

# CE 201: Engineering Materials (Aggregates)

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# Aggregates

- Granular material= sand, gravel, crushed stone (stone chips), crushed brick (brick chips), blast furnace slag, shingles
- 60-75% volume of concrete
- Affect workability of fresh concrete, and properties of hardened concrete

??????????

CA

#4 (4.75 mm)

FA

#200 (0.075 mm)

Silt and clay

Bring 3 Semi-log Graph Paper in the Next Class

# Particle Size Distribution or Grain Size Distribution or Grading of Aggregate

- Gradation curve or particle size distribution curve can be obtained by

## Sieve analysis

Let's take a scale and start to measure dimensions of particles.

R U Ready???

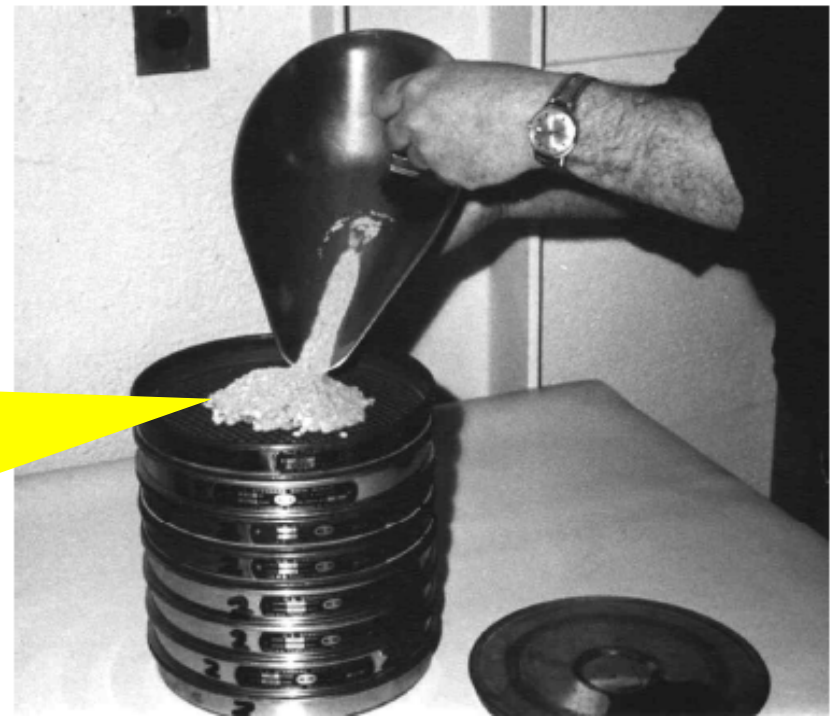


Fig. 1—Nest of sieves.

**Table 1—Sieves commonly used for concrete aggregate sieve analysis**

Standard sieve designation		Nominal sieve opening	
		mm	in.
Coarse sieves			
75.0 mm	3 in.	75.0	3
63.0 mm	2-1/2 in.	63.0	2.5
50.0 mm	2 in.	50.0	2
37.5 mm	1-1/2 in.	37.5	1.5
25.0 mm	1 in.	25.0	1
19.0 mm	3/4 in.	19.0	0.75
12.5 mm	1/2 in.	12.5	0.5
9.5 mm	3/8 in.	9.5	0.375
Fine sieves			
4.75 mm	No. 4	4.75	0.1870
2.36 mm	No. 8	2.36	0.0937
1.18 mm	No. 16	1.18	0.0469
600 $\mu\text{m}^*$	No. 30	0.60	0.0234
300 $\mu\text{m}$	No. 50	0.30	0.0117
150 $\mu\text{m}$	No. 100	0.15	0.0059
75 $\mu\text{m}$	No. 200	0.075	0.0029

\*1000  $\mu\text{m}$  = 1 mm.

### Example 1: Calculations for sieve analysis of fine aggregate

A sample of fine aggregate with a mass of 510.5 g is passed through the sieves shown below and the masses retained on each sieve are as shown.

Sieve size	Mass retained, g	Individual % retained	Total % retained	Total % passing
4.75 mm (No. 4)	9.2	2	2	98
2.36 mm (No. 8)	67.6	13	15	85
1.18 mm (No. 16)	101.2	20	35	65
600 $\mu\text{m}$ (No. 30)	102.2	20	55	45
300 $\mu\text{m}$ (No. 50)	120.5	24	79	21
150 $\mu\text{m}$ (No. 100)	93.1	18	97	3
75 $\mu\text{m}$ (No. 200)	10.2	2	99	1
Pan	4.5	1	100	0
TOTAL	508.5	100	—	—

**Example 2: Calculations for sieve analysis of coarse aggregate**

A sample of coarse aggregate with a mass of 8145 g is passed through the sieves shown below and the masses retained on each sieve are as shown.

Sieve size	Mass retained, g	Individual % retained	Total % retained	Total % passing
25.0 mm (1 in.)	0	0	0	100
19.0 mm (3/4 in.)	405	5	5	95
12.5 mm (1/2 in.)	2850	35	40	60
9.5 mm (3/8 in.)	2435	30	70	30
4.75 mm (No. 4)	2030	25	95	5
2.36 mm (No. 8)	375	5	100	0
Pan	35	0	100	0
TOTAL	8130	100	—	—

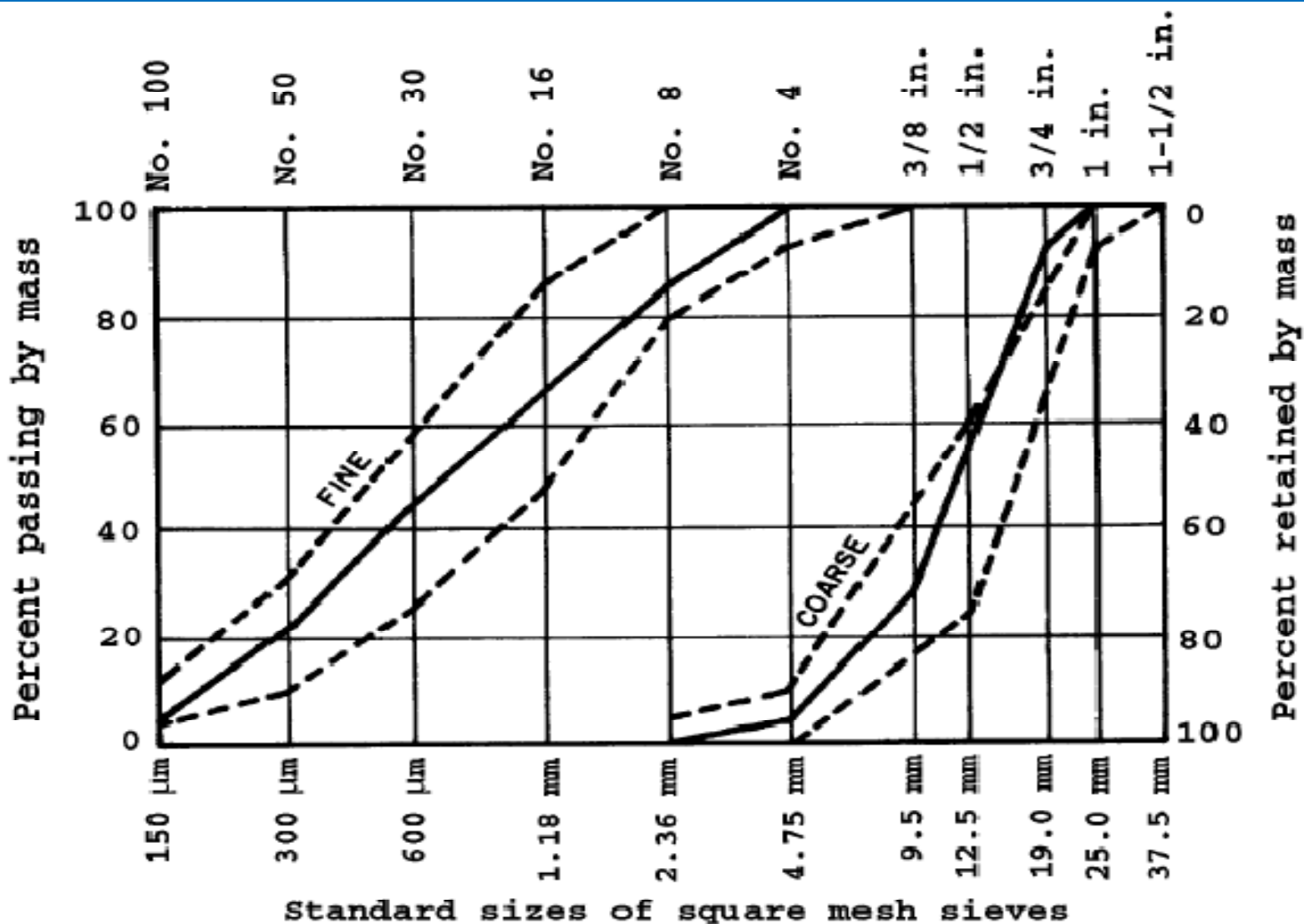
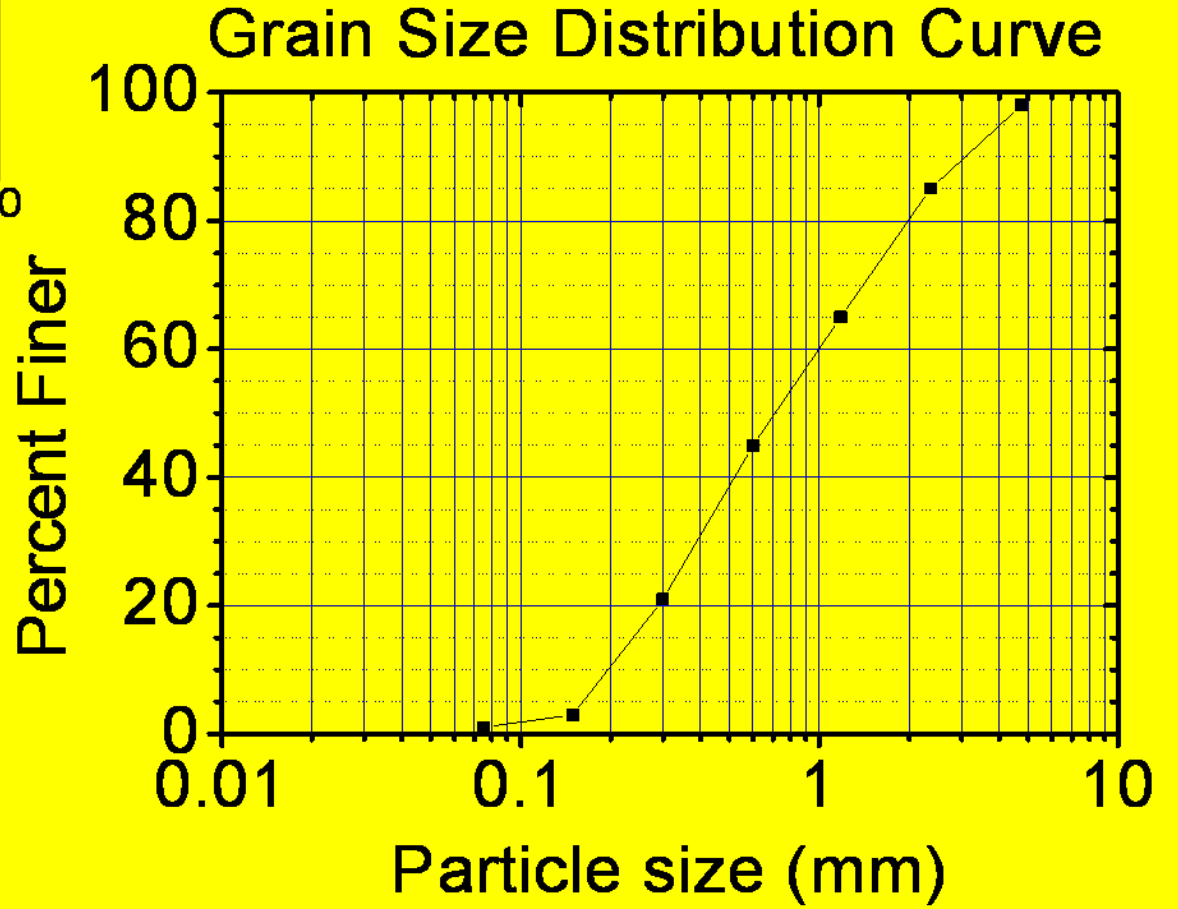
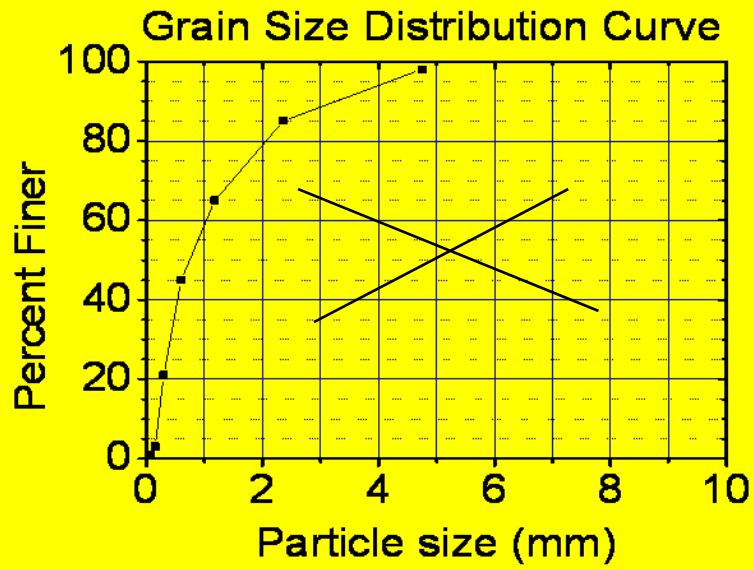


Fig. 2—Typical grading chart. Dashed lines indicate limits specified in ASTM C 33 for fine aggregates and for 25.0-mm (1-in.) coarse aggregate.



# FM = Fineness Modulus

**Example 3:** *Calculation of fineness modulus for fine aggregate*

Sieve size	Total % retained
4.75 mm (No. 4)	2
2.36 mm (No. 8)	15
1.18 mm (No. 16)	35
600 $\mu\text{m}$ (No. 30)	55
300 $\mu\text{m}$ (No. 50)	79
150 $\mu\text{m}$ (No. 100)	97
Sum	283

Fineness modulus =  $283 / 100 = 2.83$

- FM = sum of the total percentages retained on each of a specified series of sieves
- Specified sieves or standard sieves for FM = 75.0, 37.5, 19.0, and 9.5 mm + No. 4, 8, 16, 30, 50, 100
- Bottom is No. 100, top is unlimited
- Include whole range for summation????

**Example 4:** *Calculation of fineness modulus for coarse aggregate*

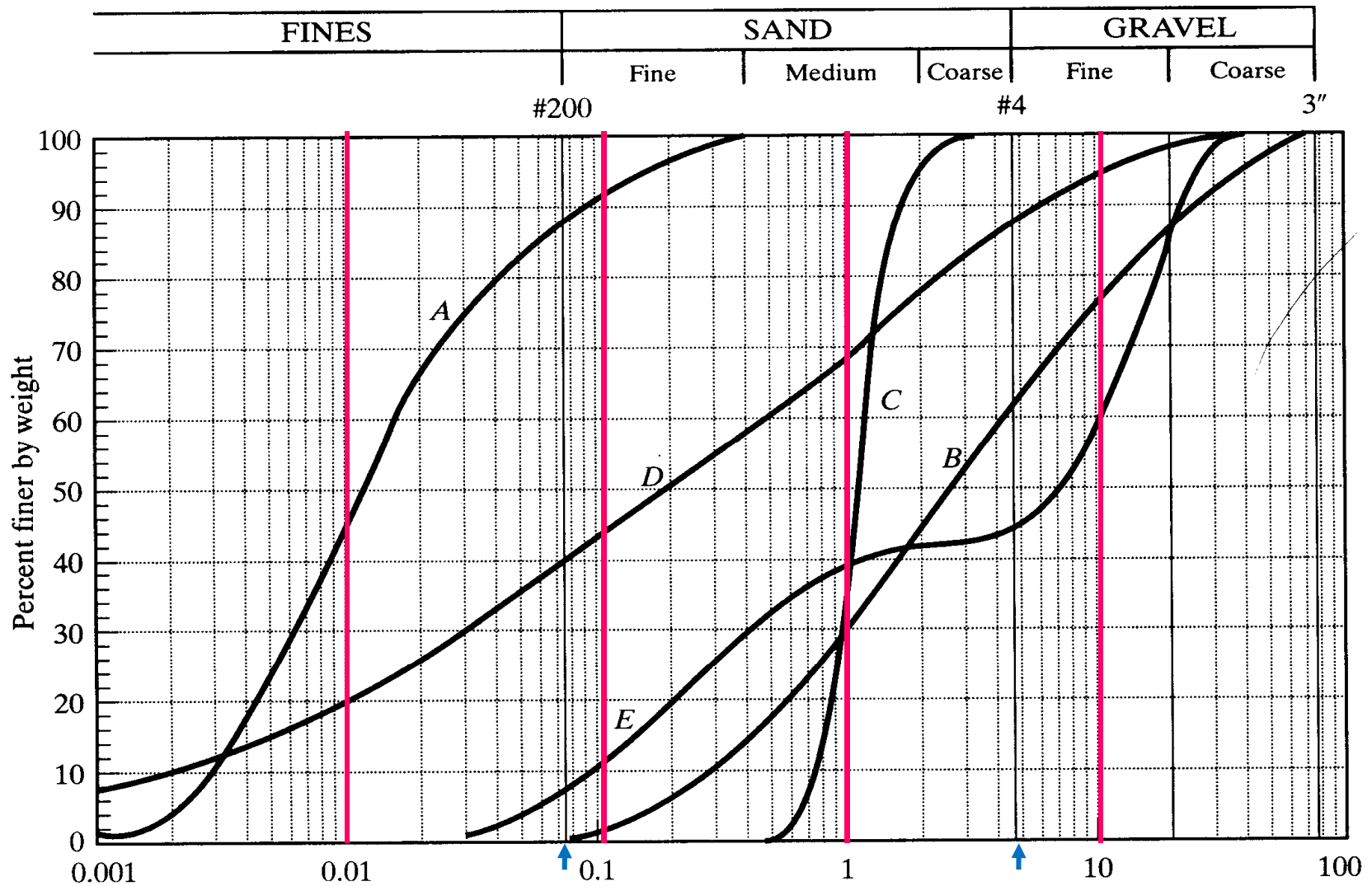
Sieve size	Total % retained
25.0 mm (1 in.)	0
19.0 mm (3/4 in.)	5
12.5 mm (1/2 in.)	40
9.5 mm (3/8 in.)	70
4.75 mm (No. 4)	95
2.36 mm (No. 8)	100

Thus, the calculation is as follows.

Sieve size	Total % retained
19.0 mm (3/4 in.)	5
9.5 mm (3/8 in.)	70
4.75 mm (No. 4)	95
2.36 mm (No. 8)	100
1.18 mm (No. 16)	100
600 $\mu\text{m}$ (No. 30)	100
300 $\mu\text{m}$ (No. 50)	100
150 $\mu\text{m}$ (No. 100)	100
Sum	670

$$\text{Fineness modulus} = 670/100 = 6.70$$

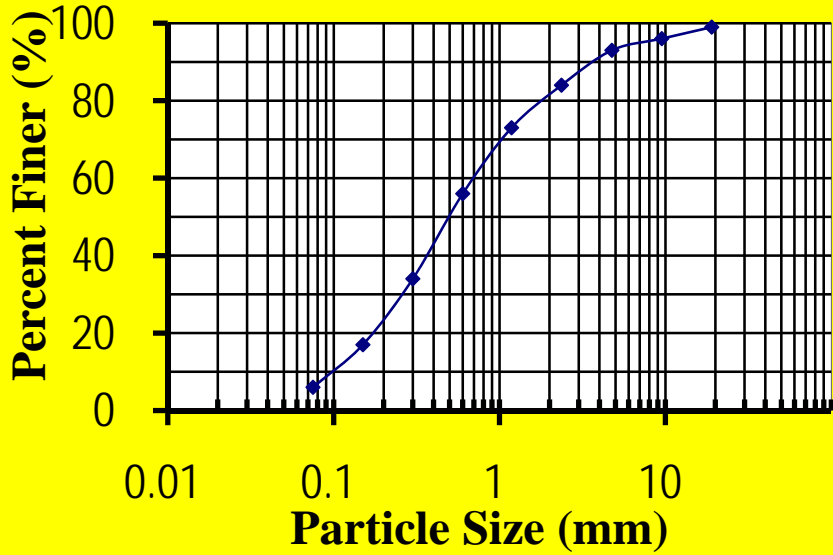
# D = Well, C = Uniform, E = Gap



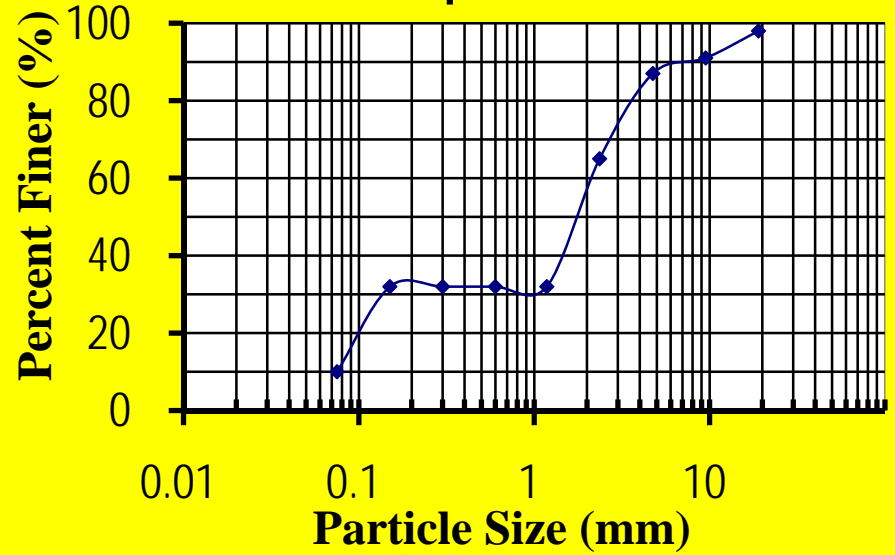
# Some Index Properties

- C..... Uniformly-graded soil
- D .... Well-graded soil ( $C_u > 4$  for gravel,  $C_u > 6$  for sand,  $C_c = 1-3$ )
- E .... Gap-graded soil
- $D_{10}, D_{30}, D_{60} = ??$
- $D_{10}$  = Effective size,  $D_{50}$  = Mean diameter
- Coefficient of Uniformity, 
$$C_u = \frac{D_{60}}{D_{10}}$$
- Coefficient of Curvature or Coefficient of Gradation, 
$$C_c = \frac{(D_{30})^2}{D_{10} D_{60}}$$

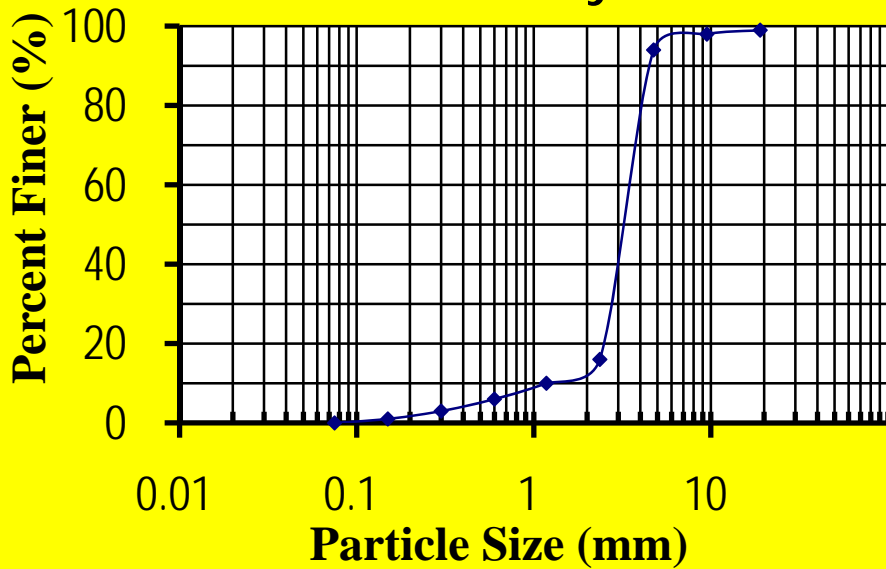
### Well Graded



### Gap Graded



### Uniformly Graded



Poorly Graded

# Homework – 1:

- 1. Draw gradation curve of three types of sand having  $FM = 2.50$
- 2. Prove that minimum  $FM$  of sand is  $0.00$  and maximum  $FM = 5.00$

# Combined grading

Sieve size	% passing		
	Aggregate 1	Aggregate 2	Aggregate 3
50 mm (2 in.)	100	100	100
37.5 mm (1-1/2 in.)	100	100	95
25.0 mm (1 in.)	100	100	51
19.0 mm (3/4 in.)	100	100	25
12.5 mm (1/2 in.)	100	99	8
9.5 mm (3/8 in.)	100	89	2
4.75 mm (No. 4)	99	24	0
2.36 mm (No. 8)	85	3	—
1.18 mm (No. 16)	65	0	—
600 $\mu$ m (No. 30)	38	—	—
300 $\mu$ m (No. 50)	15	—	—
150 $\mu$ m (No. 100)	4	—	—
75 $\mu$ m (No. 200)	1	—	—
Percentage by mass	35%	25%	40%

# Calculation of combined grading

Sieve size	Aggregate 1	Aggregate 2	Aggregate 3	% passing	% retained	Individual % retained
50 mm (2 in.)	35	25	40	100	0	0
37.5 mm (1-1/2 in.)	35	25	38	98	2	2
25.0 mm (1 in.)	35	25	20	80	<del>20</del>	18
19.0 mm (3/4 in.)	35	25	10	70	30	10
12.5 mm (1/2 in.)	35	25	3	63	<del>37</del>	7
9.5 mm (3/8 in.)	35	22	1	58	42	12
4.75 mm (No. 4)	35	6	0	41	59	17
2.36 mm	30	1		31	69	10

# Significance of aggregate grading (smooth, gap, poor, uniform)

- Need to know >>> well graded agg or smooth grading, gap grading, uniform grading, poor grading
- Smooth grading => minimum void => less cement requirement to fill void => cement paste can coat all particles
- Poor grading => Harsh concrete mix
- Excessive fine aggregate => more surface area => more cement
- Maximum size of aggregate: larger => less cement requirement /  
But too many larger agg => more void unfilled by fine agg => more cement paste requirement

- Who dictate nominal max size of agg?
  - Size and shape of concrete member
  - Clear spacing between reinforcing bars
  - Clear cover

# Harmful materials in aggregate

- Organic materials
- Silt, clay and other fine particles
- Salt
  - Harmful effects
    - Interfere in hydration process of concrete
    - Coatings prevents good bonding
    - Make unsound (volume expansion after hardening)