- ***Unit Weight UW (Bulk Density)***

The actual mass that would fill a container of unit volume. This is used to convert quantities by mass to quantities by volume.

UW= measure the volume that the graded aggregate will occupy in concrete and includes the solid aggregate particles and the voids between them.

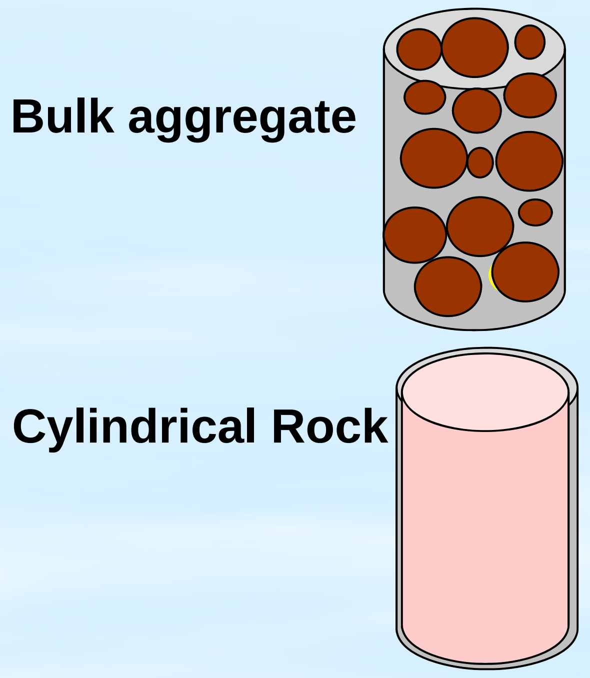
Bulk Density Reflects:
- Packing of Aggregate
- Size distribution
- Shape of Aggregate particles.
- Degree of compaction: Loose, Fully compacted

UW of aggregate influence the UW of concrete.

- ***Unit Weight UW (Bulk Density)***

-Compacted unit weight:
fill in 3 layers, compact each layer 25 times using tamping rod, and level the surface then weigh the container.
-Loose unit weight: fill the container, and level the surface then weigh the container.

Cylindrical Container = Vessel



$$UW_{\text{bulk}} = \frac{W_{Compacted\ or\ Loose\ Aggregate}}{V_{S\tan dard\ Cylinder}}$$

- *Grading (Sieve Analysis)*

It is the process of dividing a sample of aggregate into fractions of same size. Its purpose is to determine the grading or size distribution of the aggregate. General sieve Sizes are shown in Table.

Particle size: considered to be the size of the smallest sieve opening through which the sample passes.

Grading Curves:
The results of sieve analysis can be presented in a graphical form after this process (sieve analysis) is performed in a tabular form.

Methods: **ASTM C 136**

Objective: **Determine Percentages Passing of Each individual Aggregate Size.**

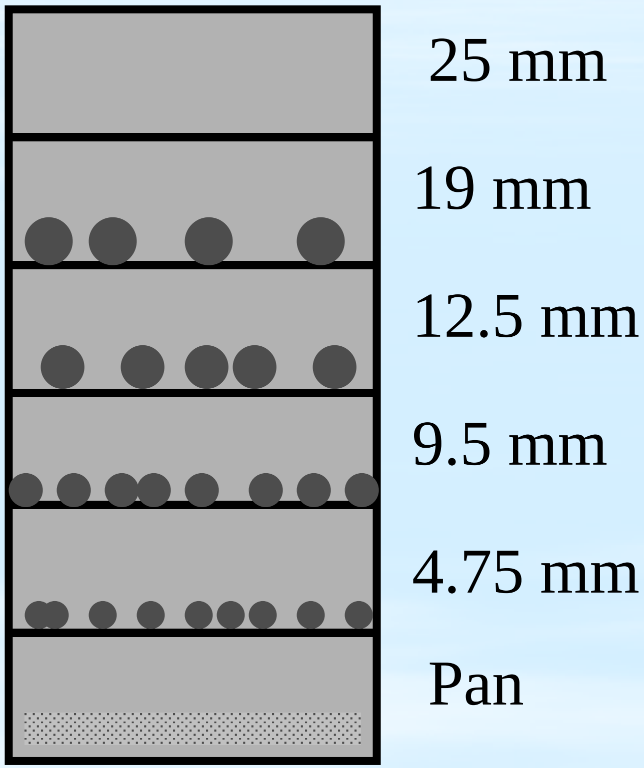
Sample: See Table

Specifications: **ASTM C33 Limitations**

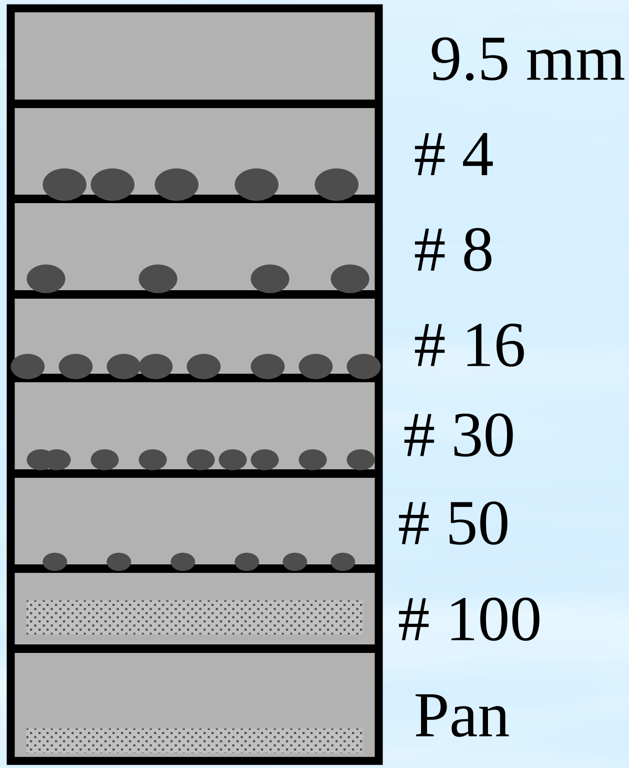
Maximum Size- Structural Concrete

$\leq$ **25 mm**

Series of Coarse Aggregate Sizes



Series of Fine Aggregate Sizes



Sample Calculation: Fine Aggregate

Sieve	Retained (Grams)	Retained (%)	%CR	%CP
# 4	0	0	0	100
# 8	100	10	10	90
# 16	100	10	20	80
# 30	450	45	65	35
# 50	200	20	85	15
# 100	130	13	98	2
Pan	20			
Total	1000		278	

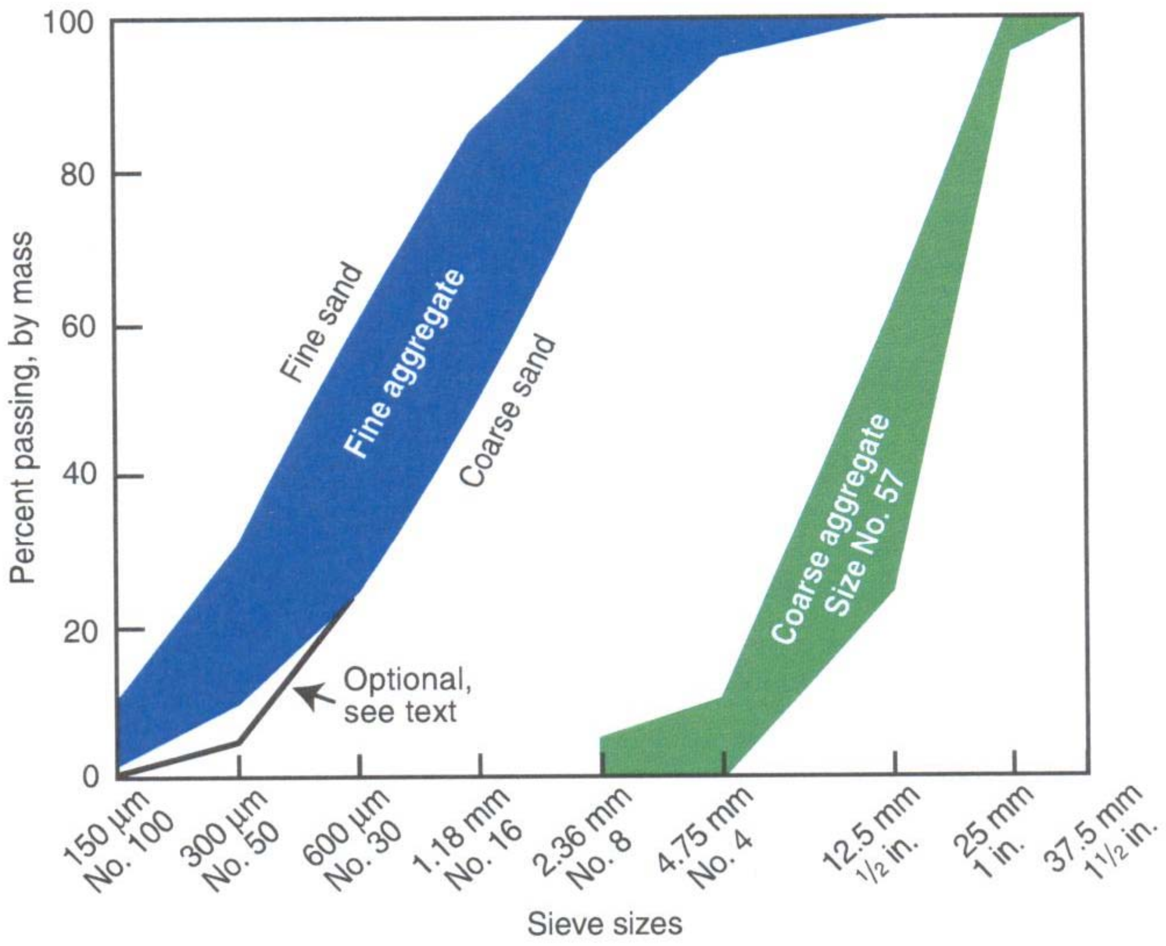


Fig. 5-6. Curves indicate the limits specified in ASTM C 33 for fine aggregate and for one commonly used size number (grading size) of coarse aggregate.

Maximum Aggregate Size

D_{max}: Designated as the smallest sieve through which 100% of the aggregate sample particles pass.

$D_{nominal}$: Designated as the largest sieve that retains some of the aggregate particles, but generally not more than 15%.

A. Structural concrete

- Larger Dmax → Less water → lower w/c → Higher Strength

-Very large Dmax → lower bond area → Discontinuities introduced by large Particles → strength↓

Dmax is controlled by:

Spacing between steel bar;

Note: Use Dmax < 1 1/2″ (40 mm)

ASTM C 33 Requirements

Coarse Aggregate

Sieve	%CP	%CP-ASTM
25 mm	100	100
19 mm	90	90-100
12.5 mm	50	20-55
9.5 mm	20	0-15
# 4	5	0-5

Max Size = 25 mm

Nominal Size = 19 mm

Fine Aggregate

Sieve	%CP	%CP-ASTM
# 4	100	95-100
# 8	90	80-100
# 16	80	50-85
# 30	35	25-60
# 50	15	10-30
# 100	2	2-10

Max Size = # 4

Nominal Size = # 8

Fineness Modulus of Fine Aggregate:

Methods: ASTM 125

Fineness Modulus (FM): **Sum of Percentage Cumulative Retained on Standard Sieves # 4, # 8, # 16, # 30, # 50, & # 100 Divided by 100.**

Specifications: **$2.3 \leq FM \leq 3.1$**

Violation of 0.25 is Allowed

Sample Calculation (previous example):

$$FM = 278/100 = 2.8$$

Grading Requirements

No ideal grading can be recommended because of interacting influences of the main influencing factors on workability:

1- The surface area of aggregate.
Low Specific Surface → low water & cement requirement Strength & low Price. But, Fines are needed for lubrication (workability).

2. Relative volume occupied by aggregate:
High (%) → High Density → less voids (less filler: Cement + FA). But, Paste and/or Mortar are needed for lubrication.

Grading Requirements

3:- Tendency to Segregation

-Preventing mortar from Passing outs of voids (between coarse aggregate).

4- Amount of Fines in the Mix

-Mix should contain materials smaller than 300μm to get satisfactory workable mix

-*Practical Grading*

Use aggregate with a grading such that a reasonable workability and minimum segregation are obtained in order to produce strong and economical concrete

Types of Grading
-Single Sized
-Poorly Graded
-Well-Graded
-Gap-Graded

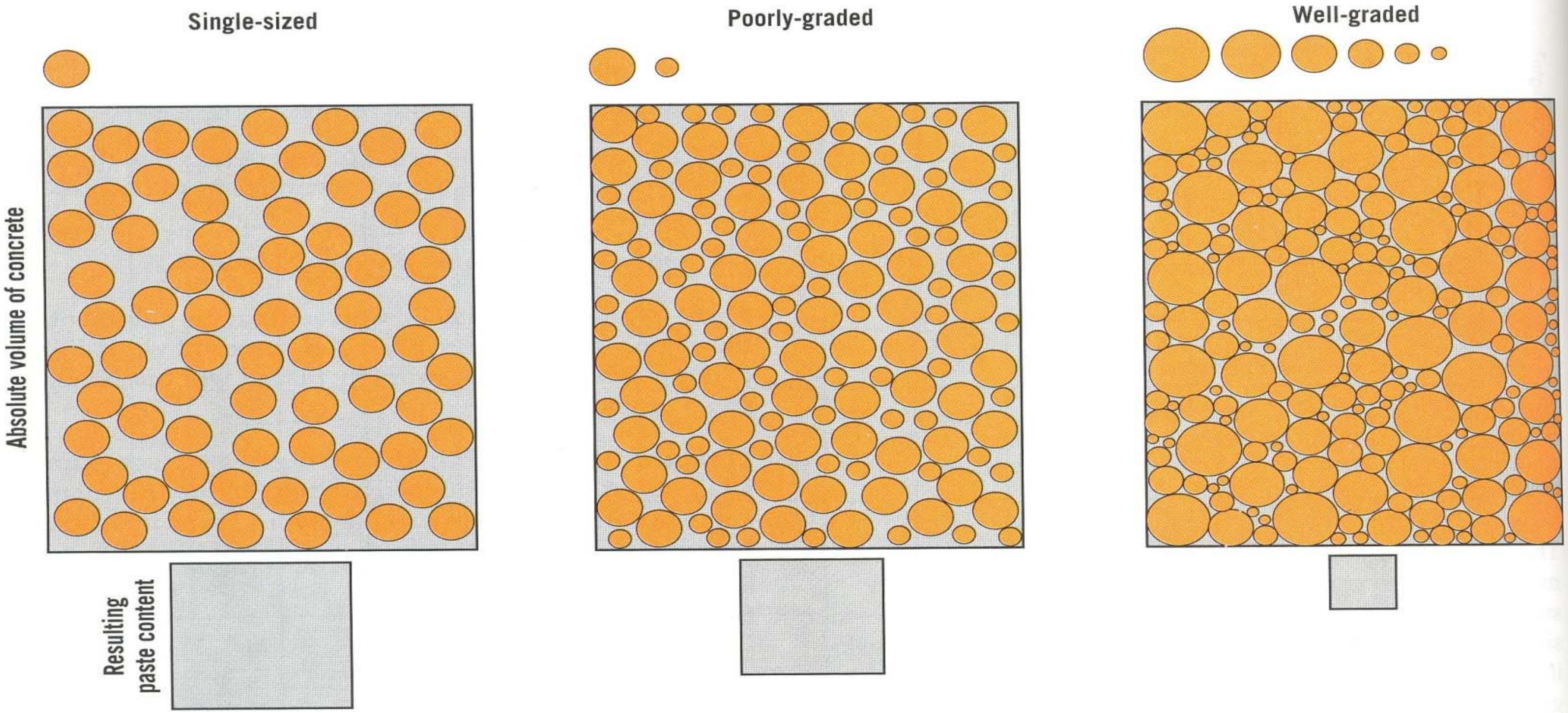


Figure 6-13. For equal absolute volumes when different sizes are combined, the void-content decreases, thus the necessary paste content decreases.

* This effect is independent of aggregate size. The voids are smaller, but the volume of voids is nearly the same (and high) when a single-size fine aggregate is used compared to a coarse aggregate. For the idealized case of spheres, the void volume is about 36% regardless of the size of particles.

Figure 6-8. Range of particle sizes found in aggregate for use in concrete.

Impurities in Aggregates:

❖ ***Deleterious Substances***

- Impurities: Interfers with the process of hydration of cement.
- Coatings: Prevent the development of good bond between aggregate and cement paste.
- Weak & Unsound Particles.
- Aggregate containing sulphate or chloride Salts

Organic Impurities

Organic matter consists of products of decay of vegetable matter in the form of humus or organic loam, usually present in sand.

$\uparrow$ Dark $\rightarrow$ Organic Content $\uparrow$

No darker than yellow color $\rightarrow$ harmless organic impurities
Darker than standard $\rightarrow$ harmful organic impurities

Clay and Other Fine Material

-Present in the form of surface coating and/or loose materials that could :

(a) Reduce bond strength.

(b) Increase water demand.

Salt Contamination

- Sand from seashore or rivers estuary contains > 6% (by mass) Salt

- If not washed by water salt existence in concrete could:	$\rightarrow$ Cause reinforced steel corrosion $\rightarrow$Absorption of moisture from air thus, causing efflorescence; white deposits on concrete surface

Table shows allowable contents of different impurities (ASTM C33-84).

Type of particle	Maximum content (%) (by mass) in:	
	FA	CA
Friable Particles	3	3.0 to 10.0
Soft Particles	-	
Coal	0.5-1	0.5 to 1.0
Chert	-	3.0 to 8.0