ACI 211.8R-15

Guide to Troubleshooting Concrete Mixture Issues as Influenced by Constitutive Materials, Jobsite Conditions, or Testing Practices

Reported by ACI Committee 211

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This guide describes adjustments that can be made to existing proportions for normal-density concrete with and without chemical admixtures, pozzolans, and slag. These adjustments are based on the performance of the concrete mixture as used in construction. The adjustments consider evaluation for placeability, consistency, strength, and durability. The procedures used in making these adjustments can be found in ACI 211.1. Adjustments to concrete mixture proportions or sources may require resubmittal to the design professional as detailed in ACI 301. This guide also provides information regarding jobsite conditions and testing practices that should be evaluated before adjustments are made to the mixture.

Keywords: admixtures; aggregates; cementitious materials; durability; fine aggregates; fly ash; metakaolin; mixture proportioning; pozzolans; quality; silica fume; slag; slag cement; slump tests; water-cementitious material ratio.

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

This document provides guidance for evaluating the performance of concrete mixture proportions and making adjustments during the construction process as well as identifying construction or testing issues that can be wrongfully attributed to mixture proportioning. Adjustments to the mixture proportions or materials in the production process may be needed to accommodate variations in materials, changes in climatic conditions, consistency or yield of the mixture, and deficiencies in the fresh or hardened concrete properties.

1.2—Scope

ACI 211.1 provides methods for selecting proportions for concrete mixtures. Concrete may require adjustments to the mixture proportions throughout the course of the project due to the normal variation of the materials used in production, and the various conditions under which it will be delivered, placed, consolidated, and finished. The concrete properties required in the hardened state may also require adjustments to the mixture proportions. It is important to note that no document can replace experience with the materials at hand when deciding what adjustments need to be made for a concrete mixture.

CHAPTER 2—DEFINITIONS

ACI provides a comprehensive list of definitions through an online resource "ACI Concrete Terminology" at http://www.concrete.org/store/productdetail.aspx?ItemID=CT13.

CHAPTER 3—REASONS FOR ADJUSTING MIXTURE PROPORTIONS

There are numerous reasons for adjusting the mixture proportions. The following are two examples showing the need to adjust mixtures to alleviate an existing problem on a jobsite and also to correct the yield as a result of the change.

3.1 *Example No. 1*—A mixture design is being used in the field and the water required to produce a 5 in. (130 mm) slump is 10 lb/yd^3 (6 kg/m^3) more than the mixture design. To correct the water content, it will be added into the design. The original mixture proportions are as follows:

a) Cement: 550 lb/yd^3 (326 kg/m^3)
b) No. 57 coarse aggregate: 1850 lb/yd^3 (1098 kg/m^3)
c) Fine aggregate: 1083 lb/yd^3 (643 kg/m^3)
d) Water: 268 lb/yd^3 (159 kg/m^3)
e) Air content: 5 percent

The following is the information used in the original mixture design:

a) Maximum water-cementitious material ratio (*w/cm*) required: 0.49
b) Coarse aggregate factor: 0.7
c) Specific gravity of cement: 3.15
d) Specific gravity of coarse aggregate: 2.48
e) Unit weight of coarse aggregate: 97.9 lb/ft^3 (1568.2 kg/m^3)
f) Specific gravity of fine aggregate: 2.63

The adjustment for the water demand will be based on the *w/cm*.

The water will increase from 268 to 278 lb/yd^3 (159 to 165 kg/m^3). To keep the *w/cm* the same, the cement will increase to 568 lb/yd^3 (337 kg/m^3). The coarse aggregate will remain the same and the fine aggregate will be adjusted so the mixture will continue to yield 27 ft^3/yd^3 (1 m^3/m^3).

The adjusted mixture proportions will be as follows:

a) Cement: 568 lb/yd^3 (337 kg/m^3)
b) No. 57 coarse aggregate: 1850 lb/yd^3 (1098 kg/m^3)
c) Fine aggregate: 1042 lb/yd^3 (618 kg/m^3)
d) Water: 278 lb/yd^3 (165 kg/m^3)
e) Air content: 5 percent

3.2 *Example No. 2*—A mixture proportioned for a design strength of 4000 psi (28 MPa) at 28 days is only achieving an average of 2700 psi (19 MPa) at 7 days. Based on historical data of the relationship of 7 to 28-day strengths, the 28-day strength is predicted to be approximately 3800 psi (26 MPa). The mixture proportion will be adjusted to increase the strength by a targeted 500 psi (3.4 MPa). The original mixture proportions are as follows:

a) Cement: 550 lb/yd^3 (326 kg/m^3)
b) No. 67 coarse aggregate: 1920 lb/yd^3 (1139 kg/m^3)
c) Fine aggregate: 1187 lb/yd^3 (704 kg/m^3)
d) Water: 275 lb/yd^3 (163 kg/m^3)
e) Air content: 4 percent
f) Water reducer: 17.0 oz./yd^3 (658 mL/m^3)

The following is the information used in the original mixture proportions:

a) *w/cm* required: 0.52 maximum
b) Coarse aggregate factor: 0.72
c) Specific gravity of cement: 3.15
d) Specific gravity of coarse aggregate: 2.68
e) Unit weight of coarse aggregate: 100.2 lb/ft^3 (1605.1 kg/m^3)
f) Specific gravity of fine aggregate: 2.63

This concrete mixture, with an expected 28-day compressive strength of 3800 psi (26 MPa) and having 550 lb/yd^3 (326 kg/m^3) of cement produces a cement efficiency at 28 days of 6.9 psi/lb (0.080 MPa/kg/m^3) (3800 psi/550 lb/yd^3 = 6.9 psi/lb/yd^3 [26 MPa/326 kg/m^3]). To adjust the mixture to yield an additional 500 psi (3.4 MPa) would take an additional 72 lb/yd^3 (43 kg/m^3) of cement (500 psi/6.9 psi/lb/yd^3 = 72 lb/yd^3 [3.4 MPa/0.080 MPa/kg/m^3 = 43 kg/m^3]).

The new mixture will be as follows:

a) Cement: 622 lb/yd^3 (370 kg/m^3)
b) No. 67 coarse aggregate: 1920 lb/yd^3 (1139 kg/m^3)
c) Fine aggregate: 1126 lb/yd^3 (668 kg/m^3)
d) Water: 275 lb/yd^3 (163 kg/m^3)
e) Air content: 4 percent