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EVALUATION OF THE EFFECT OF THE USE OF IPANEX ON ALKALI-SILICA REACTION EXPANSION[1]

BACKGROUND

Previous research concludes that IPANEX provides C-S-H seed crystals in the fresh concrete onto which newly forming C-S-H can grow into a dense, continuous matrix. The result is a more continuous microstructure that provides corrosion inhibition and waterproofing[2]. It may be further stated that such C-S-H growth causes the newly forming porosity within the microstructure of the hydrating concrete to develop more tortuously. Therefore, measurement of physical properties that rely upon the movement of fluids through the pore structure should be sensitive to the effects of the presence of IPANEX. Prior permeability and chloride ion penetration testing demonstrate this[2,3].

The objectives of this investigation were: 1. to establish a test that would demonstrate the effectiveness of IPANEX and that could be conducted easily, and, 2. to confirm results of prior ASR testing[4]. This test will then allow DOT's and other interested agencies, that are evaluating IPANEX, to have a testing protocol that could be used within the time frame of their typical product evaluation.

METHODOLOGY

ASTM C 441 "Standard Test Method for Effectiveness of Mineral Admixtures or Ground Blast-Furnace Slag in Preventing Excessive Expansion of Concrete Due to the Alkali-Silica Reaction" was selected and demonstrated. For the study, two portland cements that are readily available in the Lehigh Valley region of southeastern Pennsylvania were chosen based upon their equivalent alkali content (Type I 0.68%, Type III 1.0%). Crushed and graded Pyrex glass from the original Bureau of Mines inventory served as the expansive aggregate.

RESULTS AND DISCUSSION

Test specimens were prepared according to ASTM C 441 protocol. IPANEX was added to the mortar at the manufacturer's recommended dosage. The results of these experiments are summarized in Tables 1 and 2. Type I cement with an alkali equivalent of 0.68% resulted in an average expansion of 0.278% based on the average of three readings on each of four bars. This expansion is contrasted to 0.178% for the IPANEX equivalent. Similarly, Type III cement with an alkali equivalent of 1.0% resulted in an observed expansion of 0.298% contrasted to 0.145% for the specimens containing the IPANEX. The full data are available upon request.

From these data, it is clear that the expansion due to

Table 1. Experimental Result of ASTM C 441 Testing Type I Portland Cement

Sample	Meas. #	Percentage change
Control		
IPA 1-1	Avg. of 3	0.181
IPA 1-2	Avg. of 3	0.348
IPA 1-3	Avg. of 3	0.347
IPA 1-4	Avg. of 3	0.235
	Grand Avg.	**0.278**
IPANEX		
IPA 3-1	Avg. of 3	0.098
IPA 3-2	Avg. of 3	0.243
IPA 3-3	Avg. of 3	0.137
IPA 3-4	Avg. of 3	0.235
	Grand Avg.	**0.178**

Note: Test specimens made from the control mixture shall have an average 14 day increase in length of at least 0.250%.

Table 2. Experimental Result of ASTM C 441 Testing Type III Portland Cement

Sample	Meas. #	Percentage change
Control		
IPA 2-1	Avg. of 3	0.231
IPA 2-2	Avg. of 3	0.383
IPA 2-3	Avg. of 3	0.340
IPA 2-4	Avg. of 3	0.237
	Grand Avg.	**0.298**
IPANEX		
IPA 4-1	Avg. of 3	0.177
IPA 4-2	Avg. of 3	0.138
IPA 4-3	Avg. of 3	0.120
	Grand Avg.	**0.145**

alkali-aggregate interaction is much lower in the IPANEX containing samples than in the control samples. In the Type I cement, the reduction of expansion of the IPANEX specimens is 36% of the control; and in the Type III, 51% of the control. These values compare favorably with previously reported values of 47% and 42% reductions[4].

Figure 1 is a graphic presentation of these current data and the data from that previous study[4], contrasted to a set of expansion data reported by Krize[5] from a set of cements statistically chosen to represent the range of chemical variability in all 114 currently manufactured Type I and II portland cements.

From Reference 4, the equivalent alkali for the fly ash cement was calculated based upon the assumption that the average sodium content of Class C fly ash is 1.7 ± 0.6% and the potassium content 0.6 ± 0.6% (Scheetz et al.[6]).

SUMMARY AND CONCLUSIONS

From these data and the data from an independent testing laboratory[4], expansion data covering the range of equivalent alkali from 0.5% to 1.0% all demonstrate that the use of IPANEX can reduce the effects of alkali-aggregate expansion, Table 3. More importantly, these data demonstrate that the ASTM C 441 test protocol is a viable test methodology to economically and quickly (14 days) demonstrate the performance of IPANEX in concrete. Testing is ongoing.

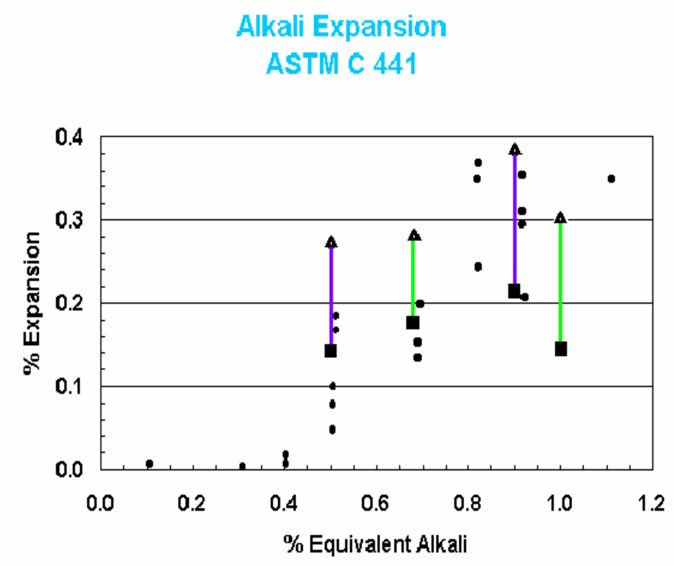

Figure 1. Effectiveness of IPANEX in reducing alkali-aggregate expansion as determined by ASTM C 441.

[The green lines represent the data collected in this study[1]; the purple lines represent data from Reference 4. In these data sets, the triangle data points are the "control" data and the filled squares are the samples containing IPANEX. The dots represent data from Krize[5].]

Table 3. Expansion results - reduced alkali-silica expansion when IPANEX is used over a range of alkali contents

Formulation	*Equivalent Alkali %*	*C 441 Expansion %*	*IPANEX % Reduction of Expansion*
Cement *	0.5	0.268	47%
Cement + IPANEX *	0.5	0.143	
Cement + fly ash *	0.9 calculated	0.380	42%
Cement + fly ash + IPANEX *	0.9 calculated	0.221	
Type I	0.68	0.278	36%
Type I + IPANEX	0.68	0.178	
Type III	1.0	0.298	51%
Type III + IPANEX	1.0	0.145	

* Resource Materials Testing, Inc.; Reference 4 — Class C Fly Ash

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