

# Example- Mixture Proportioning





## Example 1 (Inch-Pound)

### Conditions & Specifications:

- Concrete pavement
- 8-in thick
- Exposed to moisture and deicer salts in severe freeze-thaw environment
- Specified strength of 3500 psi at 28 days
- Slump of 3 in. 1 in.
- No statistical data available

## Example 1

### Coarse Aggregate:

- Well-graded gravel with some crushed particles
- 1-in. nominal maximum size
- S.G. = 2.68 (SSD)
- Dry-rodded bulk density = 2700 lb/yd<sup>3</sup> (100 lb/ft<sup>3</sup>)
- Absorption,  $abs = 0.5\%$
- Moisture content,  $mc = 2.0\%$



## Example 1

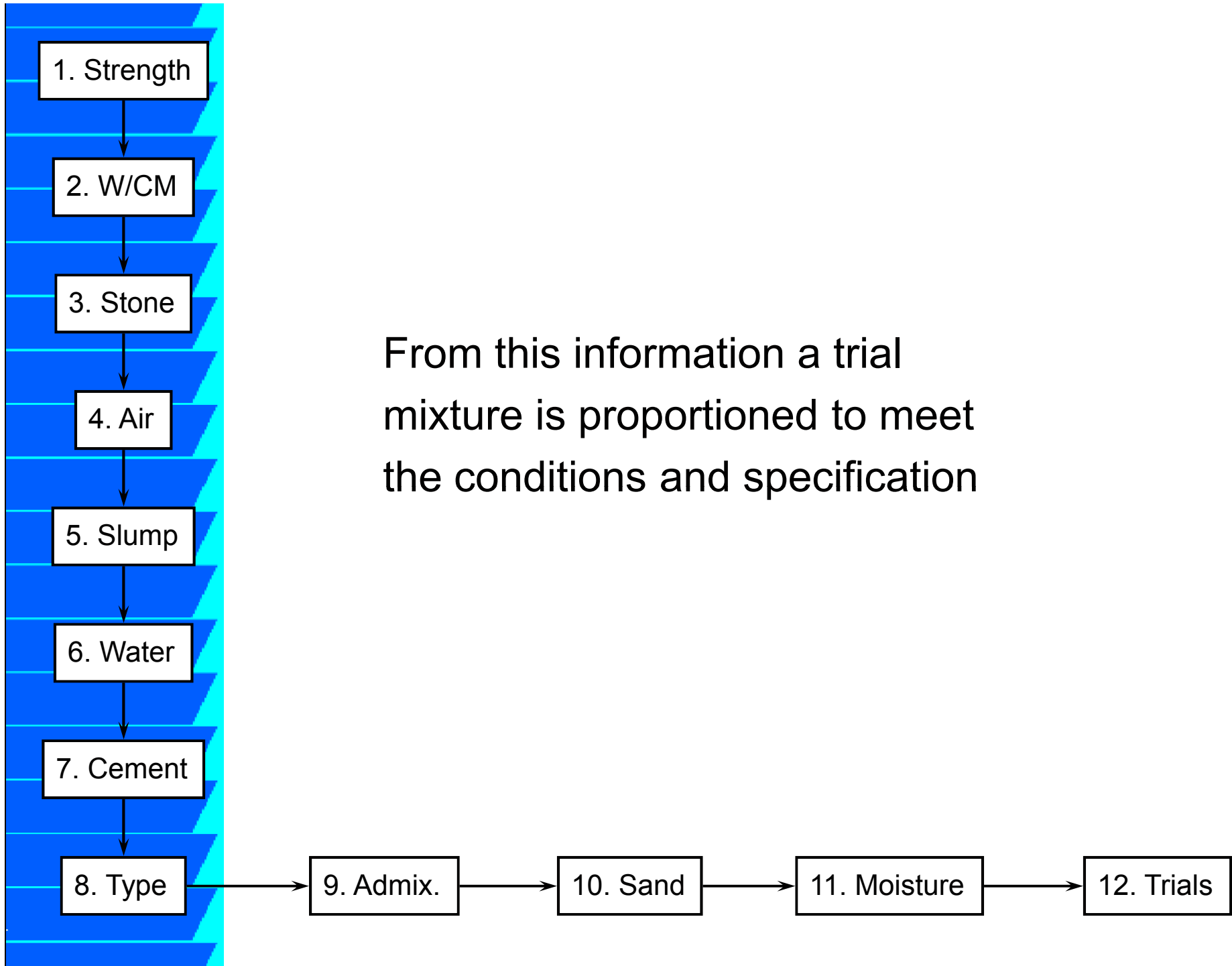
### Fine Aggregate (Sand):

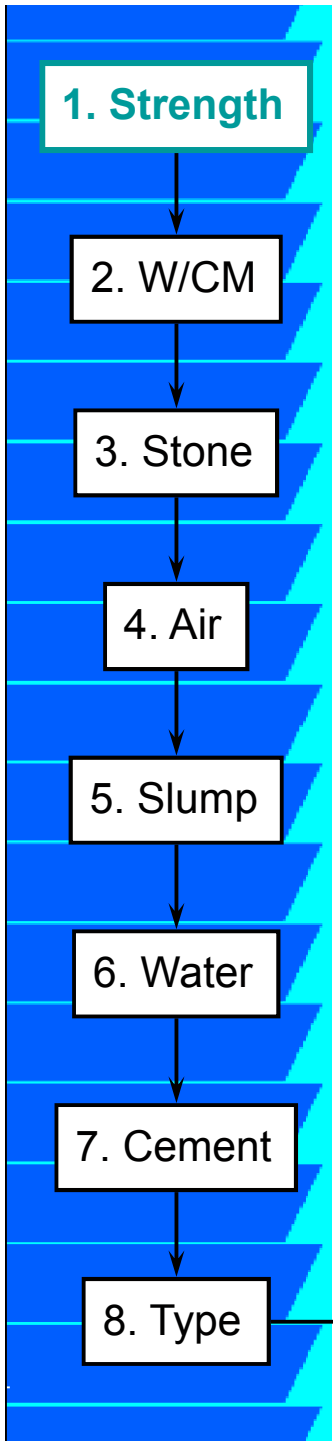
- Natural sand
- S.G. = 2.64 (SSD)
- Fineness modulus, FM = 2.70
- Absorption,  $abs = 0.9\%$
- Moisture content,  $mc = 3.5\%$

## Example 1

### Admixtures:

- Water-reducer
  - 7% water reduction at 5.5 fl oz per 100 lb of cement
  - S.G. ~ 1.0
- Air-entraining admixture
  - Manufacturer recommends 1.0 fl oz per 100 lb of cement for 6% air
  - S.G. ~ 1.0





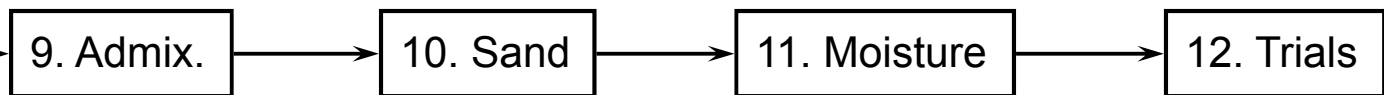
# 1. Determine Strength Requirements

Given:

Specified strength for design: 3500 psi

Exposure: Severe/deicers- F3

Statistical data available: **s** = none



1. Strength

2. W/CM

3. Stone

4. Air

5. Slump

6. Water

7. Cement

8. Type

Specified strength for design = 3500 psi  
 But, requirements of ACI 318 Building Code (Table Page 1):

Category	Severity	Class	Condition		Max w/cm	Min. $f'_c$ (psi)	Cement ?	USE ?
F (Freezing and Thawing)	Not Applicable	FO	Concrete <b>not exposed</b> to freezing-and-thawing cycles		N/A	2,500	No Type Restriction	
	Moderate	F1	Concrete exposed to freezing-and-thawing cycles and <b>occasional</b> exposure to moisture		0.45	4,500		
	Severe	F2	Concrete exposed to freezing-and-thawing cycles and in <b>continuous</b> contact with moisture		0.45	4,500		
	Very Severe	F3	Concrete exposed to freezing-andthawing and in <b>continuous</b> contact with moisture and <b>exposed to deicing chemicals</b>		0.45	4,500		<input checked="" type="checkbox"/>
S* (Sulfate)  *PCA			<b>Water-soluble sulfate (SO<sub>4</sub>) in soil (percent by weight)</b>	<b>Dissolved sulfate (SO<sub>4</sub>) in water (ppm)</b>				
	Not Applicable	SO	SO <sub>4</sub> < 0.10	SO <sub>4</sub> < 150	N/A	2,500	No Type Restriction	
	Moderate	S1	0.10 ≤ SO <sub>4</sub> < 0.20	150 ≤ SO <sub>4</sub> < 1500 Seawater	0.50	4,000	II	
	Severe	S2	0.20 ≤ SO <sub>4</sub> ≤ 2.00	1500 ≤ SO <sub>4</sub> ≤ 10,000	0.45	4,500	V	
	Very Severe	S3	SO <sub>4</sub> > 2.00	SO <sub>4</sub> > 10,000	0.40*	5000*	V*	
C (Corrosion Protection)	Not Applicable	CO	Concrete <b>dry or protected</b> from moisture		N/A	2,500	No Type Restriction	
	Moderate	C1	Concrete <b>exposed to moisture</b> but <b>not to external sources of chlorides</b>		N/A	2,500		
	Severe	C2	Concrete <b>exposed to moisture and an external source of chlorides</b> from deicing chemicals, salt, brackish water, seawater, or spray from these sources		0.40	5,000		
<b>Summary of Most Restrictive Requirements</b>								

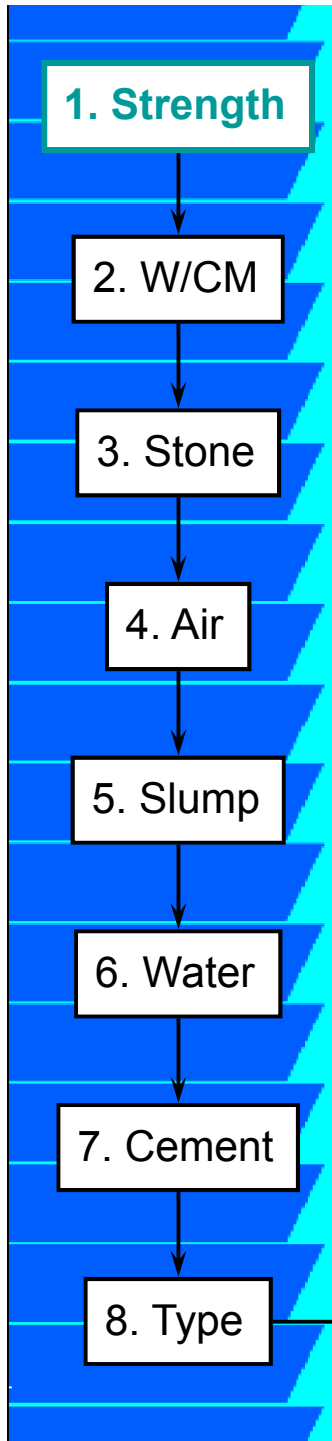
9. Admix.

10. Sand

11. Moisture

12. Trials



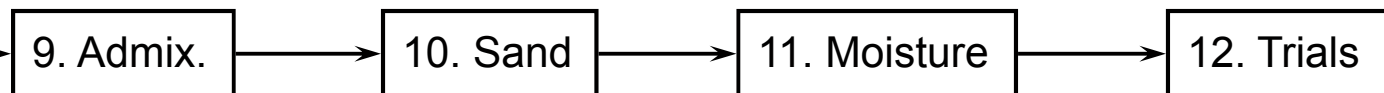


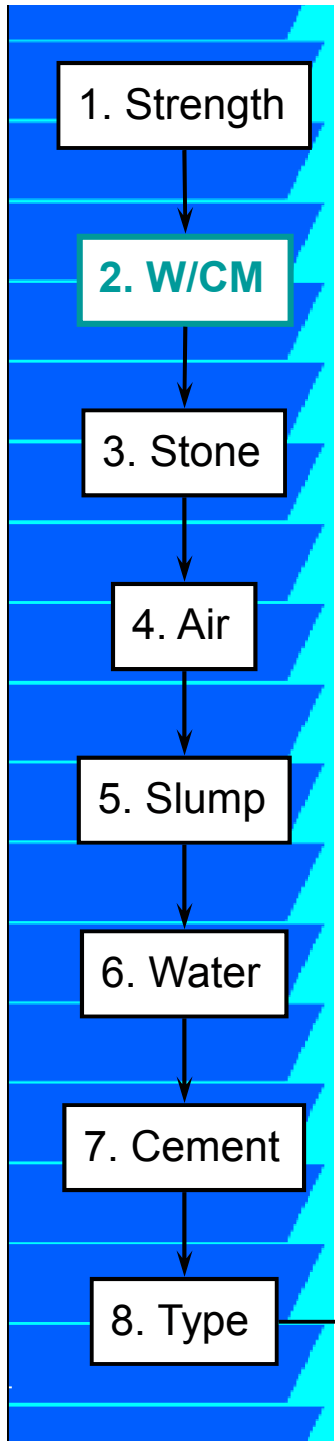
$$\therefore f_c' = 4500 \text{ psi}$$

Since less than 15 consecutive tests are available  
(Table Page 2)

Specified Strength $f_c'$ (psi)	Required Average Strength $f_{cr}'$ (psi)
Less than 3000	$f_c' + 1000$
<b>3000 to 5000</b>	<b><math>f_c' + 1200</math></b>
Over 5000	$1.10f_c' + 700$

$$f_{cr}' = 4500 + 1200 = 5700 \text{ psi}$$



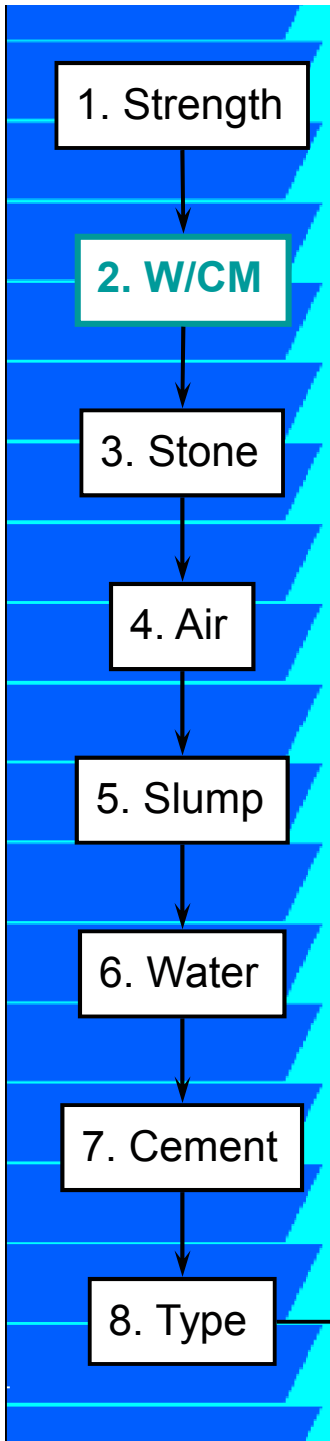


## 2. Determine the Water-Cement Ratio Required

Given:

W/C is determined from:

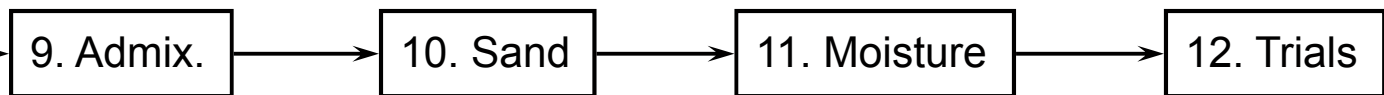
- Required strength  $f_{cr}$ : 5700 psi
- Durability considerations: Severe/deicers



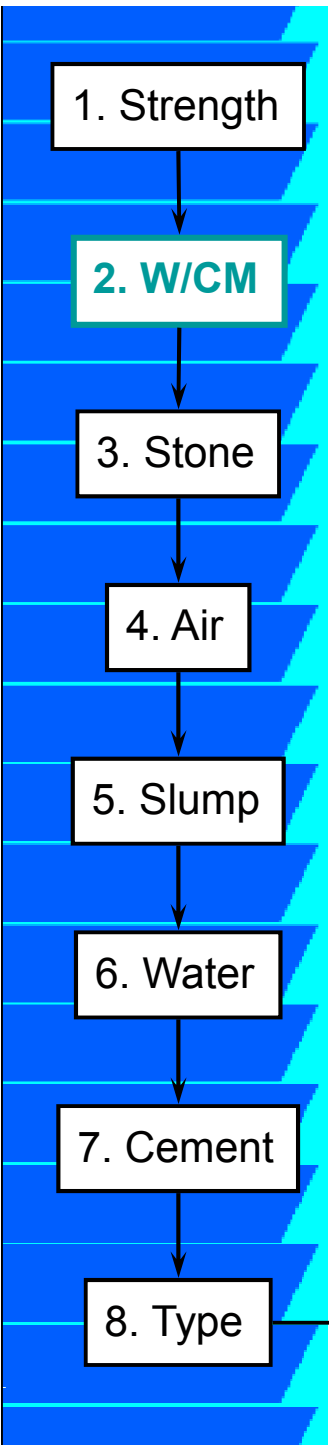
W/CM required for strength (Table Page 3):

Required design strength $f_{cr}'$ (psi)	W/CM	
	Non-Air Entrained	Air-Entrained
7000	0.33	-
<b>6000</b>	0.41	<b>0.32</b>
<b>5000</b> <b>5700</b>	0.48	<b>0.40</b> <b>0.34</b>
4000	0.57	0.48
3000	0.68	0.59
2000	0.82	0.74

**W/CM = 0.34**

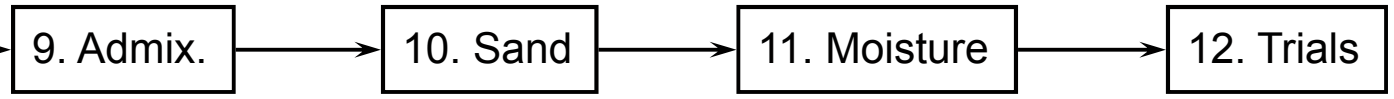


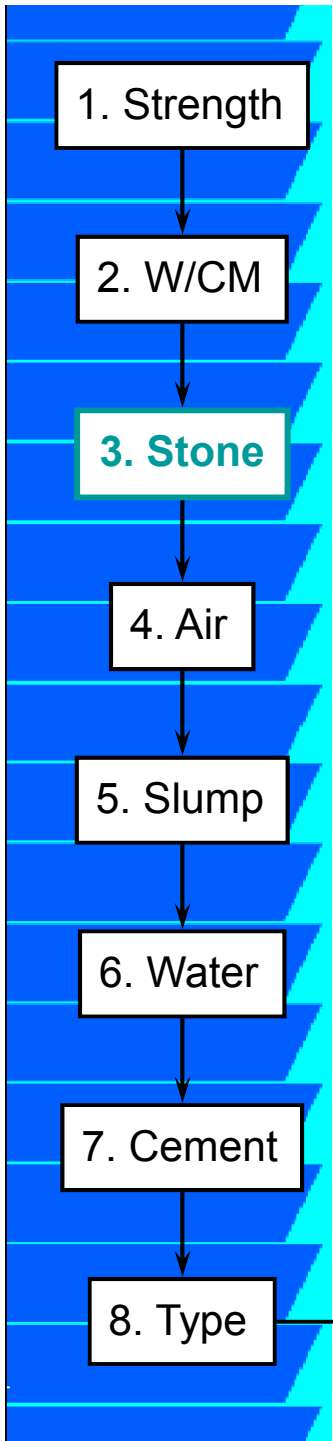
## W/CM required for Durability Requirements of ACI 318 Building Code (Table Page 1):



Category	Severity	Class	Condition		Max w/cm	Min. f <sub>c</sub> (psi)	Cement ?	USE ?
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<b>Summary of Most Restrictive Requirements</b>								

**∴ critical W/CM = 0.34**



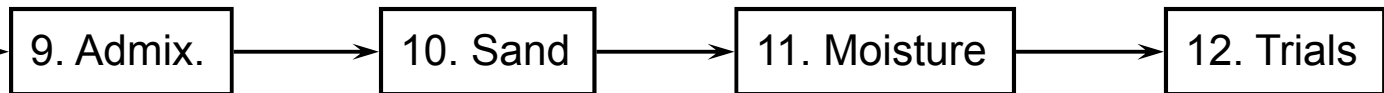


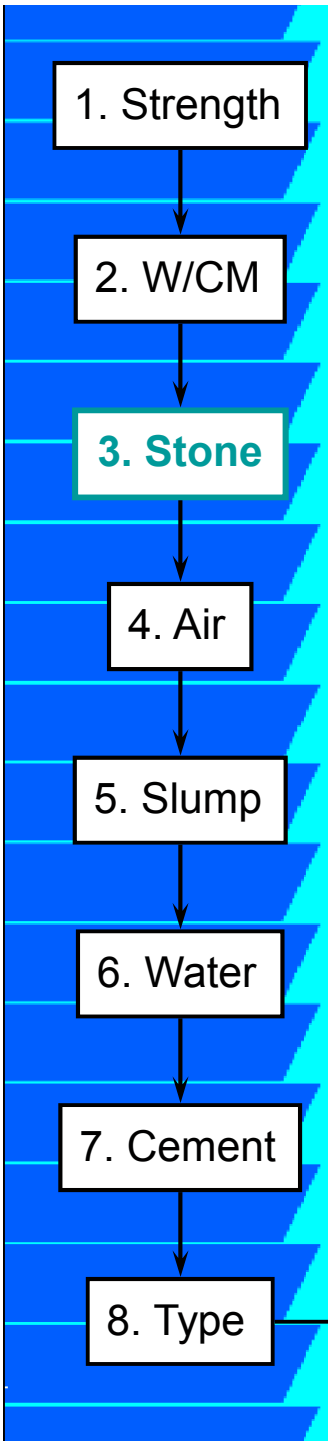
### 3. Determine Bulk Volume of Coarse Aggregate

Given:

Coarse Aggregate-

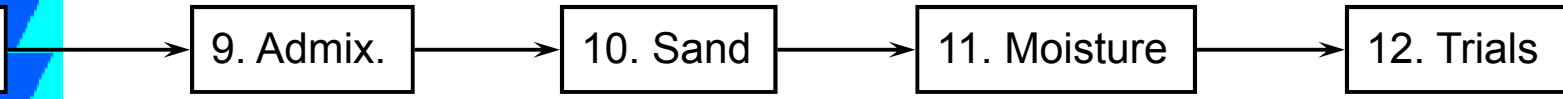
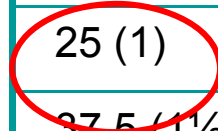
- Max size (nominal): 1 in.
- F.M.: 2.7
- Bulk Density: 2700 lb/yd<sup>3</sup>
- abs*: 0.5%

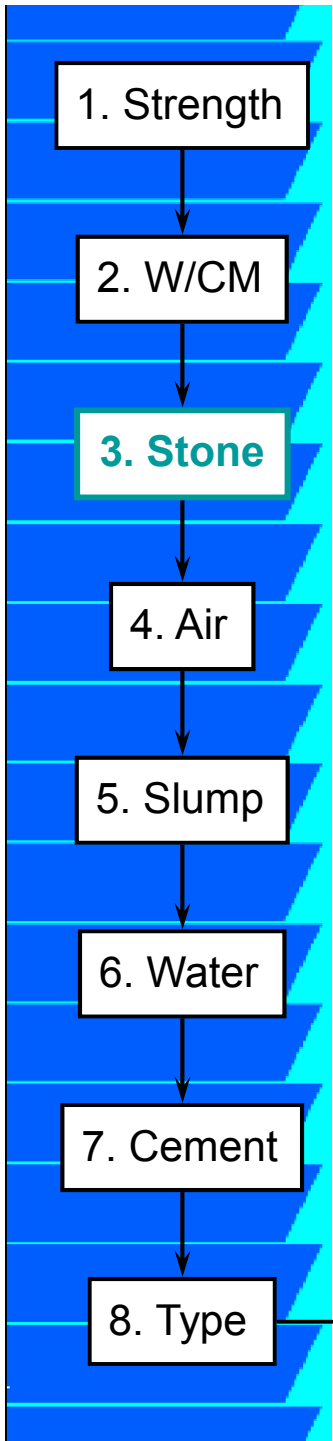




## Bulk Volume of Coarse Aggregate [\(Table Page 4\)](#):

Max. Size mm (in.)	Bulk volume of dry-rodded coarse aggregate per unit volume of concrete for different fineness moduli of fine aggregate				
	2.40	2.60	2.70	2.80	3.00
10 (3/8)	0.50	0.48	0.46	0.46	0.44
12.5 (1/2)	0.59	0.57	0.55	0.55	0.53
20 (3/4)	0.66	0.64	0.62	0.62	0.60
25 (1)	0.71	0.69	0.67	0.67	0.65
37.5 (1 1/2)	0.75	0.73	0.71	0.71	0.69
50 (2)	0.78	0.76	0.74	0.74	0.72
75 (3)	0.82	0.80	0.78	0.78	0.76
150 (6)	0.87	0.85	0.83	0.83	0.81





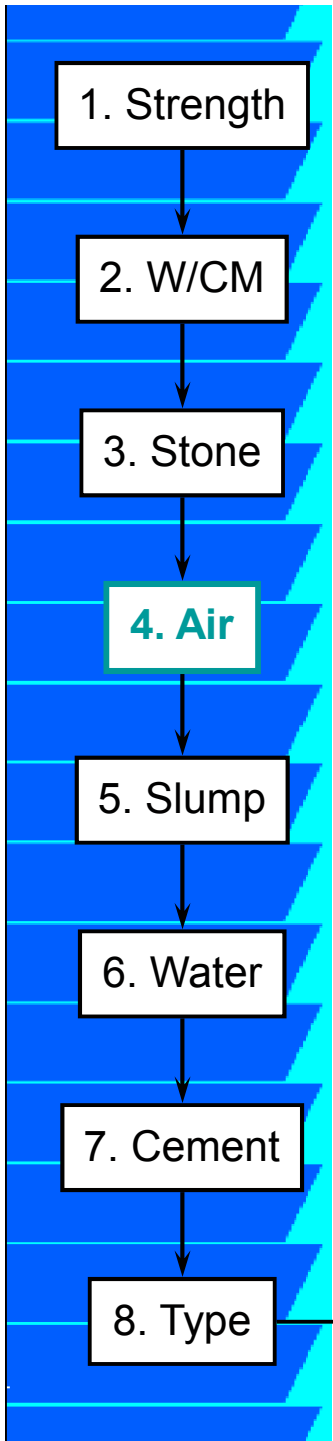
### Mass of Coarse Aggregate

Oven dry mass = bulk volume x bulk density

$$\text{Oven dry mass} = \underline{0.68 \times 2700 = 1836 \text{ lb}}$$

$$\text{Mass in SSD} = \underline{1836 \times 1.005}$$

$$\text{Coarse Agg. Content (SSD)} = \underline{1845 \text{ lb/yd}^3}$$



## 4. Determine Air Content

Given:

Exposure:

**Severe/deicers- F3**

Max Agg:

**1 in.**

8. Type

9. Admix.

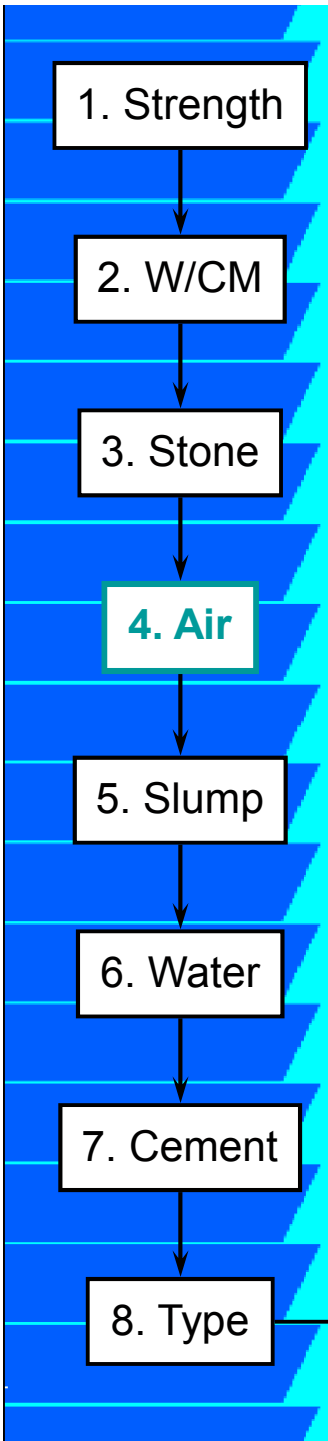
10. Sand

11. Moisture

12. Trials







# ACI 318-08 Durability Requirements:

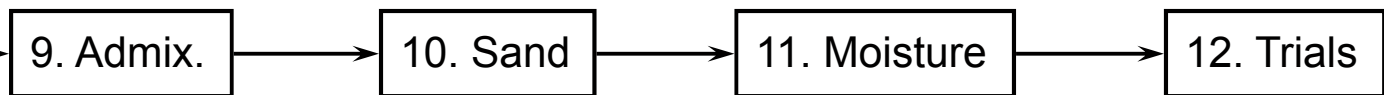
(Table Page 5)

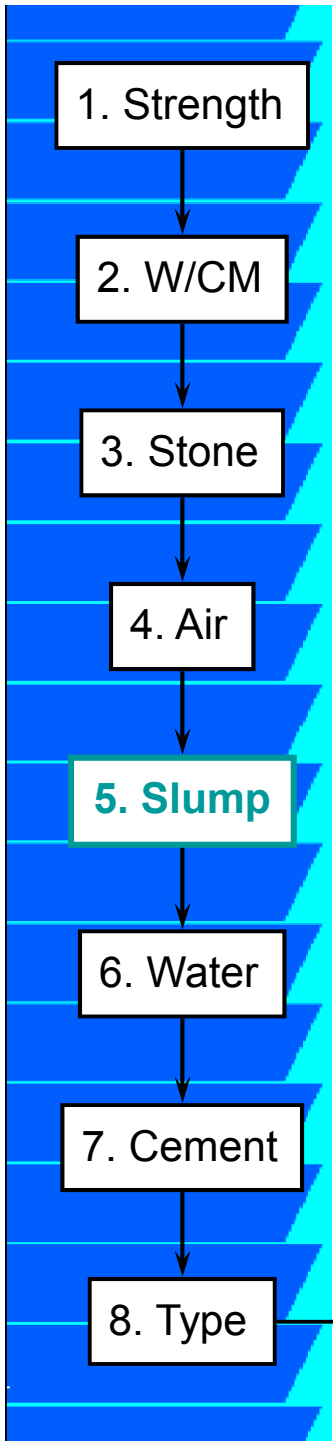
Nominal maximum aggregate size, in.*	Air content, percent	
	Exposure Class F1	Exposure Classes F2 and F3
3/8	6	7.5
1/2	5.5	7
3/4	5	6
1	4.5	6
1-1/2	4.5	5.5
2 <sup>†</sup>	4	5
3 <sup>†</sup>	3.5	4.5

\*See ASTM C33 for tolerance on oversize for various nominal maximum size designations.

†Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 in. are removed by sieving and air content is measured on the sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on the sieved fraction passing the 1-1/2 in. sieve in accordance with ASTM C231.

**Air required = 6.0% 1.5%**





## 5. Determine Slump

Given:

Slump: specified at 3 in. 1 in.

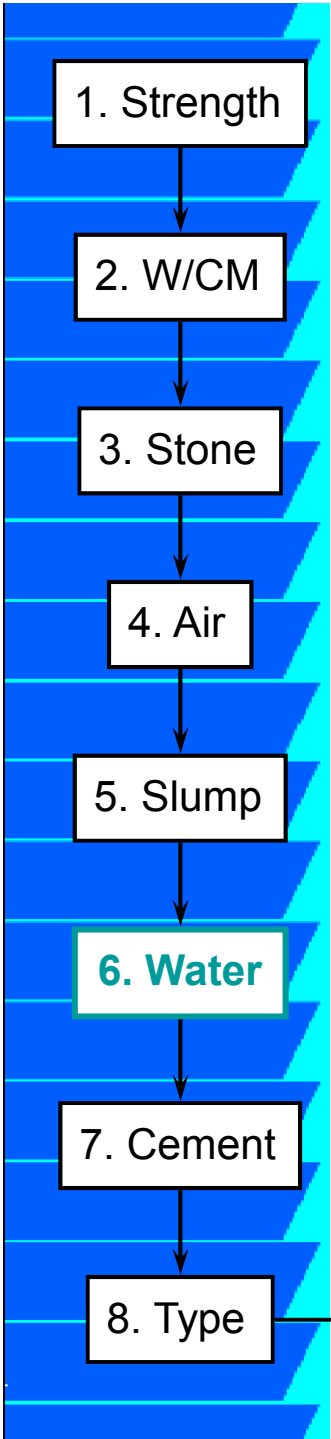
8. Type

9. Admix.

10. Sand

11. Moisture

12. Trials



## 6. Water Content

Given:

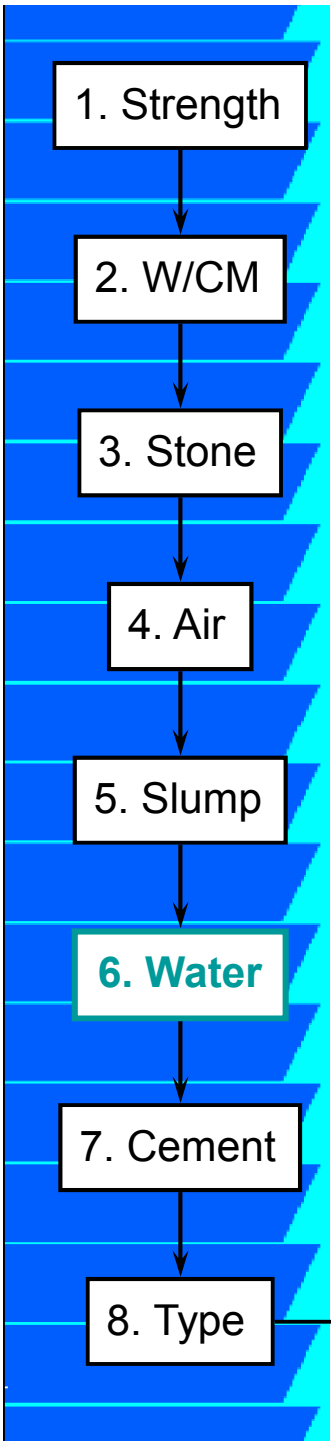
Slump: 3 in. ± 1 in.

Max Agg: 1 in.

Agg. Shape: rounded gravel with some crushed particles

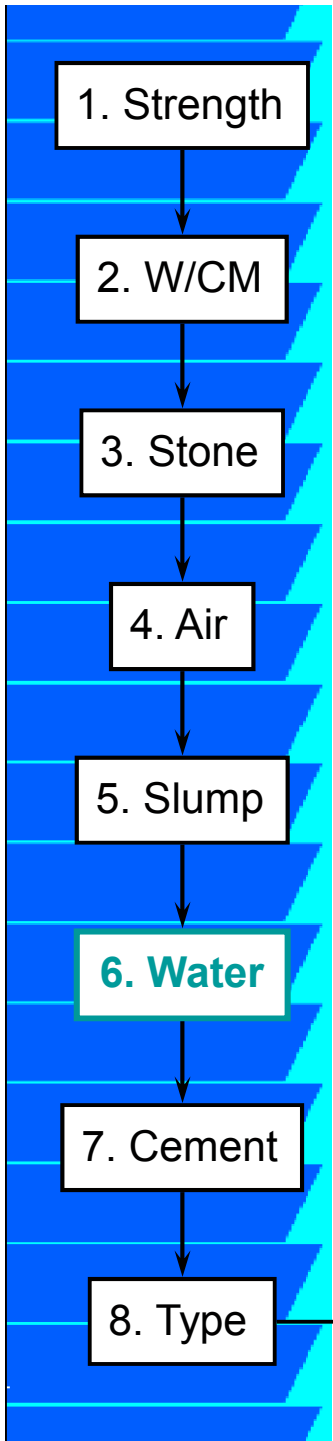
Water Reducer: 7% water reduction





Water requirements (lb/yd<sup>3</sup>) for air-entrained concrete  
 (Table Page 6)

Slump (in)	Nominal Maximum Aggregate Size						
	3/8 in.	1/2 in.	3/4 in.	1 in.	1-1/2 in.	2 in.	3 in.
1 to 2	305	295	280	270	250	240	205
<b>3 to 4</b>	340	325	305	<b>295</b>	275	265	225
6 to 7	365	345	325	310	290	280	260

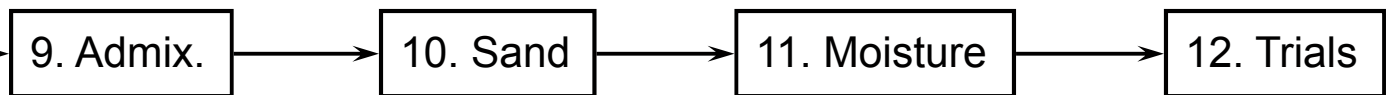


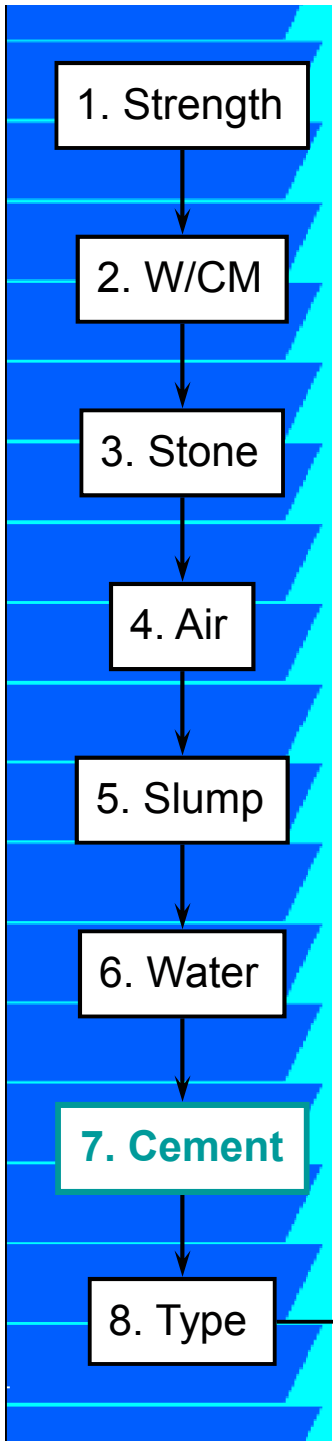
### Reduction for Aggregate Shape and Admixtures:

$$\begin{array}{r}
 \underline{295} \quad \left\{ \begin{array}{l} \text{Table} \\ \text{Page 6} \end{array} \right\} - \underline{35} \quad \left\{ \begin{array}{l} \text{reduction for} \\ \text{aggregate shape} \end{array} \right\} = \underline{260} \\
 \text{Water} \\
 \text{Content} \qquad \qquad \qquad \text{rounded gravel with some} \\
 \qquad \qquad \qquad \qquad \qquad \qquad \text{crushed particles}
 \end{array}$$

$$\begin{array}{r}
 \underline{260} - \underline{18} \quad \left\{ \begin{array}{l} \text{reduction for} \\ \text{water-reducer} \end{array} \right\} = \underline{242} \\
 \text{Water} \\
 \text{Content} \qquad \qquad \qquad 7\%
 \end{array}$$

**Water content = 242 lb/yd<sup>3</sup>**





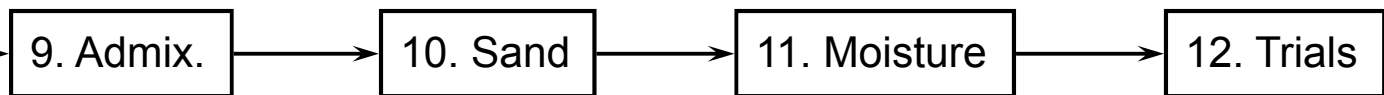
## 7. Cement Content

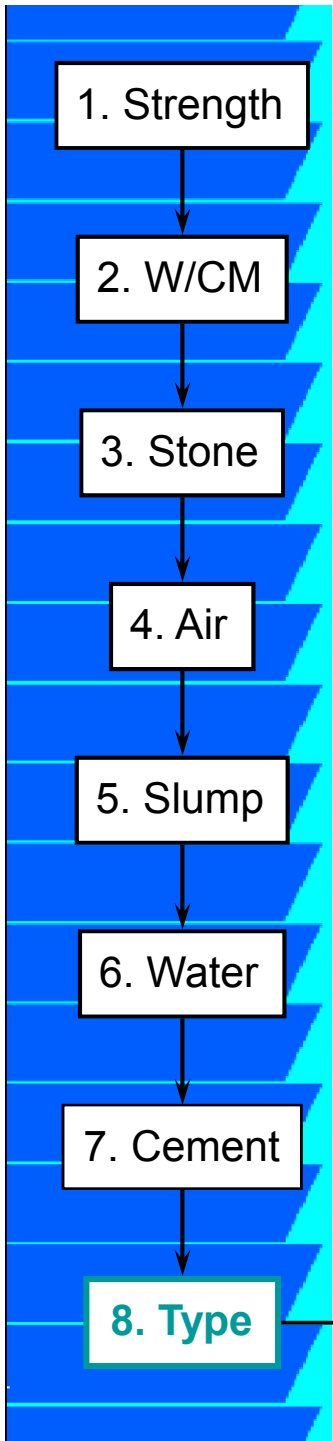
(Table Page 7)

$$\text{Cement content} = \frac{\text{Water content}}{\text{W/CM}}$$

$$\text{Cement content} = \frac{242}{0.34} = 712$$

$$\text{Cement content} = 712 \text{ lb/yd}^3$$





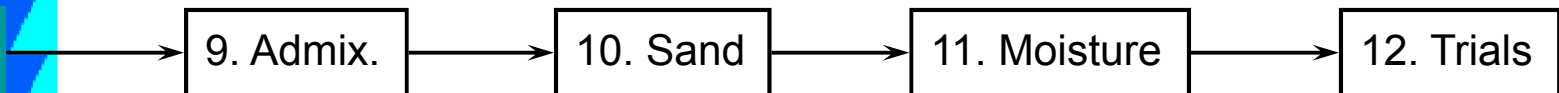
## 8. Cement Type

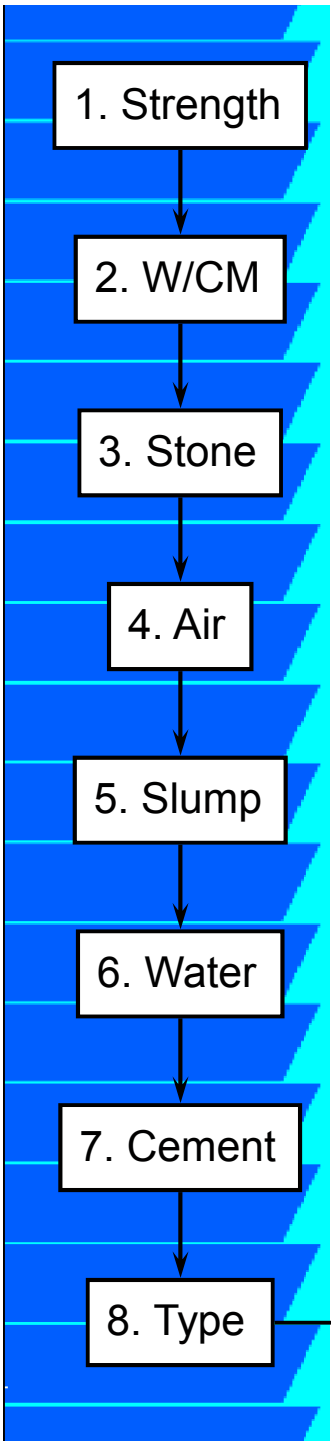
(Table Page 1)

No special requirements

Use either {  
Type I (ASTM C 150)  
Type GU (ASTM C 1157)

Note: if pozzolans or slag used ensure that proportions do not exceed limits of ACI 318 Building Code for concrete exposed to deicer salts

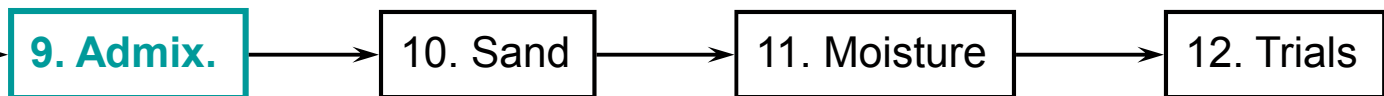




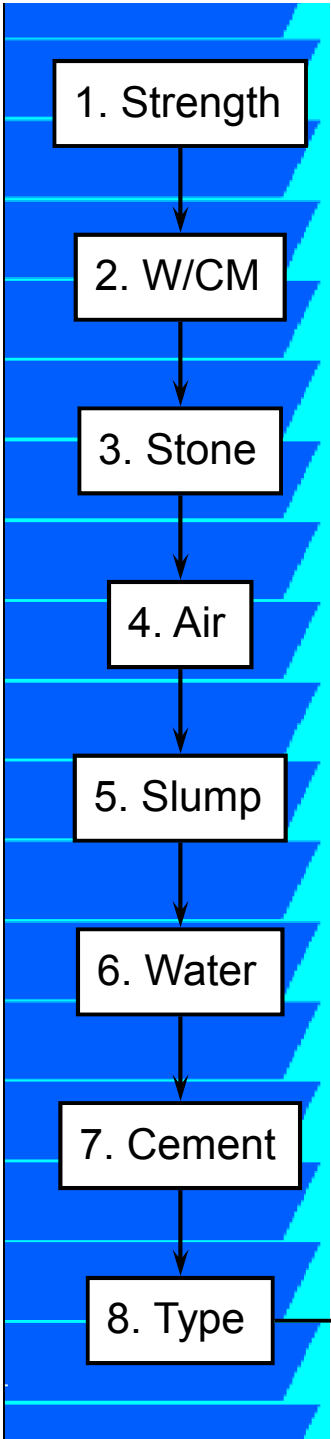
## 9. Admixtures

$$\begin{aligned} \text{Water-reducer dose} &= 5.5 \text{ fl oz} / 100 \text{ lb} \times 712 \text{ lb/yd}^3 \\ &= 39 \text{ fl oz/yd}^3 \end{aligned}$$

$$\begin{aligned} \text{Air-entrainment dose} &= 1.0 \text{ fl oz} / 100 \text{ lb} \times 712 \text{ lb/yd}^3 \\ &= 7 \text{ fl oz/yd}^3 \end{aligned}$$





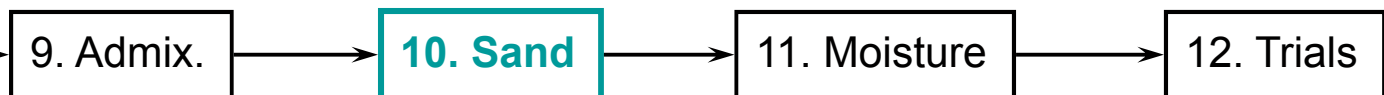


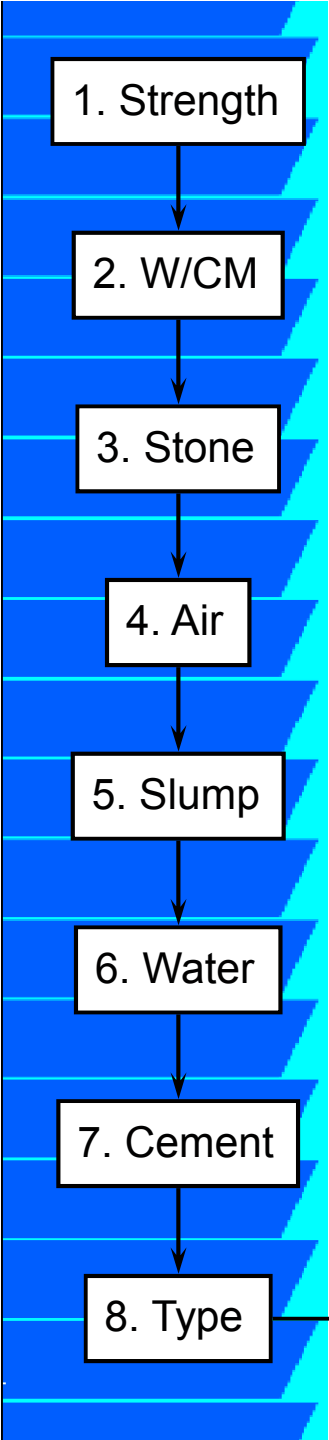
## 10. Fine Aggregate

Already Determined:

Mass proportions (lb/yd<sup>3</sup>)

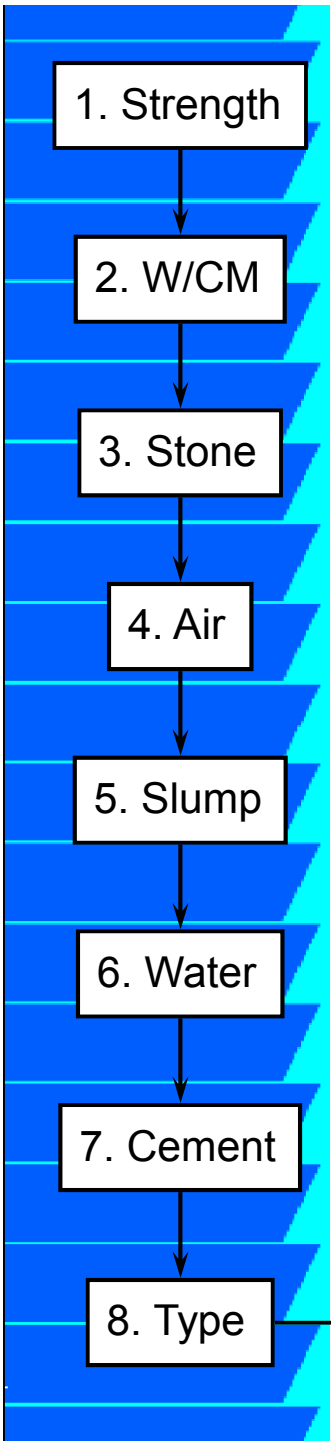
- Cement content: 712
- Water content: 242
- Coarse aggregate content: 1845 (SSD)
- Air content (% volume): 6%



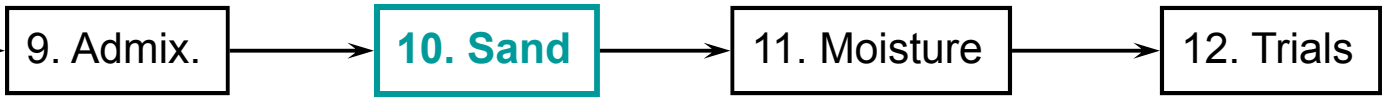


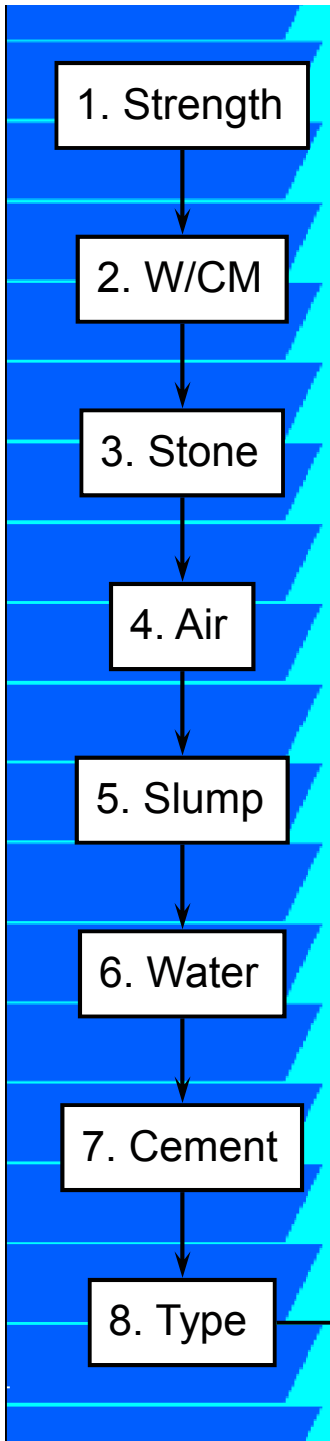
	<b>Mass (lb/yd<sup>3</sup>)</b>		<b>Density (lb/yd<sup>3</sup>)</b>
<b>Cement</b>	<b>712</b>	$(62.4 \times 3.15 \times 27) =$	<b>5307</b>
<b>Water</b>	<b>242</b>	$(62.4 \times 27) =$	<b>1685</b>
<b>Stone (SSD)</b>	<b>1845</b>	$(62.4 \times 2.68 \times 27) =$	<b>4515</b>
<b>Air</b>	<b>6% by volume</b>		
			<b>Total =</b>





	<b>Mass (lb/yd<sup>3</sup>)</b>	<b>Density (lb/yd<sup>3</sup>)</b>		<b>Volume (yd<sup>3</sup>)</b>
<b>Cement</b>	<b>712</b>	<b>5307</b>	<u><b>712</b></u> <b>5307</b>	<b>0.134</b>
<b>Water</b>	<b>242</b>	<b>1685</b>	<u><b>242</b></u> <b>1685</b>	<b>0.144</b>
<b>Stone (SSD)</b>	<b>1845</b>	<b>4515</b>	<u><b>1845</b></u> <b>4515</b>	<b>0.409</b>
<b>Air</b>	<b>6% by volume</b>		<u><b>6</b></u> <b>100</b>	<b>0.060</b>
			<b>Total =</b>	<b>0.747yd<sup>3</sup></b>





$$\text{Volume of sand} = 1.000 - \underline{0.747} = \underline{0.253 \text{ yd}^3}$$

**Mass of sand = volume x density**

$$\text{Mass of sand} = \underline{0.253 \times 4448} = \underline{1125 \text{ lb (SSD)}}$$

$$\text{Fine Agg. Content (SSD)} = \underline{1125 \text{ lb/yd}^3}$$



## Mixture Proportions

**Cement** **712 lb/yd<sup>3</sup>**

**Water** **242 lb/yd<sup>3</sup>**

**Coarse Agg. (SSD)** **1845 lb/yd<sup>3</sup>**

**Fine Agg. (SSD)** **1125 lb/yd<sup>3</sup>**

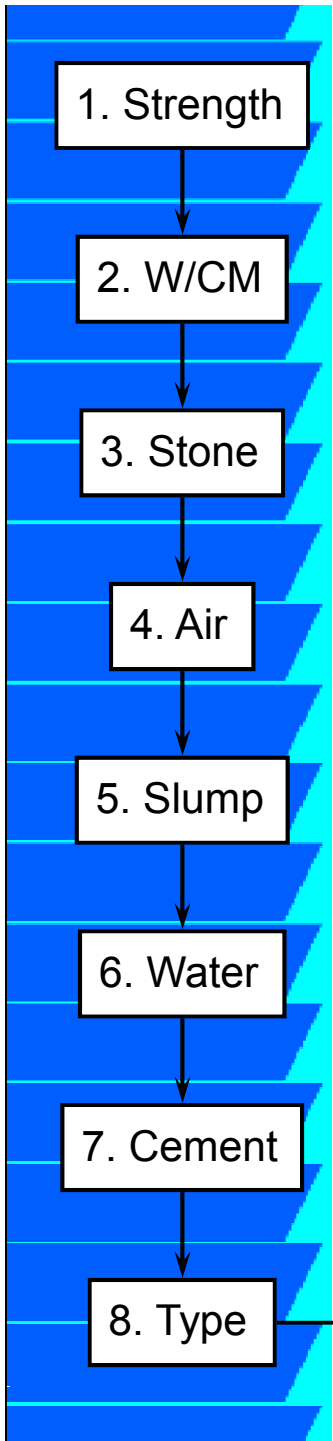
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**Total mass** **3924 lb/yd<sup>3</sup>**

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**WRA** **39 fl oz/yd<sup>3</sup>**

**AEA** **7 fl oz/yd<sup>3</sup>**



## Moisture Corrections:

$$M_{batch} = M_{SSD} \times \frac{1 + mc}{1 + abs}$$

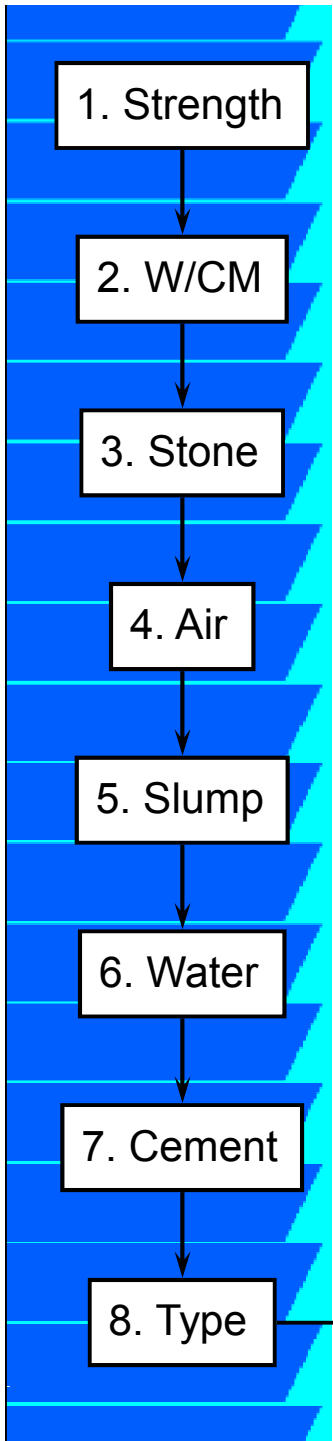
### Coarse Aggregate

$$M_{batch} = 1845 \times \frac{1.020}{1.005} = 1873 \text{ lb/yd}^3$$

### Fine Aggregate

$$M_{batch} = 1125 \times \frac{1.035}{1.009} = 1154 \text{ lb/yd}^3$$





$$W_{corr} = M_{SSD} \times \frac{(abs - mc)}{1 + abs}$$

Coarse Aggregate

$$W_{corr} = 1845 \times \frac{(0.005 - 0.020)}{1.005} = -28 \text{ lb/yd}^3$$

Fine Aggregate

$$W_{corr} = 1125 \times \frac{(0.009 - 0.035)}{1.009} = -29 \text{ lb/yd}^3$$

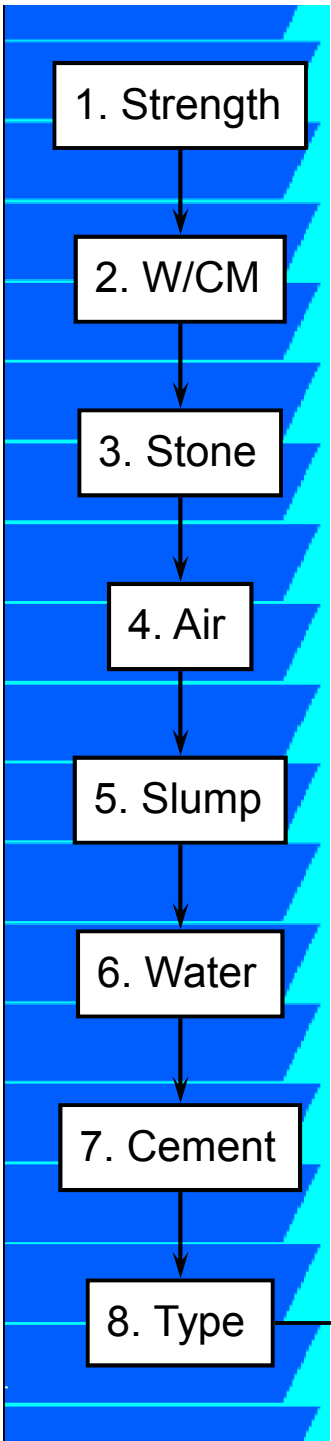
$$\text{Total water correction} = 28 + 29 = -57 \text{ lb/yd}^3$$



# Mixture Proportions

		<u>Moisture Corrections</u>	<u>Batch Proportions</u>
Cement	712 lb/yd <sup>3</sup>		712 lb/yd <sup>3</sup>
Water	242 lb/yd <sup>3</sup>	- 57	185 lb/yd <sup>3</sup>
Coarse Agg. (SSD)	1845 lb/yd <sup>3</sup>	+ 28	1873 lb/yd <sup>3</sup>
Fine Agg. (SSD)	1125 lb/yd <sup>3</sup>	+ 29	1154 lb/yd <sup>3</sup>
<b>Total mass</b>	<b>3924 lb/yd<sup>3</sup></b>		<b>3924 lb/yd<sup>3</sup></b>
WRA	39 fl oz/yd <sup>3</sup>		39 fl oz/yd <sup>3</sup>
AEA	7 fl oz/yd <sup>3</sup>		7 fl oz/yd <sup>3</sup>



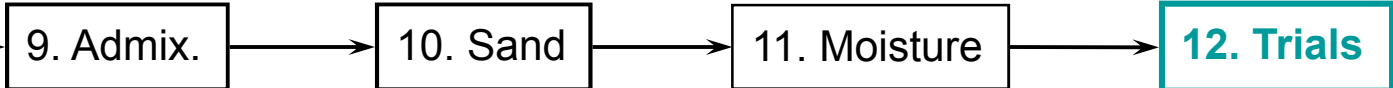


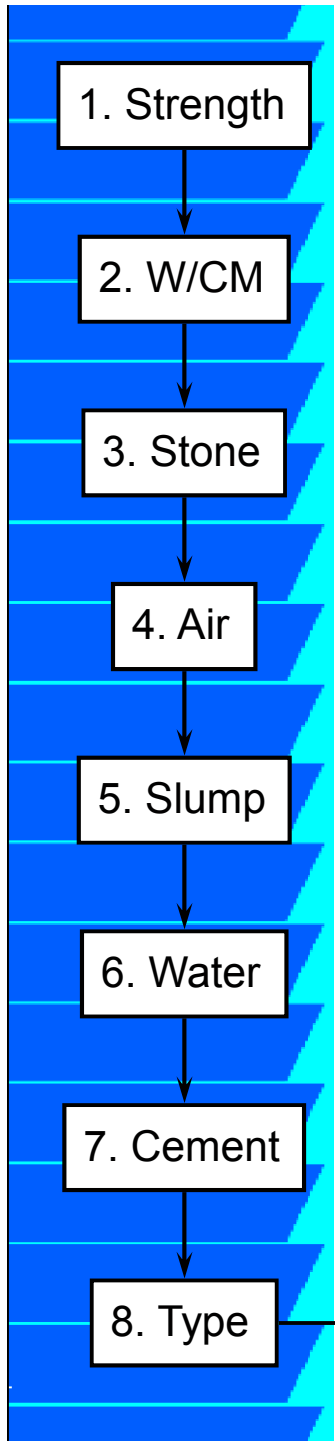
## 12. Trial Batch

For a 1 cubic foot (0.037 yd<sup>3</sup>) batch:

**Quantities  
for batch**

<b>Cement</b>	<b>712 lb/yd<sup>3</sup></b>	<b>x 0.037 =</b>	<b>26.344 lb</b>
<b>Water</b>	<b>185 lb/yd<sup>3</sup></b>	<b>x 0.037 =</b>	<b>6.845 lb</b>
<b>Coarse Agg.</b>	<b>1873 lb/yd<sup>3</sup></b>	<b>x 0.037 =</b>	<b>69.301 lb</b>
<b>Fine Agg.</b>	<b>1154 lb/yd<sup>3</sup></b>	<b>x 0.037 =</b>	<b>42.698 lb</b>
<b>Total mass</b>	<b>3924 lb/yd<sup>3</sup></b>	<b>x 0.037 =</b>	<b>145.188 lb</b>
<b>WRA</b>	<b>39 fl oz/yd<sup>3</sup></b>	<b>x 0.037 =</b>	<b>1.44 fl oz</b>
<b>AEA</b>	<b>7 fl oz/yd<sup>3</sup></b>	<b>x 0.037 =</b>	<b>0.26 fl oz</b>



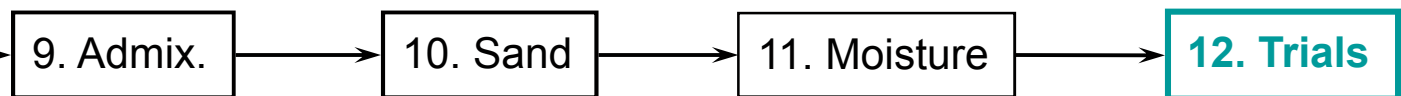


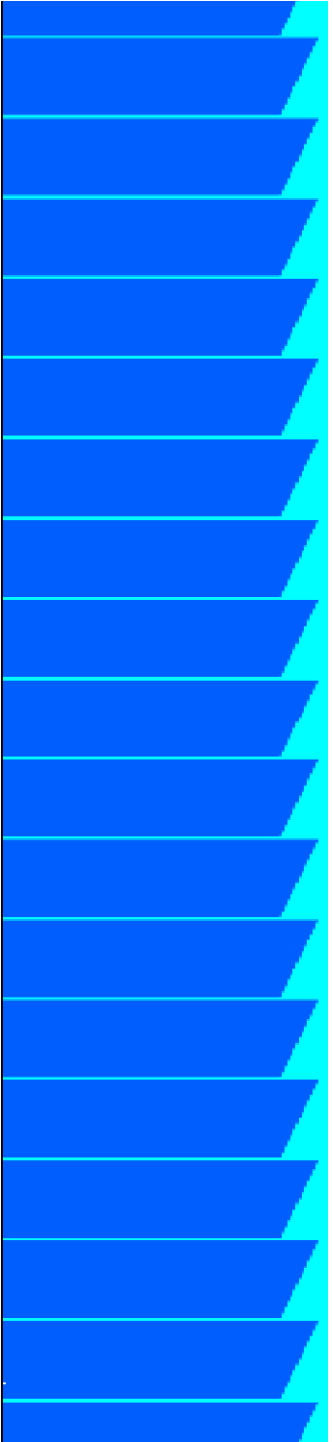
Trial batches tested for:

- Slump
- Air content
- Strength

Adjustments made:

- Water Content
- Admixture Doses
- Cement Content
- Sand Content





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