PhD Position

A combined experimental and numerical approach to spalling of high-performance concrete due to fire

Project summary

High-Performance Concrete (HPC) is a modern building material with superior properties compared to traditional concrete. Due to its high compressive and tensile strength, high modulus of elasticity, low permeability and good durability, HPC is widely used in high-rise buildings, thin walled (especially prefabricated and pre-stressed) elements for building façades, prefabricated columns, elements for tunnels. A major limitation to the widespread use of HPC is that it is prone to explosive spalling when exposed to fire. Explosive spalling of the concrete cover exposes the reinforcement and may lead to premature failure of concrete members. Research on spalling has been concentrated on extensive testing and identifying the main influencing parameters. Several spalling theories have emerged, but explanations are mostly qualitative and no general consensus on a single theory has been reached. As a consequence, no design methodologies exist and the construction industry has to rely on expensive large-scale tests.

The goal of the proposed research is to better understand the mechanisms involved in spalling and to come up with a model that can be verified both theoretically and experimentally in a quantitative way. Like others, we will mainly consider the combined action of pore pressure and thermal stresses. However, in addition to the commonly used temperature and pressure measurements, we will also measure the moisture content by neutron radiography and combine this information with a numerical mesoscopic approach well adapted to the material scale.

This combined numerical-experimental strategy will give insight into the fundamental mechanisms and allow for quantitative verification of assumptions used in different theories. For instance, we will be able to see whether and how moisture clogs, considered to be one of the main factors leading to excessive pressure build-up, develop and how they are related to spalling. To be able to assess different theories, we will develop a thermo-hygral-mechanical model based on a mesoscopic approach that explicitly takes into account the heterogeneous structure of the material, thus allowing a direct correlation with the experimental observations. The model will be first applied to small-samples (10 cm) neutron tests measuring temperature, pressure, and moisture. Different concrete mixtures with and without PP-fibres fibres will be investigated. Material properties will be measured on the same concrete mixtures that are used in the fire tests, thus allowing the creation of a consistent database.

Location and practical aspects

The successful applicant will develop the numerical part of the project at laboratory 3SR, University of Grenoble (France) and the experimental tasks at Empa Zurich (Switzerland). He/she will work under the supervision of prof. Dal Pont (3SR) and Dr. Weber (Empa).

The gross salary will be 1787 euros/months, equivalent to a net salary of 1452 euros/month (3 years PhD fellowship offer).

Qualifications of the applicant

An MSc (or equivalent experience) in Civil and Structural Engineering or a subject closely related is required. It will be given preference to candidates with analytical or numerical research experiences (Matlab, Castem or other programming languages) on multiphase porous media. Effective communication in English and report writing skills are required.

Applications

Interested candidates should send their CV and cover letter to S.Dal Pont (Stefano.dalpont@3sr-grenoble.fr) and B.Weber (Benedikt.Weber@empa.ch)

Deadline for the application:

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