The University of Queensland - IIT Delhi Academy of Research Joint PhD Project

PROJECT TITLE	**EXPERIMENTAL AND NUMERICAL INVESTIGATION OF FIRE-INDUCED CONCRETE SPALLING UNDER BIAXIAL STRESSES**
PROJECT CODE	**UQIDAR 00189**
PROJECT DESCRIPTION	Unlike metals, brittle materials like concrete and rocks undergo fracture without significant plastic deformation prior to failure. Tensile fracturing of concrete can therefore be abrupt and violent, leading to shattering without any pre-warning. Such spontaneous fractures in the field are commonly known as stress spalling or bursting caused by buckling of the rock layers detached by the tensile fractures in underground rock structures or in concrete structures at high temperatures. Fire-induced spalling in concrete have jeopardised the safety of personnel, seriously damaged structures, and shut down operations from months to more than a year, or permanently. The fire-induced spalling was responsible for the structural collapse of the Mont Blanc tunnel in 1999, which resulted in 39 deaths and 34 injures and in the rehabilitation cost of over 300 million euros. However, there are yet limited engineering knowledge of governing mechanisms in concrete spalling due to the erratic nature of this phenomenon and the inhomogeneity of concrete mixes. Given the complex thermo-hydro-chemo-mechanical nature of brittle concrete fractures, many factors have been deemed to affect concrete bursting failure modes including the stress path, rate of mechanical loading/unloading, moisture condition and build-up of pore pressure during damage accumulation, heated area, heterogeneity, and certain concrete admixtures. Nevertheless, the presence of intermediate principal stress and its effect on the spalling failure in many of the available models has largely been ignored. This present study aims to develop new methods of monitoring, predicting and preventing dangerous failures in concrete surfaces under stress conditions in underground tunnels that have received very little attention in the literature. Both experimental and numerical studies have been proposed to be conducted on the small-scale as well as large-scale tunnel models under elevated temperature. The findings of these studies would be utilized in developing the prediction models and to propose new design guidelines for preventing fire-induced spalling in precast and shotcrete concrete.
PROJECT OUTCOMES	The proposed project consists of three overlapping stages: (i) extensive experimental (physical modelling) program, (ii) analytical and numerical modelling program, and (iii) development of methods of monitoring, prediction and prevention of failures caused by catastrophic fracture propagation in concrete under biaxial compression. The main objectives are to: (1) Develop coupled thermo-mechanical models to predict dangerous fire-induced concrete spalling; (2) Provide practical procedures during the site characterization and laboratory investigation phases to assess if fire-induced concrete spalling should be anticipated during construction or the life-time of the project; and (3) If spalling is expected, provide design procedures to identify the (lateral and radial) extent of the spalled zone for risk assessment purposes.

ADVISORY TEAM	**Dr Mehdi Serati** Civil Engineering, UQ https://researchers.uq.edu.au/researcher/10399 **Associate Professor Dipti Ranjan Sahoo** Civil Engineering, IITD http://web.iitd.ac.in/~drsahoo/ **Additional advisors** Dr Cristian Maluk, UQ
TYPE OF STUDENT	Applications are open to **i or q student**s who meet eligibility criteria.
DISCIPLINE BACKGROUND OF STUDENT	In the experimental part of the program, physical modelling of catastrophic fracture propagation in cubic samples of concrete with different mixes under biaxial compression will be studied first. Then, fire-induced spalling in concrete structures under the same loading conditions will be investigated further by preparing a through-hole (tunnel) in the concrete blocks subjected to heat flux with a flame jet located inside the borehole. The stress field acting at the surface of an excavation (tunnel) and under the heated surface at the time of spalling will be finally reconstructed in a numerical platform for the interpretation of the experimental results and for performing parametric studies. A student with a background and experience in the area of Civil Engineering (particularly in concrete testing and fire safety engineering) and familiarity with coupled thermo-mechanical numerical modelling is preferred.
IDEAL CANDIDATE	**Essential capabilities:**Knowledge in geotechnical and/or Structural and/or Fire Safety Engineering with high grades in academics. **Desirable capabilities:**Experience in experimental testing and/or numerical simulations knowledge in coupled thermo-mechanical modelling or structural fire safety engineering. In case the student does not have the relevant experience, the student will be encouraged to undertake additional studies in this field at UQ and/or IIT Delhi. **Expected qualifications (courses, degrees, etc):** Masters Degree in Structural Engineering or Civil Engineering or a related discipline.
APPLICATION PROCESS	Apply online by the due date: https://www.uqidar.org/students/how-to-apply/