

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 211.1 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

Consistency description	Approximate relative water content, %	
	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 table⁴ 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. Thaulow⁵ extended this concept of relative water contents to include stiffer mixtures, as shown in Table 2.2.

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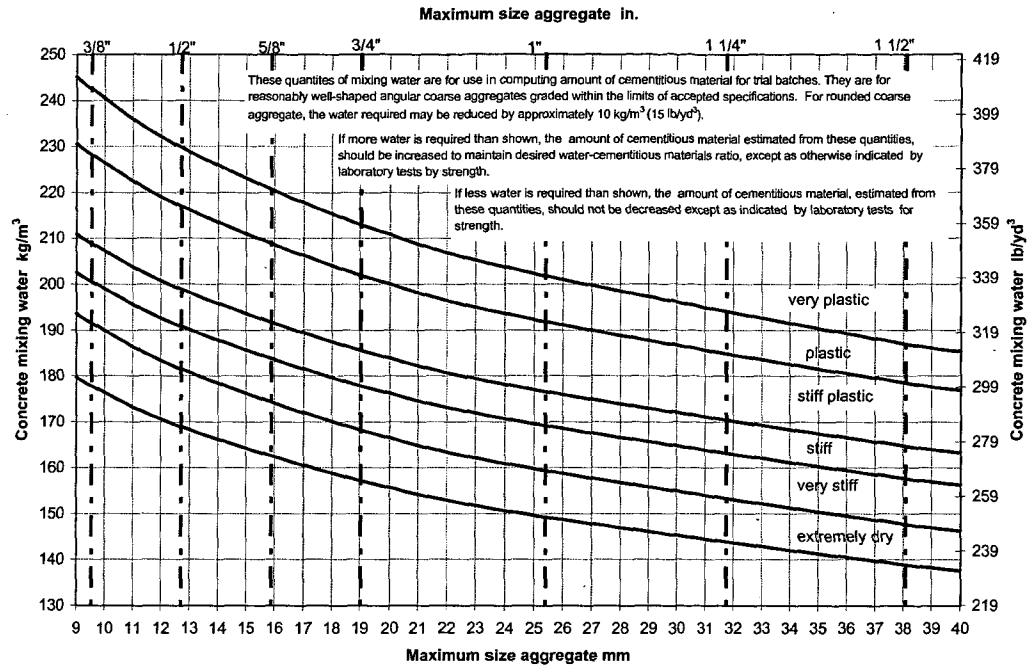


Fig. 2.1—Approximate mixing water requirements for different consistencies and maximum-size aggregate for nonair-entrained concrete.

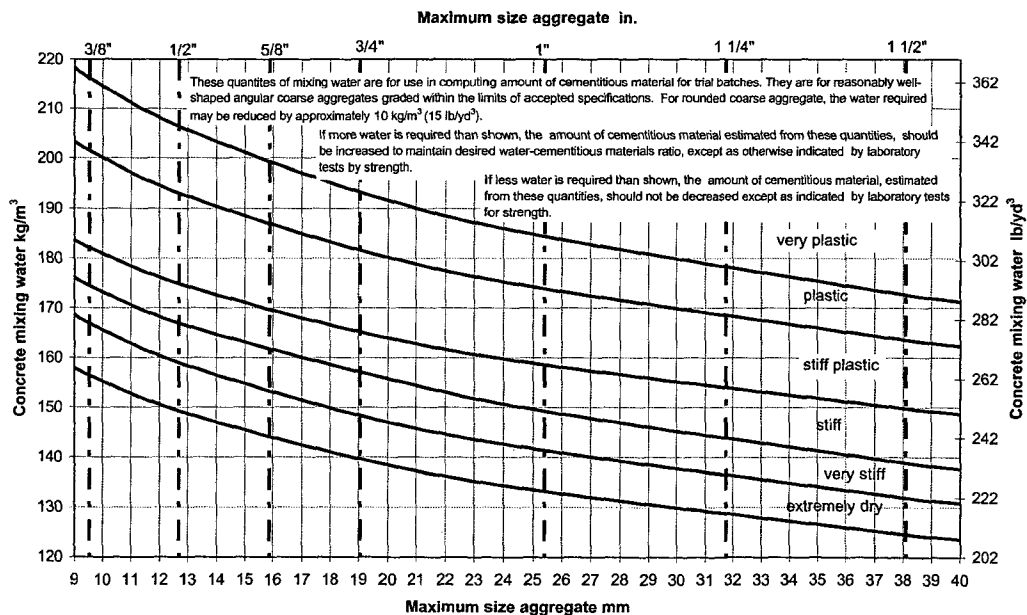


Fig. 2.2—Approximate mixing water requirements for different consistencies and maximum-size aggregate for air-entrained concrete.

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/m³ (lb/yd³) using the relative water contents shown by Thaulow⁵ 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.

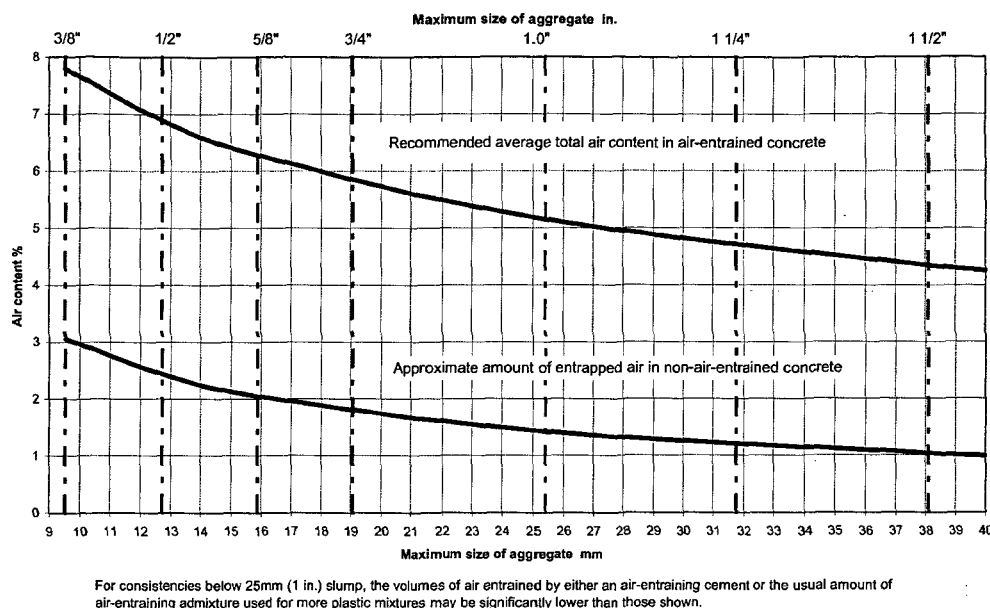


Fig. 2.3—Air content of concrete mixtures for different maximum size aggregate.

CHAPTER 3—SELECTING PROPORTIONS

3.1—General

Cementitious materials include the combined mass of cement, natural pozzolans, fly ash, ground granulated-blast-furnace slag (GGBFS), and silica fume that are used in the mixture.

As recommended in ACI 211.1, concrete should be placed using the minimum quantity of mixing water consistent with mixing, placing, consolidating, and finishing requirements because this will have a favorable influence on strength, durability, and other physical properties. The major considerations in selecting proportions apply equally well to no-slump concretes as to the more plastic mixtures. These considerations are:

- Adequate durability in accordance with ACI 201.2R to satisfactorily withstand the weather and other destructive agents to which it may be exposed;
- Strength required to withstand the design loads with the required margin of safety;
- The largest maximum-size aggregate consistent with economic availability, satisfactory placement, and concrete strength;
- The stiffest consistency that can be efficiently consolidated; and
- Member geometry.

3.2—Slump and maximum-size aggregate

ACI 211.1 contains recommendations for consistencies in the range of stiff plastic to very plastic. These, as well as stiffer consistencies, are included in Fig. 2.1 and 2.2. Consistencies in the very-stiff range and drier are often used in the fabrication of various precast elements such as, pipe, prestressed members, CMU, and roof tiles. Also, roller-compacted and pervious concretes fall into the no-slump categories as discussed in Appendix 3 through 6. There is no apparent justification for setting limits for maximum and minimum consistency in the manufacture of these materials

because the optimum consistency is highly dependent on the equipment, production methods, and materials used. It is further recommended that, wherever possible, the consistencies used should be in the range of very stiff or drier, because the use of these drier consistencies that are adequately consolidated will result in improved quality and a more economical product.

The nominal maximum size of the aggregate to be selected for a particular type of construction is dictated primarily by consideration of both the minimum dimension of a section and the minimum clear spacing between reinforcing bars, prestressing tendons, ducts for post-tensioning tendons, or other embedded items. The largest permissible maximum-size aggregate should be used; however, this does not preclude the use of smaller sizes if they are available and their use would result in equal or greater strength with no detriment to other concrete properties.

For reinforced, precast concrete products such as pipe, the maximum coarse aggregate size is generally 19 mm (3/4 in.) or less.

3.3—Estimating water and aggregate-grading requirements

The quantity of water per unit volume of concrete required to produce a mixture of the desired consistency is influenced by the maximum size, particle shape, grading of the aggregate, and the amount of entrained air. It is relatively unaffected by the quantity of cementitious material below about 360 to 390 kg/m³ (610 to 660 lb/yd³). In mixtures richer than these, mixing water requirements can increase significantly as cementitious materials contents are increased. Acceptable aggregate gradings are presented in ASTM C 33 and AASHTO M 6 and M 80.

Aggregate grading is an important parameter in selecting proportions for concrete in machine-made precast products such as pipes, CMU, roof tile, manholes, and prestressed products. Forms for these products are removed immediately after the concrete is placed and consolidated, or the concrete

is placed by an extrusion process. In either case, the concrete has no external support immediately after placement and consolidation; therefore, the fresh concrete mixture should be cohesive enough to retain its shape after consolidation. Cohesiveness is achieved by providing sufficient fines in the mixtures. Some of these fines can be obtained by careful selection of the fine aggregate gradings. Pozzolans, such as fly ash, have also been used to increase cohesiveness. In some cases, the desired cohesiveness can be improved by increasing the cementitious materials content. This approach is not recommended, however, because of negative effects of excessive cementitious materials such as greater heat of hydration and drying shrinkage.

The quantities of water shown in Fig. 2.1 and 2.2 of this guide are sufficiently accurate for preliminary estimates of proportions. Actual water requirements need to be established in laboratory trials and verified by field tests. This should result in water-cementitious materials ratios (w/cm) in the range of 0.25 to 0.40 or higher. Examples of such adjustments are given further in this guide.

For machine-made, precast concrete products such as pipes and CMU, the general rule is to use as much water as the product will tolerate without slumping or cracking when the forms are stripped.

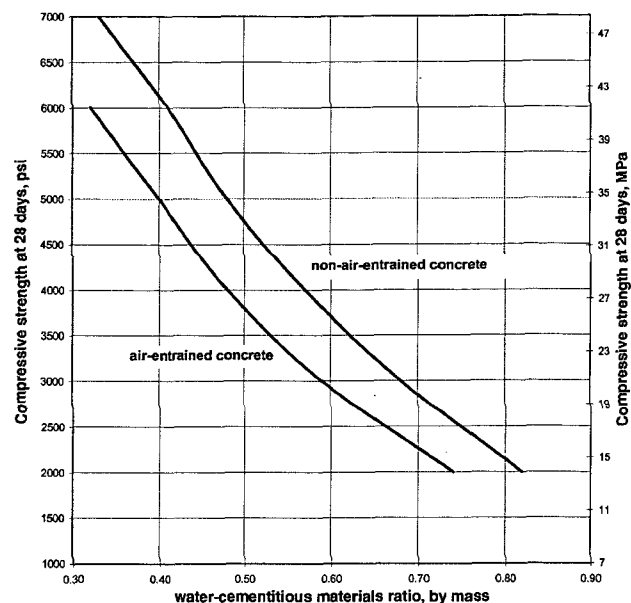
3.4—Selecting water-cementitious materials ratio

The selection of w/cm depends on the required strength. Figure 3.1 provides initial information for w/cm . The compressive strengths are for 150 x 300 mm (6 x 12 in.) cylinders, prepared in accordance with ASTM C 192, subjected to standard moist curing, and tested at 28 days in accordance with ASTM C 39 for the various ratios. The required w/cm to achieve a desired strength depends on whether the concrete is air-entrained.

Using the maximum permissible w/cm from Fig. 3.1 and the approximate mixing water requirement from Fig. 2.1 and 2.2, the cementitious material content can be calculated by dividing the mass of water needed for mixing by the w/cm . If the specifications for the job contain a minimum cementitious material content requirement, the corresponding w/cm for estimating strength can be computed by dividing the mass of water by the mass of the cementitious material. The lowest of the three w/cm —those for durability, strength, or cementitious material content—should be selected for calculating concrete proportions.

Air-entraining admixtures or air-entraining cements can be beneficial in ensuring durable concrete in addition to providing other advantages, such as reduction in the mixture harshness with no increase in water. Air-entrained concrete should be used when the concrete products are expected to be exposed to frequent cycles of freezing and thawing in a moist, critically saturated condition. ASTM C 666 testing before construction is recommended to assess resistance to freezing-and-thawing characteristics of the no-slump concrete. If these no-slump concrete mixtures may be exposed to deicer salts, they should also be tested in accordance with ASTM C 666.

Figure 3.1 is based on the air contents shown in Fig. 2.3. In Fig. 3.1 at equal w/cm , the strengths for the air-entrained



Values are estimated average strengths for concrete containing not more than the percentage of air shown in Fig. 2.3. For a constant water-cementitious materials ratio, the strength of concrete is reduced as the air content is increased. Strength is based on 150 x 300 mm (6 x 12 in.) cylinders prepared in accordance with ASTM C 31/31M and moist-cured 28 days at $23 \pm 1.7^\circ\text{C}$ ($73.4 \pm 3^\circ\text{F}$). Relationship assumes maximum size aggregate about 19 to 25 mm ($3/4$ to 1 in.) for a given source; strength produced for a given water-cementitious materials ratio will increase as maximum size of aggregate decreases.

Fig. 3.1—Relationships between water-cementitious materials ratio and compressive strength of concrete.

concrete are approximately 20% lower than for the nonair-entrained concrete. These differences may not be as great in the no-slump mixtures because the volume of entrained air in these mixtures using an air-entraining cement, or the usual amount of air-entraining admixture per unit of cementitious material, will be reduced significantly with practically no loss in resistance to freezing and thawing and density. In addition, when cementitious material content and consistency are constant, the differences in strength are partially or entirely offset by reduction of mixing water requirements that result from air entrainment.

The required average strength necessary to ensure the strength specified for a particular job depends on the degree of control over all operations involved in the production and testing of the concrete. See ACI 214 for a complete guide. If flexural strength is a requirement rather than compressive strength, the relationship between w/cm and flexural strength should be determined by laboratory tests using the job materials.

3.5—Estimate of coarse aggregate quantity

The largest quantity of coarse aggregate per unit volume of concrete should be used and be consistent with adequate placeability. For the purpose of this document, placeability is defined as the ability to adequately consolidate the mixture with the minimum of physical and mechanical time and effort. For a given aggregate, the amount of mixing water required will then be at a minimum and strength at a maximum. This quantity of coarse aggregate can best be determined from laboratory investigations using the materials for the intended work with later adjustment if the materials for the

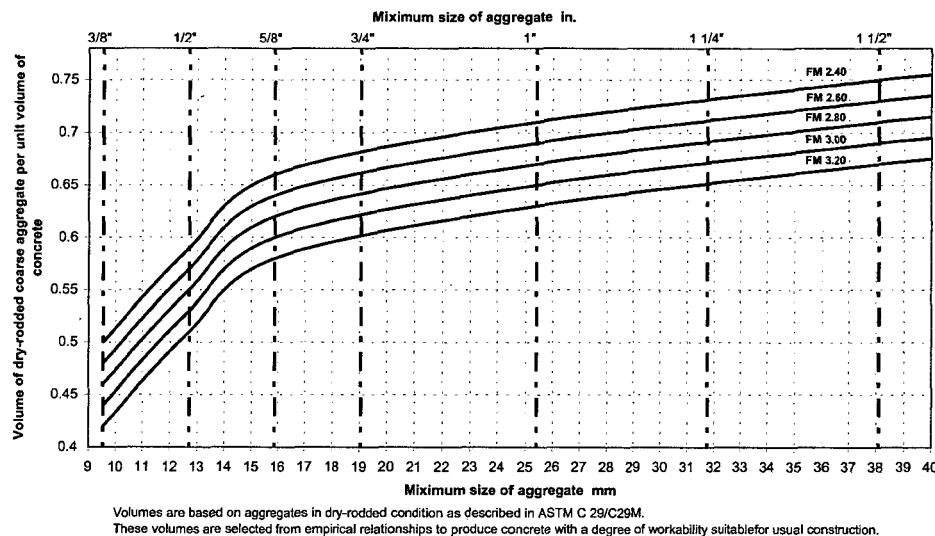


Fig. 3.2—Volume of coarse aggregate per unit volume of concrete of plastic consistency (75 to 125 mm [3 to 5 in.] slump).

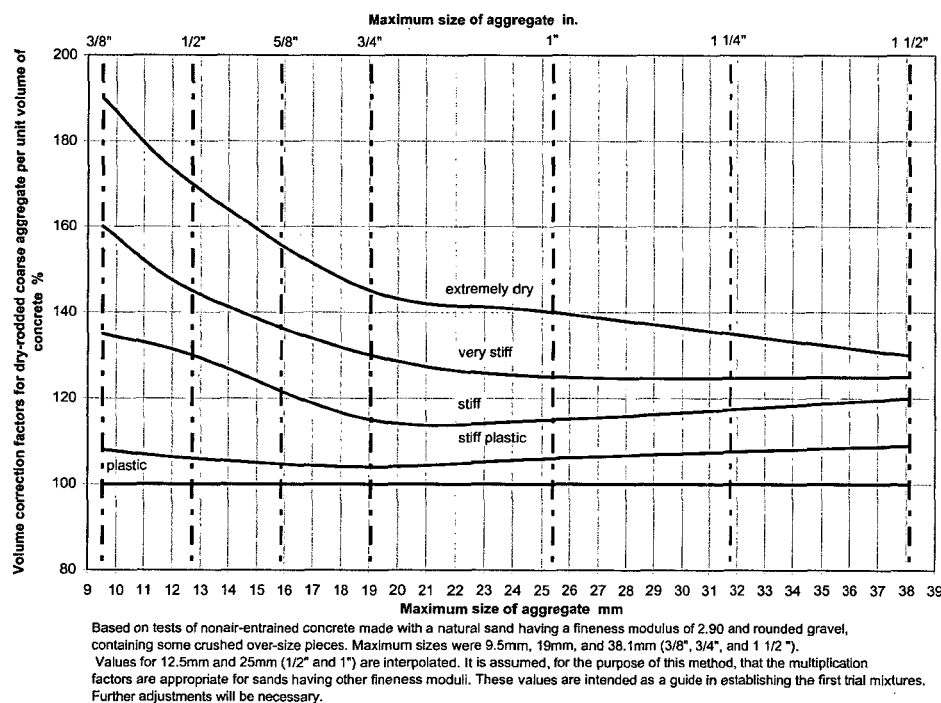


Fig. 3.3—Volume correction factors for dry-rodded coarse aggregate for concrete of different consistencies.

If such data are not available or cannot be obtained, Fig. 3.2 provides a good estimate of the amount of coarse aggregate for various concrete having a degree of workability suitable for usual reinforced concrete construction (approximately 75 to 100 mm [3 to 4 in.] slump). These values of dry-rodded volume of coarse aggregate per unit volume of concrete are based on established empirical relationships for aggregates graded within conventional limits. Changes in the consistency of the concrete can be affected by changing the amount of coarse aggregate per unit volume of concrete. As greater amounts of coarse aggregate per unit volume are

used, the consistency will decrease. For the very plastic and plastic consistencies, the volume of coarse aggregate per unit volume of concrete is essentially unchanged from that shown in Fig. 3.2. For the stiffer consistencies—those requiring vibration—the amount of coarse aggregate that can be accommodated increases rather sharply in relation to the amount of fine aggregate required. Figure 3.3 shows some typical values of the volume of coarse aggregate per unit volume of concrete for different consistencies, expressed as a percentage of the values shown in Fig. 3.2. The information contained in these two figures provides a basis for selecting

an appropriate amount of coarse aggregate for the first trial mixture. Adjustments in this amount will probably be necessary in the field or plant operation.

In precast concrete products where cohesiveness is required to retain the concrete shape after the forms are stripped, the volume of coarse aggregate can be reduced somewhat from the values indicated in Fig. 3.2. The degree of cohesiveness required depends on the particular process used to make the concrete product. Uniformly graded aggregate is important in precast concrete pipe; therefore, blends of two or more coarse aggregates are frequently used.

Concrete of comparable workability can be expected with aggregates of comparable size, shape, and grading when a given dry-rodded volume of coarse aggregate per unit volume of concrete is used. In the case of different types of aggregates, particularly those with different particle shapes, the use of a fixed dry-rodded volume of coarse aggregate automatically makes allowance for differences in mortar requirements as reflected by void content of the coarse aggregate. For example, angular aggregates have a higher void content, and therefore, require more mortar than rounded aggregates.

This aggregate-estimating procedure does not reflect variations in grading of coarse aggregates within different maximum-size limits, except as they are reflected in percentages of voids. For coarse aggregates falling within the limits of conventional grading specifications, this omission probably has little importance. The optimum dry-rodded volume of coarse aggregate per unit volume of concrete depends on its maximum size and the fineness modulus of the fine aggregate as indicated in Fig. 3.2.

CHAPTER 4—PROPORTIONING COMPUTATIONS (SI UNITS)

4.1—General proportioning criteria

Computation of proportions will be explained by one example. The following criteria are assumed:

- The cement specific gravity is 3.15;
- Coarse and fine aggregates in each case are of satisfactory quality and are graded within limits of generally accepted specifications such as ASTM C 33 and C 331;
- The coarse aggregate has a specific gravity, bulk oven dry, of 2.68, and an absorption of 0.5%; and
- The fine aggregate has a specific gravity, bulk oven dry, of 2.64, an absorption of 0.7%, and fineness modulus of 2.80.

4.2—Example of proportioning computations

Concrete is required for an extruded product in northern France that will be exposed to severe weather with frequent cycles of freezing and thawing. Structural considerations require it to have a design compressive strength of 30 MPa at 28 days. From previous experience in the plant producing similar products, the expected coefficient of variation of strengths is 10%. It is further required that no more than one test in 10 will fall below the design strength of 30 MPa at 28 days. From Fig. 4.1(a) of ACI 214, the required average strength at 28 days should be 30 MPa $\times$ 1.15, or 35 MPa. The size of the section and spacing of reinforcement are such that a nominal maximum-size coarse aggregate of 40 mm, graded

to 4.75 mm, can be used and is locally available. Heavy internal and external vibration are available to achieve consolidation, enabling the use of very stiff concrete. The dry-rodded density of the coarse aggregate is 1600 kg/m³. Because the exposure is severe, air-entrained concrete will be used. The proportions may be computed as follows:

From Fig. 3.1, the *w/cm* required to produce an average 28-day strength of 35 MPa in air-entrained concrete is shown to be approximately 0.40 by mass.

The approximate quantity of mixing water needed to produce a consistency in the very stiff range in air-entrained concrete made with 40 mm nominal maximum-size aggregate is 130 kg/m³ (Fig. 2.2). In Fig. 2.3, the required air content for the more plastic mixture is indicated to be 4.5%, which will be produced by using an air-entraining admixture. An air-entraining admixture, when added at the mixer as liquid, should be included as part of the mixing water. The note to the figure calls attention to the lower air contents entrained in stiffer mixtures. For this concrete, assume the air content to be 3.0% when the suggestions in the note are followed.

From the preceding two paragraphs, it can be seen that the required cementitious material is 130/0.40 = 325 kg/m³. Only portland cement will be used.

Figure 3.2, with a nominal maximum-size aggregate of 40 mm and a fineness modulus of sand of 2.80, 0.71 m³ of coarse aggregate on a dry-rodded basis, would be required in each cubic meter of concrete having a slump of about 75 to 100 mm.

In Fig. 3.3, for the very stiff consistency desired, the amount of coarse aggregate should be 125% of that for the plastic consistency, or 0.71 $\times$ 1.25 = 0.89 m³. The quantity in a cubic meter will be 0.89 m³, which in this case is 0.89 m³ $\times$ 1600 kg/m³ = 1424 kg.

With the quantities of cement, water, coarse aggregate, and air established, the sand content is calculated as follows:

Solid volume of cement	=	$\frac{325}{3.15 \times 1000}$	= 0.103 m ³
Volume of water	=	$\frac{130}{1000}$	= 0.130 m ³
Solid volume of coarse aggregate	=	$\frac{1424}{2.68 \times 1000}$	= 0.531 m ³
Volume of air	=	1 $\times$ 0.030	= 0.030 m ³
Total volume of ingredients except sand			= 0.794 m ³
Solid volume of sand required	=	1 - 0.794	= 0.206 m ³
Required mass of oven-dry sand	=	0.206 $\times$ 2.64 $\times$ 1000	= 544 kg
Water absorbed by oven-dry aggregates	=	(544 $\times$ 0.007) + (1424 $\times$ 0.005)	= 11 kg



Table 4.1—Comparison between computed batch quantities and those used in production

Ingredients	Batch quantities of concrete per cubic meter	
	Computed, kg	Used in production, kg
Cement	325	325
Net mixing water	130	130
Sand	544 (oven dry)	571 (moist)
Coarse aggregate	1424 (oven dry)	1438 (moist)
Water absorbed	11	—
Excess water	—	–30
Total	2434	2434
Water added at mixer	141	100

The estimated batch quantities per cubic meter of concrete are:

Cement	= 325 kg
Water	= 141 kg (130 + 11)
Sand, oven-dry	= 544 kg
Coarse aggregate, oven-dry	= 1424 kg
Air-entraining admixture	= (as required) for 3% air

4.3—Batching quantities for production-size batching

For the sake of convenience in making trial mixture computations, the aggregates have been assumed to be in an oven-dry state. Under production conditions, they generally will be moist and the quantities to be batched into the mixer should be adjusted accordingly.

With the batch quantities determined in the example, assume that tests show the sand to contain 5.0% and the coarse aggregate 1.0% total moisture. Because the quantity of oven-dry sand required was 544 kg, the amount of moist sand to be weighed out should be $544 \text{ kg} \times 1.05 = 571 \text{ kg}$. Similarly, the amount of moist, coarse aggregate should be $1424 \times 1.01 = 1438 \text{ kg}$.

The free water in the aggregates, in excess of their absorption, should be considered as part of the mixing water. Because the absorption of sand is 0.7%, the amount of free water which it contains is $5.0 - 0.7 = 4.3\%$. The free water in the coarse aggregate is $1.0 - 0.5 = 0.5\%$. Therefore, the mixing water contributed by the sand is $0.043 \times 544 = 23 \text{ kg}$ and that contributed by the coarse aggregate is $0.005 \times 1424 = 7 \text{ kg}$. The quantity of mixing water to be added is $130 - (23 + 7) = 100 \text{ kg}$. Table 4.1 shows a comparison between the computed batch quantities and those to be used in the field for each cubic meter of concrete. The actual quantities used during production will vary because it depends on the moisture contents of the stockpiled aggregates which will vary.

The preceding trial mixture computations provide batch quantities for each ingredient of the mixture per cubic meter of concrete. It is seldom desirable or possible to mix concrete in exactly 1 m^3 batches. It is therefore necessary to convert these quantities in proportion to the batch size to be used. Let it be assumed that a 0.55 m^3 capacity mixer is available. Then to produce a batch of the desired size and maintain the same proportions, the cubic meter batch quantities of all ingredients should be reduced quantities to the following quantities:

Cement	= $0.55 \times 325 = 179 \text{ kg}$
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Sand (moist)	= 0.55×571	= 314 kg
Coarse aggregate (moist)	= 0.55×1438	= 791 kg
Water to be added	= 0.55×100	= 55 kg

4.4—Adjustment of trial mixture

The estimate of total water requirement given in Fig. 2.1 and 2.2 may understate the water required. In such cases, the amount of cementitious materials should be increased to maintain the w/cm , unless otherwise indicated by laboratory tests. This adjustment will be illustrated by assuming that the concrete for the example was found in the trial batch to require 135 kg of mixing water instead of 130 kg. Consequently, the cementitious materials content should be increased from 325 to $(135/130) \times 325 = 338 \text{ kg/m}^3$ and the batch quantities recomputed accordingly.

Sometimes less water than indicated in Fig. 2.1 and 2.2 may be required, but it is recommended that no adjustment be made in the amount of cementitious materials for the batch in progress. Strength results may warrant additional batches with less cementitious materials. Adjustment in batch quantities is necessary to compensate for the loss of volume due to the reduced water. This is done by increasing the solid volume of sand in an amount equal to the volume of the reduction in water. For example, assume that 125 kg of water is required instead of 130 kg for the concrete of the example. Then $125/1000$ is substituted for $130/1000$ in computing the volume of water in the batch. This results in 0.005 m^3 less water; therefore, the solid volume of sand becomes $0.206 + 0.005 = 0.211 \text{ m}^3$.

The percentage of air in some no-slump concrete that can be consolidated in the container by vibration can be measured directly with an air meter (ASTM C 231) or it can be computed gravimetrically from measurement of the fresh concrete density in accordance with ASTM C 138. For any given set of conditions and materials, the amount of air entrained is approximately proportional to the quantity of air-entraining admixture used. Increasing the cementitious materials content or the fine fraction of the sand, decreasing slump, or raising the temperature of the concrete usually decreases the amount of air entrained for a given amount of admixture. The grading and particle shape of aggregate also have an effect on the amount of entrained air. The job mixture should not be adjusted for minor fluctuations in w/cm or air content. A variation in w/cm of ± 0.02 , 0.38 to 0.42 in the above example, resulting from maintaining a constant consistency, is considered normal for no-slump concrete where compactability and densification respond better to target values for w/cm . A variation of $\pm 1\%$ in air content is also considered normal. This variation in air content will be smaller in the drier mixtures.

CHAPTER 5—REFERENCES

5.1—Referenced standards and reports

The standards of the various standards producing organizations applicable to this document are listed below with their serial designations. Since some of these standards are revised frequently, generally in minor details only, the user of this document should contact the sponsoring group, if it is desired to refer to the latest document.