METHOD OF TEST FOR EVALUATION OF LATEX MODIFIERS FOR USE IN CONCRETE

1. SCOPE

1.1 This method covers test requirements for evaluation of latex modifiers for use in concrete. It includes determination of air content, slump, compressive and flexural strength, slant shear composite strength, resistance to salt scaling and chloride permeability for latex modified concrete.

2. RELEVANT DOCUMENTS

2.1 OPSS 1002, 1301, 1302, 1303, 1312

2.2 MTO Test Methods LS-401, 402, 403, 404, 405, 407, 408, 412

2.3 CSA A23.2-2C

2.4 AASHTO T260

3. DEFINITION

3.1 Latex modifier is a dispersion of polymeric particles in water which, when added to concrete, decreases its permeability without significantly adversely affecting its other properties.

4. PREPARATION OF SAMPLES

4.1 CEMENT: The cement shall be Type 10 complying with the requirements of OPSS 1301.

4.2 FINE AGGREGATE: The fine aggregate shall be natural sand having a fineness modulus of 2.6 to 2.9 and shall comply with the requirements of OPSS 1002.

4.3 COARSE AGGREGATE: The coarse aggregate shall be crushed rock of 13.2 mm nominal maximum size and shall comply with the requirements of OPSS 1002.

4.4 WATER: Water shall comply with the requirements of OPSS 1302.

4.5 AIR ENTRAINING ADMIXTURE: The air entraining admixture shall comply with the requirements of OPSS 1303.

4.6 LATEX EMULSION: The test latex shall be as provided by manufacturer.

4.7 MIX PROPORTIONS: The mix proportions shall be as shown in Table I.

Table 1

PARAMETER	LATEX MODIFIED CONCRETE	REFERENCE CONCRETE
Cement, kg/m3	390	390
Air, %	max. 9.0	6.0 ± 1.0
Fine to Total Aggregate Ratio by Absolute Volumes	0.46	0.46
Latex Solids % by Mass of Cement	15	----
Air Entraining Admixture	----	Sufficient amount to produce the specified air content
Water, Including Water in the Latex Emulsion, kg	Sufficient amount to produce a slump of 130 ± 20 mm	Sufficient amount to produce a slump of 80 ± 10 mm

4.7 BATCHING AND MIXING: The fine and coarse aggregate shall be saturated in accordance with CSA Test Method A23.2-2C.

The batch size shall be 50 L in all cases and the mixer shall be "buttered" as described in LS-401.

A laboratory pan type or rotary drum mixer shall be used for mixing the concrete using the following procedure:

4.7.1 Latex Modified Concrete:

Add coarse aggregate and latex, mix 0.5 min., add fine aggregate and cement, mix 1.0 min., add remaining water, mix 2.5 min.

4.7.2 Reference Concrete:

Add coarse aggregate and about one half of the water containing the entire amount of the air entraining admixture, mix 0.5 min., add fine aggregate and cement, mix 1.0 min., add remaining water, mix 2.5 min.

The mixed concrete shall be covered with damp burlap between completion of the mixing and testing of the concrete.

5. TESTING PLASTIC CONCRETE

5.1 Two batches of the latex modified concrete shall be prepared. Room temperature shall be controlled at 23 ± 2°C and relative humidity at 50 ± 5 % for the duration of the test.

5.2 The slump and air content of each batch of concrete shall be measured 4 minutes after completion of mixing. The concrete used for determination of the slump and air content shall be discarded.

5.3 Following determination of the initial (4 minute) slump and air content the batch of concrete shall be discharged into a non-absorptive pan whose size is such that the surface area of concrete exposed to laboratory air shall be approximately 0.5 m^2. No other agitation will be performed except that required to remove samples for slump tests.

5.4 Fresh concrete shall be removed from the pan at 15 minute intervals to determine the slump. The concrete used in each slump test shall be discarded. The testing shall be continued until all the concrete is used or the slump is 25 % of the initial value determined 4 minutes after completion of mixing.

5.5 A plot of slumps versus the various times for each batch shall be produced. The times to reach a 50 % slump loss shall be averaged. The initial slump and air content for each batch, the slump versus time curve for each batch and the average time to reach the 50 % slump loss shall be reported.

6. COMPRESSIVE AND FLEXURAL STRENGTH

6.1 One batch of the latex modified concrete and one batch of the reference concrete shall be made. Each batch shall be tested for slump, air content and density 4 minutes after completion of mixing and then the specimens shall be made in accordance with LS-401.

6.2 The compressive specimens shall be 100 mm diameter by 200 mm long cylinders and the flexural specimens shall be 75 x 100 x 400 mm beams. A minimum of three specimens per test age shall be made for each batch of concrete. The test ages and curing procedures shall be as detailed in Table II.

6.3 The compressive and the flexural strength shall be determined in accordance with LS-407 and LS-408.

6.4 The mean strength of the latex modified concrete at 24 h and 28 d shall be reported as a percentage of that of the reference concrete of equal age for both the compressive and flexural tests. The mean decrease in compressive and flexural strength of the latex modified concrete between 28 d and 42 d shall also be reported.

7. SLANT SHEAR COMPOSITE STRENGTH

7.1 The specimens shall be:

1) 100 mm diameter and 200 mm long composite cylinders consisting of a base of hardened reference concrete and an upper portion of latex concrete, and

2) 100 mm diameter and 200 mm long cylinders of the latex modified concrete.

7.2 A minimum of five composite and five latex specimens shall be tested at each age of 24 h, 28 d and 42 d (note age measured in terms of latex modified concrete for composite cylinders). The cylinders shall be tested at the specified ages in accordance with LS-407.7.3 To prepare the composite specimens, a batch of reference concrete shall be prepared . The composite cylinders shall be fabricated by first making concrete cylinders with the reference concrete in accordance with LS-401. These cylinders shall be cured 1 d under wet burlap, demoulded and then stored in a moisture room until needed but not less than 27 d. The cylinders shall then be cut to the shape shown in Fig. 1. The top half of each cylinder shall be discarded and the bottom half shall be returned to the moisture room until needed.

Table 2

	CURING PROCEDURE	
TEST AGE	LATEX CONCRETE	REFERENCE CONCRETE
1 d	1 d wet burlap	1 d wet burlap
28 d	1 d wet burlap 27 d lab. air	1 d wet burlap 27 d moisture room
42 d	1 d wet burlap 27 d lab. air 14 d lime saturated water	1 d wet burlap 27 d moisture room 14 d lime saturated water
1 d wet burlap	- cure for 24 ± 1 h in moulds covered with wet burlap at 23 ± 2°C	

27 d lab. air	- storage of demoulded specimens at 23 ± 2°C and 50 ± 5 % RH
27 d moisture room	- storage of demoulded specimens at 23 ± 2°C and at least 95 % RH
14 d lime saturated water	- completely immersed in 23 ± 2°C water containing 2 g/L or more $Ca(OH)_2$ in solution

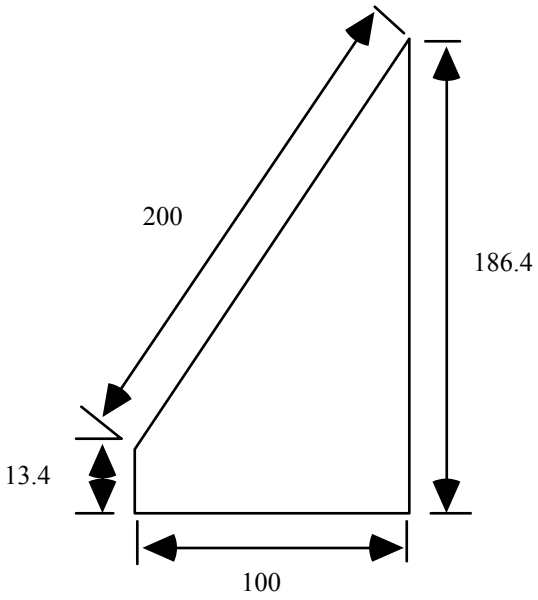

Figure 1

Base for slant shear composite specimen
Note: All dimensions in millimetres

7.4 Within 24 hours of cutting the cylinders, a batch of latex modified concrete shall be prepared . The reference concrete bases shall be removed from the moisture room and dried to a saturated

surface dry condition, then a bond coat of the latex concrete shall be applied by brushing it into the cut surface. The bases shall then be put in 100 x 200 mm cylinder moulds. This shall be followed immediately by placing the upper half of the composite cylinders using the latex concrete. The monolithic latex concrete cylinders shall be made at this time as well, in accordance with LS-401. The latex concrete for both types of cylinders shall be from the same batch. Curing procedures for both the composite and the latex cylinders shall be as detailed for latex concrete in Table II.

7.5 The individual specimen strength at each age and the mean compressive strength of each type of cylinder at each age shall be reported. Using the means, the strength of the composite cylinders shall be reported as a percentage of that of the monolithic latex modified concrete cylinders of equal age. The mean percentage change in the compressive strength of the composite cylinders between 28 d and 42 d shall also be reported.

8. RESISTANCE TO SALT SCALING

8.1 The specimens shall be 300 x 300 x 75 mm slabs of the latex modified concrete fabricated in accordance with LS-412 with the exception of the curing. Curing shall be 1 d under wet burlap, 27 d in normal laboratory air and 14 d in a lime saturated water. The specimens shall be sandblasted prior to 28 d of age to remove 2 to 4 mm of each slab surface and then dyked.

8.2 Testing shall be in accordance with LS-412 , except that the test will start at an age of 42 d. A graph showing the average cumulative mass loss in kg/m^2 versus the number of cycles shall be prepared. The loss of mass shall be reported to the nearest 0.1 kg/m^2.

9. CHLORIDE PERMEABILITY

9.1 Four 300 x 300 x 50 mm slabs of the reference concrete shall be fabricated by placing the concrete in one layer (slightly over-filling the moulds) and compacting the concrete by rodding with a standard tamping rod (as per LS-412) 144 times. The mould shall be tapped to close any voids and around the periphery the concrete shall be spaded with a flat trowel. The surface shall then be levelled with several passes of a wood float. The slabs shall be cured for 1 d under wet burlap and a minimum of 13 d in a moisture room.

9.2 The slabs shall be overlaid with a 30 mm layer of the latex modified concrete, which is to be prepared as directed in section 4, Preparation of Samples. The overlay shall be compacted and finished in the same manner as the base slabs. The overlay shall be cured 1 d under wet burlap and then 41 d in normal laboratory air. Prior to 28 d of age, the slabs shall be sandblasted to remove 2 to 4 mm of each slab surface and dykes then installed or cast around three of the specimens as described in LS-412.

9.3 The undyked slab shall be stored in normal laboratory air. On the 43rd day of overlay age, the three dyked slabs shall be subjected to continuous ponding to a 13 mm depth with a 3 % sodium

chloride solution for 90 d. Glass plates shall be placed over the specimens to retard the evaporation of the solution, although the surface of the slab shall not be sealed from the surrounding atmosphere. Additional solution shall be added as needed to maintain the 13 mm depth. After 90 d of ponding the solution shall be removed from the slabs, the slabs shall be allowed to dry and then the surfaces shall be wire brushed until all salt crystal build-up is completely removed.

9.4 Four cores, 50 mm diameter x 50 mm deep, (wet coring allowed) shall be obtained from each of the ponded and the unponded slabs. Each core shall be sawed (wet sawing allowed) to obtain discs representing the 2 to 13 mm and 13 to 25 mm depths. Each entire disc shall be crushed and pulverized and the total chloride content for each disc determined in accordance with AASHTO T 260.

9.5 The baseline chloride ion content shall be calculated as the mean total chloride ion content of the eight discs obtained from the unponded slab (B). The absorbed chloride ion content of each disc (X_i) from the ponded slabs shall be the difference between the total chloride ion content for that disc (A_i) and the baseline chloride ion content (B). Chloride ion content shall be expressed as percent Cl^- by mass of concrete.

$$X_i = A_i - B$$

The average absorbed chloride ion content (X) , the standard deviation (σ) and the 95 percent absorbed chloride (X_{95}) in percent by mass of concrete for each depth within the ponded slabs shall be calculated using the following formulae:

$$\overline{X} = \sum_{i=1}^{n} \frac{X_i}{n} \qquad \sigma = \sqrt{\frac{\sum X_i^2 - n\overline{X}^2}{n-1}}$$

$$X_{95} = \overline{X} + 1.645\sigma$$

The 95 percent absorbed chloride levels for the latex modified concrete shall be reported to the nearest 0.001 percent Cl^- at both the 2 to 13 mm depth and the 13 to 25 mm depth.

10. LATEX MODIFIER REQUIREMENTS

The latex modified concrete shall comply with the requirements of Table III.

Table 3

TESTS	REQUIREMENTS
Plastic Concrete	The air content of each latex modified batch shall not be higher than 9.0 %. The mean time to 50 % slump loss for the latex modified concrete shall be at least 50 minutes.
Compressive Strength	The mean compressive strength of the latex modified concrete at 24 h and 28 d shall be at least 50 and 75 %, respectively, of the mean compressive strength of the reference concrete of equal age. The mean decrease in compressive strength of the latex modified concrete between 28 d and 42 d shall not exceed 25 %.
Flexural Strength	The mean flexural strength of the latex modified concrete of 24 h and 28 d shall be at least 60 and 90 %, respectively, of that of the reference concrete of equal age. The mean decrease in the strength of the latex modified concrete between 28 d and 42 d shall not exceed 25 %.
Slant Shear Composite Strength	The mean compressive strength of the composite cylinders at each age shall be at least 45 % of that of the monolithic latex modified concrete cylinders of equal age. The mean decrease in the compressive strength of the composite cylinders between 28 d and 42 d shall not exceed 20 %.
Resistance to Salt Scaling	The mean cumulative surface mass loss shall not be higher than 0.8 kg/m^2.
Chloride Permeability	The 95 percent absorbed chloride levels for the latex modified concrete shall be less than 0.320 % Cl^- at 2 to 13 mm depth and less than 0.064 % Cl^- at 13 to 25 mm depth.