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Crack assessment of hardening concrete structures:
Comparisons between DIANA, two alternative programs and experimental results.

Authors: **Anja B.E.Klausen[1], Øyvind Bjøntegaard[2] and Terje Kanstad[1]**

[1] Department of Structural Engineering, NTNU - Trondheim
[2] Norwegian Public Roads Administration, Tunnel and concrete section

Participant and presenter: **Anja B.E.Klausen**
Department of Structural Engineering, NTNU - Trondheim
Rich. Birkelandsvei 1, 7491 Trondheim, Norway
e-mail: anja.klausen@ntnu.no

ABSTRACT

Hydration reactions in the concrete during the hardening phase will cause temperature development as well as volume changes, and if these movements are restrained by the concrete's structure, stresses will be generated, which again may lead to cracking. Autogenous deformation and thermal dilation are shown to be the major driving forces to stress generation and cracking in real concrete structures. The amount of stress generated by autogenous deformation and thermal dilation in a given time interval is dependent on the degree of restraint by the surrounding structures and the creep/relaxation properties of the concrete.

The Temperature-Stress-Testing-Machine (TSTM) System at NTNU consists of a TSTM and a Dilation Rig. The Dilation Rig measures the free deformation of concrete, i.e. the sum of autogenous deformation and thermal dilation. The TSTM is constructed to measure the concrete stress generation in the hardening phase for a prescribed temperature history at a given degree of restraint. Laboratory experiments with hardening concrete have been carried out in the TSTM System. The concretes used in the experiments are concretes for infrastructure projects made with new environmentally friendly low heat cements; this means concrete where substantial parts of the cement are replaced by fly ash. The experimental behavior is simulated by four different approaches:

1) A self-made Visual Basic program based on the integral form of the linear superposition principle for aging materials
2) The recently developed special purpose program CrackTeSt-COIN made especially for early age concrete problems
3) DIANA - using the Double power law and the solution based on Taylor series, which is the most commonly used method for Diana and young concrete.
4) DIANA - using the general viscoelastic model with Maxwell chain elements. Parameters determined via the Swedish program Relax.

In general the agreement is very good which is a clear improvement related to earlier experience. However, the approach with DIANA and the Taylor series solution seems to be insufficient for some of the considered stress histories. Some theoretical stress histories are simulated to enlighten the problems.