Aggregates for Use In Concrete

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Learning Objective

- Develop a basic understanding of aggregates and aggregate properties.

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Aggregates

- Fine
  - Consists of natural sand, manufactured sand or crushed stone
  - <3/8”
  - Fine aggregate will pass the # 4 sieve
- Coarse
  - Natural or crushed stone
  - 3/8” to 1 ½” (or more)
  - Coarse aggregate is larger than a #4 sieve

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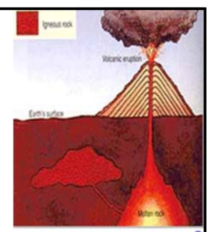
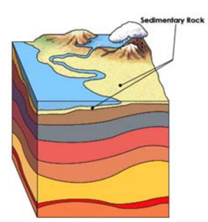
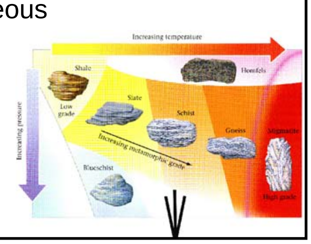
Mineralogy



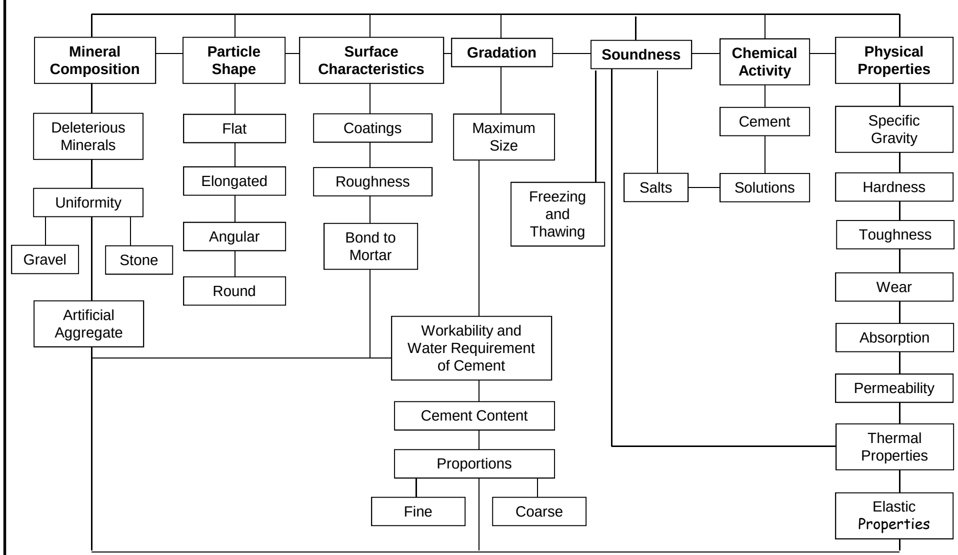
- Igneous (Latin - “Fire”)
  - Formed from volcanic processes and the heating and cooling of magma
    - Example: granite



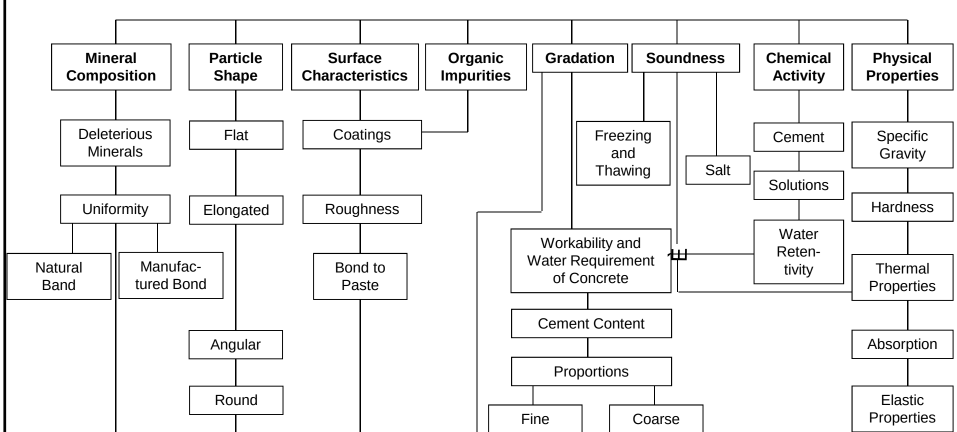
- Sedimentary (Latin - “Settling”)
  - Formed by the layering of sediments due to the action of wind or water
    - Example: sandstone
- Metamorphic (Greek - “Change”)
  - Result from long-term high temperature and pressure on igneous and sedimentary rocks
    - Example: marble



Coarse Aggregate



Fine Aggregate



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Aggregates

Important Properties

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

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Aggregate Specifications

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

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Designation: C 76 – 05

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

This standard is issued under the fixed designation C 76; 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 (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope

1.1 This specification covers reinforced concrete pipe intended to be used for the conveyance of sewage, industrial wastes, and storm water, and for the construction of culverts.

1.2 A complete metric companion to Specification C 76 has been developed—C 76M; therefore, no metric equivalents are presented in this specification. Reinforced concrete pipe that conform to the requirements of C 76 M, are acceptable under this Specification C 76 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 construction specifications. The owner of the reinforced concrete pipe specified herein is cautioned that he must correlate the field requirements with the class of pipe specified and provide inspection at the construction site.

NOTE 2—Attention is called to the specification for reinforced concrete D-load culvert, storm drain, and sewer pipe (Specification C 655).

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 33 Specification for Concrete Aggregates
C 76M Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
C 150 Specification for Portland Cement
C 309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
C 497 Test Methods for Concrete Pipe, Manhole Sections, or Tile
C 595 Specification for Blended Hydraulic Cements
C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
C 655 Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
C 822 Terminology Relating to Concrete Pipe and Related Products
C 989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
C 1116 Specification for Fiber-Reinforced Concrete and Shotcrete
C 1157 Performance Specification for Hydraulic Concrete

3. Terminology

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Aggregate Specifications

- ASTM C33 - Normal Weight Aggregates
  - Durability requirements

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Deleterious Substances C 33

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 %.

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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.**

Lignite is sometimes found in natural sand. The amount varies, depending on the quarry and the particular deposit. When sand containing lignite is used in making concrete, lignite particles near the surface can expand and cause the pop outs. Lignite is often referred to as brown coal, it is the lowest rank of coal quality.

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Organic Impurities C 40 (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.

What is the effect on Concrete if negative result?

3.0% Sodium Hydroxide Solution

Meets the following standards
ASTM C-40
AASHTO T-21

Larger Aggregate Test

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- 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 and FDOT Sections 901 and 902 for amount and type of allowable fine material.
- Use a "Mason jar"

Durability of Materials…Soundness ASTM C 88

Standard Test Method for
Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate[1]

1. Scope

1.1 This test method covers the testing of aggregates to estimate their soundness when subjected to weathering action in concrete or other applications. This is accomplished by repeated immersion in saturated solutions of sodium or magnesium sulfate followed by oven drying to partially or completely dehydrate the salt precipitated in permeable pore spaces. The internal expansive force, derived from the rehydration of the salt upon re-immersion, simulates the expansion of water on freezing. This test method furnishes information helpful in judging the soundness of aggregates when adequate information is not available from service records of the material exposed to actual weathering conditions.

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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

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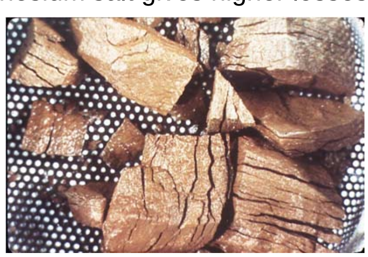
Soundness

- 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



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L.A. Abrasion Test

- Purpose
  - 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

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

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Aggregate Specifications

ASTM C33 - Normal Weight Aggregates

- Size and Gradation

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Always read 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

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

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.

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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”.

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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

Ro-Tap® Sieve Shakers

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Most Common Sieve Series

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

Aggregate Screen Shakers

Aggregate Size Effects:

- As the maximum size aggregate increases, the amount of paste needed for a given slump decreases.
- The maximum aggregate size used in a concrete mix is dictated by the size of the structural member and the spacing between reinforcing steel.

"Design & Control of Concrete Mixtures," 14th Edition, Portland Cement Association.

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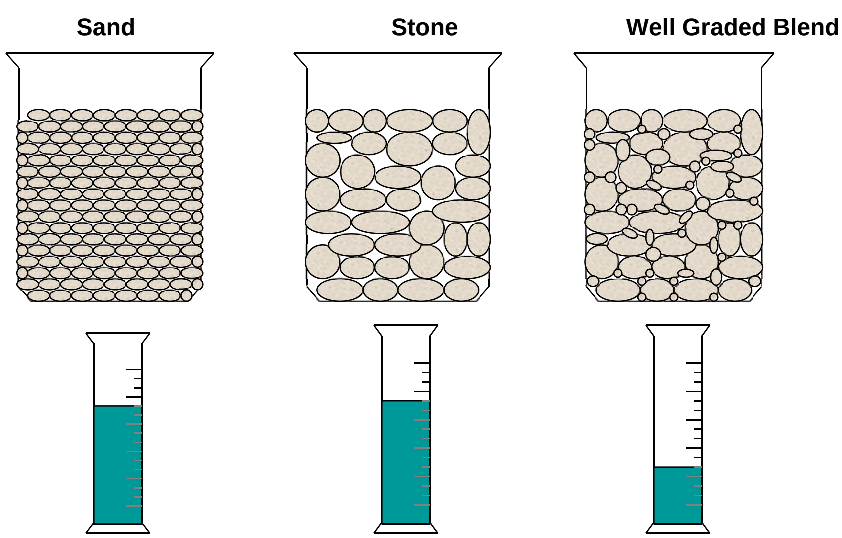
Graded Aggregate



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Gradation

- Distribution of particle sizes
- Grading is determined by ASTM C 136
- Well graded concrete aggregates will result in fewer voids between particles = less cement paste demand

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Aggregate Gradation Affects:

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

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Fineness Modulus (FM)

- A single number system used to express the fineness or coarseness of an aggregate
- Higher values indicate coarser grading
- Sum of cumulative % retained on the standard sieves
- Certain sieves are NOT counted (even if used)
- Can be helpful in calculating blends of two materials
- FM of coarse aggregate can also be calculated and can aid in blending coarse and medium size materials

FM & Gradation are NOT the SAME

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Fine Aggregate Gradation

- Fineness Modulus (FM) should be between 2.3 and 3.1
- FM is empirical # determined by dividing the sum of percent retained on a standard series of sieves by 100 (No. 4, 8, 16, 30, 50, 100)
- Coarser fine aggregate has a higher FM

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

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Percent 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)

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Gradation & Fineness Modulus:

Dry Sample Wt.			g		
Sample:					
		Retained			
Sieve Size, (mm)	Sieve Size, (US)	Mass, (g)	Ind. % Retained	Cum % Retained	% Passing
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					

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Gradation & Fineness Modulus:

Dry Sample Wt. 1267 g

Sample:

Sieve Size, (mm)	Sieve Size, (US)	Retained Mass, (g)	Ind. % Retained	Cum % Retained	% Passing
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%

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Gradation & Fineness Modulus:

Dry Sample Wt. 1267 g

Sample:

Use original dry mass

Sieve Size, (mm)	Sieve Size, (US)	Retained Mass, (g)	Ind. % Retained	Cum % Retained	% Passing
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%			

(25 / 1267) x 100 = 2.0

(163 / 1267) x 100 = 12.9

Gradation & Fineness Modulus:

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" & 1/2" sieve are NOT used to calculate FM

Never include the Pan when calculating the FM

∑ Cum% retained/100

Gradation & Fineness Modulus:

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

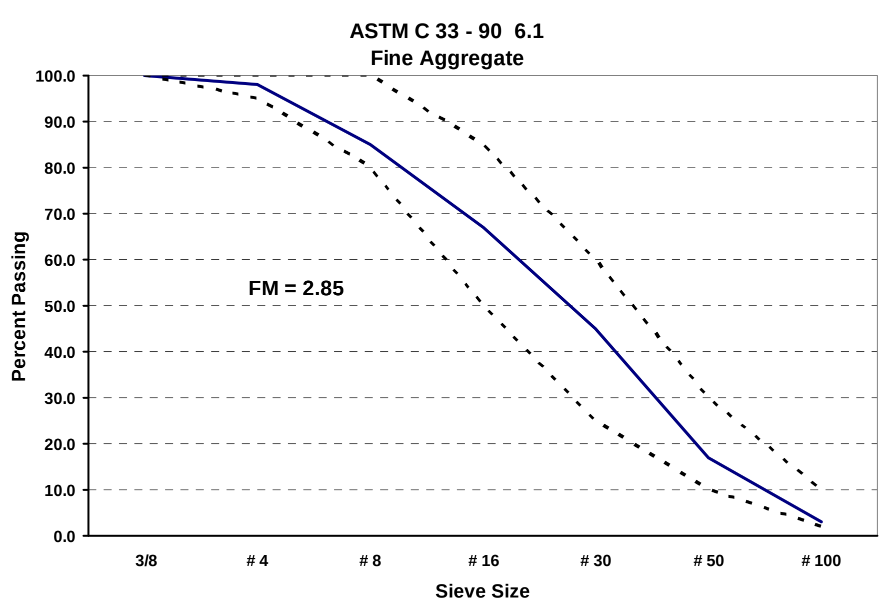
100 - 14.9 = 85.1

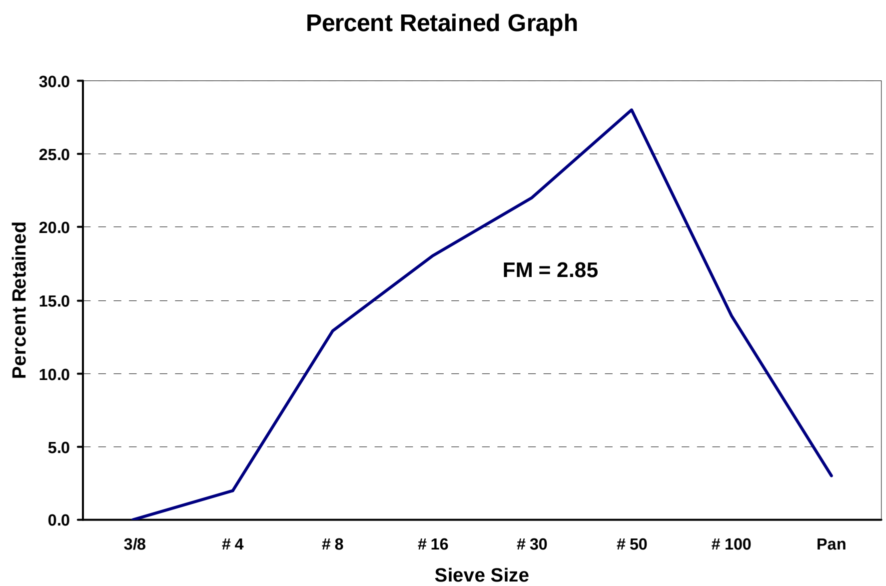
Gradation & Fineness Modulus:

Dry Sample Wt.	1267	g	
Sample:			

Can you use this SAND to manufacture Pipe under C76?

Sieve Size, (mm)	Sieve Size, (US)	Retained Mass, (g)	Ind. % Retained	Cum % Retained	% Passing	ASTM C33 6.1 Fine Aggregate Min	ASTM C33 6.1 Fine Aggregate 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%					



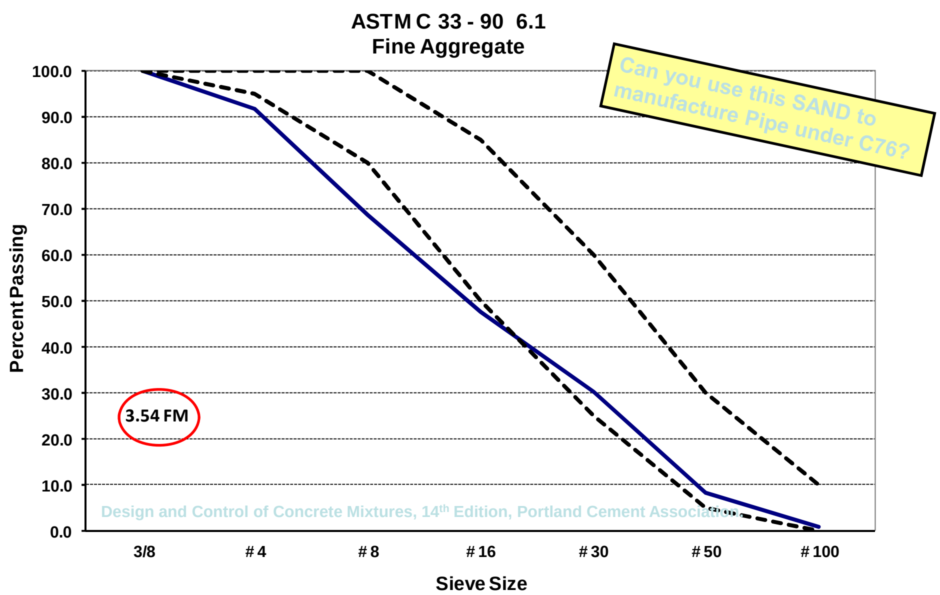


Gradation High Fineness Modulus:

Dry Sample Wt. 1091 g

Sample:

Sieve Size, (mm)	Sieve Size, (US)	Retained 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%					



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Fine Aggregates: Greatest Affect on Water Demand

Fine aggregates have between 25 and 40 times more surface area than coarse aggregates of same weight and volume.

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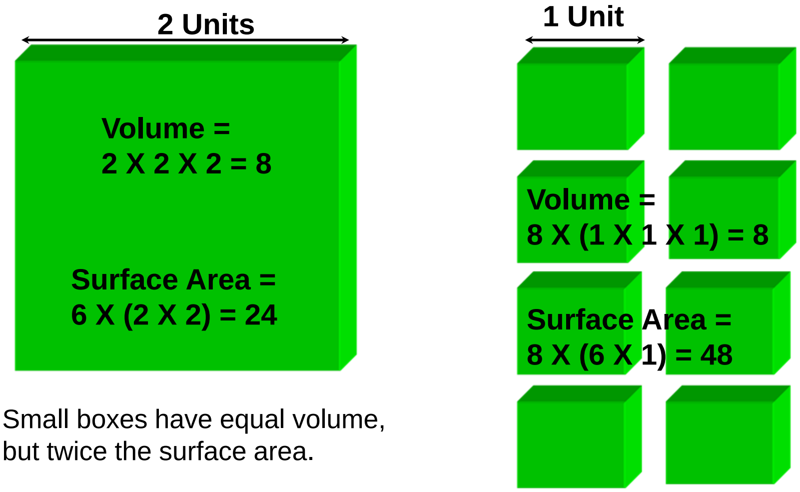
Why Aggregates Affect Water Demand



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

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Aggregates Critical to the 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.

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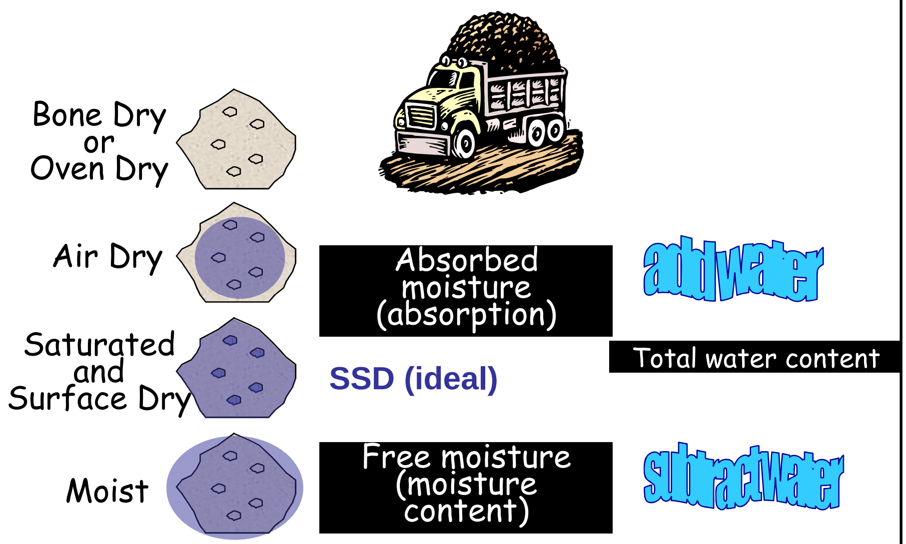
Absorption and Moisture Content



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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.

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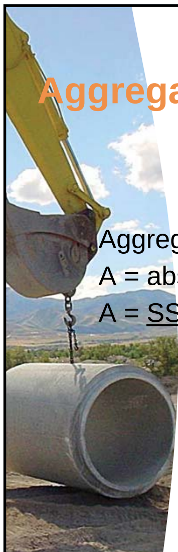

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Aggregate Absorption * Aggregate Total Moisture

Aggregate absorption
A = absorption of an aggregate
A = SSD Wt – Dry Wt X100%
Dry Wt

Aggregate total moisture
MC = Moisture content
MC = Wet Wt – Dry Wt x 100%
Dry Wt

Wet Wt is the field weight of the aggregate with moisture

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Aggregate Moisture

Total Moisture = Free moisture + Aggregate absorbed moisture

% Total Moisture Content = (Wet Wt - Dry Wt) X 100
Dry Wt

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

1000 - 980 X 100 = 2.4%
980

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 — Free water

Total Moisture = Free moisture + Aggregate absorbed moisture

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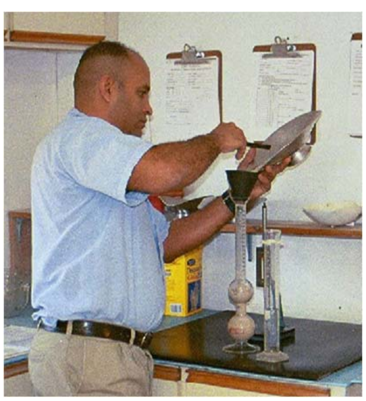
Chapman Flask - Moisture Determination



- 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

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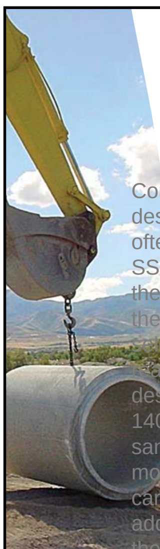
Moisture Compensation



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

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Moisture Adjustment

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

Total moisture = Free moisture + Aggregate absorption

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Moisture Probes

- Used in batching
- Installed per manufactures recommendations
- Must be calibrated
- There is a difference between a mixer probe and a bin probe

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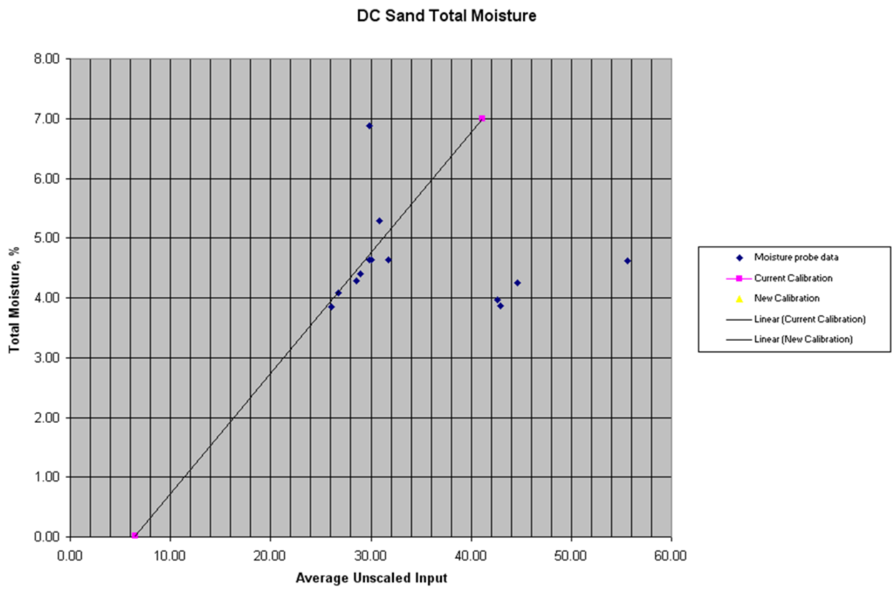
Moisture Probes



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Concrete Properties Influenced by Aggregates

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

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Concrete Properties Influenced by Aggregates

- **Workability**
  - Grading
    - 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

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
- **Volume Change**
  - 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

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Fine Aggregates in Concrete

- 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

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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

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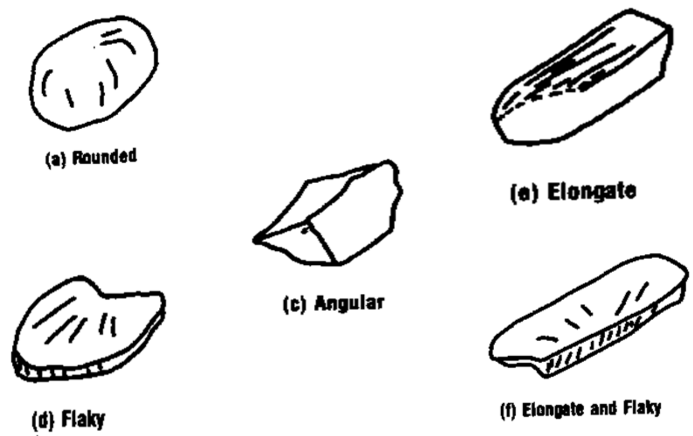
Particle Shape



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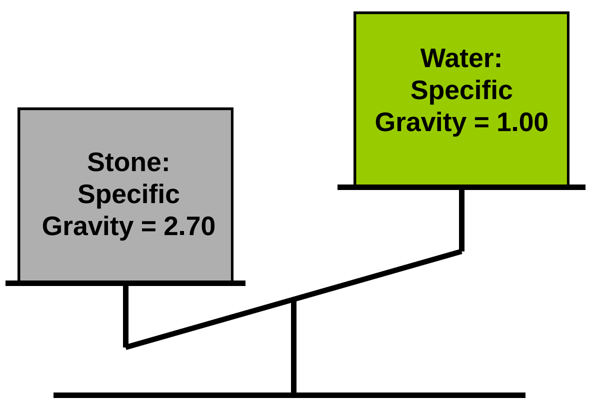
Specific Gravity



Same Volume, but 2.70 Times More Mass

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Specific Gravity

- The relative density of a material compared to water
- The ratio of a material's weight to the weight of an equal volume of water
- Bulk specific gravity (SSD):
  - Used to determine the "solid volume" (absolute volume) of a material going into concrete
  - It is determined by submerging the material in water for 24 hours in order to fill any permeable voids
- Absorption is the penetration liquid into aggregate particles
- Test Procedures: ASTM C 127 for CA and C 128 for FA
- Not a measure of quality
- Ensures proper yield
- SG of normal weight aggregates vary from 2.40 to 2.80

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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.

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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.

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Sample Splitter

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Reducing Field Samples (stockpile method)

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

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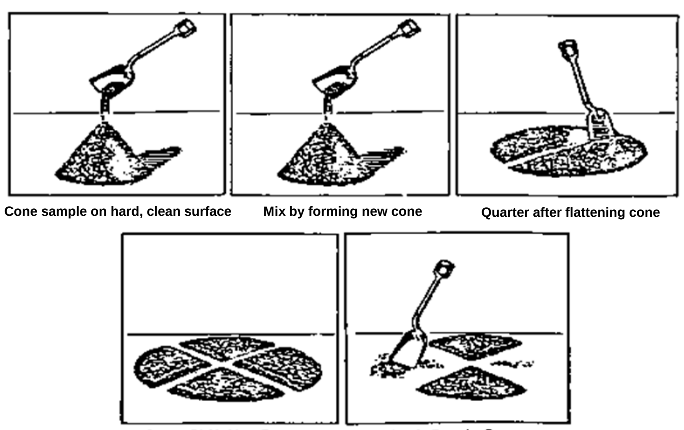
Reducing Field Samples



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

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Aggregate Quality Control

- Critical to obtain predictable and consistent concrete properties
- QC Program

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