

ASR related service life estimation for concrete pavements

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Extended Abstract

In 2010/11, the federal highway research institute of Germany (BAST) launched a large-scale survey on highway concrete pavements. That is around 5800 km of the highway network. The result was that more than 1500 km were more or less affected by an ASR, i.e. more than 25 %. Based on these results, the BAST starts a large research program in 2012 to clarify the reasons for the damage and to derive measures to safely avoid further damage to concrete pavements.

Overall, 53 highway sections across Germany were selected for the sampling. Among the 53 selected highway sections, 33 were built single-layered and 20 dual-layered with different concrete compositions in each layer. In total 71 different concrete compositions had to be investigated. Residual expansion measurements were performed with the climate simulation concrete prism test (CS-CPT). The CS-CPT was developed at the Bauhaus-University Weimar to test specific concrete compositions (job mixtures) for their ASR potential with the option to take external alkalis into consideration [1, 2]. For the test, concrete samples are applied with a test solution (water, de-icer solutions etc.) while subjected to cycles of alternating temperature and moisture conditions (Figure 1).

The expansions for the 71 concrete compositions exposed to NaCl solution during the CS-CPT range between 0.21 and 3.45 mm/m (Figure 2), representing very different ASR potentials from very low to very high. A major difficulty emanates from the different age of the concretes. A conventional evaluation of the results by assessing the expansions after a fixed testing period would not allow comparing the different concretes directly to each other or to estimate their remaining service life. Hence, an evaluation that considers the age of the concretes, which ranges between 4 to 32 years, was required. Based on an earlier correlation between the CS-CPT and field performance, the testing period until reaching the expansion limit and the time when first damage (cracks) appeared in the field was plotted against each other. The function that fits best to those data points as well as to some extra boundary conditions was used to convert the period of testing into a corresponding time in the field. The converted expansion curves were used to estimate the remaining service life for every concrete individually (Figure 3).

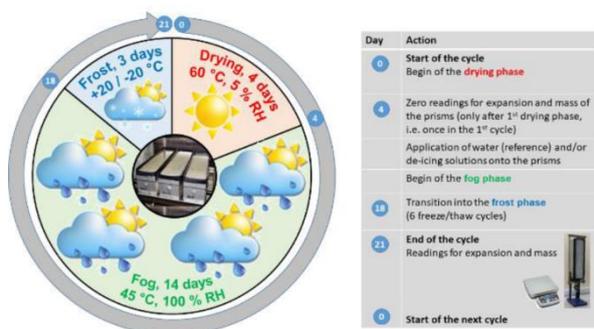


Figure 1: Schematic diagram of the 3 phases of a climate simulation cycle (12 cycles are required to evaluate the suitability of pavement concrete compositions with the CS-CPT)

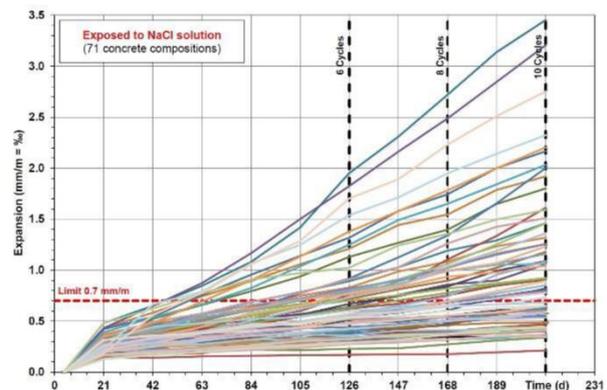


Figure 2: Expansions during the CS-CPT for the 71 different concrete compositions exposed to NaCl solution

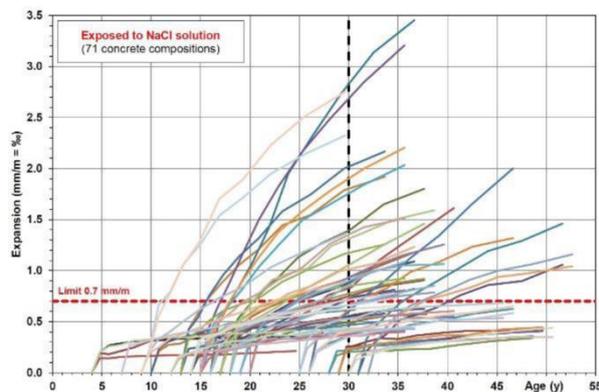


Figure 3: Expansions during the CS-CPT for the 71 different concrete compositions exposed to NaCl solution, converted from testing time in days (Figure 2) into real time in years and assigning the concretes to their age at the time of sampling

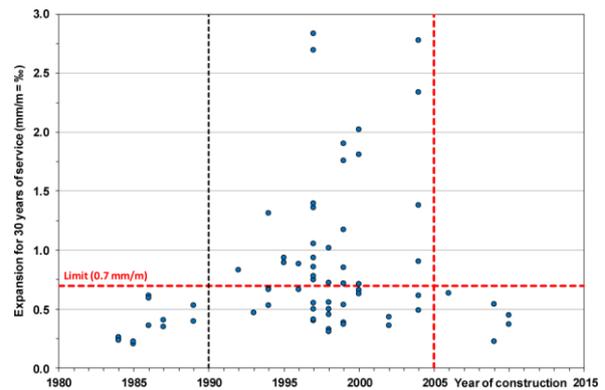


Figure 4: Comparison between year of construction and 30-year expansion (Figure 3) exposed to NaCl solution for all sampled highway sections (sections ≥ 30 years old not included, in case of dual-layered highway sections, top and bottom concrete separately)

In the result, 51 % of the sampled highway sections would reach a service life of at least 30 years without ASR damage (Figure 4). Some of those sections were around 30 years old at the time of sampling and without any ASR damage. For those concretes, only low residual expansions were measured what confirms the correctness of these CS-CPT results. For 49 % of the sampled highway sections, however, it is likely that ASR damage occurs prior to a 30 year service life. All of them were built between 1990-2005, showing that the regulation applied at that time (German "Alkali-Guideline") was ineffective in reliably preventing ASR. For all the highway sections built after 2005, a sufficiently low ASR potential was found, what confirms the effectiveness of the new regulations for preventing ASR in highway pavement concrete (ARS 04/2013) in Germany, introduced in 2005.

For one highway section, a first agreement between the service life estimation and the field performance could be found. More highway sections will be monitored over the next years to obtain a greater data base to verify and further improve the approach. The derived service life estimation for highway pavement concretes is provided as a tool for better planning and conducting maintenance and repair measures in the field.

With the current state of knowledge and a consistent application of the CS-CPT, ASR damage can be reliably avoided when building new concrete highways.

The authors gratefully acknowledge the financial support of the Federal Ministry of Transport and Digital Infrastructure (BMVI) and the BAST and the fruitful collaboration with the project partners. This report is based on the research project carried out at the request of the Federal Ministry of Transport and Digital Infrastructure, represented by Federal Highway Research Institute, under research project No. 08.2014/2011/LRB. The authors are solely responsible for the content.

- [1] Giebson C (2013) Die Alkali-Kieselsäure-Reaktion in Beton für Fahrbahndecken und Flugbetriebsflächen unter Einwirkung alkalihaltiger Enteisungsmittel. Dissertation, Bauhaus-Universität Weimar. <http://nbn-resolving.de/urn:nbn:de:gbv:wim2-20131217-20916>
- [2] Sims I, Poole AB (2017) Alkali-aggregate reaction in concrete: A world review. CRC Press/Balkema, London

This article was published in special issue of *Materiales de Construcción Journal* devoted to the 16th ICAAR (<https://doi.org/10.3989/mc.2022.15921>).