EVALUATION AND CONTROL OF ALKALI REACTIVITY OF CONCRETE AGGREGATE

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ABSTRACT

The alkali-reactivity of various Egyptian aggregates has been investigated using different analytical (such as XRF, XRD, and SEM) and mechanical (such as CPT, AMBT, and rock cylinder test) test methods. Six Egyptian aggregates representing a wide range of mineralogical composition and petrographic facies were evaluated. Three Canadian aggregates; Spratt; Pittsburg; and dolomite, were utilized as reference alkali-silica reactive, alkali-carbonate reactive, and non-reactive aggregates, respectively. Moreover, adopting the newly-developed concrete microbar test (CMBT) for evaluating alkali-silica and alkali-carbonate reactivity of Egyptian aggregates has been proposed. A practical and economical method for sample preparation of the rock cylinder test was recommended as well.

The effect of various levels of expansion due to alkali-carbonate reaction on the engineering properties of concrete such as strength and permeability was examined. The various expansion levels were produced using concrete mixes containing highly-reactive, marginally-reactive, and non-reactive aggregates. Low-alkali cement (LAC) and adequate mineral admixtures such as fly ash (FA), silica fume (SF), metakaolin (MK), slag or ternary blends of FA/SF or slag/SF were proposed as preventive measures for AAR-induced expansion of Egyptian aggregates. The factors affecting the expansion due to alkali-aggregate reaction (AAR) of Egyptian carbonate aggregates such as alkalis level, temperature, and clay minerals content, were studied. The mechanism of AAR for representative Egyptian aggregate sources was also investigated.

The main findings of this investigation were as follows:

1- The analytical test techniques such as XRF, XRD, SEM and petrographic examination are useful tools in studying the alkali-reactivity of concrete aggregate, and explaining the behavior of aggregates when used in concrete or mortar. However, for adequate evaluation of aggregates without prior history of testing, it is recommended to run both analytical and mechanical tests.

2- Concrete microbar test (CMBT) represents a promising accelerated test for evaluating alkali-silica and alkali-carbonate reactivity of Egyptian aggregates. The expansion recorded at 14 and 28 days are satisfactory for evaluating alkali-silica and alkali-carbonate reactive aggregates, respectively.

3- The rock cylinder/prism test was found an appropriate test that can provide quick and accurate evaluation of the alkali-carbonate reactivity of aggregates. An easy and economic set-up to run the test was developed.

4- The presence of marginally-reactive aggregate in concrete did not have noticeable effects on the concrete compressive, tensile and bond strengths, and ion migration. However, highly reactive aggregates were found to have negative effects on these properties.

5- Low-alkali cement (LAC) with $Na_2Oe < 0.6$ % by mass, reduced the expansion due to ACR of marginally-reactive aggregates. However, other sources of alkalis could contribute to the expansion during the service life of the structures. Intermediate calcium fly ash used at replacement level of 25 % was also able to reduce the expansion at 2 years.

6- Some constituents present within the rock matrix of carbonate aggregate such as quartz and clay minerals may undergo alkali-aggregate reaction in severe regimes of alkalis or elevated temperatures. However, field exposure tests of these aggregates are required to determine whether or not these aggregates will undergo AAR.

7- Dolomitic limestone rocks such as KM101 Egyptian aggregate undergo dedolomitization reaction in concrete prism test. The reaction products (calcite and brucite) were detected in the concrete prisms accompanied with 1-year expansion of 0.042 %. These aggregates are considered moderately alkali carbonate reactive aggregates.

Key Words: Alkali-aggregate reaction (AAR), Alkali-silica reaction (ASR), Alkali-carbonate reaction (ACR), Dedolomitization, Concrete prism test (CPT), Concrete microbar test (CMBT), Rock cylinder test, Egyptian aggregates, and marginally-reactive aggregates.

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