

# Section 4

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



**WMTG Concrete Training & Certification Seminar**

# 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

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

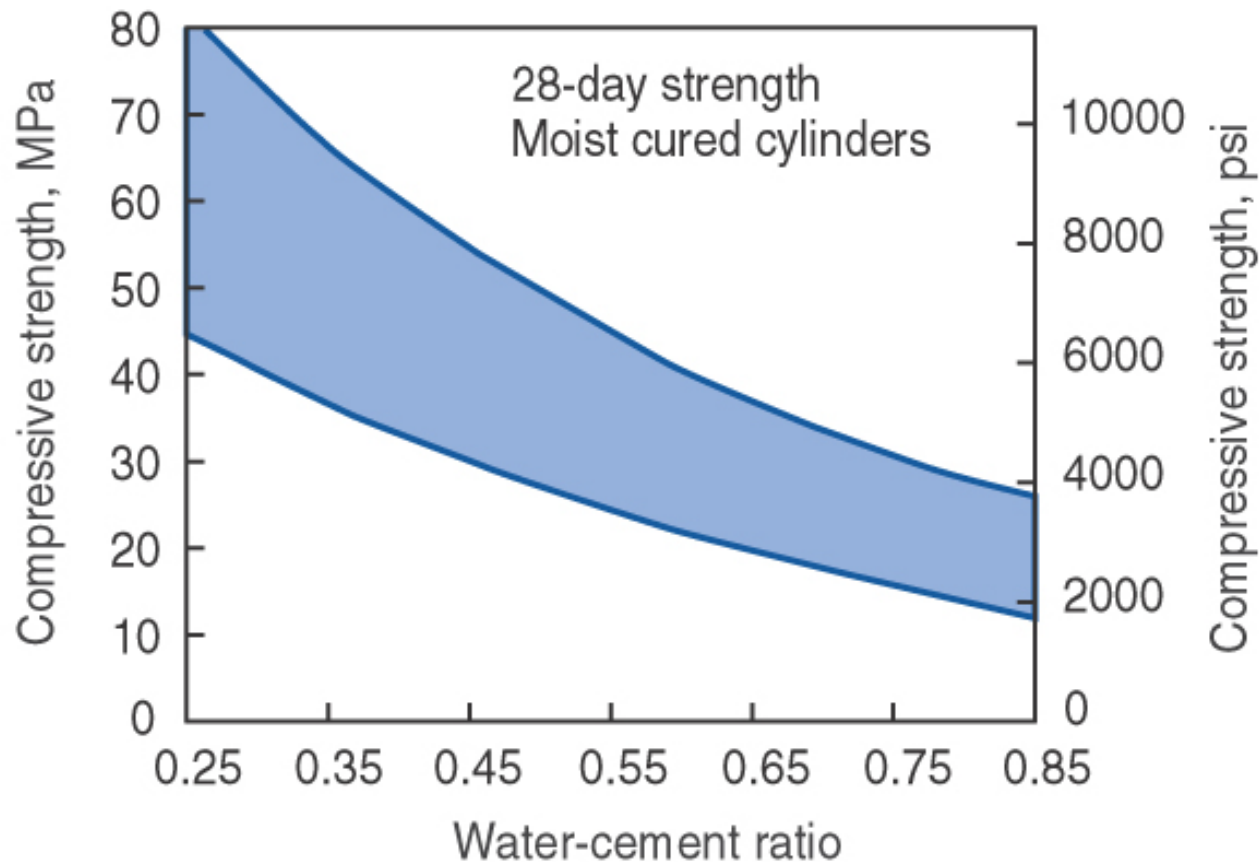
Minimum w/cm for hydration .... about 0.25

Practical minimum ... about 0.35 for workability without admixtures

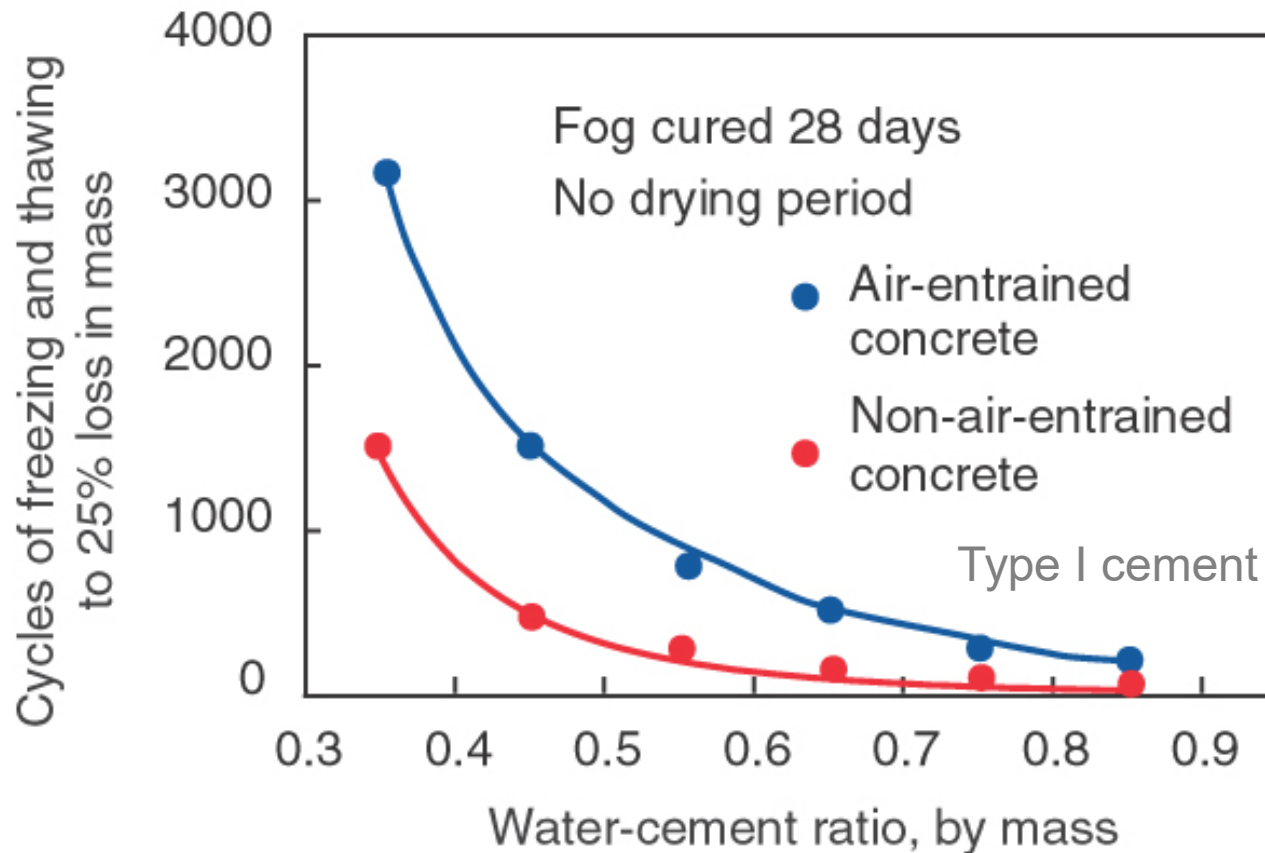
WYDOT w/cm ratios  
(SSRBC 414.4.7 & 513.4.4)

Structural	0.45
Pavement	0.45

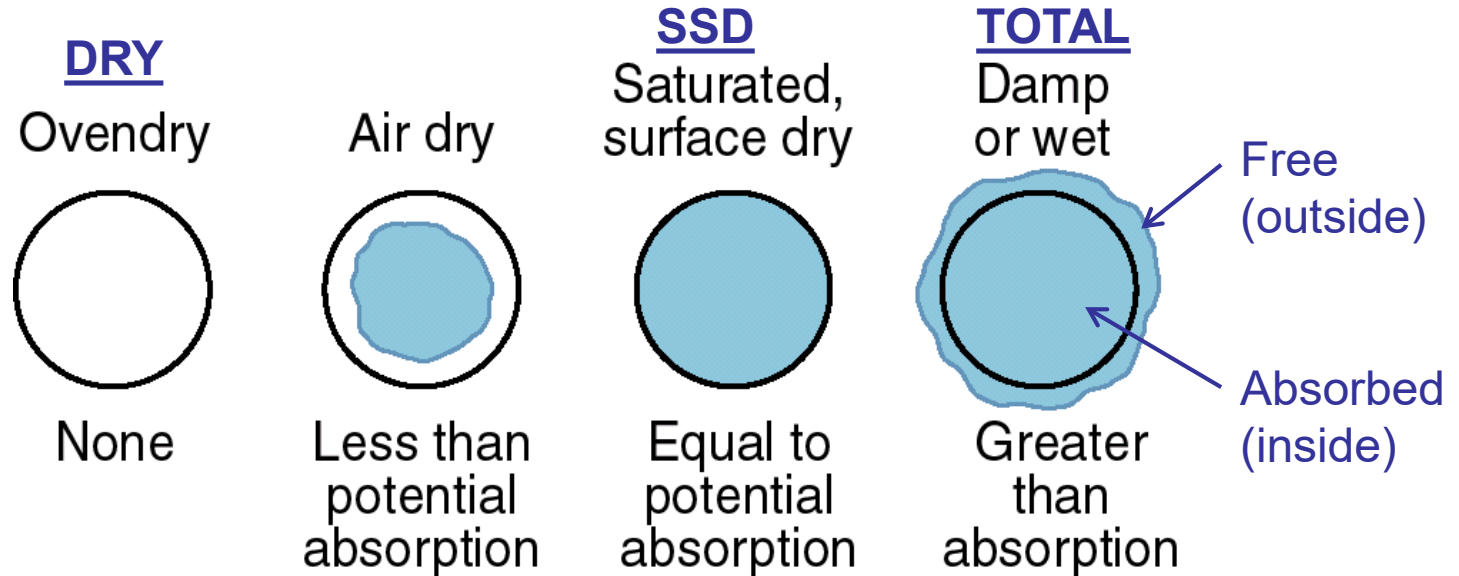
# Typical Relationships of Strength to w/cm Ratio



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



# Aggregate Absorption & Surface Moisture



**Total Moisture = Absorbed + Free (Net) Moisture**

**Free (Net) Moisture = Total – Absorbed Moisture**

# Total Moisture = Absorbed Moisture + Free Moisture

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

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

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

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

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

**% 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.*

# % Total Moisture

**Total Wt of Water = Wet Wt of Agg. - Dry Wt of Agg.**

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

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



# Example #1

## Mix Design

588 lbs Cement

1181 lbs Sand (dry)

1781 lbs Rock (dry)

1 gal water = 8.34 lbs

1.482 % Absorption

2.0% Moisture Content

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

# 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*

# w/cm ratio example ...

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

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

# 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?**

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**

$$\text{Max Total Water} = 0.45 \times 588 \text{ lbs/cy} = 264.60 \text{ lbs/cy}$$

$$\text{Max water that can be added} = 264.60 - 225.97 = 38.63 \text{ lbs/cy}$$

$$\text{Or } \frac{38.63 \text{ lbs/cy}}{8.34 \text{ lbs/gal}} = 4.63 \text{ gal/cy}$$

# OK to adjust slump if ...

1. Not more than  $\frac{1}{4}$  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!**

# 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