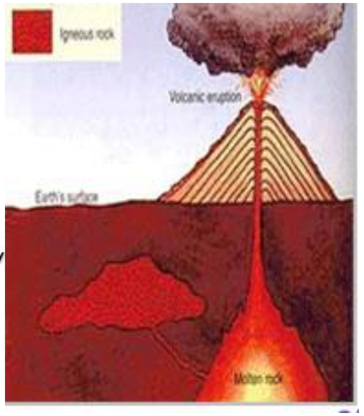
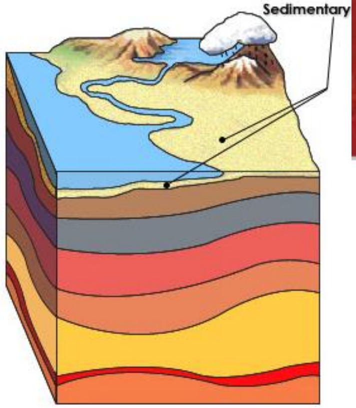
Aggregates for Use In Concrete

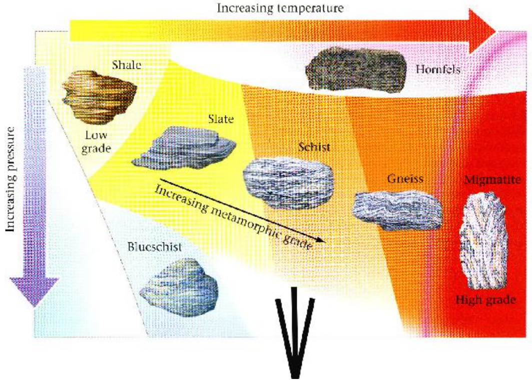
American Concrete Pipe Association

Mineralogy

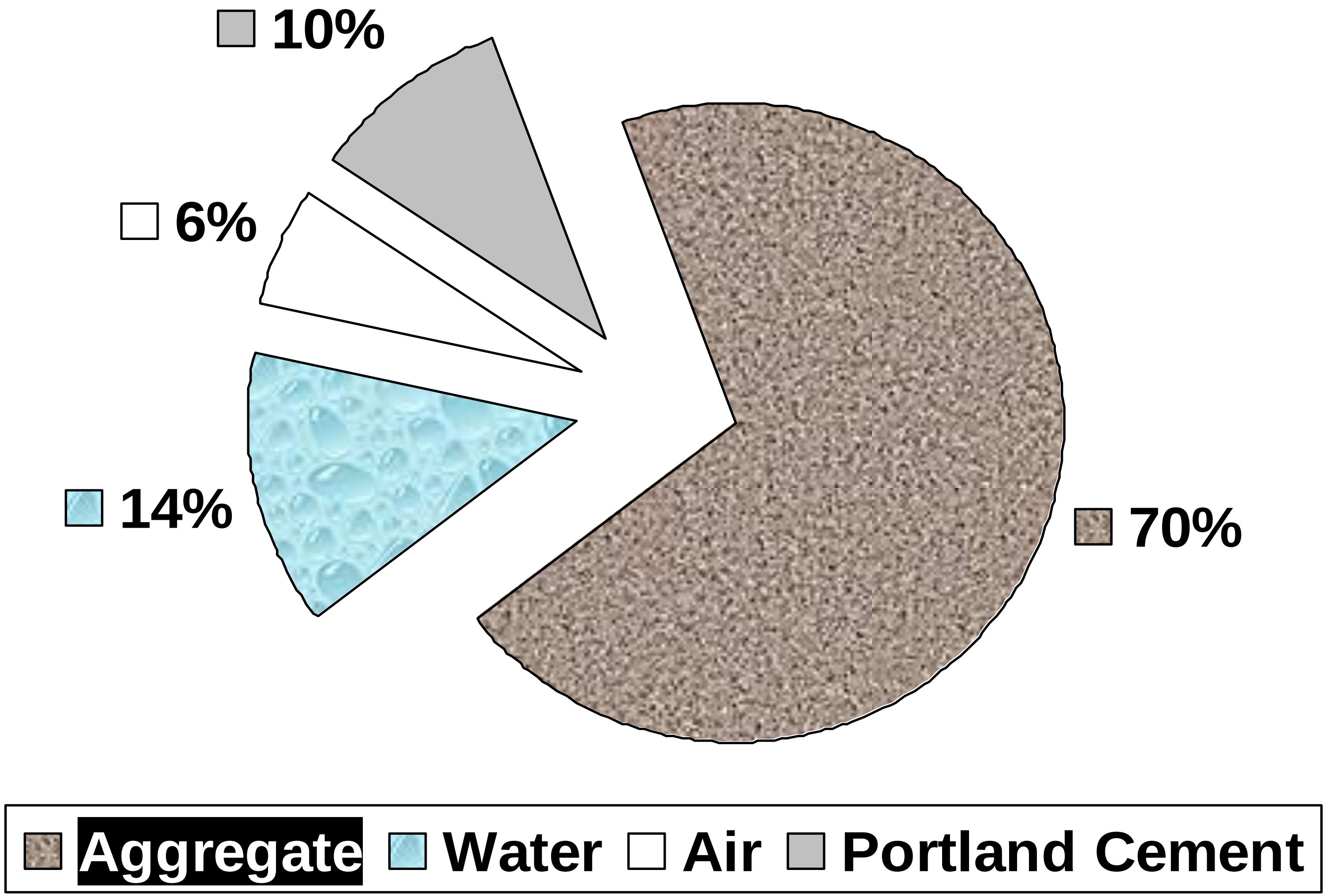
- Igneous (Latin - "Fire")
  - Formed from volcanic processes and the heating and cooling of magma
    - Example: granite
- Sedimentary (Latin - "Settling")
  - Formed by the layering of sediments due to the action of wind or water
    - Example: sandstone
- Metamorphic (Greek - "Change")
  - Result from long-term high temperature and pressure on igneous and sedimentary rocks
    - Example: marble







Concrete Composition



Aggregate Types

- **Natural Aggregates** –
  - particle sizes from boulder to clay;
  - May have poor quality without modification

- **Manufactured Aggregates** –
  - produced through crushing, screening, separating, and recombining rock deposits or natural aggregates

Coarse Aggregate

- Gravel and crushed stone
- ≥ 4.75 mm (0.2 in.), larger than #4 sieve
- typically between 9.5 and 37.5 mm (3/8 & 1½ in.)

Fine Aggregate

- Natural sand, manufactured sand or crushed stone
- < 4.75 mm (0.2 in.), will pass #4 sieve
- F.A. content usually 35% to 45% by mass or volume of total aggregate

Important Aggregate Properties

- Durability, Freeze - Thaw and Chemical Resistance
- Hardness, Toughness, Abrasion
- Texture & Shape
- Strength
- Unit Weight / Density
- Cleanliness

Aggregate Specifications

- ASTM C33 - Normal Weight Aggregates
- ASTM C330 - Lightweight Aggregates
- ASTM C637 - Radiation Shielding Aggregates (Heavyweight)

QUALITY SCHOOL

2024 PIPE SCHOOL
STRENGTH. RESILIENCE. SUSTAINABILITY.

ASTM INTERNATIONAL

Designation: C76 – 18a

Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe[1]

This standard is issued under the fixed designation C76; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (´) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers reinforced ... ete pipe intended to be used for the conveyance of ... wastes, and storm water, and for the construction o...

1.2 This specification is the inch-pound companion to Specification C76M; therefore, no SI equivalents are presented in this specification. Reinforced concrete pipe that conform to the requirements of C76M, are acceptable under this Specification C76 unless prohibited by the Owner.

NOTE 1—This specification is a manufacturing and purchase specification only, and does not include requirements for bedding, backfill, or the relationship between field load condition and the strength classification of pipe. However, experience has shown that the successful performance of this product depends upon the proper selection of the class of pipe, type of bedding and backfill, and care that installation conforms to the

A706/A706M Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
A1064/A1064M Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
C33/C33M Specification for Concrete Aggregates
C76M Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
C150/C150M Specification for Portland Cement
C260/C260M Specification for Air-Entraining Admixtures for Concrete
C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
C443 Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets

Aggregate Specifications

- ASTM C33 - Normal Weight Aggregates
  - Durability requirements

7. Deleterious Substances

7.1 The amount of deleterious substances in fine aggregate shall not exceed the limits prescribed in Table 1.

7.2 *Organic Impurities*:

7.2.1 Fine aggregate shall be free of injurious amounts of organic impurities. Except as herein provided, aggregates subjected to the test for organic impurities and producing a color darker than the standard shall be rejected.

7.2.2 Use of a fine aggregate failing in the test is not prohibited, provided that the discoloration is due principally to the presence of small quantities of coal, lignite, or similar discrete particles.

7.2.3 Use of a fine aggregate failing in the test is not prohibited, provided that, when tested for the effect of organic impurities on strength of mortar, the relative strength at 7 days, calculated in accordance with Test Method C 87, is not less than 95 %.

Harmful Materials in Aggregates

Substances	Effect on Concrete	Test Designation
Organic impurities	Affect setting and hardening, may cause deterioration	ASTM C 40 ASTM C 87
Materials finer than # 200 sieve	Affect bond, increase water requirement	ASTM C 117
Coal, lignite, or other lightweight materials	Affect durability, may cause stains and popouts	ASTM C 123
Soft participles	Affect durability	
Clay lumps and friable particles	Affect workability and durability, may cause popouts	ASTM C 142
Chart of less than 2.40 specific gravity	Affects durability, may cause popouts	ASTM C123 ASTM C 295
Alkali-reactive aggregates	Abnormal expansion, map cracking, popouts	ASTM C 227 ASTM C 289 ASTM C 295 ASTM C 289 ASTM C 342 ASTM C 586

Deleterious Substances

Item	Mass % of Total Sample
Clay lumps and friable particles	3.0
Material finer than 75 micron (No. 200) sieve:	
Concrete subject to abrasion	3.0*
All other concrete	5.0*
Coal and lignite:	
Where surface appearance of concrete is of importance	0.5
All other concrete	1.0

Source: Table 1 Limits for Deleterious Substances in Fine Aggregate for Concrete, ASTM C 33.
*** In the case of manufactured sand, if the material finer than the 75-micron (No. 200) sieve consists of the dust or fracture, essentially free of clay or shale, these limits are permitted to be increased to 5 and 7%, respectively.**

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Organic Impurities C40 (fine aggregate)

Lovibond AF347 Test Kit

Organic Impurities in Fine Aggregrates, according to ASTM C 40

- Compact, robust and easily portable for site use
- No need to prepare a standard solution
- Simple, straightforward test procedure
- Gives dependable measurements that are easily interpreted
- Includes stable-coloured, glass standards for long-term use

The Lovibond AF347 kit employs a test method for organic impurities in fine aggregate, conforming to the alternative procedure specified in ASTM C 40. Organic impurities, usually in the form of tannic acid and its derivatives are typically present in fine aggregates such as sand. These may interfere with the chemical reactions of hydration and may affect the strength of the cement, mortar or concrete where the aggregate is being used. The results given by the kit are designed to serve as a warning that unacceptable levels of organic impurities may be present.

3.0% Sodium Hydroxide Solution

Two procedures one uses a standard color solution and the other uses a glass color standard, if color is darker possible further testing may be necessary

Aggregate Silt Test

- Check for silt or clay
- Mason jar test is not official test, but only an indication of how much fine material is present
- Check ASTM C33 for amount and type of allowable fine material
- Use a “Mason jar”

Aggregate Durability - Soundness

- Needed to resist breakdown or disintegration when subjected to wetting/drying and/or freezing/thawing

Aggregate Durability - Soundness

- Resistance to weathering action
- Standard Test
  - ASTM C 88, Sodium or Magnesium Sulfate Soundness
  - Intended to simulate wet/dry and freezing/thawing conditions
- Reproducibility of results is sometimes difficult

Aggregate Durability - Soundness

- Test consists of 5 cycles of soaking in sulfate solution followed by drying. After the 5 cycles any breakdown of the aggregate is removed and the loss in weight calculated.
- This value is reported as the “Soundness Loss”
- Typical Specification Limits are between 8-18% depending on which salt is used
- Magnesium salt gives higher losses than Sodium

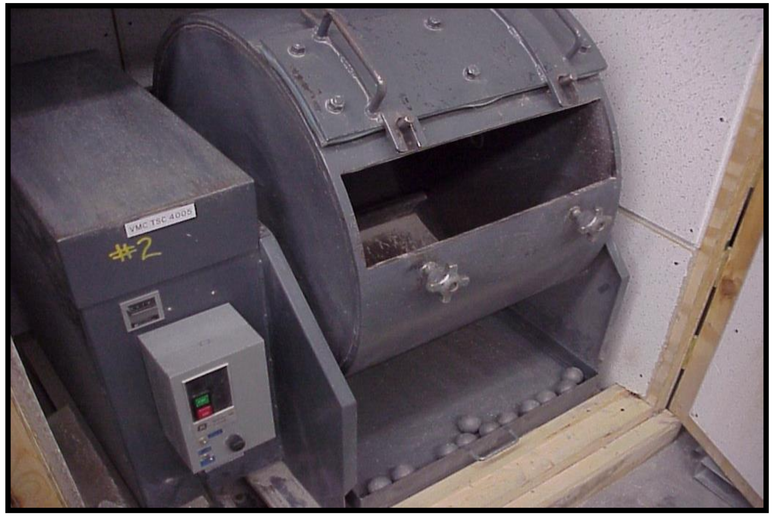
Aggregate Durability – Toughness/Abrasion Resistance

- Needed to resist crushing, degradation, and disintegration during stockpiling, mix production, construction, and traffic

Aggregate Durability – Toughness/Abrasion Resistance

- L.A. Abrasion Test
  - To evaluate the aggregate's resistance to degradation during processing, mixing, placing, and later while in service
- Standard Test Methods
  - ASTM C 131 (aggregates < 1-1/2")
  - ASTM C 535 (larger aggregates)

- ASTM C33 50% maximum loss



$$Loss = \frac{W_{initial} - W_{final}}{W_{initial}} \times 100$$

Aggregate Specifications

ASTM C33 - Size and Gradation

Always read the Materials section of an ASTM

6. **Materials**

6.1 The aggregate shall be so sized, graded, proportioned, and mixed with such proportions of Portland cement, blended hydraulic cement, or Portland cement and supplementary cementing materials, or admixtures, if used, or a combination thereof, and water to produce a homogenous concrete mixture of such quality that the pipe will conform to the test and design requirements of the specification. In no case, however, shall the proportion of Portland cement, blended hydraulic cement, or a

6.2.5.2 Portland blast furnace slag cement only,

6.2.5.3 Slag modified portland cement only,

6.2.5.4 Portland pozzolan cement only,

6.2.5.5 Hydraulic cement conforming to Specification C 1157,

6.2.5.6 A combination of portland cement or hydraulic cement and ground granulated blast-furnace slag, or

6.2.5.7 A combination of portland cement or hydraulic cement and fly ash.

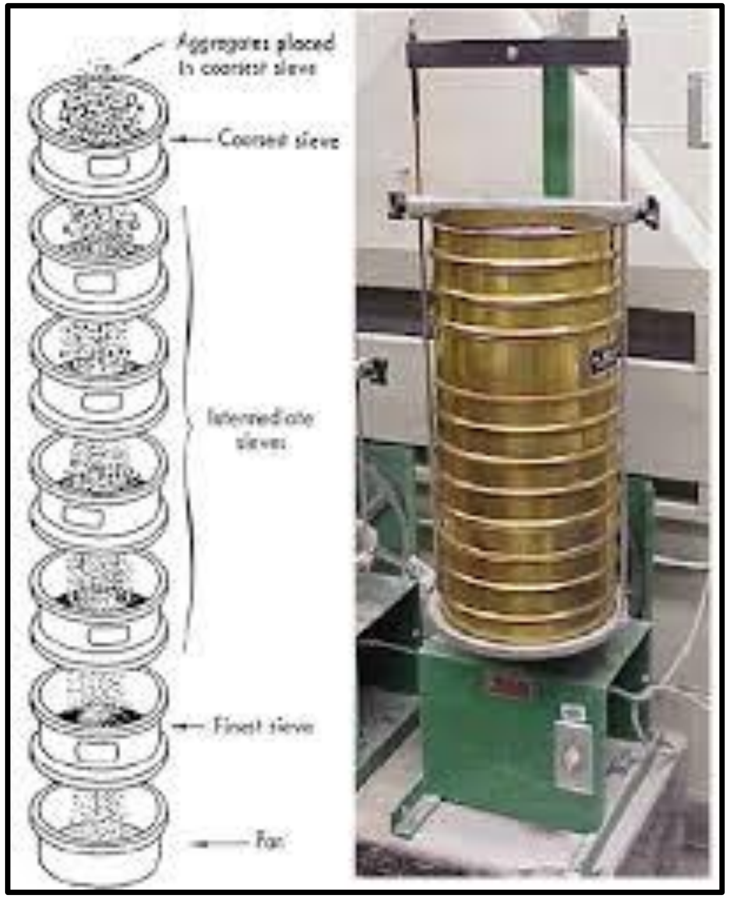
6.3 *Aggregates*—Aggregates shall conform to Specification C 33 except that the requirement for gradation shall not apply.

Coarse Aggregate Size

- Maximum Size:
  - The smallest sieve opening through which the entire amount of aggregate is required to pass
- Nominal Maximum Size:
  - The smallest sieve opening through which the entire amount of aggregate is permitted to pass
- Example: ASTM C33 requires that 100% of a #57 coarse aggregate MUST pass the 1.5” sieve but 95 - 100% MAY pass the 1” sieve, therefore #57 aggregate is considered to have a Maximum size of 1.5” and an Nominal Maximum size of 1”

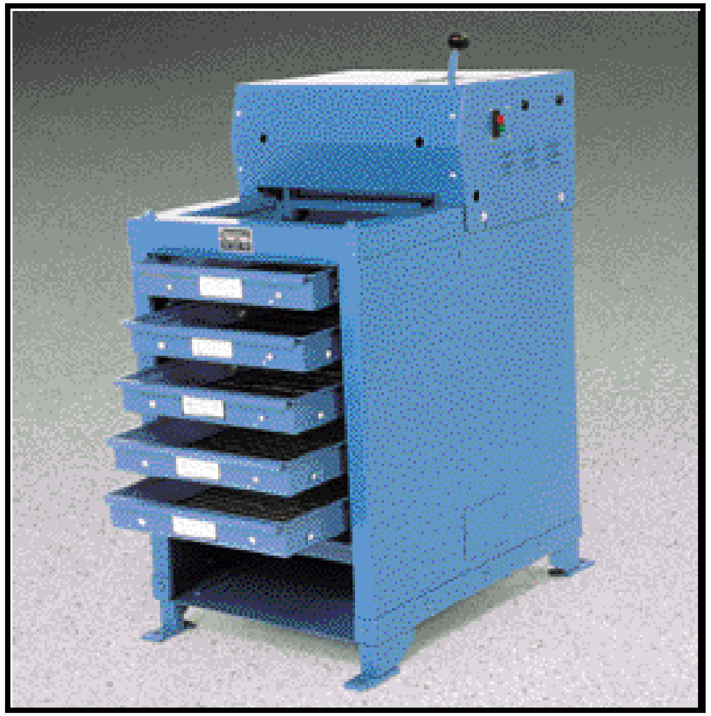
Aggregate Gradation

- Also known as “sieve analysis”
- It is the distribution of particle sizes
- “Well-graded” aggregates:
  - particles evenly distributed among sieve sizes
  - require less cement and water than “poorly graded” aggregates
- Careful choice of aggregates provides for optimization of cement, water and admixtures

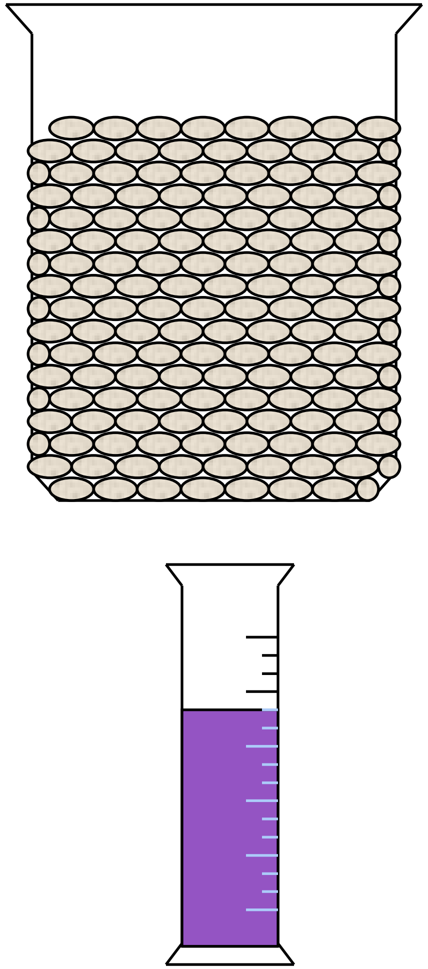


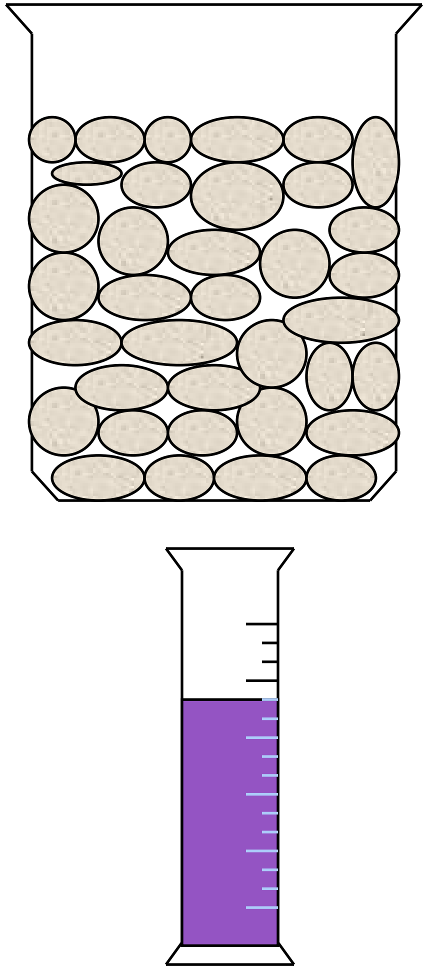
Standard Sieve Sizes

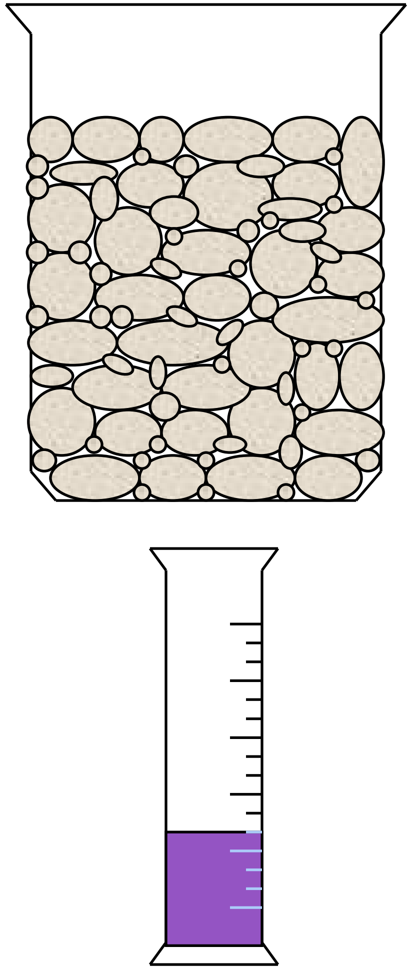
Sieve Size	Metric Size	International
1-1/2”	38 mm	37.5 mm
1”	25 mm	---
3/4”	20 mm	19 mm
1/2”	12.5 mm	---
3/8”	10 mm	9.5 mm
#4	4.75 mm	4.75 mm
#8	2.50 mm	2.36 mm
#16	1.12 mm	1.18 mm
#30	0.6 mm	0.6 mm
#50	0.3 mm	0.3 mm
#100	0.15 mm	0.15 mm
#200	0.075 mm	0.075 mm



Not used in FM Calculation


Sand


Stone


Well Graded Blend

Aggregate Gradation Affects:

- Workability
- Pumpability
- Economy
- Porosity
- Shrinkage
- Durability

Fineness Modulus (FM)

- A single number system used to express the fineness or coarseness of an aggregate
- Sum of cumulative % retained on the standard sieves
- Certain sieves are NOT counted (1/2” & pan even if used)

ASTM C 33 Grading for Fine Agg

Sieve	Percent Passing
3/8 in	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	5-30
No. 100	0-10

Fineness Modulus (FM)

- Per ASTM C33, FM of fine aggregate should be between 2.3 and 3.1
- Higher FM values indicate coarser grading
- Lower FM values indicate finer grading
- FM of coarse aggregate can also be calculated and can aid in blending coarse and medium size materials

CONSISTENCY IS THE KEY!

Fine Material passing the No. 200 Sieve

- Very fine material such as silt, clay, or dust of fracture can increase the water demand in concrete
- Fines limit is 3% in ASTM C 33 for concrete subject to abrasion
- Manufactured sands 5% and 7%
- Coarse aggregate limit is 1% (1.5% for crushed stone)

Gradation and Fineness Modulus - Example

Dry Sample Wt.			**g**		
Sample:					
		Retained			
Sieve Size, (mm)	**Sieve Size, (US)**	**Mass, (g)**			
150	**1 1/2"**				
75	**1"**				
37.5	**3/4"**				
19	**1/2"**				
9.5	**3/8**				
4.75	**# 4**				
2.36	**# 8**				
1.18	**#16**				
0.6	**# 30**				
0.3	**# 50**				
0.15	**# 100**				
Pan	**Pan**				
Total					
Sieve Loss Check					

Gradation and Fineness Modulus - Example

Dry Sample Wt.		1267	**g**			
Sample:						
		Retained				
Sieve Size, (mm)	**Sieve Size, (US)**	**Mass, (g)**				
150	**1 1/2"**	0				
75	**1"**	0				
37.5	**3/4"**	0				
19	**1/2"**	0				
9.5	**3/8**	0				
4.75	**# 4**	25				
2.36	**# 8**	163				
1.18	**#16**	228				
0.6	**# 30**	278				
0.3	**# 50**	355				
0.15	**# 100**	177				
Pan	**Pan**	38				
Total		1264				
Sieve Loss Check		0.24%				

ASTM 136
If the amounts differ by more than 0.3%,based on the original dry sample mass, results should not be used.
(1267-1264) / 1267 x 100 = 0.24%

Gradation and Fineness Modulus - Example

Dry Sample Wt.		1267	g		
Sample:					
		Retained			
Sieve Size, (mm)	**Sieve Size, (US)**	**Mass, (g)**	**Ind. % Retained**		
150	**1 1/2"**	0	0		
75	**1"**	0	0		
37.5	**3/4"**	0	0		
19	**1/2"**	0	0		
9.5	**3/8**	0	0		
4.75	**# 4**	25	2.0		
2.36	**# 8**	163	12.9		
1.18	**#16**	228	18.0		
0.6	**# 30**	278	22.0		
0.3	**# 50**	355	28.1		
0.15	**# 100**	177	14.0		
Pan	**Pan**	38	3.0		
Total		1264	100		
Sieve Loss Check		0.24%			

Use original dry mass

(25 / 1267) x 100 = 2.0

(163 / 1267) x 100 = 12.9

Gradation and Fineness Modulus - Example

Dry Sample Wt.		1267	g		
Sample:					
		Retained			
Sieve Size, (mm)	**Sieve Size, (US)**	**Mass, (g)**	**Ind. % Retained**	**Cum % Retained**	
150	**1 1/2"**	0	0	0	
75	1"	0	0	0	
37.5	**3/4"**	0	0	0	
19	1/2"	0	0	0	
9.5	**3/8**	0	0	0	
4.75	**# 4**	25	2.0	2.0	
2.36	**# 8**	163	12.9	14.9	
1.18	**#16**	228	18.0	32.9	
0.6	**# 30**	278	22.0	54.9	
0.3	**# 50**	355	28.1	83.0	
0.15	**# 100**	177	14.0	97.0	
Pan	**Pan**	38	3.0		
Total		1264	100	2.85 FM	
Sieve Loss Check		0.24%			

1/2" sieve NOT used to calculate FM

Never include the Pan when calculating the FM

∑ Cum% retained/100

Gradation and Fineness Modulus - Example

Dry Sample Wt.		1267	g		
Sample:					
		Retained			
Sieve Size, (mm)	**Sieve Size, (US)**	**Mass, (g)**	**Ind. % Retained**	**Cum % Retained**	**% Passing**
150	**1 1/2"**	0	0	0	100
75	1"	0	0	0	100
37.5	**3/4"**	0	0	0	100
19	1/2"	0	0	0	100
9.5	**3/8**	0	0	0	100
4.75	**# 4**	25	2.0	2.0	98.0
2.36	**# 8**	163	12.9	14.9	85.1
1.18	**#16**	228	18.0	32.9	67.1
0.6	**# 30**	278	22.0	54.9	45.1
0.3	**# 50**	355	28.1	83.0	17.0
0.15	**# 100**	177	14.0	97.0	3.0
Pan	**Pan**	38	3.0		
Total		1264	100	2.85 FM	
Sieve Loss Check		0.24%			

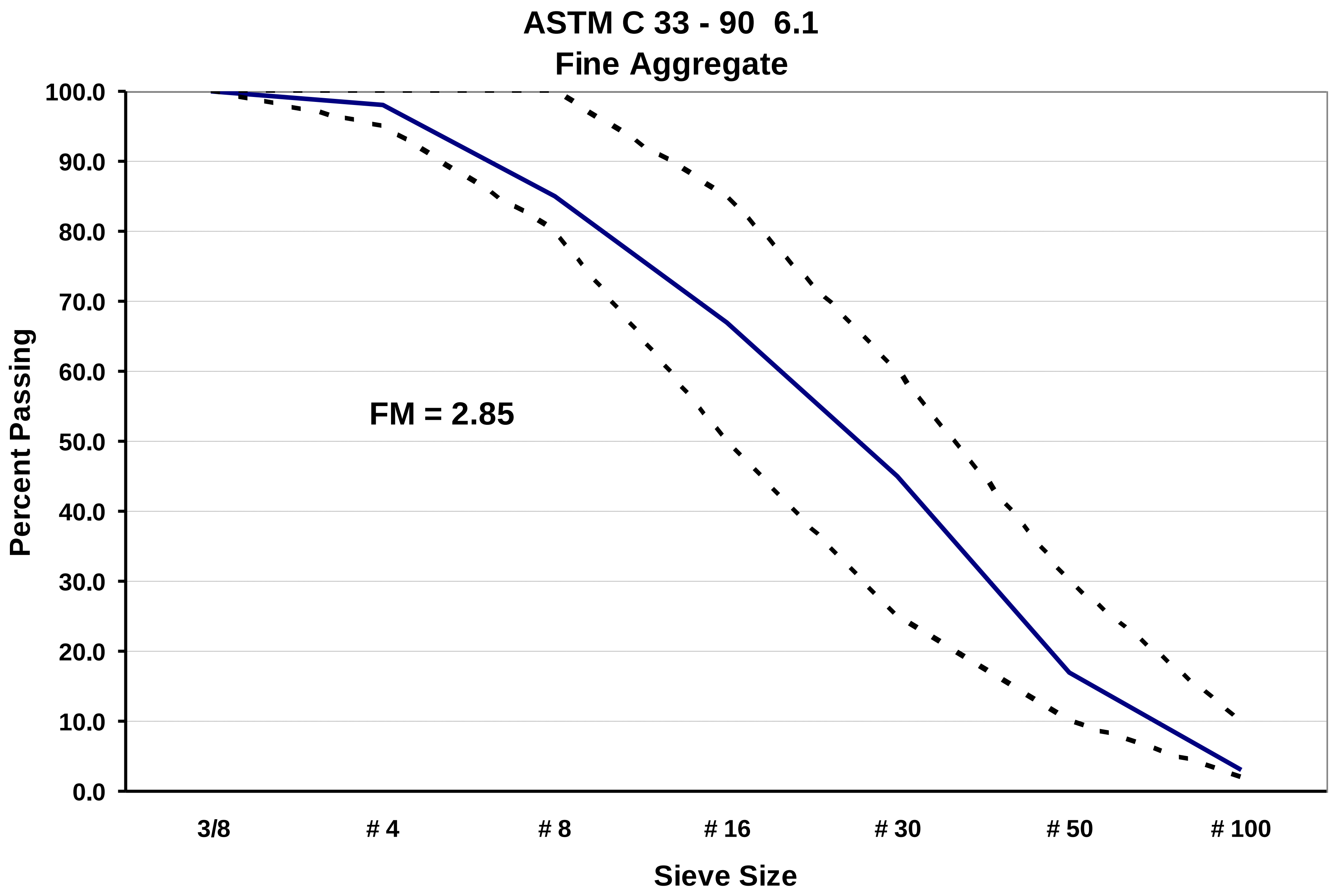
100 - 2 = 98

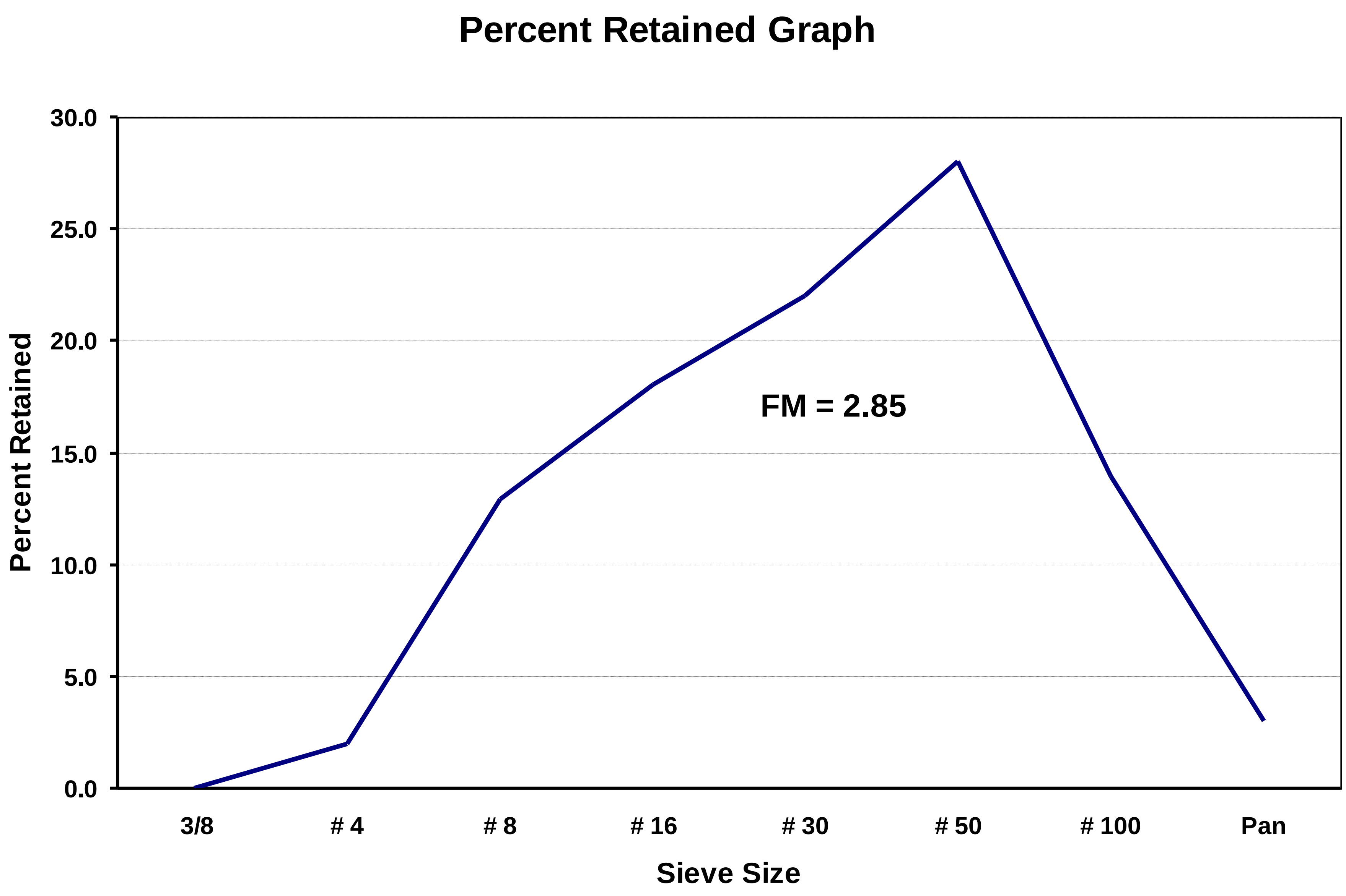
100 - 14.9 = 85.1

Gradation and Fineness Modulus - Example

Can you use this SAND to manufacture Pipe under C76?

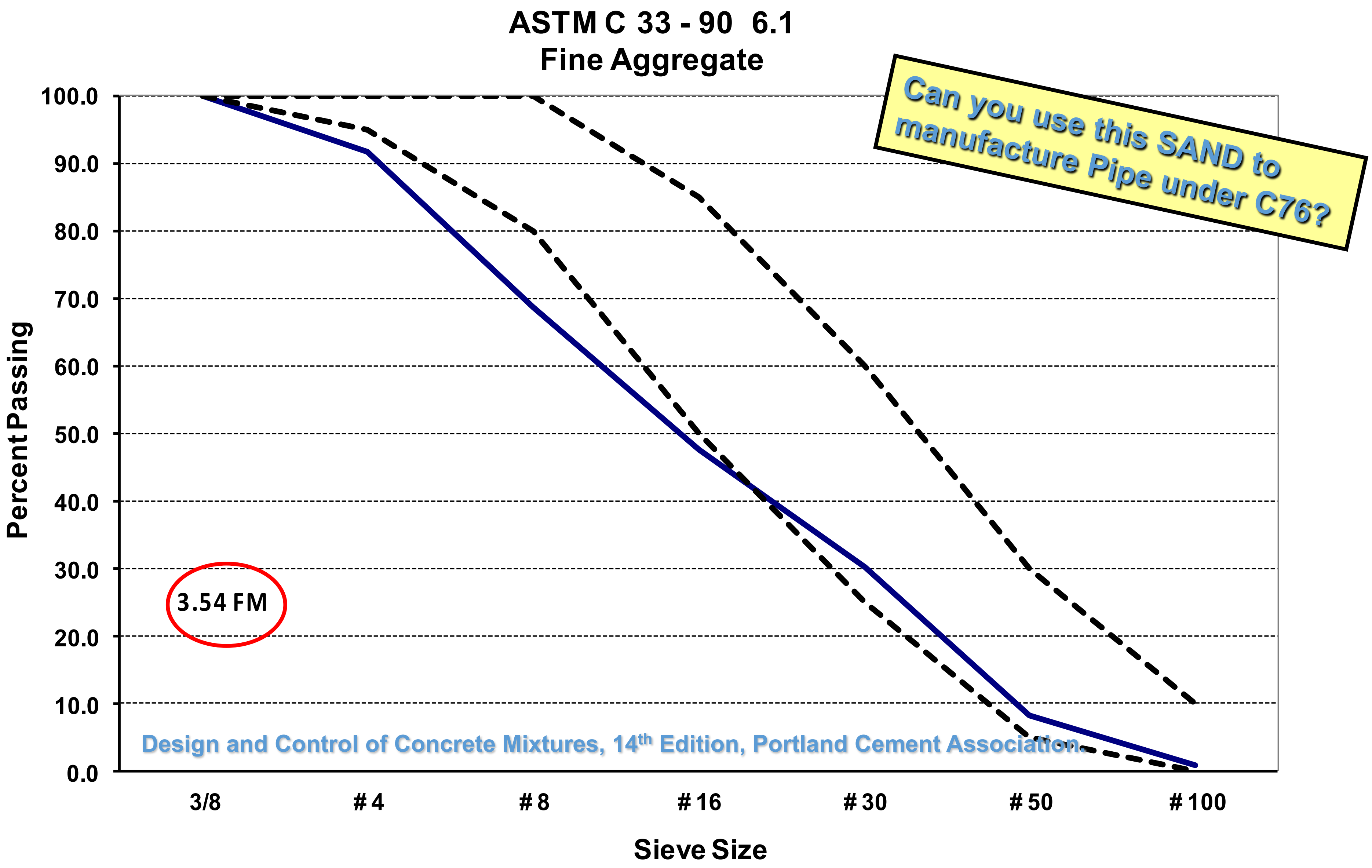
Dry Sample Wt.		1267	g				
Sample:							
		Retained					
Sieve Size, (mm)	**Sieve Size, (US)**	**Mass, (g)**	**Ind. % Retained**	**Cum % Retained**	**% Passing**	**ASTM C33 6.1 Fine Aggregate**	
						Min	**Max**
150	**1 1/2"**	0	0	0	100	100	100
75	**1"**	0	0	0	100	100	100
37.5	**3/4"**	0	0	0	100	100	100
19	**1/2"**	0	0	0	100	100	100
9.5	**3/8**	0	0	0	100	100	100
4.75	**# 4**	25	2.0	2.0	98.0	95	100
2.36	**# 8**	163	12.9	14.9	85.1	80	100
1.18	**#16**	228	18.0	32.9	67.1	50	85
0.6	**# 30**	278	22.0	54.9	45.1	25	60
0.3	**# 50**	355	28.1	83.0	17.0	5	30
0.15	**# 100**	177	14.0	97.0	3.0	0	10
Pan	**Pan**	38	3.0				
Total		1264	100	**2.85 FM**		**FM 2.3**	**FM 3.1**
Sieve Loss Check		0.24%					


ASTM C 33 - 90 6.1
Fine Aggregate
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Percent Passing
FM = 2.85
3/8
4
8
16
30
50
100
Sieve Size


Percent Retained Graph
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Percent Retained
FM = 2.85
3/8
4
8
16
30
50
100
Pan
Sieve Size

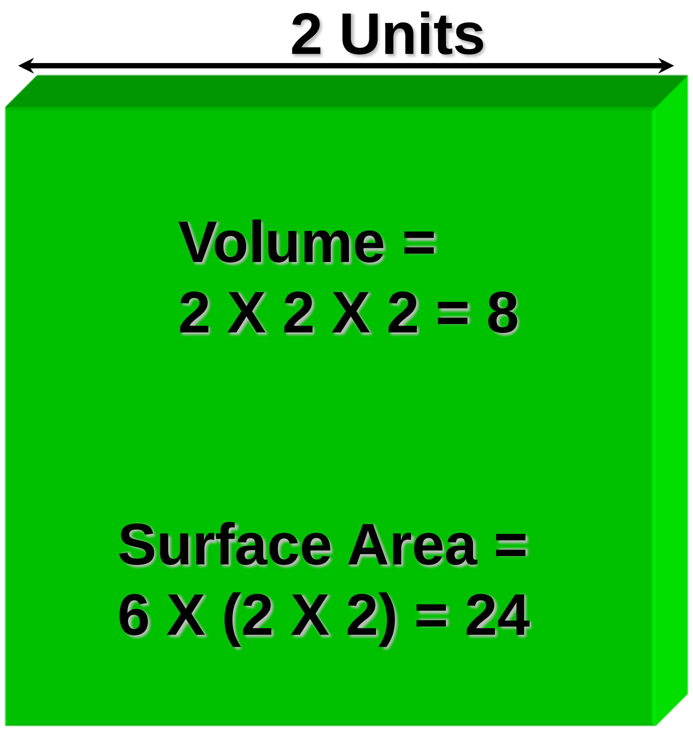
Gradation and High Fineness Modulus - Example

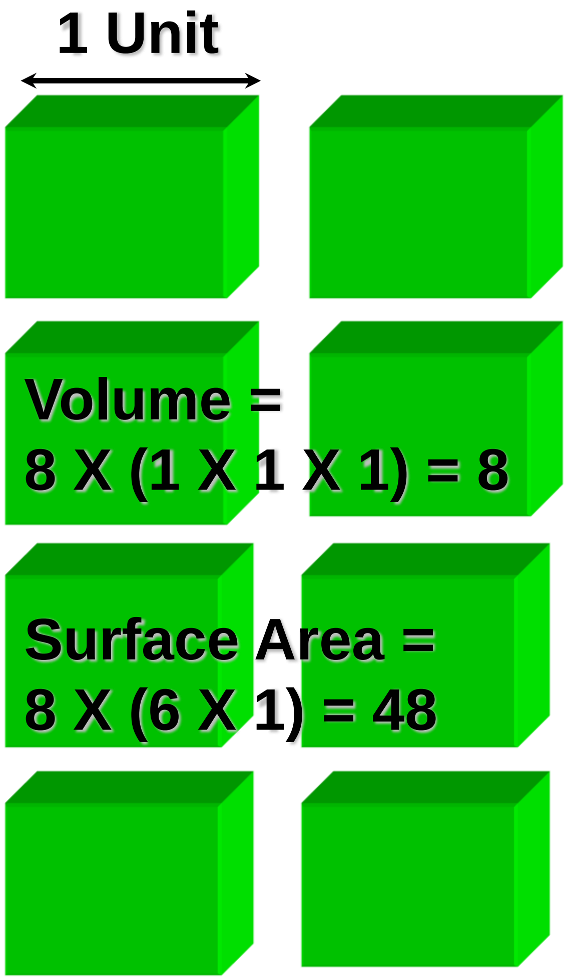
Dry Sample Wt.		1091	g				
Sample:							
		Retained					
Sieve Size, (mm)	**Sieve Size, (US)**	**Mass, (g)**	**Ind. % Retained**	**Cum % Retained**	**% Passing**	**ASTM C33 6.1 Fine Aggregate**	
						Min	**Max**
150	**1 1/2"**	0	0	0	100	100	100
75	**1"**	0	0	0	100	100	100
37.5	**3/4"**	0	0	0	100	100	100
19	**1/2"**	0	0	0	100	100	100
9.5	**3/8**	0	0	0	100	100	100
4.75	**# 4**	90	8.3	8.3	91.7	95	100
2.36	**# 8**	251	23.1	31.4	68.6	80	100
1.18	**#16**	230	21.1	52.5	47.5	50	85
0.6	**# 30**	190	17.5	70.0	30	25	60
0.3	**# 50**	240	22.1	92.1	7.9	5	30
0.15	**# 100**	77	7.1	99.2	0.8	0	10
Pan	**Pan**	10	0.9				
Total		1088	100	3.54		**FM 2.3**	**FM 3.1**
Sieve Loss Check		0.275%					


ASTM C 33 - 90 6.1
Fine Aggregate
Can you use this SAND to manufacture Pipe under C76?
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Percent Passing
3.54 FM
Design and Control of Concrete Mixtures, 14th Edition, Portland Cement Association.
3/8
4
8
16
30
50
100
Sieve Size

Fine Aggregates: Greatest affect on water demand

Fine aggregates can have 40 times more surface area than coarse aggregates of same weight and volume





Small boxes have equal volume,
but twice the surface area.

Aggregates critical to water demand

- Aggregates take up the largest amount of volume in concrete
- Aggregate particle size, distribution, shape, and texture affect the amount of water needed in concrete
- Therefore, more than any other material, aggregates have the greatest affect on the water needed for a given concrete workability

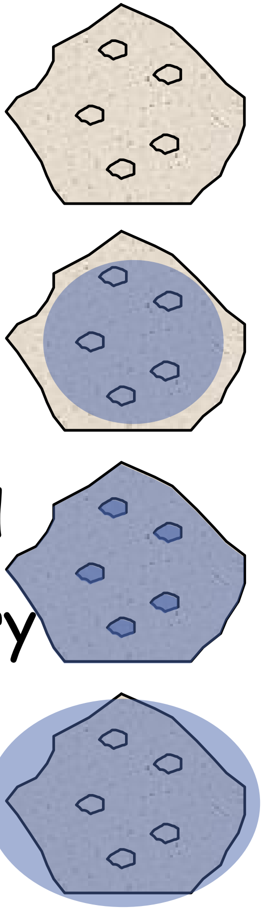
Absorption and moisture content

Bone Dry
or
Oven Dry

Air Dry

Saturated
and
Surface Dry

Moist



Absorbed moisture (absorption)

SSD (ideal)

Free moisture (moisture content)

add water

Total water content

subtract water

Absorption

- Aggregate particles are not solid...they contain pores that absorb water
- Concrete mixes are designed based on aggregates being in the saturated surface-dry (SSD) condition
- Aggregate in the SSD condition is in a state of equilibrium...it will neither absorb water from nor give up water to a concrete mix
- In reality, this state is not achievable in production concrete

Aggregate Moisture Calculations

Total Moisture = Free moisture + Aggregate absorbed moisture

% Total Moisture Content = $\frac{\text{(Wet Wt - Dry Wt)}}{\text{Dry Wt}}$ X 100

Example:
Wet Wt = 1000 g
Dry Wt = 980 g

$\frac{1000 - 980}{980}$ X 100 = 2.04%

Never include the weight of the pan!

%Free Moisture = Total Moisture - Absorbed Moisture

How do we measure moisture in aggregates

- Cook out method — **Total moisture**
  - Stove top or microwave
- Chapman Flask
- "Speedy" moisture meter

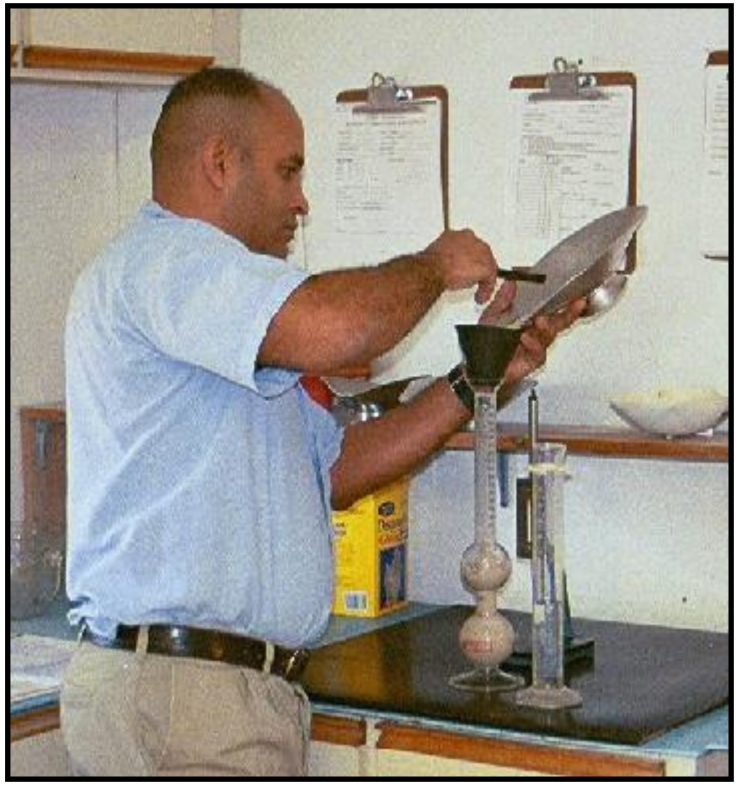
(Chapman Flask and "Speedy" moisture meter) — **Free water**

- Moisture Probes — **Total or free moisture**

Total Moisture = Free moisture + Aggregate absorbed moisture

Chapman Flask Method

- Fill Chapman flask to 200 ml mark with water
- 500.0 gram sample of damp aggregate
- Add aggregate sample to flask
- Agitate flask with sample to remove entrapped air
- obtain reading from flask
- Using SSD specific gravity of sand look up free moisture on chart



CHAPMAN FLASK - MOISTURE DETERMINATION

Total Vol.	Specific gravity of SSD Sand										
	2.50	2.52	2.54	2.56	2.58	2.60	2.62	2.64	2.66	2.68	2.70
385	-	-	-	-	-	-	-	-	-	-	0.0
386	-	-	-	-	-	-	-	-	-	-	0.3
387	-	-	-	-	-	-	-	-	-	0.0	0.6
388	-	-	-	-	-	-	-	-	0.0	0.3	1.0
389	-	-	-	-	-	-	-	0.0	0.3	0.6	1.3
390	-	-	-	-	-	-	-	0.3	0.6	1.0	1.7
391	-	-	-	-	-	-	0.0	0.6	1.0	1.3	2.0
392	-	-	-	-	-	0.0	0.3	1.0	1.3	1.7	2.3
393	-	-	-	-	-	0.3	0.6	1.3	1.7	2.0	2.7
394	-	-	-	-	0.0	0.6	1.0	1.7	2.0	2.3	3.0
395	-	-	-	0.0	0.3	1.0	1.3	2.0	2.3	2.7	3.3
396	-	-	-	0.3	0.6	1.3	1.7	2.3	2.7	3.0	3.7
397	-	-	0.0	0.6	1.0	1.7	2.0	2.7	3.0	3.3	4.0
398	-	0.0	0.3	1.0	1.3	2.0	2.3	3.0	3.3	3.7	4.3
399	-	0.3	0.6	1.3	1.7	2.3	2.7	3.3	3.7	4.0	4.7
400	0.0	0.6	1.0	1.7	2.0	2.7	3.0	3.7	4.0	4.3	5.0
401	0.3	1.0	1.3	2.0	2.3	3.0	3.3	4.0	4.3	4.7	5.3
402	0.6	1.3	1.6	2.3	2.7	3.3	3.7	4.3	4.7	5.0	5.7
403	1.0	1.6	2.0	2.7	3.0	3.7	4.0	4.7	5.0	5.3	6.0
404	1.3	2.0	2.3	3.0	3.3	4.0	4.3	5.0	5.3	5.7	6.5
405	1.6	2.3	2.7	3.3	3.7	4.3	4.7	5.3	5.7	6.0	7.0
406	2.0	2.7	3.0	3.7	4.0	4.7	5.0	5.7	6.0	6.5	7.3
407	2.3	3.0	3.3	4.0	4.3	5.0	5.3	6.0	6.5	7.0	7.7
408	2.7	3.3	3.7	4.3	4.7	5.3	5.7	6.5	7.0	7.3	8.0
409	3.0	3.7	4.0	4.7	5.0	5.7	6.0	7.0	7.3	7.7	8.3

Moisture Probes

- Used in batching
- Installed per manufactures recommendations
- Must be calibrated
- There is a difference between a mixer probe and a bin probe
  - Mixer probe measures the moisture of the material in your mixer and controls the water to optimize the moisture
  - Bin probes measure the moisture of fine aggregates and crushed stone in bin

Moisture Compensation Example

Concrete Mix designs are most often based on SSD conditions for the aggregates, these conditions seldom exist in reality. A mix design containing 1400 pounds of sand with a free moisture of 5% will carry 70 pounds of addition water in to the mix. This water must be adjusted out of the design water

Mix design calls for:
Sand (SSD) 1400 lb.
Water 300 lb.

Design Weights

Batch Weights

SAND:
1400 lb X 5% (free) = 70.00 pounds of water
Batch out (1400 + 70) = 1470

WATER:
300 - 70 = 230 net water

!

All aggregates must be adjusted

Materials	Pounds of Material	S.G.	Abs Volume	SSD	Moisture Adjustment	Batch Weight
Cement	400	3.15	2.04	400		400
Type F Ash	100	2.48	0.65	100		100
Miller Stone	1873	2.85	10.53	1873	37	1910
Evert Sand	1247	2.62	7.63	1247	50	1297
Water	300	1.00	4.81	300	87	213
Air	5%		1.35	5%		
Total	3920		27.00			3920
Density	145.2					145.2

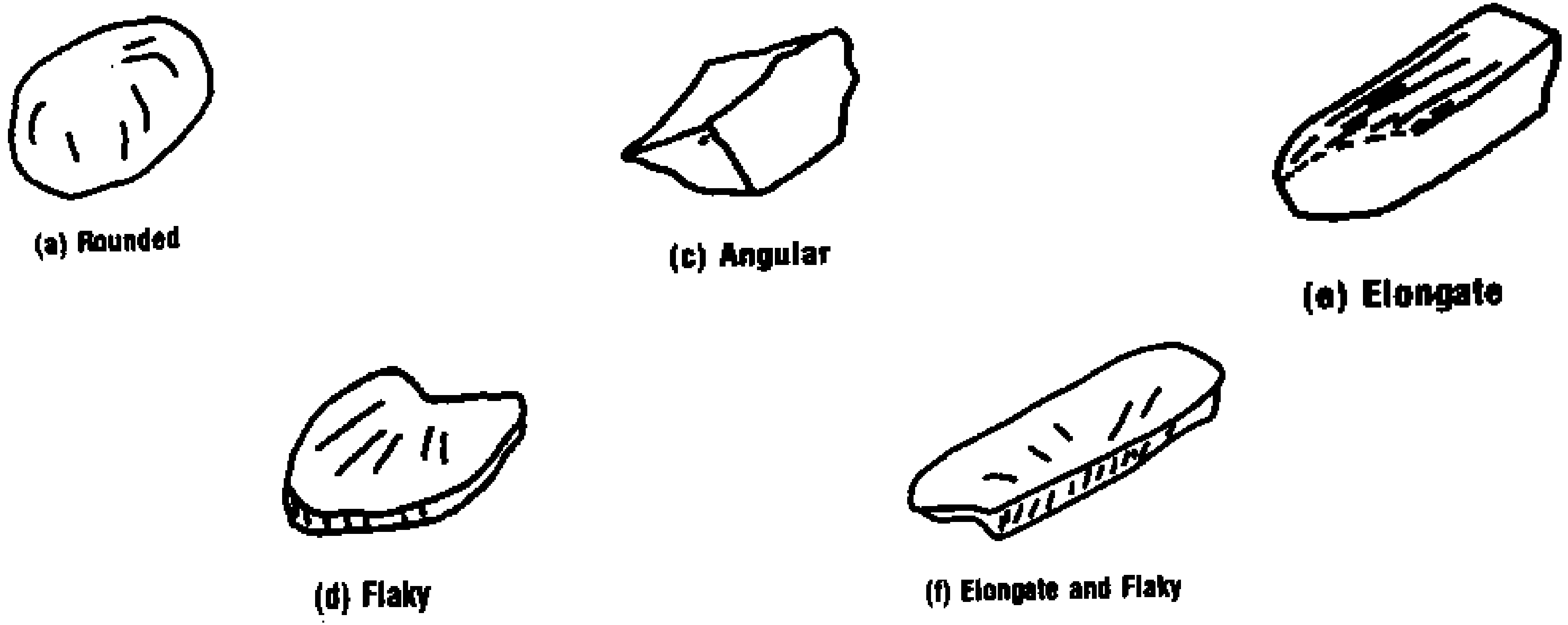
Materials	Total Moisture %	Absorption %	Free %	Moisture Adjustment
Miller Stone	3.00	1.00	2.00	37
Evert Sand	5.50	1.50	4.00	50

<u>Total moisture</u> = Free moisture + Aggregate absorption

Aggregate Texture and Shape

- Affect the properties of fresh concrete:
  - rough textured, angular, elongated particles have greater surface area and require more cement paste than do smooth rounded particles
  - angular and poorly graded aggregates are harder to finish
- Generally:
  - rounded gravel makes stronger and more finishable lean mixes
  - angular crushed stone is better suited for high strength, richer cement paste mixes

Aggregate Texture and Shape



Review – Concrete Properties Influenced by Aggregates

- **Strength**
  - Mineralogy
  - Compressive or Flexural strength
  - Surface texture and cleanliness
  - Particle shape, max size, and gradation
  - Compatibility
- **Finishability**
  - In general, the more rounded (especially in sand) the particle shape = better finishability
- **Water Requirements**
  - Grading, particle shape, mineralogy, and absorption

Review – Concrete Properties Influenced by Aggregates

- **Workability**
  - Gradation
    - Particle size and distribution
    - Affects economy of mix design
    - Should be graded up to the largest size practical for job conditions
    - Affects workability and placeability
  - Nature of particles
    - Shape, porosity, surface texture

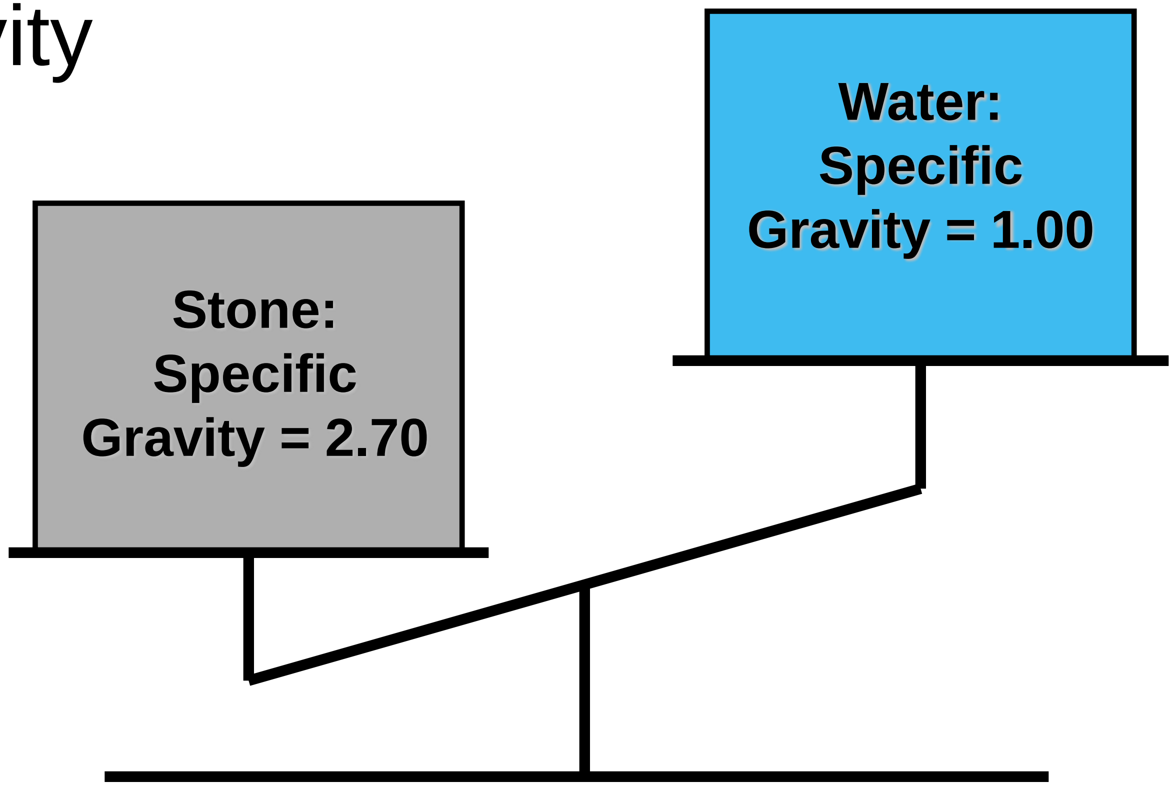
Review – Concrete Properties Influenced by Aggregates

- **Durability**
  - Freeze-thaw resistance, potential for cracking, abrasion, wet/dry, heat/cool, ASR
  - Air entrainment will not protect against concrete made with non-durable aggregates
- **Shrinkage**
  - Larger the volume fraction of aggregate, the lower the drying shrinkage of concrete
  - Use largest nominal max size of coarse aggregate to reduce potential of drying shrinkage

Review – Concrete Properties Influenced by Aggregates

- Coarse sand or under-sanded mixes:
  - hard to pump
  - hard to consolidate
  - bleed excessively
  - segregate
  - hard to get accurate slump
- Fine sand or over-sanded mixes:
  - increase water demand
  - sticky, hard to finish surface
  - reduced strength
  - blister
  - bugholes
  - scaling

Specific Gravity



Same Volume, but 2.70 Times More Mass

Specific Gravity

- The ratio of a material’s weight to the weight of an equal volume of water
- Also, the relative density of a material compared to water
- Bulk specific gravity (SSD)
  - Used to determine the “solid volume” (absolute volume) of a material going into concrete
- Ensures proper yield
- SG of normal weight aggregates vary from 2.40 to 2.80

Sampling Aggregate for testing

- Obtain truly representative sample
  - Critical to any standardized testing of concrete materials.
- Every time aggregate is moved, handled or stored they tend to segregate.
  - As particles tend to segregate (fines vs. coarse) samples obtained may not represent the pile

Collecting and Reducing Field Samples

- ASTM D75 Collecting Sample from Stockpile
- ASTM C702 Reducing Samples of Aggregate to Testing Size
- Sample Splitter Method
  - Each sample must be representative of total product (i.e., sampled correctly)
  - Sample Splitter
    - Must have equal width chutes
    - Must have two receptacles
  - Place sample in hopper
  - Distribute Evenly
  - Allow to Freely Flow
  - Repeat as many times as necessary.

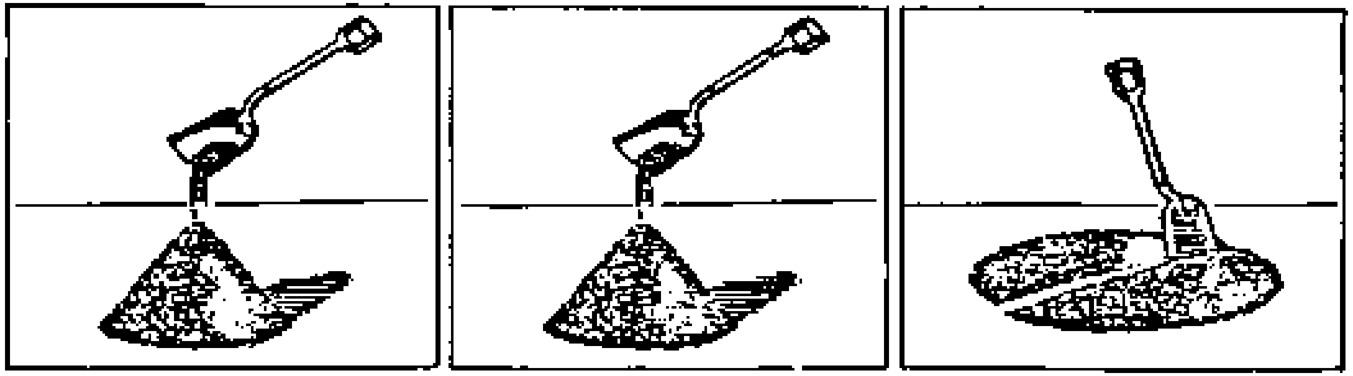
Reducing Field Samples

- Sample Splitter Method
  - Each sample must be representative of total product (i.e., sampled correctly)
  - Sample Splitter
    - Must have equal width chutes
    - Must have two receptacles
  - Place sample in hopper
  - Distribute Evenly
  - Allow to Freely Flow
  - Repeat as many times as necessary.

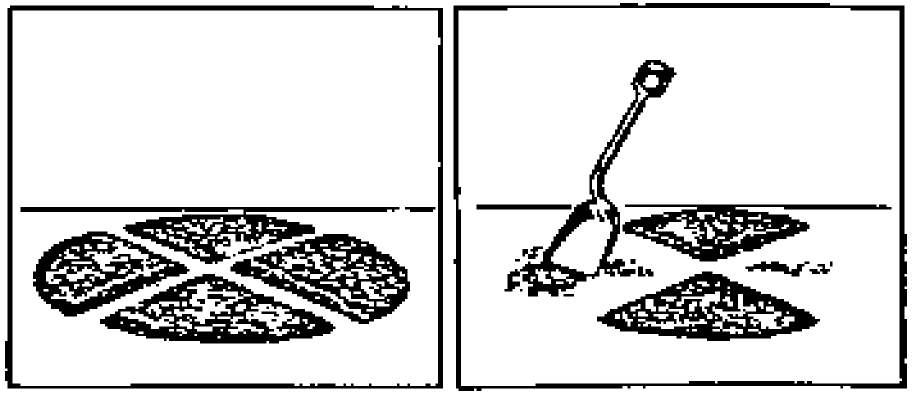
Reducing Field Samples

- Stockpile Method
  - Mix Sample
  - Place in Single Pile
  - Divide Into Equal Quarters
  - Collect Opposite Quarters

Reducing Field Samples



Cone sample on hard, clean surface — Mix by forming new cone — Quarter after flattening cone



Sample divided into quarters — Retain opposite corners, reject other two corners

Quartering on a Hard, Clean Surface

QC/QA Program

- Ensures aggregates are sampled and tested correctly
- Critical to obtain predictable and consistent concrete properties


Thank You