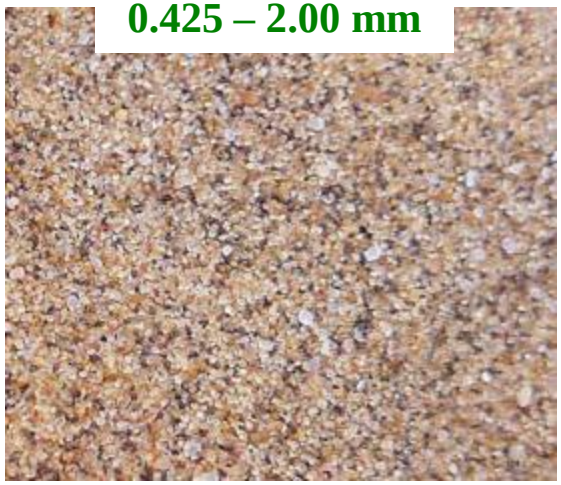
BS: British Standard

Unit: mm

Fine Sand



Medium Sand



Coarse Sand

SIEVE DESIGNATION – Larger

Sieves larger than the No. 4 sieve are designated by the *size of the openings in the sieve*.

Commonly used larger sieve sizes:

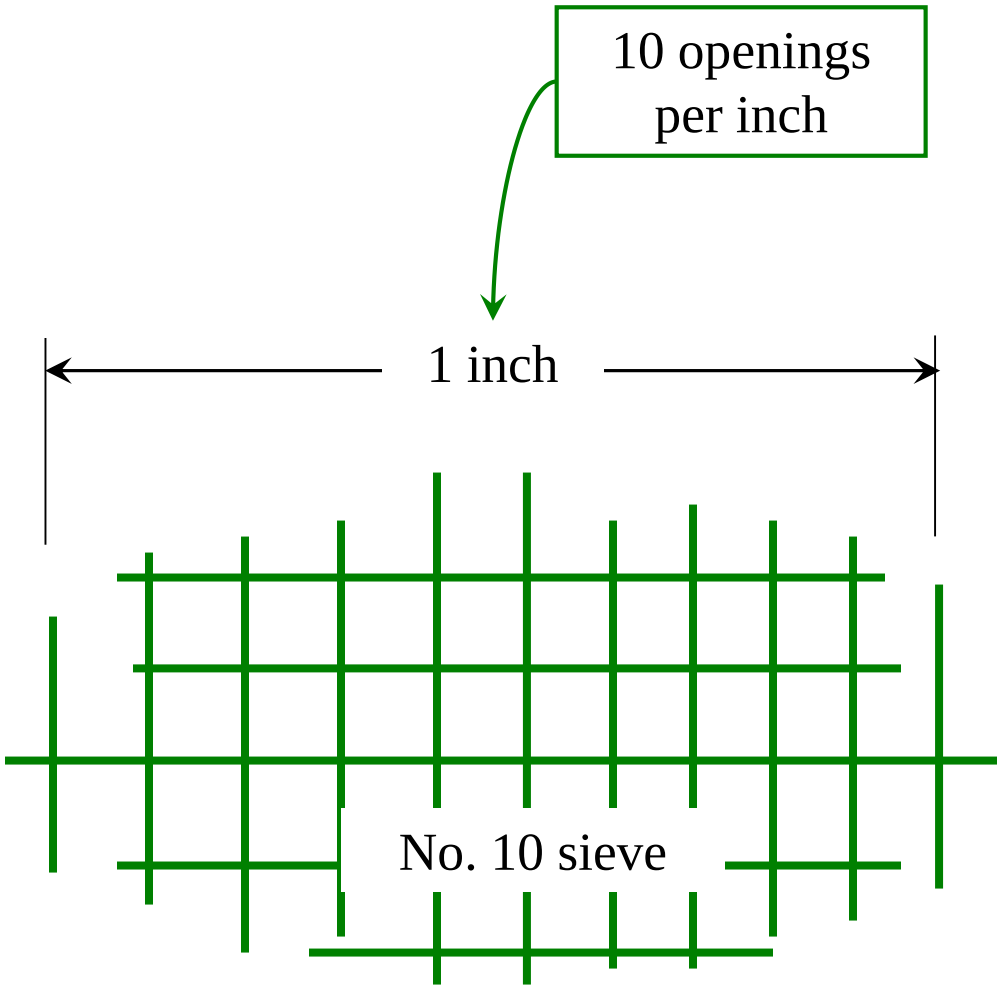
- 3 in.
- 2 in.
- 1.5 in.
- 1 in.
- 3/4 in.
- 1/2 in.
- 3/8 in.

SIEVE DESIGNATION – Smaller

Smaller sieves are numbered according to the *number of openings per inch*.

Commonly used smaller size sieves:

- No. 4
- No. 10
- No. 20
- No. 40
- No. 60
- No. 140
- No. 200



US STANDARD SIEVE SIZES

Sieve No.	Opening (mm)	Sieve No.	Opening (mm)
3 inch	76.200	20	0.850
2 inch	50.800	25	0.710
1.5 inch	38.100	30	0.600
1 inch	25.400	35	0.500
3/4 inch	19.000	40	0.425
3/8 inch	9.520	50	0.355
4	4.750	60	0.250
5	4.000	70	0.212
6	3.350	80	0.180
7	2.800	100	0.150
8	2.360	120	0.125
10	2.000	140	0.106
12	1.700	170	0.090
14	1.400	200	0.075
16	1.180	270	0.053
18	1.000		

SIEVE ANALYSIS – Procedure

- Soil used in sieve analysis is oven-dried and all lumps are broken.
- A stack of sieves *(sieve nest)*, with sieve opening of decreasing size from top to bottom, is arranged.
- A pan is placed below the stack.
- The soil is then shaken through this sieve nest.
- *Mass retained* on each sieve is determined.

Wet Sieving Technique

- Breaking lumps in clayey soils may be difficult. If soils contain silts and clays, the wet sieving is usually used to preserve the fine content.
- In this case, the soil may be mixed with water to make a slurry and then washed through sieves.
- Portions retained on each sieve are collected separately and oven-dried.

SIEVE ANALYSIS – Procedure

Finer (Passing)

76.2 mm — **100 %**

Gravel

100 – 93 = 7% — **Gravel**

4.75 mm — **93 %**

Sand

93 – 62 = 31% — **Sand**

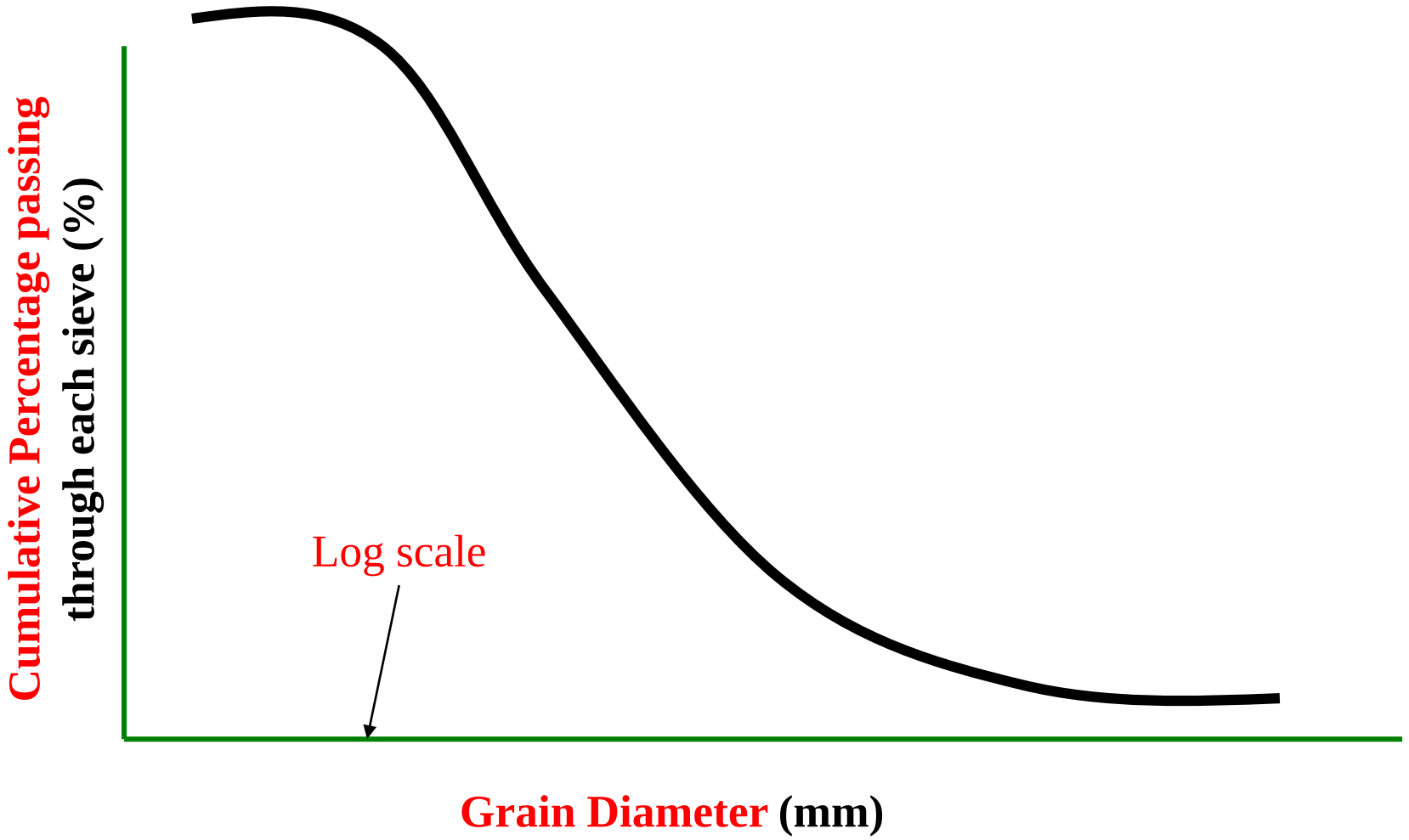
0.075 mm — **62 %**

Silt and Clay

62 – 0 = 62% — **Silt and Clay**

Pan — **0 %**

SIEVE ANALYSIS – Results *(Gradation Curve)*



SIEVE ANALYSIS – Calculations

Sieve No.	Diameter (mm)	Wt. of soil retained (gm)	Cumulative soil weight retained on each sieve (gm)	Cumulative percentage retained (%)	Cumulative percentage passing (%)
(Col. 1)	(Col. 2)	(Col. 3)	(Col. 4)	(Col. 5)	(Col. 6)

(Col. 4) = (Col. 3) + (Col. 4) of previous line

(Col. 5) = [(Col. 4)/Total wt.] x 100

(Col. 6) = 100 – (Col. 5)

SIEVE ANALYSIS – Example

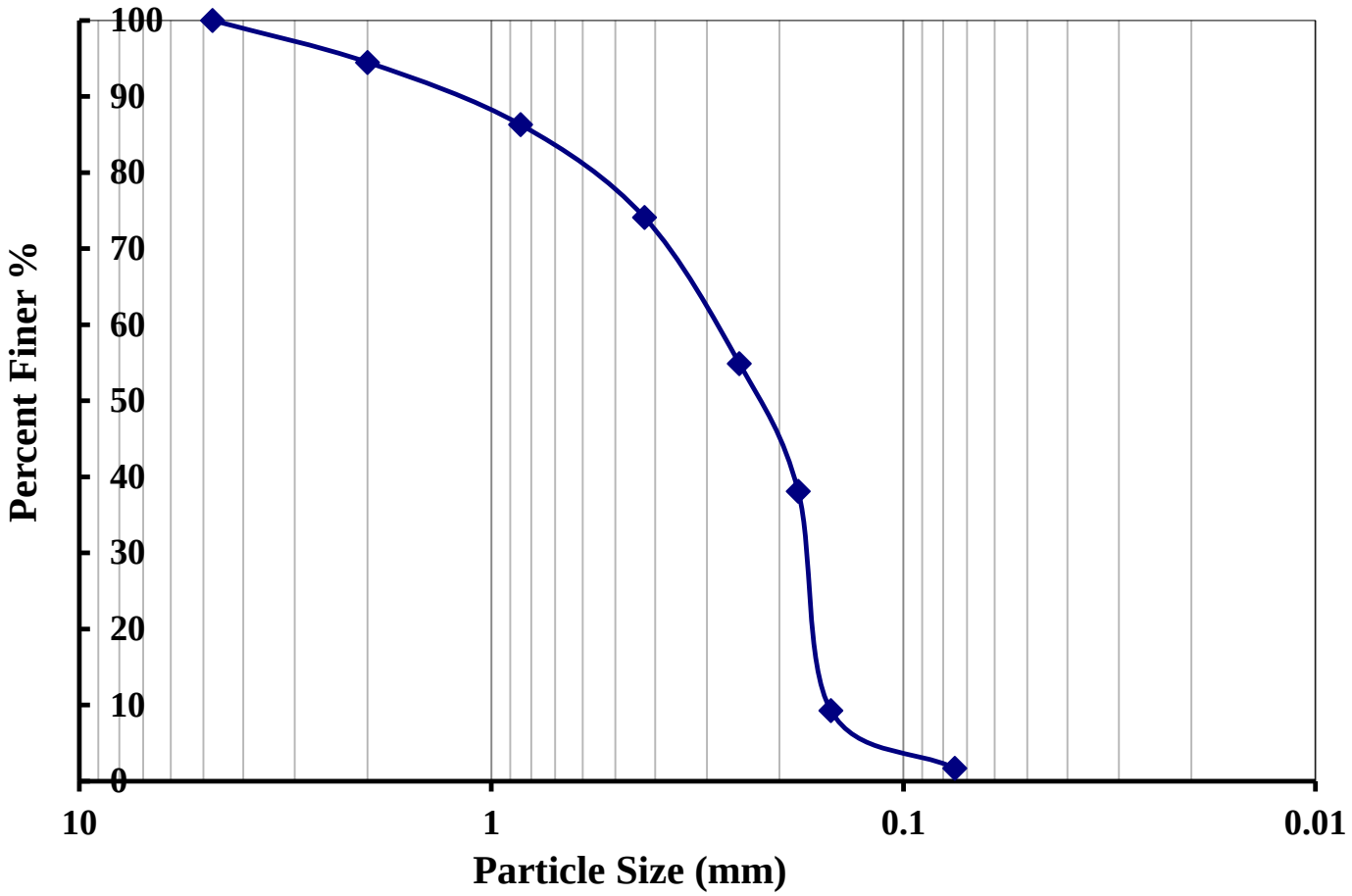
U.S. sieve size	Mass of soil retained on each sieve (g)
4	0
10	40
20	60
40	89
60	140
80	122
100	210
200	56
Pan	12

Following are the results of a sieve analysis. Make the necessary calculations and draw a particle-size distribution curve.

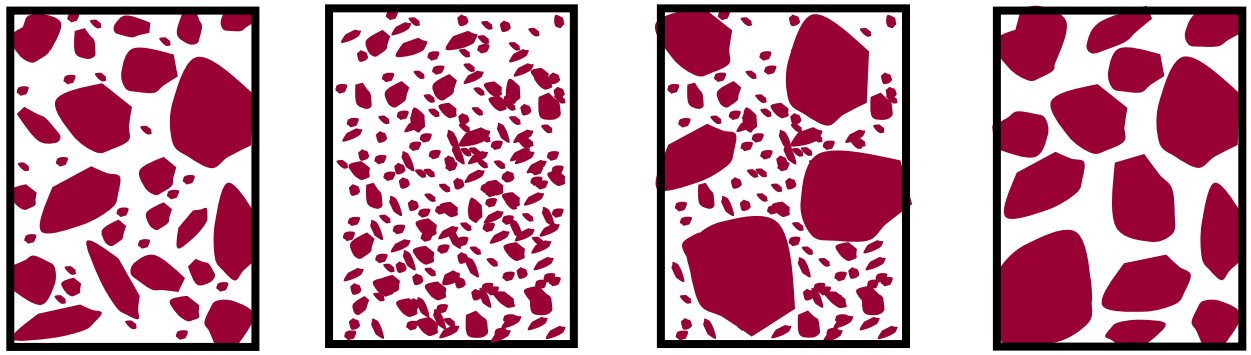
SIEVE ANALYSIS – Example

U.S. sieve (1)	Opening (mm) (2)	Mass retained on each sieve (g) (3)	Cumulative mass retained above each sieve (g) (4)	Percent finer[a] (5)
4	4.75	0	0	**100**
10	2.00	40	0 + 40 = 40	**94.5**
20	0.850	60	40 + 60 = 100	**86.3**
40	0.425	89	100 + 89 = 189	**74.1**
60	0.250	140	189 + 140 = 329	**54.9**
80	0.180	122	329 + 122 = 451	**38.1**
100	0.150	210	451 + 210 = 661	**9.3**
200	0.075	56	661 + 56 = 717	**1.7**
Pan	—	12	717 + 12 = 729 = ΣM	**0**

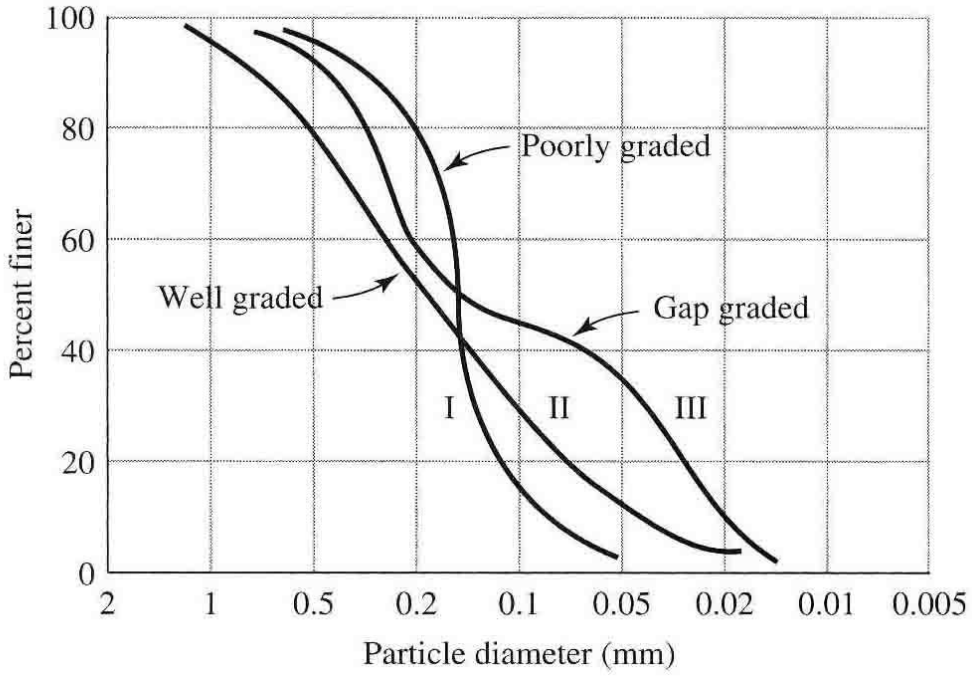
SIEVE ANALYSIS – Example



SOIL GRADATIONS



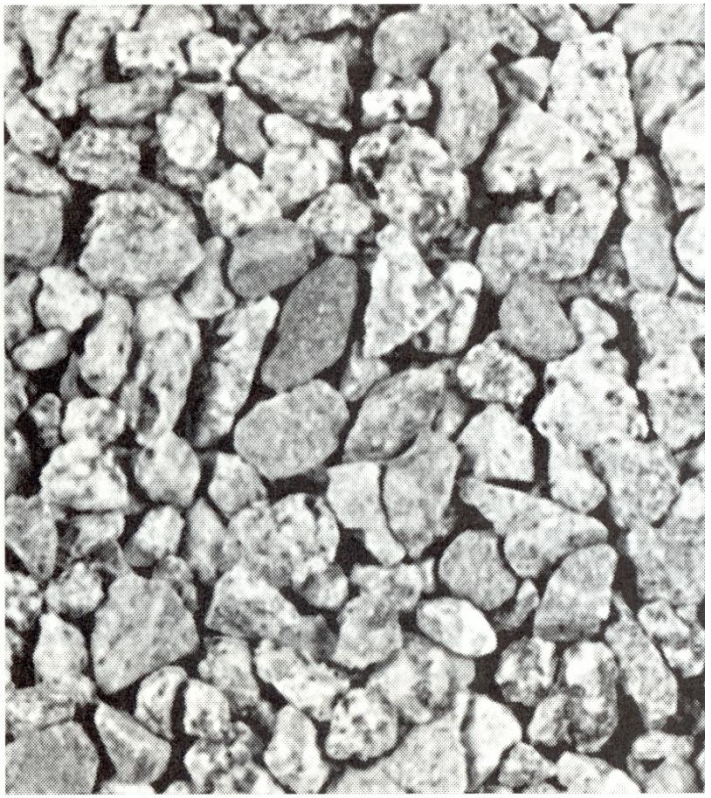
- Well graded soils
- Poorly graded soils
  - Uniformly graded soils
  - Gap graded soils



GRAIN SIZE DISTRIBUTION CURVE

Well-graded soil

Poorly-graded
(uniformly graded) soil



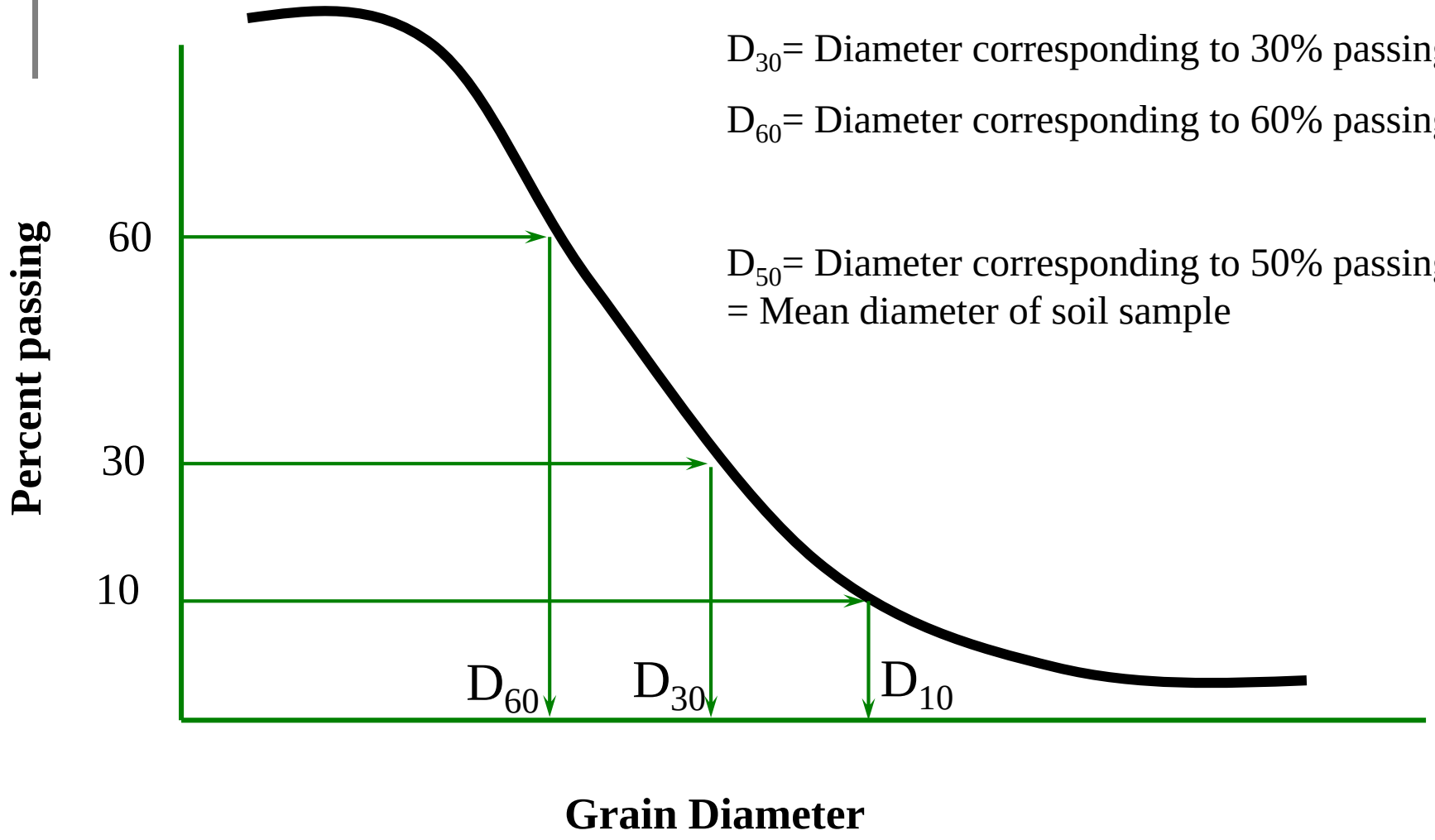
D_{10}, D_{30}, and D_{60}

D_{10}= Diameter corresponding to 10% passing

D_{30}= Diameter corresponding to 30% passing

D_{60}= Diameter corresponding to 60% passing

D_{50}= Diameter corresponding to 50% passing
= Mean diameter of soil sample



COEFFICIENTS OF GRADATION

Coefficient of Uniformity

$$C_u = \frac{D_{60}}{D_{10}}$$

For a well-graded soils

$$1 \le C_c \le 3$$

and

$C_u \ge 4$ (*for gravels*)

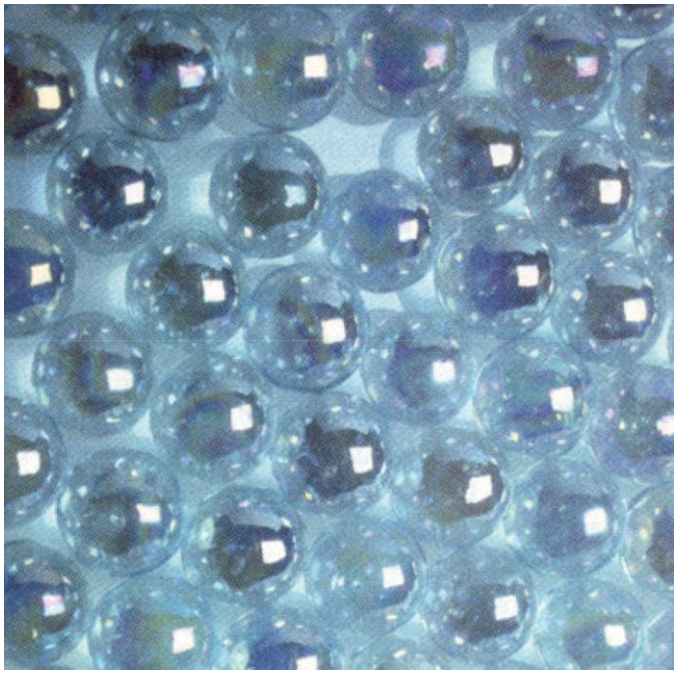
$C_u \ge 6$ (*for sands*)

Coefficient of Curvature

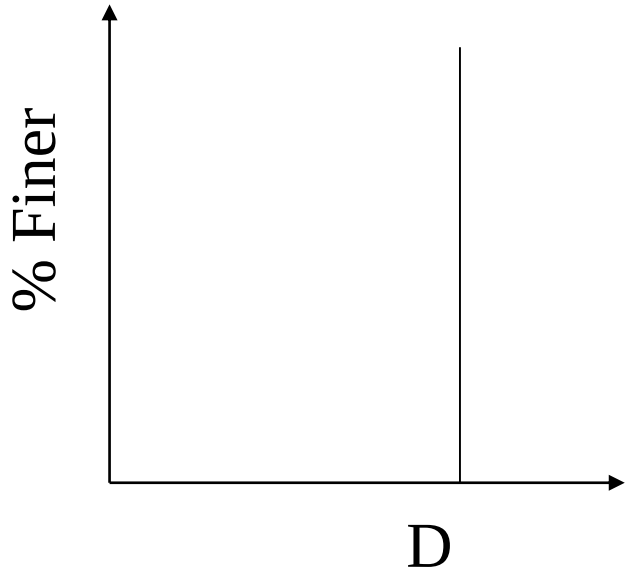
$$C_c = \frac{D_{30}^2}{(D_{60} \times D_{10})}$$

POINT TO PONDER!!!

What is the C_u for a soil with only one grain size?



C_u of Uniformly Graded Soil

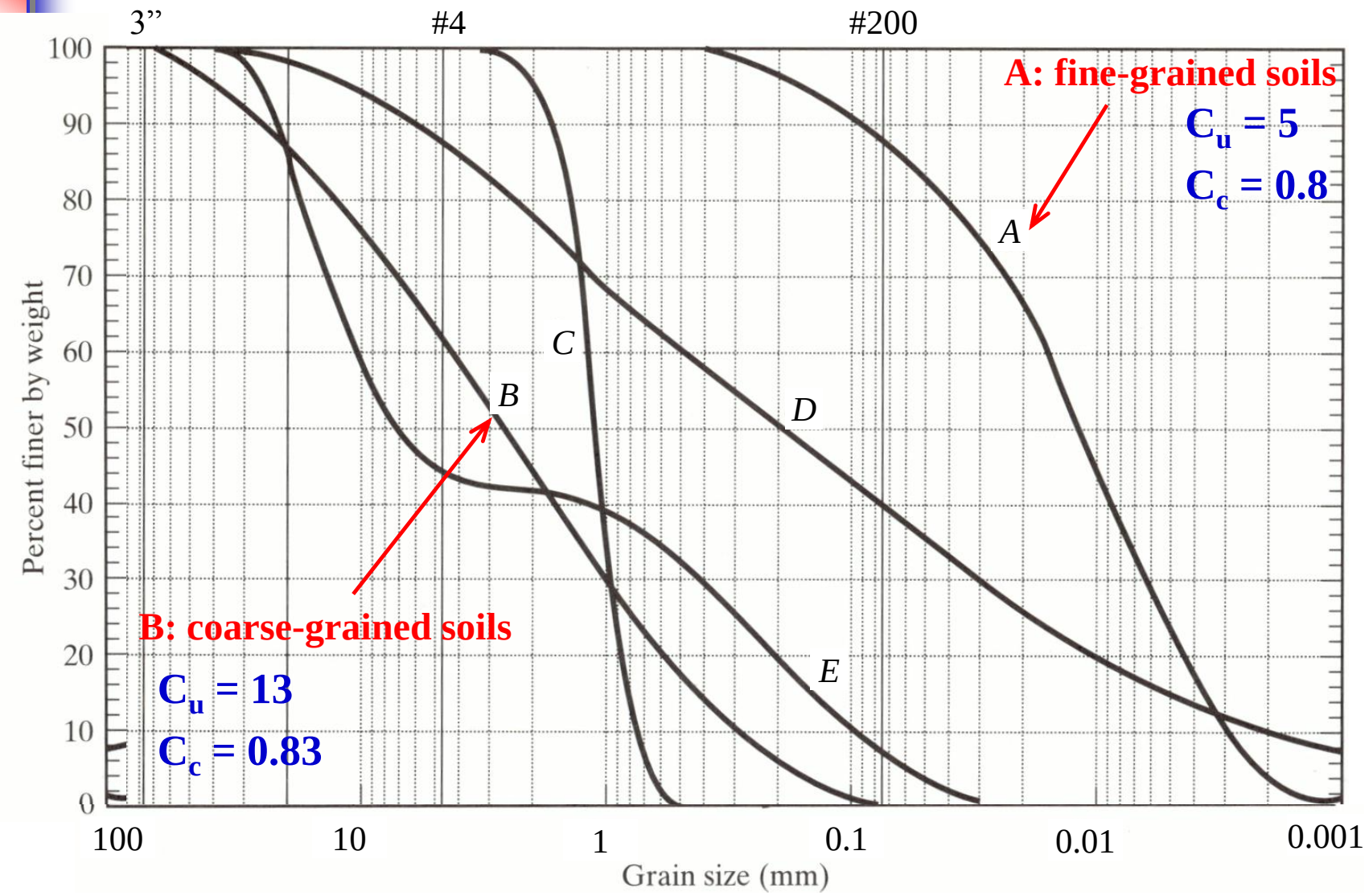


Grain Size Distribution

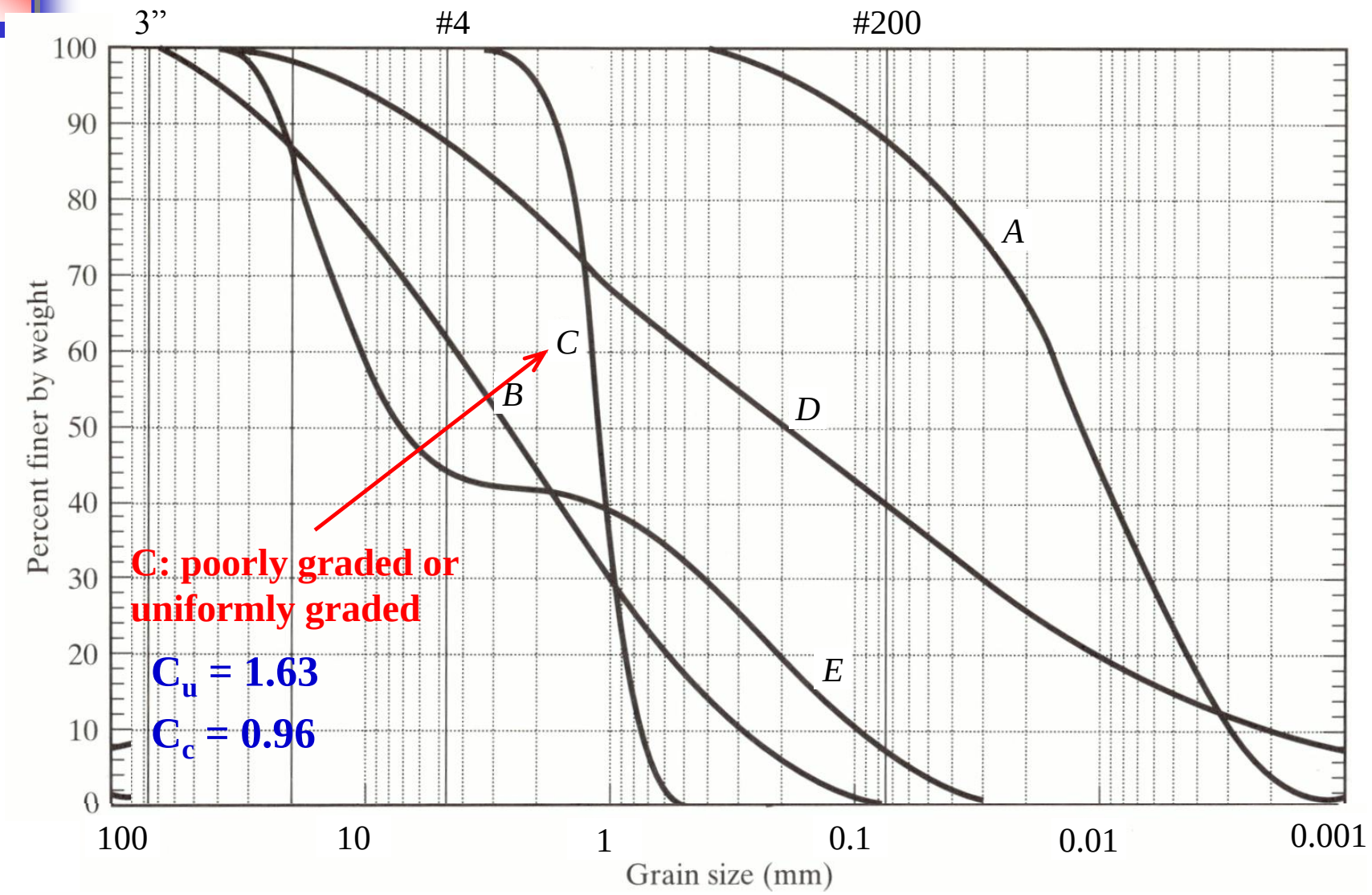
Coefficient of uniformity

$$C_u = \frac{D_{60}}{D_{10}} = 1$$

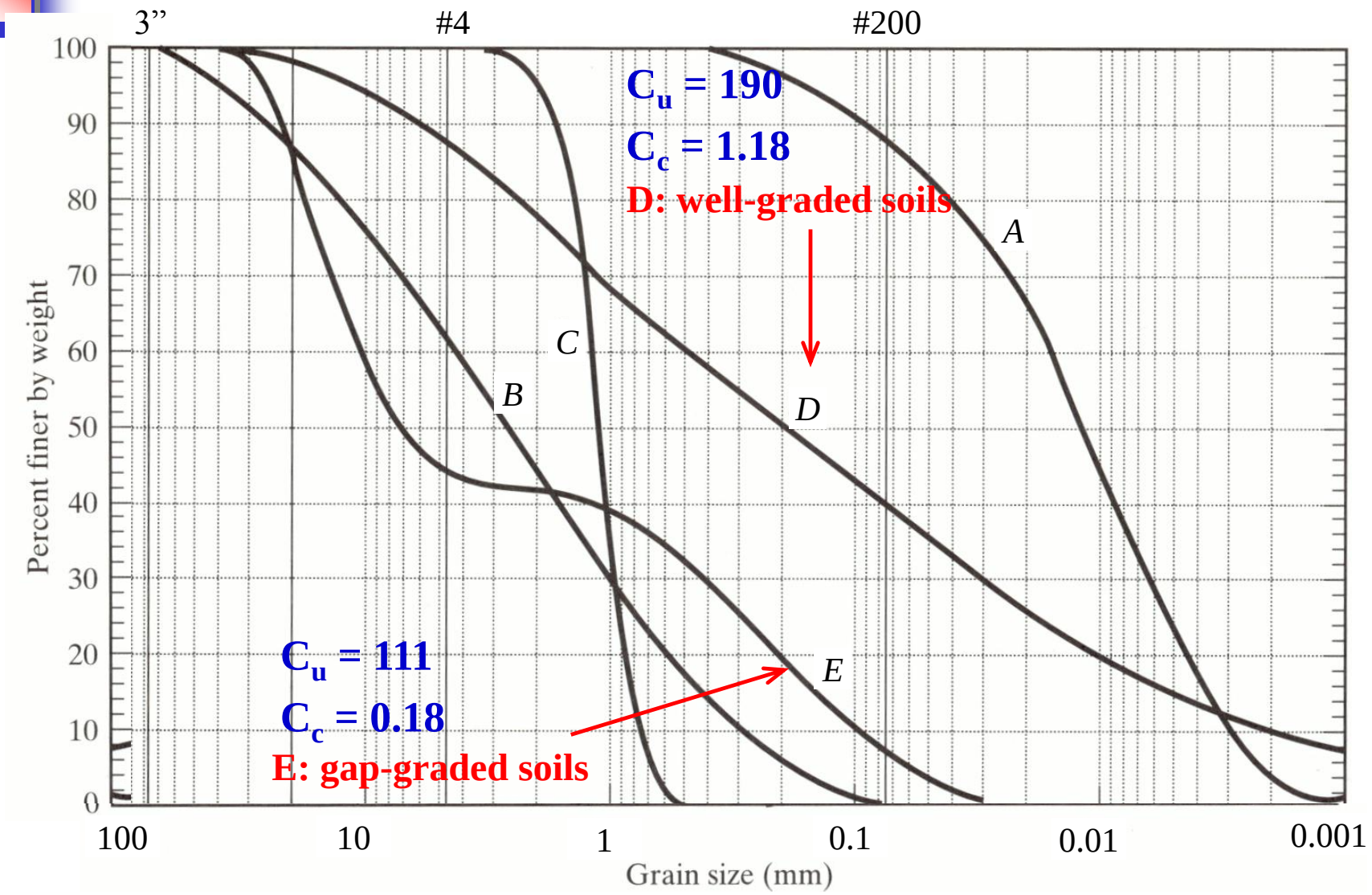
GRAIN SIZE DISTRIBUTION CURVE



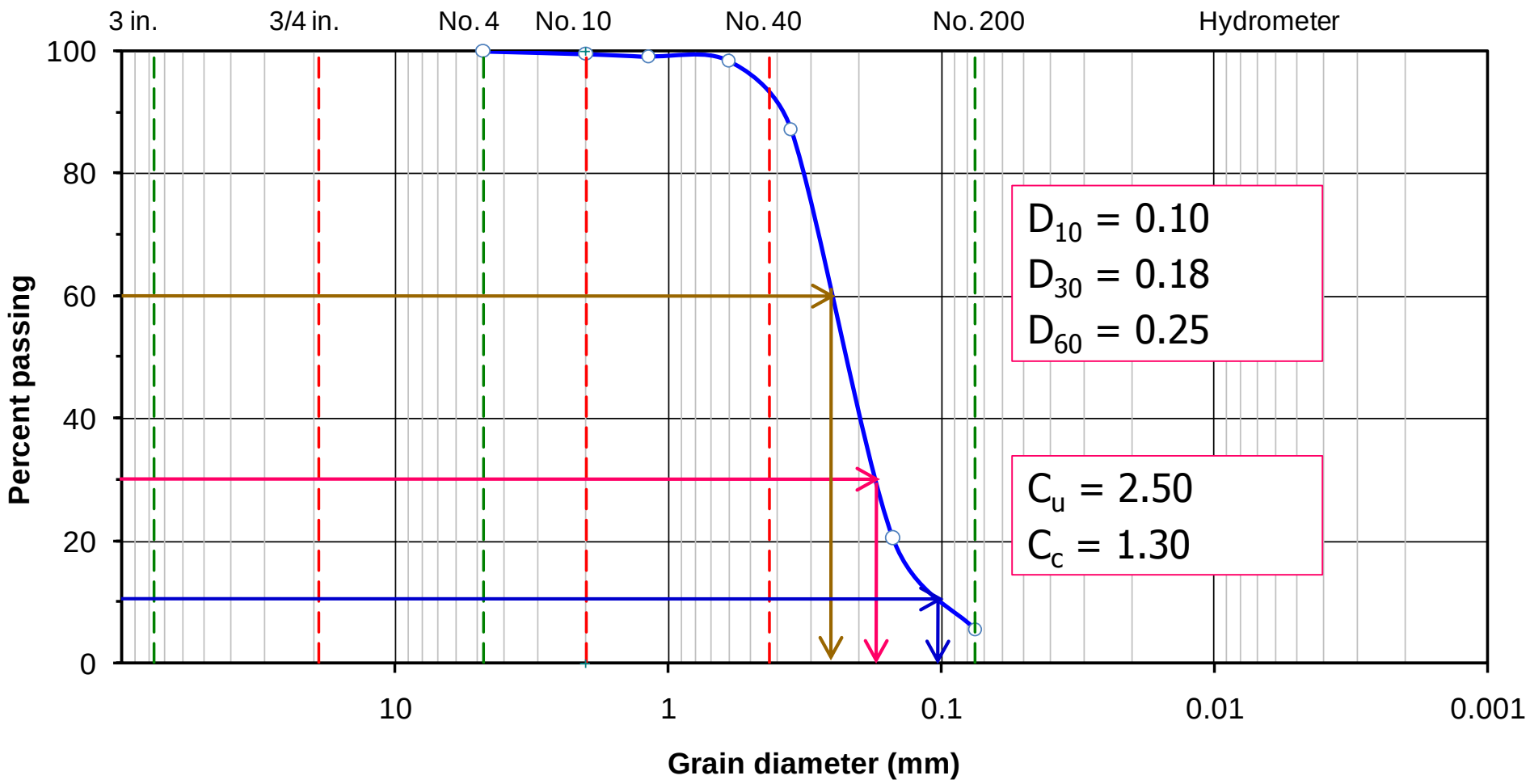
GRAIN SIZE DISTRIBUTION CURVE



GRAIN SIZE DISTRIBUTION CURVE



Grain-size distribution curve



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

CONCLUDED