13th Euroseminar on Microscopy Applied to Building Materials
14-18 June 2011, Ljubljana, Slovenia

PETROGRAPHIC CHARACTERIZATION OF GRANITIC AGGREGATES. COMPARISON WITH THE RESULTS FROM LABORATORY TESTS

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Keywords: granitic aggregates, petrographic characterization, expansion tests

Introduction

Granitic rocks are widely used as aggregates for concrete in Portugal. Although this type of rock is known in some countries to be non-potentially reactive to alkalis, there are reported cases of alkali-silica reaction related to granitic aggregates.

As defined by the Portuguese specification LNEC E 461, petrographic analysis is the first to be carried out when aggregates of unknown performance need to be characterized. The characterization is based on the determination of the percentage of reactive forms of silica in order to classify the aggregate as innocuous or as potentially reactive, according to classes similar to those defined in RILEM AAR-1. This assessment is followed by the mortar bar test (ASTM C 1260 or RILEM AAR-2) when the aggregate is classified in Class II or III. The local experience is that some of the granitic aggregates classified as innocuous by RILEM AAR-2 show a field performance different from that predicted by the tests. Therefore, a research project is being carried out in which systematic concrete prism tests (RILEM AAR-3 and RILEM AAR-4.1) are used to validate the results obtained by petrography and to establish which laboratory test(s) is(are) the most accurate for the assessment of the alkali reactivity of granites.

In the present work, the first results of the research are presented, aiming to contribute to the reformulation of the national specification and to establish a possible correlation among the results from different methods.

Materials and methods

Three types of crushed granitic aggregates, from Portuguese quarries, were sampled and studied, assessing their petrographic characteristics and their laboratory performance, when applied as aggregates in mortar and concrete. In order to predict the field performance of the aggregates and to compare results, petrographic characterization (RILEM AAR-1, 2003) and expansion tests, namely ASTM C 1260 (2007) accelerated mortar bar test, RILEM AAR-3 (2000) and RILEM AAR-4.1 (2011) concrete prism tests were carried out.

Results and discussion

Petrographic characterization

The results of point-counting of the analyzed aggregates are displayed in Table 1.

The assessment of reactivity to alkalis revealed that aggregate A contains strained quartz crystals. Most of the strained crystals show undulatory extinction (~18º). Quartz is also present as myrmekite in plagioclase and in goticular form in K-feldspar. Quartz, along with K-feldspar and plagioclase, are frequently microcracked.

The examination of aggregate B showed the same deformation features as aggregate A. In this case, the angle of undulatory extinction is about 16º and myrmekite and goticular quartz are also common.

Aggregate C, besides featuring quartz with undulatory extinction (~20º) and deformation lamellae, exhibits a quite substantial amount of microcrystalline and sub-granulated quartz. Goticular forms of quartz are present in K-feldspars and plagioclases. Besides quartz, deformation is also confirmed by the presence of sheared phyllosilicates and plagioclases and by preferential orientation of the minerals. According to the percentage of potentially reactive features, it can be said that only aggregate A can be classified as innocuous to alkalis by petrographic characterization. On the contrary, aggregate B and, especially, aggregate C present values of the potentially reactive features above 2%, which classify them as potentially-reactive.

Table 1: Results of the point-counting method (values in %).

Mineral	**Aggregate A**	**Aggregate B**	**Aggregate C**
Plagioclase	36.0	30.5	26.1
Quartz	28.8	25.1	12.5
Potassium Feldspar	20.4	26.8	26.3
Muscovite	9.5	3.8	9.7
Biotite + Chlorite	3.8	10.2	3.1
Recrystallized and/or goticular, and/or myrmekite quartz	**1.0**	**2.4**	**21.7**
Accessory minerals	0.5	1.2	0.66
Total	100.0	100.0	100.0

Expansion tests

When submitted to ASTM C 1260 accelerated mortar bar test at 80ºC, aggregates A, B and C showed 14 days expansion values of 0.02%, 0.01% and 0.02%, respectively. With the aim to confirm the results, the mentioned tests were carried on for another 14 days. According to the expansion results, all aggregates were considered as being non-reactive. So far, the results achieved by the AAR-3 concrete prism test at 38ºC are related just to 6 months, half of the time considered as a minimum for any final conclusions to be drawn. All three concrete samples present a similar behavior. After 196 days, aggregate C concrete prism exhibits the highest expansion value (0.03%), followed by aggregates A (0.02%) and aggregate B (0.01%). Therefore, it seems appropriate to wait for the completion of this test to draw any further conclusion. The aggregates performance during the 20 weeks long AAR-4.1 concrete prism test at 60ºC revealed all aggregates as being reactive, with aggregate C, displaying the highest final expansion (0.07%). Till now, only AAR-4.1 concrete prism test was able to detect reactivity and confirm some of the results observed by the petrographic characterization, namely for aggregates B and C.

Conclusions

The tests performed in the 3 granitic samples lead to the conclusion that the ASTM C-1260 mortar bar test shows a poor correlation with the petrographic characterization of the three aggregate A, B and C. The AAR-4.1 (60ºC) concrete prism test is showing to better mirror the expected reactivity assessed by petrographic methods. Although the AAR-3 (38ºC) concrete prism test is assumed to be the laboratory test which best reproduces the field conditions, the duration until now does not permit to draw any final conclusions from the results obtained. It should also be kept in mind that crushing certain types of aggregates for laboratory tests may change some of their characteristics (microstructure) and therefore the grading actually used in the concrete structures should preferably also be used as such in the laboratory tests. This means that concrete prism tests should be privileged to reproduce field conditions and further experiments need to be done to study the accuracy of the AAR-4.1 (60ºC).

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