Accelerated expansion caused by alkali-silica reactions

Damage occur to an increasing number of Danish and international concrete bridges as a result of lack of maintenance, poor concrete mix and expected or unexpected demolition mechanisms. One of the major challenges is damage caused by alkali-silica reactions (ASR). ASR is a chemic reaction caused by the interaction among reactive aggregates, water and alkalis from for example concrete or de-icing salt. The reaction exerts an expansive pressure in the concrete and if the internal expansive forces exceed the tensile strength of the cement paste, cracks will occur. This phenomenon is known as ASR-induced damage.

Globally, records have shown that many bridges are affected by serious ASR damage. Furthermore, the expectations are that a large number of existing and well-functioning concrete bridges are at great risk of developing ASR-induced damage under the adverse circumstances. The Danish Road Directorate has estimated that in Denmark alone, about 600 highway bridges are at risk of developing ASR-induced damage in the near future.

To make the right decision concerning the future of the damaged concrete bridges, the engineers have to be capable of making a reliable assessment of the remaining load-carrying capacity of the structure. Unfortunately, it is not possible to use the present standard methods for determining the load-carrying capacity, as these are primarily developed for (conservative) dimensioning tools for new structures and not for damaged concrete structures. Consequently, the engineers are often left to give their own rough estimates of the remaining load-carrying capacity.

When developing a feasible method to assess the remaining load-carrying capacity of an ASR-damaged bridge, it is important to know which mechanisms are activated in response to the ASR-induced expansions in the concrete.

Very few tests have been made to determine the load-carrying capacity of ASR-damaged concrete structures. The tests show that the remaining load-carrying capacity is not reduced to the extent feared. This is due to the fact that the reinforcement keeps the concrete together during the ASR-induced expansion. A load-carrying capacity test is in principle a snapshot; thus, it cannot be used to predict whether the remaining load-carrying capacity is continuously reduced over time. New full-scale tests performed on an existing ASR-damaged bridge have shown a significant reinforcement expansion. The tests indicated that the reinforcement expansion stagnates, whereas the ASR damage continues. This will probably imply a further reduction in the load-carrying capacity of the bridge after the reinforcement expansion has stagnated. It is therefore of utmost importance to know this context in order to be able to develop a feasible method, which can predict the load-carrying capacity of ASR-damaged bridges.

In the autumn of 2015, PhD student Søren Gustenhoff Hansen from the University of Southern Denmark will perform a series of tests with concrete slabs during which the ASR damage will be accelerated. The measuring equipment will be embedded with the purpose of measuring and comparing the reinforcement expansion with the resulting ASR-induced damage. COWIfonden has supported the implementation of the experimental tests.