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Evaluation of laboratory test methods for assessing the alkali-reactivity potential of aggregates by field site tests

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Extended Abstract

As part of the European “PARTNER” project (2002-2006) [1] field site tests were carried out to assess the reliability of the tests developed by RILEM and some regional tests to evaluate the alkali-reactivity potential of aggregates (eight tests were included). One hundred concrete cubes made with 13 different European aggregate combinations were stored on eight different European field sites from Italy to Norway to compare their expansions with the laboratory test results. This document presents the results of field site tests after 15 years of outdoor exposure to evaluate the four expansion test methods AAR-2, -3,--4.1 and -4.1 with wrapped prisms developed by RILEM and four regional concrete test methods. The regional tests are: the German concrete test at 40°C, the Norwegian concrete prism test at 38°C, the Danish mortar bar test TI-B51 at 50°C and the Danish Chatterji method.

Results of field site tests

All highly reactive aggregates expanded within the first six years at all field sites and showed high expansions from 0.3% to 1.6% after 15 years. In the mild and warm climates of Dusseldorf, Germany and Milan, Italy the expansion rates decreased after some years, whereas in cold climates like Trondheim, Norway and Borås, Sweden the expansion still continued, probably due to freeze/thaw actions that damage the concrete further once ASR has caused sufficient cracks.

The cubes with the moderately reactive aggregates expanded considerably slower with expansions of about 0.09% to 0.22% after 15 years.

The cubes with the non-reactive aggregate “French limestone” neither expanded at any field site nor showed significant cracking. However, the Damage Rating Index (DRI) determined on polished sections and qualitative damage assessment performed on thin sections revealed that an alkali-silica reaction (ASR) occurred to a small extent. The French gravel with flint was considered to be potentially reactive with clear pessimum effect and it is classified as non-reactive in this paper because damage in structures was not evident and the cubes in Milan only showed very little expansions of 0.05 % after 9 years and no significant cracking. Based on experiences from other field site tests, a limit value of 0.050% is applied to identify non-reactive aggregates.

Laboratory-field-correlations

For assessing the laboratory-field-correlations, the mean laboratory test results of all participating laboraties were used.

Both versions of the accelerated mortar bar test (AAR-2.1 and AAR-2.2) were able to reliably distinguish between non- and highly reactive aggregates. It also identified the majority of the moderately reactive aggregates.

The concrete prism test methods AAR-3 (former, wrapped version) and AAR-4.1 were effective in distinguishing between the non- and highly reactive aggregates. In general, the highly reactive aggregates showed expansions above 0.16% in AAR-3 and between 0.10% and 0.20% in AAR-4.1. An exception is the Danish flint containing sand that showed only little expansions in the laboratory tests and even passed AAR-3.

Looking at the moderately reactive aggregates, the two versions of RILEM test method AAR-4.1 were detecting its reactivity potential more reliably if the limit value of 0.03% after 20 weeks was applied. AAR-3 failed in identifying the three slowest reacting aggregates. The AAR-4.1 was far better, and displayed the reactivity potential of four out of the five moderately reactive aggregates. The results confirm the RILEM-proposed acceptance limit of 0.03% and suggest an assessment after 20 instead of 15 weeks.

The German and the Norwegian concrete test methods were able to distinguish between non- and highly reactive aggregates. However, the German method failed to identify the moderately reactive aggregates. Even the additional 300mm-cube did not show maximum crack widths ≥0.20 mm for these aggregates. The overall expansions were lower compared with AAR-3, probably caused by a higher alkali leaching rate in the German fog chamber.

Compared with AAR-3 and the German method, the Norwegian CPT had the best match with the field performance of the cubes. It correctly displayed the alkali-reactivity potential of the three tested moderately reactive aggregates. This can probably be attributed to the bigger prisms (400 x 400 x 450 mm³) and less alkali leaching compared to AAR-3 (75 x 75 x 250 mm³).

The Danish mortar bar test TI-B51 was able to show successfully the reactivity potential of the non-reactive and all highly reactive aggregates, but underestimated the reactivity potential of the moderately reactive aggregates. Four highly reactive aggregates were classified as moderately reactive according to the limit values.

The results of the Danish Chatterji method suggest that calculated delta-values of 19 and higher are indicating a potential reactivity of the aggregate. Highly reactive aggregates revealed delta-values between 30 and 50. Exceptions are aggregates with flint. The non reactive aggregate with flint gave a very high delta-value and the highly reactive sand with flint had a very low one compared to the other highly reactive aggregates.

Conclusions

After about 15 years of outdoor exposure, the main conclusions from this research are as follows:

- None of the two non-reactive aggregates showed any signs of ASR in the outdoor exposure sites.
- Highly reactive aggregate combinations caused significant expansions of concrete cubes at the field sites in Norway, Germany and Italy within the first six years of storage.
- All five moderately reactive aggregate combinations (timescale of reaction 15 to 50 years based on field experience) showed signs of damaging ASR.
- Once a deleterious ASR has occurred freeze/thaw actions can further damage the concrete.
- The field site tests confirm that all laboratory tests correctly identified highly reactive and non-reactive aggregate combinations. However, from the RILEM test methods, AAR-4.1 seems to be best suited to identity the potential reactivity of moderately reactive aggregate combinations. The results confirm the limit value of 0.03% after 20 weeks instead of 15 weeks.
- The Norwegian concrete prism test at 38°C was also reliably identifying the moderately reactive aggregate combinations, probably due to reduced alkali leaching of the prims compared to RILEM AAR-3.

References

[1] Lindgård J, Nixon P J, Borchers I, Schouenborg B, Wigum B J, Haugen M, Åkesson U (2010) The EU "PARTNER" project - European standard tests to prevent alkali reactions in aggregates: Final results and recommendations. Cement and Concrete Research (40) 611-635

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