CODE

19.3.3.4 Wet-mix shotcrete shall be sampled in accordance with ASTM C172, and air content shall be measured in accordance with ASTM C231 or ASTM C173.

19.3.3.5 Dry-mix shotcrete shall be sampled and air content shall be measured as directed by the licensed design professional.

COMMENTARY

R19.3.3.5 If the licensed design professional requires measurement of air content of fresh dry-mix shotcrete, such requirements are to be stated in the construction documents, including the sampling frequency, sampling protocol, test methods to be used, and the criteria for acceptance.

The air content required for dry-mix shotcrete is for sampling of in-place shotcrete. This air content can be verified by taking cores from shotcrete test panels for analysis in accordance with ASTM C457. During the mixture development process, shotcrete test panels may be prepared with different amounts of air-entraining admixture and cored to determine a dosage that will provide the required amount of air after placement.

The use of ASTM C457 for quality control during construction is not practical. Although there are no standard tests for air content of dry-mix shotcrete during construction, there are industry accepted methods for testing. These methods involve obtaining samples of dry-mix shotcrete and performing standard tests such as ASTM C231 to determine air content.

Field measurements of air content of dry-mix shotcrete have been obtained by shooting the material directly into a bowl of an air meter (Betrand and Vezina 1994). Samples for air content testing can also be taken from material shot into test panels, into a wheelbarrow, or onto the ground. These samples can then be used for testing in accordance with ASTM C231 (Zhang 2015).

19.3.3.6 For $f_c' \geq$ **35 MPa**, reduction of air content indicated in Table 19.3.3.1 and 19.3.3.3 by 1.0 percentage point is permitted.

R19.3.3.6 This section permits a 1.0 percentage point lower air content for concrete with f_c' equal to or greater than 35 MPa. Such higher-strength concretes, which have a lower w/cm and porosity, have greater resistance to cycles of freezing and thawing.

19.3.3.7 The maximum percentage of pozzolans, including fly ash and silica fume, and slag cement in concrete assigned to Exposure Class F3, shall be in accordance with 26.4.2.2(b).

R19.3.3.7 This provision is intended for application during concrete mixture proportioning. The provision has been duplicated in 26.4.2.2(b). Additional commentary information is presented in Chapter 26.

19.3.4 *Additional requirements for chloride ion content*

19.3.4.1 Nonprestressed concrete that will be cast against stay-in-place galvanized steel forms shall comply with the chloride ion limits for Exposure Class C1 unless a more stringent limit is required by other project conditions.

R19.3.4 *Additional requirements for chloride ion content*

R19.3.4.1 Corrosion of galvanized steel sheet or stay-in-place galvanized steel forms may occur, especially in humid environments or where drying is inhibited by the thickness of the concrete, coatings, or impermeable coverings. If stay-in-place galvanized steel forms are used, the maximum chloride limit of 0.30 percent is required. For more severe environments, such as for concrete in Exposure Class C2, a more stringent limit of 0.15 percent would be required.

At the time of design, the licensed design professional may not know if aluminum embedments or stay-in-place galva-