



Utilization of quarry by-products for reduction of expansion due to alkali-aggregate reaction



Benjamin J. Mohr^{a, *}, Lindsay B. Bryant^b

^a Department of Civil and Environmental Engineering, Tennessee Technological University, 1020 Stadium Drive, Box 5015, Cookeville, TN 38505-0001, USA

^b Smith Seckman Reid, Inc., 2995 Sidco Drive, Nashville, TN 37204, USA

ARTICLE INFO

Article history:

Received 15 November 2012

Received in revised form

26 March 2015

Accepted 21 July 2016

Available online 28 July 2016

Keywords:

Alkali-aggregate reaction

Expansion

Limestone

Screenings

Aggregates

Microscopy

ABSTRACT

The replacement of normal fine aggregate with high fines limestone screenings is a technique to reduce waste from crushed stone operations, while potentially improving the durability and performance of concrete. The main objective of this research is to evaluate varying percentages of high fines limestone screenings as a partial weight replacement of reactive fine aggregate (similar to limestone sweetening) in mortars to assess reductions in the expansion due to alkali-aggregate reaction (ASTM C 227, ASTM C 1260, and modified ASTM C 1105). Fresh and hardened properties have been evaluated to assess the effects of limestone screenings on performance criteria. Environmental scanning electron microscopy (ESEM) was performed to visually observe and confirm alkali-aggregate reaction products and associated damage. From the physical testing and microstructural analysis, it was found that 50% or more of limestone screenings significantly reduce expansions due to alkali-aggregate reaction, attributed to the preference for monocarbonate formation in the presence of limestone and/or reactive silica dilution. Replacements less than 50% did not significantly reduce expansion.

Published by Elsevier Ltd.

1. Introduction

During the production of crushed stone, screenings, typically containing nine to fifteen percent fines (i.e., particles passing the #200 sieve), are produced. It is estimated that these by-products are being produced at a rate of 175 million tons per year in the United States [1]. However, this by-product is typically not allowed as ASTM C 33 specifications are not met due to more than 10% passing the #200 sieve. As sustainability concerns rise, there is an emphasis to increase the use of manufactured by-products in concrete mixtures [2]. The replacement of normal fine aggregate with high fines limestone screenings is a potential technique to reduce waste from crushed stone operations without significantly impacting the durability and performance of concrete [3].

Currently, ASTM C 150 [4] and ASTM C 595 [5] allow up to 5 and 15% limestone, respectively, as long as the remaining prescriptive-based specifications are met. However, there is minimal literature to indicate the effects of limestone powder on ASR-induced expansions, beyond alkali-dilution. Some evidence shows that 5% limestone powder may increase expansions due to ASR [6], though

it is stated that limestone likely does not contribute to ASR. Additional research has indicated that limestone powder addition (5–15%) does not consistently alter ASR expansions either way [7,8]. Despite the apparent innocuous behavior in the presence of limestone in regards to ASR, thaumasite formation has been raised as a potential concern due to the increased available carbonates [9].

In order to utilize limestone screenings (which has a high percentage of fines/powder), the effects of screenings replacement of reactive aggregate should be subject to examination as previous research appears to be limited to up to 15% limestone powder replacement of portland cement only. Thus, the main objective of this research is to approach the limestone-ASR issue from a different direction and evaluate varying percentages of high fines limestone screenings as a partial weight replacement of reactive fine aggregate in mortars to assess reductions in the expansion due to alkali-aggregate reaction. It is anticipated that screenings will reduce expansion due to substitution (dilution) of reactive components but particular attention will be paid to any deviation from a linear relationship between expansion reduction and aggregate composition.

* Corresponding author.

E-mail address: bmohr@tntech.edu (B.J. Mohr).

Table 1
Oxide analysis and Bogue potential composition of cement used in this research.

Oxide	Type I/II Portland cement
SiO ₂	19.70
Al ₂ O ₃	4.33
Fe ₂ O ₃	3.66
CaO	63.41
MgO	3.30
Na ₂ O	0.07
K ₂ O	0.68
TiO ₂	0.23
P ₂ O ₅	0.06
SrO	0.05
SO ₃	3.11
LOI	1.40
C ₃ S	65.18
C ₂ S	7.65
C ₃ A	5.29
C ₄ AF	11.12

2. Materials and methods

2.1. Materials and mixture proportions

Cementitious mortars were prepared with a water-to-cement ratio of 0.47 and a fine aggregate-to-cement ratio of 2.25. Commercially available ASTM Type I/II portland cement and deionized water (resistivity of 18.2 MΩm) were used. Oxide analysis and Bogue potential composition for the cement are listed in Table 1. The equivalent alkali content was increased to 1.25% for ASTM C 227 testing. Highly reactive cherty sand (Jobe sand from Texas, USA) and high fines limestone screenings were used as fine aggregates. Percentages of reactive Jobe sand were replaced by the screenings on a mass basis. The combined gradations of each aggregate mixture are given in Table 2. No chemical or mineral admixtures were used in this research. Mortars were prepared according to ASTM C 305 [10].

2.2. Methods for assessment and analysis

2.2.1. Expansion due to alkali-aggregate reaction

Mortar bars (1 × 1 × 11.6") for expansion testing were prepared in triplicate (two sets for a total of six bars) according to ASTM C 1260 [11] and ASTM C 227 [12]. Based on the initial results, follow up testing was performed in triplicate (one set) according to a modified ASTM C 1105 [13]. All samples were demolded 24 h after casting.

For ASTM C 1260 testing, samples were subsequently stored in deionized water at 80 ± 2 °C for an additional 24 h after demolding. After removal from the hot water curing, initial length measurements were taken and specimens were subsequently stored in a 1 N NaOH solution at 80 ± 2 °C for the remainder of the testing.

Table 2
Sieve analysis of fine aggregate. Note: 10, 30, 50, and 100% represent percentage of screenings replacement.

Sieve number	Sieve opening (mm)	Percent passing							
		ASTM C33 min	ASTM C33 max	Control	10%	30%	50%	100%	
3/8"	9.5	100	100	100	100	100	100	100	100
#4	4.75	95	100	95.3	95.3	95.4	95.4	95.6	95.6
#8	2.36	80	100	81.9	80.0	76.3	72.6	63.3	63.3
#16	1.18	50	85	73.4	69.8	62.7	55.6	37.9	37.9
#30	0.6	25	60	53.7	50.9	45.2	39.5	25.4	25.4
#50	0.3	5	30	12.3	12.8	14.0	15.1	17.9	17.9
#100	0.15	0	10	1.5	2.7	5.2	7.6	13.8	13.8
#200	0.075	0	0	0.2	1.3	3.5	5.7	11.3	11.3

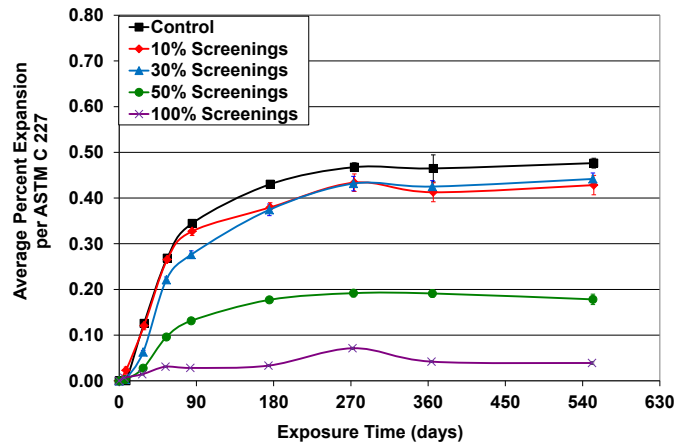


Fig. 1. Expansion of mortar bars tested per ASTM C 227.

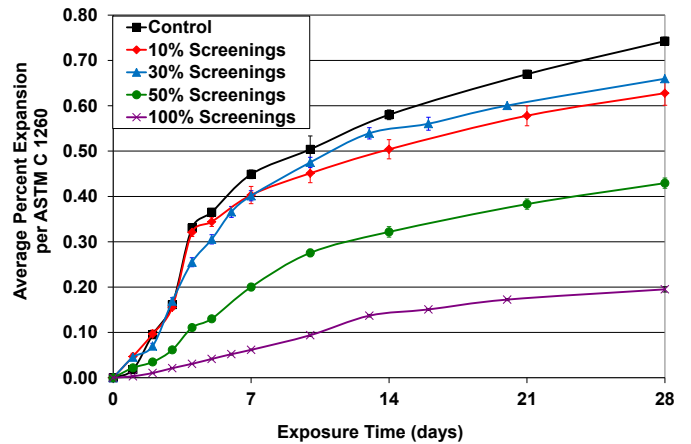


Fig. 2. Expansion of mortar bars tested per ASTM C 1260.

Measurements were taken periodically, up to 28 days of exposure to the alkali solution.

For ASTM C 227 testing (cement equivalent alkali content increased to 1.25%), samples were stored at 38 ± 2 °C over water in a sealed container. For modified ASTM C 1105 testing, samples were stored at 23 ± 2 °C and 95 ± 3% RH in an environmental chamber. Exposure conditions were replicated per ASTM C 1105, but mortar bars were used instead of concrete. Initial length measurements

Download English Version:

<https://daneshyari.com/en/article/1454245>

Download Persian Version:

<https://daneshyari.com/article/1454245>

[Daneshyari.com](https://daneshyari.com)