INTERIM TEST PROTOCOL

Test Method to Assess Potential Reactivity of Aggregates in Presence of Airfield Deicing Chemicals (Mortar Bar Test)

1. SCOPE

The test method described in here provides a means to evaluate the alkali-silica reactivity of aggregates in the presence of airfield deicing and anti-icing chemical solutions. A modification of this method as presented in Appendix-A of this document, may be used to evaluate the effectiveness of any selected mitigation measure to counter the effects of deicing chemicals.

The procedure presented in this document is developed based on an on-going research project sponsored by IPRF/FAA at Clemson University[1] and should be considered interim in nature. Due to the limitations in the scope of the research study that led to the development of this interim test procedure, the specific influence of several factors (such as the composition of the cement, the temperature of the test, the concentration of the soak solutions and other factors) that may potentially influence the observations in this test method have not been thoroughly investigated. Also, the interim test procedure does not provide any specific guidance on the acceptable level of expansion observed in the mortar bars. Despite the limitations of this interim test method as outlined above, this method has been successful employed in the IPRF/FAA research study in identifying deleterious interactions between the deicers and aggregates in a consistent manner among the aggregates evaluated in the research study. Also, this method has shown potential to distinguish the efficacy of different mitigation measures.

2. SIGNIFICANE AND USE

With this test method, it is possible to characterize the reactivity of aggregate in mortar bars, in presence of specific airfield deicing chemicals. Limited testing that was conducted in the development of this test method did not discern any specific influence of composition of typical Portland cements on the observed behavior of aggregate reactivity. Therefore, it is suggested that existing requirements for Portland cement as indicated in ASTM C 1260 test procedure be adopted in this interim test procedure. (This requirement entails the autoclave expansion of the portland cement be less than 0.2% for use in this test procedure). This test method may also be employed to study the effectiveness of any supplementary cementing materials (SCMs), when used as cement replacement materials to mitigate the observed expansions.

In this test method as the aggregate reactivity is characterized with respect to a specific deicing or anti-icing chemical, the method allows the use of different soak solutions. The airfield deicing and anti-icing chemicals that can be used as soak solutions are limited to formulations based on the following chemicals:

(i) Potassium Acetate
(ii) Potassium Formate
(iii) Sodium Acetate
(iv) Sodium Formate

With regards to the apparatus to be used in this interim test, conditioning of materials (i.e. ambient RH and temperature), and the preparation of test specimens, the proposed interim test

method follows the procedures established in standard ASTM C 1260-01 test method – *Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar Bar Method)*. The interim test procedure differs from the standard test method in the reagents that are used and the soak solution that is employed in the test. Also another significant deviation from the standard test method is the length of testing. The details of the reagents to be used, composition of the soak solution and the length of testing in the interim test method are addressed in the following sections.

3. REAGENTS AND SOAK SOLUTIONS

As the proposed test method focuses on evaluating the influence of a specific deicer on the potential reactivity of aggregate, it is recommended that the soak solution employed in the test procedure be prepared from the commercial deicing chemical under consideration, rather than a reagent grade chemical. *(Investigation of equivalent reagent grade deicer chemicals in the IPRF/FAA research project, have yielded similar results to those of commercial deicers themselves. Moreover, commercial deicers typically also include other minor ingredients such as corrosion inhibitors, dyeing agents, etc)*.

Depending on the specific deicing or anti-icing chemical and aggregate combination to be evaluated, the soak solution for use in the proposed interim test procedure be limited to one of the chemicals listed in section 2 of this test procedure.

3.1 Liquid Anti-Icing/Deicing Soak Solutions

The liquid anti-icing chemicals (potassium acetate and potassium formate-based solutions) shall be used in the test method at a concentration recommended for application in field by the manufacturer. Based on the available literature on the liquid deicer/anti-icing chemicals (potassium acetate and potassium formate), the typical concentration at which these chemicals are applied in field is at 50% solution by weight. It is therefore recommended that the deicing solutions, as obtained from the manufacturer, be used as the soak solutions in the interim test procedure.

3.2 Solid Deicing Chemicals

In case of solid deicing chemicals (sodium acetate and sodium formate-based products), the concentration of the soak solution shall be a saturated solution of the deicing chemical at room temperature. The choice of using a saturated solution of the solid deicing chemical at room temperature presents an aggressive, yet realistic exposure condition for the concrete.

Although at the time of application of the solid deicing chemical on an icy pavement, the resulting concentration of the solution generated by the melting ice may be much less than a saturated solution at room temperature, it is likely that the generated brine will be absorbed by the concrete, and due to subsequent cycles of wetting and drying can reach a level of saturation. It is therefore recommended in this test procedure that a saturated solution of the solid deicer at room temperature would provide an aggressive, yet realistic environment for evaluating the susceptibility of the aggregate.

The saturated solution of the solid deicing chemicals is prepared by dissolving sufficient quantity of the deicer chemical in deionized or distilled water, such that a portion of the solid deicer remains as a precipitate at the bottom of the container after a 24-hour period of dissolution. Alternately, the saturated solution can be prepared by heating a mixture of the solid deicer and

water and cooling it to room temperature, such that a precipitate of the solid deicer is present in the mixture upon cooling of the solution to room temperature.

4. LENGTH OF TESTING

The standard ASTM C 1260-01 test method specifies a 14-day soak period in the 1 N NaOH solution for evaluating the potential reactivity of the aggregate. Based on the IPRF/FAA research study[1] on the evaluation of aggregate reactivity in deicing soak solutions, it is observed that much of the expansion in the mortar bars containing reactive aggregates occurs within the initial 14-day soak period for most of the reactive aggregates. However there are exceptions to this trend and expansion measurements at 28 days appear to be more representative. Similarly, in evaluating mitigation measures using the method presented in Appendix-A of this document (which is a modification of the interim test procedure), it has been found that expansion observed at 28-days of age is more representative of long-term expansion than that observed at 14-days in the soak solution. Based on these findings, it is proposed that the length of test in the interim procedure be set at 28 days.

5. ADDITIONAL MEASUREMENTS ON MORTAR BARS AND SOAK SOLUTIONS (OPTIONAL)

Although length-change measurements have traditionally been used in assessing the reactivity of aggregates, it is suggested in this test that additional measurements to determine the dynamic modulus of the mortar bar test specimens and the composition of the soak solution be conducted.

5.1 Measurements for Dynamic Modulus of Elasticity

Dynamic modulus of elasticity of mortar bars (per ASTM C 215) measurements provides additional insight into the nature of the deterioration and the physical condition of the mortar bar exposed to the deicing solutions. It is suggested that the dynamic modulus measurements on the mortar bars be conducted soon after the length-change measurements during the course of testing. Based on the work conducted by Rangaraju et al.[2], the changes that occur in dynamic modulus of elasticity of mortar bars are unique to each of the deicers investigated, and present an interesting insight into the nature of the deterioration caused by the deicing chemicals.

5.2 Soak Solution Composition

Unlike the 1N sodium hydroxide soak solution employed in the standard ASTM C 1260-01 test procedure (pH = 14), the deicing chemical soak solutions employed in the interim test procedure typically do not have high levels of pH, that is required for initiating and sustaining active alkali-silica reaction in mortar bars. However, based on the work conducted by Rangaraju et al.[2], it is clearly established that with certain deicers, the composition of the soak solution undergoes a dramatic change in terms of its composition, particularly its pH level, during the course of testing. The documentation of the compositional changes that occur in the soak solution presents an important evidence to suggest that with deicing soak solutions, the interactions are not necessarily just between the aggregate and the soak solutions, but the nature of the cementitious materials used in preparation of the mortar bars plays an active role in creating the adverse conditions for the distress to occur. In this regard, measurement of the pH of the soak solution should be considered as an important auxiliary test in this interim test protocol. In addition, a more comprehensive analysis of the soak solution for tracking changes in Ca^{+2}, Na^{+}, K^{+}, SO_4^{-2}, and OH^{-} concentration may be conducted to develop a more through understanding of the changes that occur in the soak solution. It is suggested that the compositional analysis of the soak solution be

conducted prior to soaking the mortar bars into the soak solution (at the beginning of the test) and at the end of the test (28 days after soaking the mortar bars in the soak solution).

APPENDIX - A

Test Method to Assess Effectiveness of Supplementary Cementing Materials in Mitigating Expansions Induced in Mortar Bars by Exposure to Airfield Deicing Chemicals

1. EVALUATION OF SUPPLEMENTARY CEMENTING MATERIALS

The test procedure to assess the effectiveness of supplementary cementing materials (SCMs) is precisely similar to the Interim Test Protocol – *Test Method to Assess the Potential Reactivity of Aggregates in Presence of Airfield Deicing Chemicals*, with exception of the composition of the cementitious material used in preparation of the mortar bars. The SCM, whose effectiveness is to be evaluated, is used as a cement replacement material on a mass basis. It is particularly important with the evaluation of the mitigation measures, that the test be conducted up to a minimum of 28 days. It has been noticed in the on-going IPRF/FAA research work that certain mitigation measures show a temporary mitigation (low levels of expansion) during the first two weeks, and thereafter show a dramatic failure (significant jump in expansion of mortar bars). It has been observed in the IPRF/FAA work that expansions measured at 28 days are in general very representative of the long-term expansions (i.e. at 56 days in the test method).

REFERENCE

1. Potential for Acceleration of ASR In Presence of Airfield Deicing Chemicals. IPRF Project 01-G-002-03-9, Principal Investigator: Rangaraju, P. at Clemson University. Start Date: May 2004.

2. Rangaraju, P., Sompura K., Olek, J., Diamond S., and Lovell, J. Potential for Development of ASR in Presence of Airfield Deicing Chemicals, *Proceedings of 8th International Conference on Concrete Pavements*, Colorado Springs, CO, August 14-18, 2005. (to be published).