

Section 4
Batch Water, Aggregate Moisture,
w/cm Ratio & Adjusting Slump



WMTG Concrete Training & Certification Seminar

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Water-cementitious materials ratio

ratio of the amount of water, *minus water absorbed by the aggregates*, to the amount of cementitious material in the concrete

$$\text{w/cm ratio} = \frac{\text{wt of total water} - \text{wt of absorbed water}}{\text{wt of cementitious materials}}$$

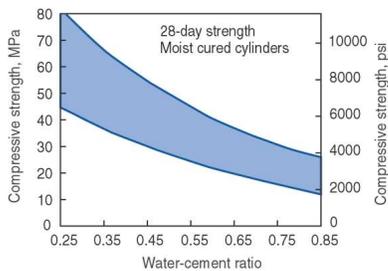
Minimum w/cm for hydration about 0.25

Practical minimum ... about 0.35 for workability without admixtures

WYDOT w/cm ratios	Structural	0.45
(SSRBC 414.4.7 & 513.4.4)	Pavement	0.45

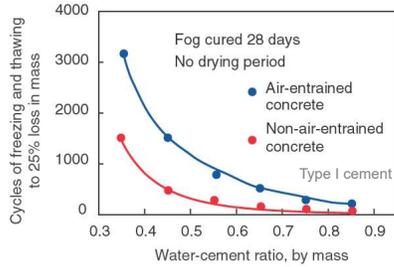
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Typical Relationships of Strength to w/cm Ratio



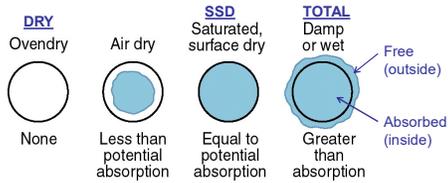
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Relationship Between Freeze-Thaw Resistance, w/cm Ratio, and Different Concretes & Curing Conditions



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Aggregate Absorption & Surface Moisture



Total Moisture = Absorbed + Free (Net) Moisture

Free (Net) Moisture = Total – Absorbed Moisture

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Total Moisture = Absorbed Moisture + Free Moisture

Aggregate Moisture Percentages ...
always computed from dry aggregate weight

Wt. of Water **ABSORBED** = Agg. Wt **SSD** - Agg. Wt **DRY**

$$\% \text{ Absorp.} = \frac{\text{Wt. of Water ABSORBED}}{\text{Agg. Wt DRY}} \times 100$$

$$\% \text{ Absorp.} = \frac{\text{Agg. Wt SSD} - \text{Agg. Wt DRY}}{\text{Agg. Wt DRY}} \times 100$$

% Absorption is usually a relatively constant, a known aggregate property determined by lab.

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% Free (Net) Moisture *Use to Adjust Batch Weights*

$$\% \text{ Free Moist.} = \% \text{ Total Moist.} - \% \text{ Absorption}$$

or

$$\text{Wt. Free Moist.} = \text{Wt. Total Moist.} - \text{Wt. Absorb. Moist.}$$

Always use % Absorption, % Total or % Free with Aggregate DRY Weight.

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% Total Moisture

$$\text{Total Wt of Water} = \text{Wet Wt of Agg.} - \text{Dry Wt of Agg.}$$

$$\% \text{ Total Moist.} = \frac{\text{Total Wt of Water}}{\text{Agg. Wt DRY}} \times 100$$

$$\% \text{ Total Moist.} = \frac{\text{Agg. Wt WET} - \text{Agg. Wt DRY}}{\text{Agg. Wt DRY}} \times 100$$

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Example #1

<u>Mix Design</u>	1 gal water = 8.34 lbs
588 lbs Cement	
1181 lbs Sand (dry)	1.482 % Absorption 2.0% Moisture Content
1781 lbs Rock (dry)	0.831% Absorption 1.0% Moisture Content
Batch water added:	29.4 gal/cy or 244.9 lbs/cy
Water added-on-site:	1.3 gal/cy or 10.8 lbs/cy

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Calculate w/cm Ratio

1. Calculate free (net) water from sand

$$1181 \text{ lbs.} \times (2.0\% - 1.482\%) = 6.12 \text{ lbs/cy}$$

2. Calculate free (net) water from rock

$$1781 \text{ lbs.} \times (1.0\% - 0.831\%) = 3.01 \text{ lbs/cy}$$

3. Calculate Total Free (net water)

$$244.9 + 10.8 + 6.12 + 3.01 = 264.8 \text{ lbs/cy}$$

batch + on-site + sand + rock = total water

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w/cm ratio example ...

$$\text{w/cm ratio} = \frac{264.8 \text{ lbs water}}{588 \text{ lbs cement}}$$

$$\text{w/cm ratio} = 0.45$$

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Example #2

Mix Design

588 lbs Cement Max. w/cm ratio = 0.45
1181 lbs Sand (dry) 1.482 % Absorption
 2.0% Moisture Content

1781 lbs Rock (dry) 0.831% Absorption
 1.0% Moisture Content

Batch Water Added: 26.0 gal/cy or 216.84 lbs/cy

How much water can be added-on-site?

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1. Calculate free (net) water from sand
 $1181 \text{ lbs.} \times (2.0\% - 1.482\%) = 6.12 \text{ lbs/cy}$
2. Calculate free (net) water from rock
 $1781 \text{ lbs.} \times (1.0\% - 0.831\%) = 3.01 \text{ lbs/cy}$
3. Calculate Total Free (net water)
 $216.84 + 6.12 + 3.01 = 225.97 \text{ lbs/cy}$
batch + sand + rock = total water

Max Total Water = w/cm Ratio x Cement

Max Total Water = $0.45 \times 588 \text{ lbs/cy} = 264.60 \text{ lbs/cy}$
 Max water that can be added = $264.60 - 225.97 = 38.63 \text{ lbs/cy}$
 Or $38.63 \text{ lbs/cy} = 4.63 \text{ gal/cy}$
 8.34 lbs/gal

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OK to adjust slump if ...

1. Not more than ¼ cy of concrete has been discharged from truck
2. Max. w/cm ratio is not exceeded
3. After adding water (adjusting slump), turn drum at mixing speed for 30 revolutions (min)

DO NOT RETEMPER!

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WYDOT On-site Mix Adjustments

(SSRBC 414.10.3 & 513.4.9.4)

- Do not add water while hauling
- Accurately meter added water
- Do not exceed allowable w/cm ratio
- Mix for at least 30 additional revolutions
- Only 2 on-site mix adjustments allowed (water, admixture if approved)
- Adjust while concrete still plastic & within 45 minutes of initial mixing
- Do not re-dose partial loads
- Do not add water to concrete that has started to set
- Engineer may approve adding on-site admixtures for slump & air
- Add admixtures in accordance with manufacturer's recommendations
- Adjusting mix does not increase allowable placing time limits
- Do not use air reducing admixtures
- Document all re-dosing actions on batch ticket & placing report

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