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Guide for Selecting Proportions for No-Slump Concrete

Reported by ACI Committee 211

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This guide is intended as a supplement to ACI 211.1. A procedure is presented for proportioning concrete that has slumps in the range of zero to 25 mm (1 in.) and consistencies below this range, for aggregates up to 75 mm (3 in.) maximum size. Suitable equipment for measuring such consistencies is described. Tables and charts similar to those in ACI 211.1 are provided which, along with laboratory tests on physical properties of fine and coarse aggregate, yield information for obtaining concrete proportions for a trial mixture.

This document also includes appendixes on proportioning mixtures for roller-compacted concrete, concrete roof tile, concrete masonry units, and pervious concrete for drainage purposes. Examples are provided as an aid in calculating proportions for these specialty applications.

Keywords: durability; mixture proportioning; no-slump concrete; roller-compacted concrete; slump test; water-cementitious materials ratio.

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ACI 211.3R-02 supersedes ACI 211.3R-97 and became effective January 11, 2002.

CHAPTER 1—SCOPE AND LIMITS

ACI 211.1 provides methods for proportioning concrete with slumps greater than 25 mm (1 in.) as measured by ASTM C 143/C 143M. This guide is an extension of ACI 211.1 and addresses the proportioning of concrete having slump in the range of zero to 25 mm (1 in.).

The paired values stated in inch-pound and SI units are the results of conversions that reflect the intended degree of accuracy. Each system is used independently of the other in the examples. Combining values from the two systems may result in nonconformance with this guide.

In addition to the general discussion on proportioning no-slump concrete, this guide includes proportioning procedures for these classes of no-slump concrete: roller-compacted concrete (Appendix 3); roof tiles (Appendix 4); concrete masonry units (CMU) (Appendix 5); and pervious concrete (Appendix 6).

CHAPTER 2—PRELIMINARY CONSIDERATIONS

2.1—General

The general comments contained in ACI 211.1 are pertinent to the procedures discussed in this guide. The description of the constituent materials of concrete, the differences in proportioning the ingredients, and the need for knowledge of the physical properties of the aggregate and cementitious materials apply equally to this guide. The level of overdesign indicated in ACI 301 and ACI 318/318R should be applied to the compressive strength used for proportioning.

2.2—Methods for measuring consistency

Workability is the property of concrete that determines the ease with which it can be mixed, placed, consolidated, and finished. No single test is available that will measure this property in quantitative terms. It is usually expedient to use some type of consistency measurement as an index to workability. Consistency may be defined as the relative ability of freshly mixed concrete to flow. The slump test is the most familiar test method for consistency and is the basis for the measurement of consistency under ACI 211.1.

Table 2.1—Comparison of consistency measurements for slump and Vebe apparatus

Consistency description	Slump, mm	Slump, in.	Vebe, s
Extremely dry	—	—	32 to 18
Very stiff	—	—	18 to 10
Stiff	0 to 25	0 to 1	10 to 5
Stiff plastic	25 to 75	1 to 3	5 to 3
Plastic	75 to 125	3 to 5	3 to 0
Very plastic	125 to 190	5 to 7-1/2	—

Table 2.2—Approximate relative water content for different consistencies

	Approximate relative water content, %	
Consistency description	Thaulow[5]	Table 6.3.3, ACI 211.1
Extremely dry	78	—
Very stiff	83	—
Stiff	88	—
Stiff plastic	93	92
Plastic	100	100
Very plastic	106	106

No-slump concrete will have poor workability if consolidated by hand-rodding. If vibration is used, however, such concrete might be considered to have adequate workability. The range of workable mixtures can therefore be widened by consolidation techniques that impart greater energy into the mass to be consolidated. The Vebe apparatus,[1,2] the compacting factor apparatus,[3] the modified compaction test, and the Thaulow drop table[4] are laboratory devices that can provide a useful measure of consistency for concrete mixtures with less than 25 mm (1 in.) slump. Of the three consistency measurements, the Vebe apparatus is frequently used today in roller-compacted concrete and will be referred to in this guide. The Vebe test is described in Appendix 2. If none of these methods are available, consolidation of the trial mixture under actual placing conditions in the field or laboratory will, of necessity, serve as a means for determining whether the consistency and workability are adequate. Suitable workability is often based on visual judgement for machine-made precast concrete products.

A comparison of Vebe test results with the conventional slump test is shown in Table 2.1. Note that the Vebe test can provide a measure of consistency in mixtures termed "extremely dry." Vebe time at compaction is influenced by other factors such as moisture condition of aggregates, time interval after mixing, and climatic conditions.

2.3—Mixing water requirement

In ACI 211.1, approximate relative mixing water requirements are given for concrete conforming to the consistency descriptions of stiff plastic, plastic, and very plastic, as shown in Table 2.2 of this guide. Considering the water requirement for the 75 to 100 mm (3 to 4 in.) slump as 100%, the relative water contents for those three consistencies are 92, 100, and 106%, respectively. Thaulow[5] extended this concept of relative water contents to include stiffer mixtures, as shown in Table 2.2.

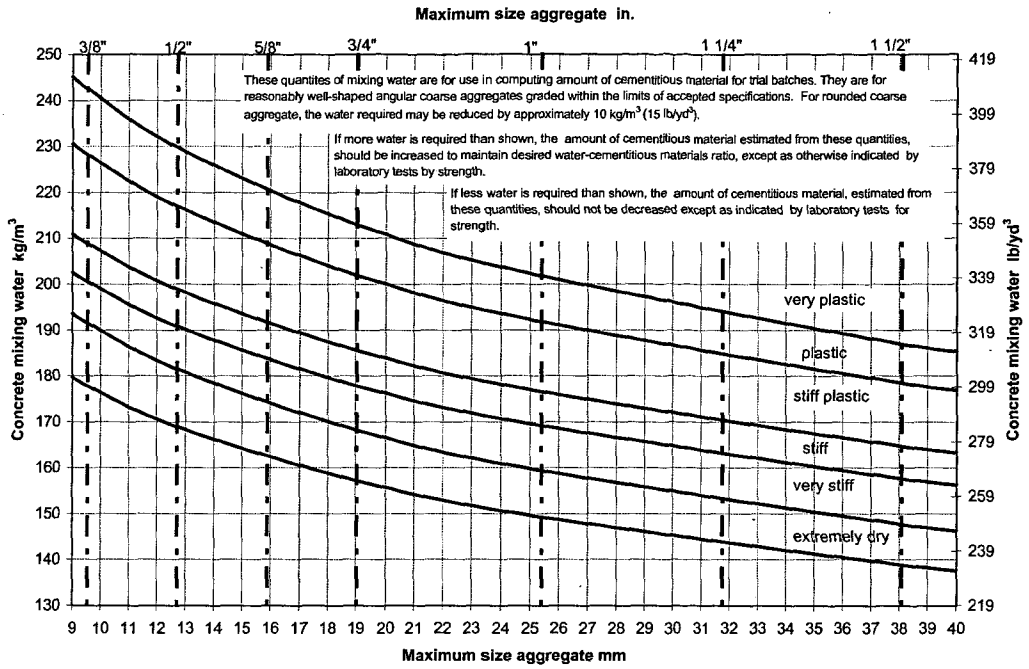

Fig. 2.1—Approximate mixing water requirements for different consistencies and maximum-size aggregate for nonair-entrained concrete.

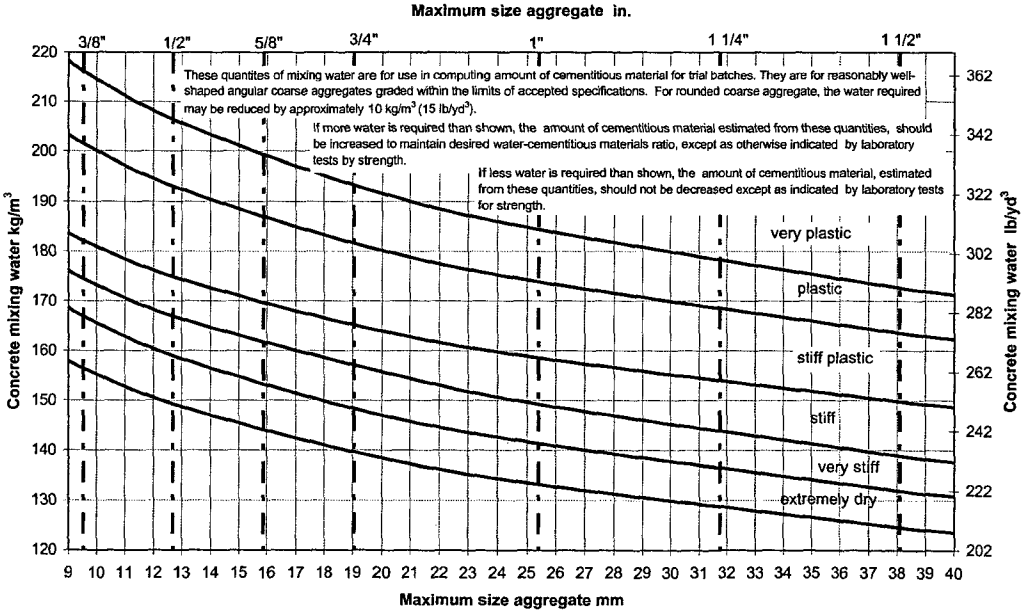

Fig. 2.2—Approximate mixing water requirements for different consistencies and maximum-size aggregate for air-entrained concrete.

Figures 2.1 and 2.2 have been prepared based on the results from a series of laboratory tests in which the average air contents were as indicated in Fig. 2.3. These tests show that the factors in Table 2.2 need to be applied to the quantities given in ACI 211.1 to obtain the approximate water content for the six consistency designations. Approximate relative mixing water requirements are given in kg/m^3 (lb/yd^3) using the relative water contents shown by Thaulow[5] for the stiff, very stiff, and extremely dry consistencies. For a given combination of materials, a number of factors will affect the actual mixing water requirement and can result in a considerable difference from the values shown in Fig. 2.1 and 2.2. These factors include particle shape and grading of the aggregate, air content and temperature of the concrete, the effectiveness of mixing, chemical admixtures, and the method of consolidation. With respect to mixing, for example, spiral-blade and pan-type mixers are more effective for no-slump concretes than are rotating-drum mixers.