

# Water-Cementitious Materials Ratio for Concrete to Receive a Trowel Finish

## ASCC Position Statement #46

The ACI 318-19 Building Code, Table 19.23.2.1, requires a maximum water-cementitious materials ratio ( $w/cm$ ) for concrete in accordance with the severity of the anticipated exposure of members for each exposure category:

- Freezing and thawing (F);
- Sulfate (S);
- In contact with water (W); and
- Corrosion protection of reinforcement (C)

The  $w/cm$  specified in the Code varies from N/A (not applicable) to 0.55, 0.50, 0.45, and 0.40, depending on the severity of the exposure. Interior concrete to receive a trowel finish is rarely anticipated to be in an exposure category for which the Code limits the maximum  $w/cm$ . Unfortunately, many specifications require a maximum  $w/cm$  for interior concrete, often as low as 0.40, which results in undesirable consequences for the surface finish.

Some specifiers believe that a low  $w/cm$  increases abrasion resistance to forklift traffic and results in a faster drying time for concrete to receive a moisture-sensitive floor covering.

Kettle and Sadegzadeh (“Influence of Construction Procedures on Abrasion Resistance,” SP-100: *Concrete Durability*, 1987, pp. 1385-1410) showed that repeated power troweling resulted in greater abrasion resistance and decreased the influence of the mixture design by providing a lower surface water-cement ratio ( $w/c$ ) due to the troweling.

ACI 302.2R-06, “Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials,” Section 9.4, recommends  $w/cm$  of 0.50 as the best compromise between drying rate and finishing performance. Further, specifying a maximum  $w/cm$  for adequate concrete workability is not useful, as stated in ACI 302.1R-15, “Guide to Concrete Floor and Slab Construction,” Section 8.4.4: “The amount of water needed to produce a workable mixture is generally determined by the characteristics of the combined aggregate material used in the mixture and is not effectively controlled by specifying  $w/cm$ .” And specifying a maximum  $w/cm$  may be harmful, as stated in NRMCA Publication 2PE004-21, “Guide to Improving Specifications for Ready Mixed Concrete,” Section 2.11: “Including a maximum  $w/cm$  for concrete where it is not essential can adversely affect the ability to place and finish concrete and the concrete performance because of possibly increased paste content, elevated concrete temperature, and increased propensity for cracking.”

If  $w/cm$  must be specified, ACI 302.1R-15, Section 8.4.4, recommends a  $w/cm$  in the range of 0.47 to 0.55 for

concrete floors to receive a trowel finish. However, concretes with the same specified strength but with a different  $w/cm$  will not have identical workability and finishability. For example, consider the difference in water content for the concrete with a compressive strength,  $f_c$ , of 4000 psi (28 MPa), which contains 500 lb/yd<sup>3</sup> (297 kg/m<sup>3</sup>) of total cementitious materials, with a  $w/cm$  of 0.40 and 0.50. The water contents are 24 and 30 gal./yd<sup>3</sup> (119 and 149 L/m<sup>3</sup>), respectively. The 6 gal./yd<sup>3</sup> (30 L/m<sup>3</sup>) difference can dramatically affect concrete placing and finishing properties.

In addition, ACI 302.1R-15, Section 8.3, states that for troweled concrete, “a minimum amount of water is required to produce a workable, finishable mixture with predictable uniform setting characteristics. Currently available water-reducing admixtures perform best when they are mixed with concrete that has enough water to produce a water-induced slump of 3 to 4 in. [75 to 100 mm] if no admixture was added. If this water slump is not achievable with the admixture, setting times and finishability can vary when the concrete is subjected to normal variations of ambient temperature and time between batching and discharge. The slump envelope results in predictable setting times and the required sequence of finishing operations.”

Often, ready mixed concrete producers will hold back water during batching, and they will indicate the amount on the batch ticket. While reducing the water content results in a higher compressive strength, it does not, however, provide concrete with predictable setting times or consistent finishing. The practice of holding back water must be discussed at the concrete preconstruction meeting, as this practice can result in an undesirable surface finish on concrete that is to receive a trowel finish.

Adding water on site must also be discussed as ASTM C94/C94M-21b, “Standard Specification for Ready-Mixed Concrete,” Section 12.7, allows water to be added if water is held back during batching or to not exceed the maximum  $w/cm$ . If water is required after the maximum  $w/cm$  has been reached, ACI 302.1R-15, Section 9.2.1, recommends that it “should be done with an ASTM C494/C494M Type A or Type F admixture. Care should be taken in using these materials, as they may affect the setting or finishing characteristics of the concrete. The added fluidity can also affect the air content of the concrete and create air contents in excess of the normal 2 to 3 percent entrained air contents in the absence of air-entraining agents... The sequence of addition of admixtures and cementitious materials can impact the properties of concrete.”

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ASCC concrete contractors encourage specifiers to consider recommendations provided in ACI 302.1R-15 and ACI 302.2R-06 for *w/cm* for concrete to receive a trowel finish. ASCC concrete contractors will work with the owner, design team, construction manager/general contractor, testing agency, and ready mixed suppliers to assist in avoiding surface finish issues as a result of low *w/cm* concretes.

If you have questions, contact your ASCC concrete contractor or the ASCC Technical Hotline at (800) 331-0668.

