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EXPANSION TESTS FOR ALKALI-REACTIVITY OF AGGREGATES – A COMPARISON BASED ON A KINETICS APPROACH

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Abstract. The reactivity of aggregates regarding the alkali-silica reaction (ASR) has been measured by different properties affected by the reaction. Among these properties, one of the most often used is the linear dilatation of mortar bars or concrete prisms.

Many test-methods use this property to measure aggregate reactivity. They differ in procedures for measuring and accelerating the reaction, as well as implementing conditions and criteria. Criteria are usually proposed by comparing with performance records of aggregates in field structures.

This study suggests that different values for reactivity, i.e., essentially the same kinetic parameter, yielded by different test-methods measuring the same property should be kinetically inter-related. The inter relation should match the known effect on kinetics when changing major factors, particularly alkalinity, and temperature.

This paper presents a kinetic inter relationship between standards used, i.e. NF P 18-590, ASTM C 1260, and ASTM C 1293. Globally, they cover a temperature range from 38 to 127 ºC, and different alkalinities. The relationship found shows consistency also for several aggregates, tested for the first two methods and ASTM C 227. Aspects related to the different experimental conditions on the test-methods and their effects are discussed.

For all three tests, the critical expansions were converted to reaction rates, and these rates were corrected for the change in alkalinity to pre-fixed reference conditions. The rates obtained were plotted as an Arrhenius plot. The linearity of the representation was considered as a criterion of kinetic compatibility of the tests.

Main assumptions made were a constant rate of expansion for aggregates critically reactive (as suggested by limiting expansion values, but checked with several aggregates to be just approximate, as shown in figure 1), a relation between cement alkali contents and pore solution alkalinity as given by Helmut equation and, as general criterion an Arrhenius type dependence of rate of reaction and temperature. The rates are expressed as inverse of the equivalent time required to reach 0.1% strain.

Figure 2 depicts such an Arrhenius plot for reference tests ASTM C 1260, ASTM C 1293 and NF P18-590. The high correlation regression line defines two fields: the reactive one, above it (higher rates or lower equivalent times) and the non reactive one, below. Test ASTM C 227 (corrected for leaching) falls in the reactive field, in line with comments referring that it may fail to identify aggregates with reactive record.

Figure 3 depicts an Arrhenius plot of the inverse of equivalent times from data of

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expansion tests NF P18-590, ASTM C 1260 and ASTM C 227 on sand aggregates of varying reactivity (same as in Figure 1). AR 5, clearly reactive, departs form linearity. Others are quasi reactive, near the threshold line. The regression lines and respective correlation coefficients are tabled.

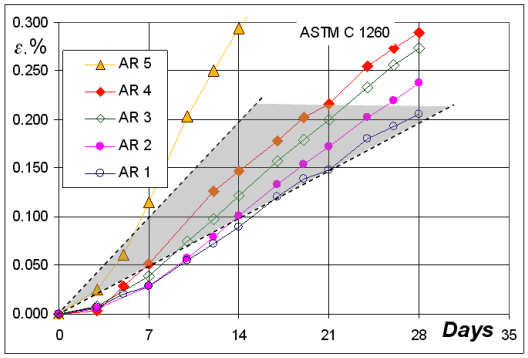

Figure 1-ASTM C 1260 data for sand aggregates; expansion is nearly linear in shaded area (near-reactive range).

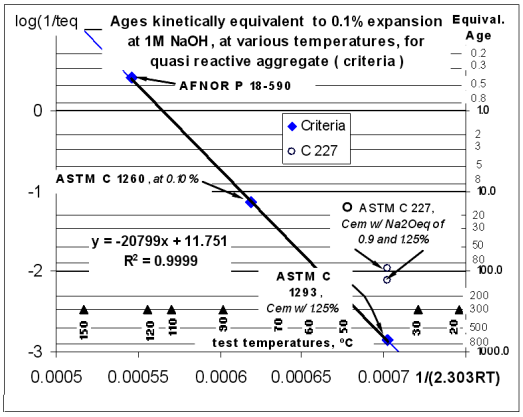

Figure 2 Arrhenius plot relating reference tests ASTM C 1260, ASTM C 1293 and NF P18-590

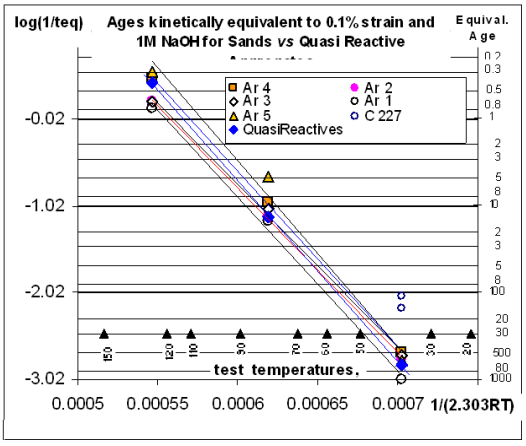

Figure 3 Arrhenius plot comparison between results of the 3 tests on sand aggregates (same as in Figure 1).

Results obtained suggest that the standards used and the aggregate reactivity, at the given conditions, are fairly consistent from the kinetic point of view. Some suggestions are made for improvements of accuracy of the relationship obtained.