METHOD OF TEST FOR EVALUATION OF CHEMICAL ADMIXTURES FOR CONCRETE

1. SCOPE

This method covers physical requirements and qualification tests for chemical admixtures. It applies to water reducing, strength increasing, set retarding, and accelerating admixtures.

These tests are based on arbitrary stipulations that make possible highly standardized testing in the laboratory and are not intended to simulate actual job conditions.

Note 1: This test method is based on CSA - A266.2-M78, Chemical Admixtures for Concrete which is not currently in existence as a CSA specification.

2. RELEVANT DOCUMENTS

2.1 MTO Test Methods LS-401, LS-407, LS-481

2.2 CSA Standards A5, A 23.1, A 23.2-12A, A 23.2-4C, A 23.2-5C, A 23.2-6C

2.3 ASTM C 157

2.4 ASTM C 359

2.5 ASTM C 403

2.6 ASTM C 457

2.7 ASTM C 494

2.8 ASTM C 666

2.9 ACI Standard Practice 211.1

3. DEFINITIONS

3.1 WATER REDUCING ADMIXTURES

3.1.1 Type WN - An admixture that increases the strength of concrete primarily as a result of reducing the water required for a given consistency and does not significantly affect the initial set. (Equivalent to ASTM Type A admixture).

3.1.2 Type WR - An admixture that increases the strength of concrete primarily as a result of reducing the water required for a given consistency and retards the initial set of concrete. (Equivalent to ASTM Type D admixture).

3.2 STRENGTH INCREASING ADMIXTURES

3.2.1 Type SN - An admixture that increases the strength of concrete without substantially affecting the water requirement for a given consistency and does not significantly affect the initial set (no ASTM equivalent).

3.2.2 Type SR - An admixture that increases the strength of concrete without substantially affecting the water requirement for a given consistency and retards the initial set of concrete (no ASTM equivalent).

3.3 SET RETARDING ADMIXTURES

3.3.1 Type R - An admixture that moderately retards the initial set of concrete. (Included under ASTM Type B admixtures).

3.3.2 Type RX - An admixture that produces extended retardation of the initial set of concrete. (Included under ASTM Type B admixtures).

3.4 ACCELERATING ADMIXTURES

Type AC - an admixture that accelerates the initial set and early strength development of concrete. (Equivalent to ASTM Type C admixtures).

4. PHYSICAL REQUIREMENTS

4.1 The admixture shall be evaluated by comparing the properties of a test concrete containing the admixture with the properties of a reference concrete containing similar materials without the admixture. The test concrete and the reference concrete shall be air entrained. When prepared and tested in accordance with this test method, the test concrete shall meet the requirements specified in Table 1.

Table 1

Physical Requirements

		Types						
Property	**Calculation**	**WN**	**WR**	**SN**	**SR**	**R**	**RX**	**AC**
Water Content Maximum, %	T/R x 100	95	95	97	98	97	97	100
Initial Set Minimum, hours:min. Maximum, hours:min.	T - R	-1:20 +1:20	+1:00 +3:00	-1:20 +1:20	+1:00 +3:00	+1:00 +3:00	+5:00 --------	-1:00 -3:00
Compressive Strength Minimum, % 3 days 7 days 28 days 6 months 1 year	T/R x 100 x 1.05	 115 115 115 100 100	 115 115 115 100 100	 120 120 120 100 100	 120 120 120 100 100	 110 110 110 100 100	 100 110 110 100 100	 125 110 105 100 100
Length Change	If R exceeds 0.030 %, T/R shall not exceed 1.35. If R is not more than 0.030 %, T-R shall not exceed 0.010 %							
Air-Void Spacing Factor Maximum, mm	T	0.23	0.23	0.21	0.21	0.21	0.21	0.21
Relative Durability Factor Minimum, %	T/R x 100 x 1.10	100	100	100	100	100	100	100

5. CONCRETE MATERIALS

The materials used for the preparation of concrete shall be uniform in quality, properly blended where required and prepared in sufficient quantity so that one lot of material is used for the entire test program.

5.1 CEMENT: Cement shall meet the requirements of CSA Standard A5, Portland Cements, and shall be a blend of equal parts of Normal Portland Cement (Type 10) from three different mills, St. Lawrence, Mississauga, Ontario, St. Marys Cement Company, St. Marys, Ontario, and Essroc Italcementi Group, Picton. Ontario. When the blend of cements is tested for early stiffening in accordance with CSA Standard A5 (Appendix A), the penetration shall be at least 50 %.

5.2 WATER: The water used in the preparation of mixes shall be drinkable water approved by the Ministry of Health.

5.3 AGGREGATE : All aggregate used in the preparation of concrete mixes shall meet the requirements of CSA Standard A23.1, except as specified herein.

Aggregate shall meet the grading requirements of Table 2 and shall be batched in a water saturated condition which shall be attained by soaking the aggregate, completely submerged, for 24 hours in water. To meet the grading requirements specified, it is necessary to sieve the coarse aggregate through the 26.5, 19.0, 13.2, 9.5 and 4.75 mm sieves and recombine the material to the specified grading.

Table 2

Aggregate Grading Requirements

Type	**Sieve Size**	**Percent Passing**	**(Alternative)**
Fine Aggregate	4.75 mm	95 -100	
	1.18 mm	65 - 80	
	300 µm	10 - 30	
	150 µm	2 - 10	
Coarse Aggregate	26.5 mm	100	(100)
	19.0 mm	80	(75)
	13.2 mm	50	(50)
	9.5 mm	30	(25)
	4.75 mm	0	(0)

5.4 Air Entraining Admixture

The air entraining admixture shall be neutralized vinsol resin.

6. CONCRETE MIX PROPORTIONS

The same mix proportions shall be used in all batches of both test and reference concrete. MTO Laboratory Test Method LS-481, Selecting Proportions for MTO Structural and Pavement Concrete (ACI Standard 211.1, Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete) shall be used as a proportioning guide.

Both the reference concrete and the test concrete shall have a cement content of 305 ± 5 kg/m^3. The slump of the reference and test concrete shall fall in the range of 80 - 100 mm and the slump of the test concrete shall be within 10 mm of that of the reference concrete.

The air content of the reference and test concrete shall be in the range of 5 - 7 % and the air content of the test concrete shall be within 0.5 % of that of the reference concrete.

7. MIXING OF CONCRETE

The following mixing procedure shall be followed:

7.1 Ensure that the mixer is buttered either by mixing a butter batch similar to the reference concrete or through having discharged another test batch just previously;

7.2 Prior to starting the mixer, place about 1/2 the mixing water, the saturated coarse aggregate, the solutions of air entraining and chemical admixtures when required, the saturated fine aggregate, and the cement in the mixer in that order. The admixture solutions shall be diluted with part of the mixing water;

7.3 Start the mixer and mix for 1/2 minute;

7.4 Continue mixing for a further 3-1/2 minutes while adding the remainder of the mixing water

Note 2: An experienced operator may add water incrementally during mixing to adjust to the desired slump.

7.5 Stop mixer for 3 minutes. During this rest period cover the mixer with damp burlap or other suitable material to prevent evaporation;

7.6 Mix for 1 minute. Stop the mixer and let the concrete rest for 2 minutes before removing any concrete for testing. During this period cover the mixer as during the previous rest period.

Note 3: An experienced operator may add water incrementally during mixing to adjust to the desired slump.

The total mixing time shall be 5 minutes plus 5 minutes rest period.

8. TEST PROGRAM

8.1 Each of the properties listed in Table 1, except the air-void spacing factor, shall be determined from each round of at least three rounds of tests made on different days. The air-void spacing factor shall be determined from one round only. A round of tests shall consist of sufficient batches to provide the required number of test and reference specimens. Reference and test mixes for comparison purposes shall always be made on the same day. Where it is apparent that the reproducibility within three rounds of tests is poor, repeat tests shall be carried out until satisfactory reproducibility is obtained.

8.2 The values for compressive strength, time of initial set, length change, and relative durability factor shall be those obtained by averaging the results from three consecutive rounds of tests and applying the appropriate correction factors (see Table 1).

9. TEST PROCEDURE

9.1 FRESH CONCRETE

9.1.1 Water Content

The water content shall be defined as the total effective water and shall include added water, surface moisture on aggregate and any water contained in the admixtures. It shall be calculated according to the following equation for each batch:

$$W_T \text{ (or } W_R) = W_A + W_B + W_C - W_D\,(1+A/100) - W_E\,(1+B/100)$$

where:

W_T = water content for test concrete

W_R = water content for reference concrete

W_A = batch mass of saturated aggregate

W_B = batch mass of added water

W_C = mass of water contained in all admixtures

W_D = oven dry mass of coarse aggregate

W_E = oven dry mass of fine aggregate

A = absorption percent of coarse aggregate as defined in CSA Test Method A23.2-12A

B = absorption percent of fine aggregate defined in CSA Test Method A23.2-6C

9.1.2 Slump

The slump shall be determined for each batch in accordance with CSA Test Method A23.2-5C, Slump of Concrete. The test shall be performed within 3 to 5 minutes after completion of mixing. The same time interval shall be used when determining the slump of reference and test concrete in the same round of testing.

9.1.3 Air Content

The air content of the freshly mixed concrete shall be determined for each batch concurrently with the slump test in accordance with CSA Test Method A23.2-4C, Air Content of Plastic Concrete by the Pressure Method. Meters designed to provide air content measurements as a function of pressure change shall have dials with each division representing not more than 0.1 percent air content in the range of 5 - 7 percent and shall be accurately calibrated by positive displacement methods in this range.

9.1.4 Density

The density shall be determined in accordance with CSA Test Method A23.2-6C, Density, Yield and Cement Factor of Plastic Concrete , except that the volume of concrete tested shall not be less than 14 L.

9.1.5 Time of Initial Set

The time of initial set shall be determined in accordance with ASTM Standard C403, Time of Setting of Concrete Mixtures by Penetration Resistance. The test shall be conducted at 23 ± 2°C and the penetration resistance apparatus used shall be of the bench or floor mounted hydraulic or spring reaction type, having a frame of sufficient stiffness to prevent lateral movement of the needle during penetration.

9.2 HARDENED CONCRETE

9.2.1 Compressive Strength

Compressive strength specimens shall be 150 mm in diameter and shall be prepared and cured in accordance with MTO Method LS-401, Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Laboratory. The specimens shall be tested in accordance with MTO Method LS-407, Method of Test for Compressive Strength of Moulded Concrete Cylinders. One test shall consist of two cylinders from each round for each age specified in Table 1.

9.2.2 Air-Void Spacing Factor

The air-void spacing factor shall be determined in accordance with ASTM Standard C457 at a minimum magnification factor of 100. Either the Linear Traverse (Rosiwal) Method or Modified Point-Count Method may be used and the paste content may be either measured or calculated. A test shall consist of one sample prepared from a 100 mm x 200 mm test cylinder cast from any batch of test concrete. The specimen shall be prepared from a longitudinal slice sawn from the centre of the cylinder.

9.2.3 Relative Durability Factor

The relative durability factor shall be determined using Procedure A (Freeze in Water, Thaw in Water) of ASTM Standard C666, Resistance of Concrete to Rapid Freezing and Thawing. The relative durability factor (RDF) shall be calculated as follows:

T (or R) = PN / 300

RDF = (T / R) x 100 x 1.10

where:

T = durability factor of the concrete containing the admixture under test

R = durability factor of concrete containing the reference admixture

P = relative dynamic modulus of elasticity in percentage of the dynamic modulus of elasticity at zero cycles (values of P will be 60 or greater)

N = number of cycles at which P reaches 60 percent, or 300 if P does not reach 60 percent prior to the end of the test (300 cycles)

A test shall consist of two specimens each of reference and test concrete from each round.

9.2.4 Length Change

The determination of length change shall be made in accordance with ASTM Standard C157, Length Change of Hardened Cement Mortar and Concrete. The moist curing period, including the period in the moulds shall be 14 days. The drying period shall also be 14 days. The drying shrinkage shall be considered to be the length change during the drying period based on initial measurement at the time of removal of the specimen from the mould. It shall be expressed as a percent, to the nearest 0.001 percent based on the specimen gauge length.