METHOD OF TEST FOR THE DETECTION OF ALKALI-REACTIVE COARSE AGGREGATE BY ACCELERATED EXPANSION OF CONCRETE PRISMS (TANG TEST)

1. SCOPE

1.1 This test allows the detection within four to eight weeks of the potential for deleterious expansion of concrete due to alkali-carbonate and alkali-silica reaction of coarse aggregate. At present, this test is under development, and there is no specification or guideline as to its application.

2. RELEVANT DOCUMENTS

2.1 CSA A23.1-1A Sampling Aggregates for Use in Concerte

2.2 ASTM C 305 Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency.

2.3 ASTM C 490 Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete.

2.4 Xu, Z., Lan, X., Deng, M., and Tang, M.S., A New Accelerated Method for Determining the Potential Alkali-Carbonate Reactivity, Proceedings of the 11th International Conference on Alkali-Aggregate Reaction, Quebec, pp. 129-138, 2000.

3. SIGNIFICANCE AND USE

3.1 This test method provides a means of screening aggregates for their potential alkali-reactivity. It is based on an Accelerated Test Method developed by Professor Tang and others (Xu et al, 2000).

3.2 Criteria to determine the potential deleteriousness of expansions measured in this test are not known at present. When excessive expansions are developed, it is recommended that supplementary information be developed to confirm that the expansion is actually due to alkali reactivity. Sources of such supplementary information include:

(a) Petrographic examination of the aggregate (see ASTM Standard C 295) to determine whether known reactive constituents are present; and

(b) Examination of the specimens after tests (see ASTM Standard C 856) to identify the products of alkali reactivity.

3.3 When it has been concluded from the results of tests performed, using this test method and supplementary information, that a given aggregate should be considered potentially deleteriously reactive, additional studies using alternative methods (see CSA Test Method A23.2-14A) may be appropriate to develop further information on the potential reactivity.

4. APPARATUS

4.1 The apparatus shall conform to ASTM Standard C 490 except as follows:

(a) Square hole, woven-wire sieves shall conform to CGSB Standard CAN/CGSB-8.2;

(b) The mixer, paddle, and mixing bowl shall conform to the requirements of ASTM Standard C 305;

(c) Moulds for casting prisms shall have either one or two compartments and shall be constructed so as to result in prisms with a cross section of 40 ± 1.0 by 40 ± 1.0 mm and have a length of 285 ± 1.0 mm. They may be made of either cold rolled steel or hard plastic.

4.2 The containers for concrete prism storage shall be of such a nature that the prisms can be totally immersed in either the water or 1 M NaOH solution. The containers shall be made of material that can withstand prolonged exposure to 80°C and shall be inert to a 1 M NaOH solution*. The containers shall be so constructed that, when used for storing specimens, the loss of moisture is prevented by tight-fitting covers, by sealing, or both. The prisms in the solution shall be placed and supported so that the solution has access to the whole of the bars; therefore, it shall be ensured that the specimens do not touch the sides of the container or each other. The specimens, if stood upright in the solution, shall not be supported by the metal gauge stud.

4.3 The convection oven shall have temperature control maintaining 80° ± 2.0°C.

**The NaOH solution will corrode glass or metal containers.*

†*A covered container that has been found to be acceptable for this purpose is sold by Rubbermaid® as a microwave-proof storage container.*

5. REAGENTS AND MATERIALS

5.1 USP or technical grade sodium hydroxide may be used provided that the Na^+ and OH^+ concentrations are shown by chemical analysis to lie between 0.99 M and 1.01 M.

5.2 Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Type IV of ASTM Standard D 1193, i.e. distilled water.

5.3 Each litre of sodium hydroxide solution shall contain 40.0 g of NaOH* dissolved in 900 mL of water and shall be diluted with additional distilled or deionized water to obtain 1.0 L of solution. The volume proportion of sodium hydroxide solution to mortar bars in a storage container shall be 4 ± 0.5 volumes of solution to 1 volume of mortar bars†.

*Precaution: Before using NaOH, review:

(a) The safety precautions for using NaOH;
(b) First aid for burns; and
(c) The emergency response to spills as described in the manufacturer's Materials Safety Data Sheet or other reliable safety literature. NaOH can cause very severe burns and injury to unprotected skin and eyes. Suitable personal protective equipment should always be used. These should include full-face shields, rubber aprons, and gloves impervious to NaOH. Gloves should be checked periodically for pin holes.

†The volume of a prism may be taken as 456 mL.

5.4 A supply of cement meeting the requirement of normal Portland cement (Type 10) as specified in CSA Standard A5 shall be used. The total alkali content of the cement shall be 0.9 ± 0.1%, calculated as $Na_2O + 0.658\ K_2O$, i.e. the Na_2O equivalent.

5.5 Control Aggregate

A supply of Spratt alkali-silica reactive control aggregate.

Note: *This aggregate is available from the Soils and Aggregates Section, Materials Research and Engineering Office, Ontario Ministry of Transportation, 1201 Wilson Avenue, Downsview, Ontario M3M 1J8, Fax 416-235-4101.*

6. CONDITIONING

6.1 Maintain the temperature of the moulding room, apparatus, and dry materials at not less than 20°C and not more than 26°C. Ensure that the temperature of the mixing water and of the moist closet or moist room does not vary from 23°C by more than 2.0°C.

6.2 The humidity of the moulding room shall be maintained at not less than 50%. The moist closet or room shall conform to ASTM Standard C 511.

6.3 Maintain the storage oven in which the specimens are stored in the containers at a temperature that shall not vary from 80°C by more than 2.0°C, and so that the temperature of the solution shall maintain a temperature of 80 ± 2.0°C.

7. SAMPLING AND PREPARATION OF TEST SPECIMENS

7.1 Sample Selection

The procedures outlined in CSA Test Method A23.2-1A shall be followed to obtain a representative sample of the aggregate to be tested. The sample, if possible, shall be obtained from a stockpile of aggregate produced in a manner identical to that which will be used in subsequent production. Aggregate proposed for use as coarse aggregates in concrete shall be processed by crushing to produce, as nearly as practicable, a graded product from which a sample can be obtained. The sample shall be representative of the composition of the coarse aggregate proposed for use.

7.2 All aggregates to which this test method is applied shall be graded on a 13.2, 9.5, and 4.75 mm sieves, and stored individually in clean containers provided with tight-fitting covers. The coarse aggregate under test shall be composed of two equal parts consisting of material between the 13.2 – 9.5 mm, and 9.5 – 4.75 mm sieves. Oversize and undersize material shall be discarded. Test samples shall be made using equal amounts by mass of material retained on the 9.5 mm and 4.75 mm sieves. After the aggregate has been separated into the various sieve sizes, each size shall be washed with water to remove adhering dust and fine particles from the aggregate. Each fraction shall be immersed in water for a minimum of 12 hours. Prior to mixing with cement paste, the coarse aggregate shall be drained and surface dried in a large absorbent cloth or towel until all visible films of water are removed.

7.3 Use a Portland Type 10 cements with a total alkali content of 0.9 ± 0.1%.

7.4 Preparation of Test Specimens

7.4.1 Make at least two test specimens for each aggregate.

7.4.2 Prepare the specimen moulds in accordance with the requirements of ASTM Standard C 490, except that the interior surfaces of the mould shall be covered with a release agent*. Consider a release agent acceptable if it serves as a parting agent without affecting the setting of the cement and without leaving any residue that will inhibit the penetration of water into the specimen.

**TFE-Fluorocarbon (Teflon) tape complies with the requirements for a mould release agent, or hydraulic oil. Alternatively, the use of plastic moulds may not require the use of a release agent.*

7.4.3 The surface dry materials for the test concrete shall be proportioned using 1 part cement to 1 part graded aggregate by mass. To make two prisms, the quantities of dry materials to be mixed at one time in the batch of concrete shall be 1000 g of cement and 1000 g of aggregate in the grading prescribed in Table 1. A water/ cement ratio equal to 0.30 by mass shall be used.

7.4.4 Mix the paste in accordance with the requirements of ASTM Practice C 305.

7.4.5 Following mixing of the paste, add the saturated surface dry coarse aggregate to the mixture and stir and mix the aggregate using a scraper or large spoon until all the aggregate is well coated with paste. Cover the mixing bowel with a damp towel and let stand for 30 seconds and remix for 10 seconds.

7.4.6 Specimens with a total elapsed time of not more than 3 minutes after completion of the original mixing of the concrete batch. Fill the moulds with two approximately equal layers, each layer being compacted with gloved fingers. Work the concrete into the corners, around the gauge studs, and along the surfaces of the mould with gloved fingers until a homogeneous specimen is obtained. After the top layer has been compacted, cut off the concrete flush with the top of the mould and smooth the surface with a few light pats of gloved fingers. Cover the filled moulds with a plastic cover immediately following finishing.

8. PROCEDURE

8.1 Place each mould in the moist cabinet or room immediately after moulds have been filled. Leave the specimens in the moulds for 24 ± 2 h. Remove the specimens from the moulds and, while they are being protected from loss of moisture, properly identify them. Place the specimens made with each aggregate sample in a storage container with sufficient tap water heated to 80 ± 2.0°C, to totally immerse them. Seal and place the containers in a convection oven at 80 ± 2.0°C for a period of 24 h.

8.2 Remove the containers from the oven one at a time. Remove other containers only after the bars in the first container have been measured and returned to the oven. Remove the bars one at a time from the water and dry their surfaces with a towel, paying particular attention to the two metal gauge-measuring studs. Make and record the initial and all subsequent measurements to the nearest 0.002 mm

(0.0001 inch). Take the initial length measurement* of each bar immediately after drying, and read as soon as the bar is in position. Complete the process of drying and measuring within 15 ± 5 s of removing the specimen from the water. Ensure that the elapsed time between removal of the container from the oven and completion of the measurements is no more than 5 minutes. After measurement, leave the specimen on a towel until the other bar has been measured. Place both specimens in a container with the 1 M NaOH, preheated at 80 ± 2.0°C. Totally immerse the samples. Seal the container and return it to the oven.

**The comparator bar should be measured prior to each set of specimens since the heat from the concrete prisms may cause the length of the comparator to change. The lower measuring stud of the comparator should be wiped dry after each measurement to prevent corrosion.*

8.3 Undertake subsequent measurements of the specimens at 7, 14, 21, 28, 56 days and at 4-week intervals thereafter.

9. CALCULATION

9.1 Calculate the length change following ASTM C 490. Calculate the difference between the initial length of the specimen and the length at each period of measurement to the nearest 0.0001% of the effective length and record as the expansion of the specimen for that period. Calculate the average expansion of the two specimens to the nearest 0.001% as the expansion for a given period.

10. USE OF A CONTROL MATERIAL

10.1 When testing is conducted, the laboratory shall demonstrate its ability to conduct the test. At the time of testing, testing with a known reactive aggregate shall be conducted.

<u>Note</u>: *Spratt coarse aggregates is available in 25-kg bags from Soils and Aggregates Section, Materials Engineering and Research Office, Ontario Ministry of Transportation, 1201 Wilson Avenue, Downsview, Ontario M3M 1J8, Fax 416-235-4101.*

11. REPORT

The report shall include the following:

(a) Type and source of coarse aggregate;
(b) Type and source of Portland cement;

(c) The alkali content (Na_2O and K_2O) of the cement;

(d) The average length change, in per cent, at each reading of the prisms, with the individual values for each prism;

(e) Any significant features revealed by examination of the concrete prisms, either during the test or at the end of the test (e.g. cracks, gel, formations, or reaction rims surrounding aggregate particles); and

(f) The expansion of concrete made with the Spratt aggregate.