



South Carolina  
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## SUMMARY REPORT

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# Investigation into ASR Potential of Aggregate in the Upstate Area of South Carolina

## EXECUTIVE SUMMARY

### Introduction

Alkali-Silica Reactivity (ASR) is a harmful chemical reaction that occurs in certain concretes containing reactive siliceous aggregates. The occurrence of ASR causes concrete to expand and crack, leading to loss of its integrity and eventually serviceability.

Historically, concrete pavements and bridges in South Carolina have not had any distress due to ASR. As a result, establishing the reactivity of aggregate sources had not been a concern for the South Carolina Department of Transportation (SCDOT). However, recent occurrence of premature distress in concrete aprons at Greenville-Spartanburg airport due to ASR raised concern about the ASR potential of local sources of aggregates.

In light of this development, SCDOT initiated a research study to determine the ASR potential of aggregates in the upstate area of South Carolina. This research study focused on determining the ASR potential of four different aggregate sources that are representative of aggregates used in highway construction in upstate area of South Carolina. These sources included aggregates from Blacksburg, Lyman, Lakeside, and Pacolet Quarries. These aggregates ranged in their rock types from marble-schist to granite-gneiss.

The ASTM C 1260 test procedure (accelerated mortar bar test procedure) was adopted to evaluate aggregates for their ASR potential. In this test, mortar bars prepared with the aggregate in question are subjected to a 1 N sodium hydroxide solution at 80°C. The expansion observed in the mortar bars at the conclusion of 14 days of immersion in the sodium hydroxide solution is indicative of the reactive or non-reactive nature of aggregate. Expansion values less 0.1% are characteristic of non-reactive aggregate, while expansions over 0.2% are positively indicative of reactive aggregates. Expansions falling between 0.1% and 0.2% after 14 days of testing suggest an inconclusive nature of the aggregate. The reactivity potential of these aggregate is established by

continuing the test up to 28 days and observing the trend of length-change. Continued increase in expansion, without any decrease in the rate, is generally indicative of reactive nature of the aggregate. Also, petrographic and scanning electron microscopic examination (SEM) along with energy dispersive X-ray analysis (EDX) are typically conducted on the test specimens to establish the ASR potential of the aggregate.

One concern with ASTM C 1260 test is the specific influence of cement used on the expansion behavior of test specimens. In order to observe the response of aggregates to variations in the compositions of different Portland cements in the ASTM C 1260 test, six different Portland cements available in the market were selected for this study. The principal difference in the composition of the six cements was their alkali content, ranging from a low value of 0.20% to a high value of 0.97% Na<sub>2</sub>O equivalent. Following the assessment of the ASR potential of the aggregates, the effectiveness of Class F fly ash and silica fume in mitigating the effects of ASR was evaluated by using a modified ASTM C 1260 test procedure. In this study, Class F fly ash was dosed at 25% by mass replacement of cement while silica fume was dosed at 10%. Petrographic, SEM and EDX investigations were conducted on polished specimens of mortar bars to study the composition of the reaction product to establish the ASR nature of the distress.

## **Results**

The results from this study clearly indicated that aggregate sources from Lyman, Lakeside and Pacolet quarry show very minimal expansion (< 0.1%) in the ASTM C 1260 test, when tested with each of the six cements, thereby suggesting their non-reactive nature. However, aggregate from Blacksburg quarry yielded expansions between 0.1% and 0.2% at 14 days with each of the different cements, indicating an inconclusive nature of reactivity of the aggregate. However, continued testing of the mortar bars in the 1 N sodium hydroxide solution at 80°C up to 28 days showed no abatement in the rate of expansion. Further investigation by means of petrographic, SEM and EDX revealed the presence of ASR gel product in the vicinity of some reacted aggregates. The composition of the gel was typical of ASR gels. Based on the expansion levels in the ASTM C 1260 test and the amount of the gel observed in the petrographic and SEM studies, Blacksburg aggregate would be classified as a mild to moderately reactive aggregate.

Modified ASTM C 1260 tests to evaluate the effectiveness of Class F fly ash and silica fume in mitigating the effects of ASR showed that both fly ash and silica fume were effective.

## **Conclusions and Recommendations**

Only one out of the four aggregates studied in this research showed potential to be susceptible to ASR based on the ASTM C 1260 studies. Based on the expansion data and petrographic and SEM-EDX results, Blacksburg aggregate can be classified as mild to moderately reactive aggregate. In this study, Class F fly ash and silica fume were found to be effective in mitigating the effects of ASR.

While, this research study focused on a limited sources of aggregates in the upstate region, it is recommended that ASTM C 1260 tests be conducted on all aggregates sources, listed for use in concrete, as a quality control measure to avoid any potential ASR-related distress in future in the state.