Civil Engineering Research Group

Invitation to Seminar

- **Development of a novel test method for heat-induced explosive spalling of concrete tunnel linings**

Damage to tunnel linings as a result of a fire requires significant time and money for repairs, no more so than when the concrete linings have spalled. Despite over a century of research, spalling remains a poorly understood phenomena and a high-risk aspect of tunnel design and operation. The results of current experimental programs and approvals tests are difficult to compare as methods being used vary greatly and often do not allow the necessary precision in control of boundary conditions. In this seminar Ieuan presents an overview of the current state of the art spalling knowledge and his PhD research in which he developed a cost and time effective testing methodology for heat-induced explosive spalling. The method was developed with a focus on ensuring proper control the parameters currently thought to affect spalling. The method allows repeatable testing of concrete mixes used in tunnel linings and assessment of the influence of heating conditions and mechanical load. The novel apparatus developed, H-TRIS, builds upon the work of a former PhD student and allows accurate control of the thermal boundary conditions through direct control of the incident heat flux applied to samples rather than control of the gas temperatures within a furnace. Dr Rickard modified the apparatus to allow the thermal exposures used for tunnel design to be replicated and built a bespoke 3MN loading frame to allow simultaneous heating and loading of samples

Dr Ieuan Rickard OFR Consultants

Ieuan is a member of the RILEM international technical committee for spalling (RILEM TC 256-SPF) and recently completed his PhD at The University of Edinburgh. Ieuan joined OFR Consultants in 2018 where he is working to incorporate state of the art fire engineering knowledge into design

- **Composite action in sprayed concrete tunnel linings**

Sprayed concrete has become widely used for tunnel linings in soft ground over the last 20 years. The flexibility of the method makes it suited for irregular shapes in underground metro stations such as on the Jubilee Line and CrossRail in London. When the method was originally used, the 'primary' lining that was first sprayed against the ground was regarded as temporary works and sacrificial, and was ignored for the permanent load case. A 'secondary' lining was sprayed later, and designed to take all the loads. However, as the quality control of the linings has steadily improved, this decision has been reassessed such that today, the primary lining is always included in the final permanent design. A second innovation has been the introduction of a sprayed waterproofing layer between the primary and secondary linings. This has the advantage of speed and flexibility compared to traditional sheet membranes. Taken together with the inclusion of the primary lining as permanent structure, this means that composite structural action of the primary and secondary lining acting together in bending becomes a possibility, where it was previously not with sheet membranes. It has been thought that composite action could lead to savings in lining thickness, which could save significant cost over a tunnel project. This is the question that this research tries to answer – does the composite action exist, and is it beneficial to the lining design? Through a research programme over several years by means of laboratory experiments and numerical modelling, Alan and his former PhD student Dr Jiang Su have tried to answer these questions and Alan will summarise the outcomes.

Dr Alan Bloodworth University of Warwick

Alan is Associate Professor at Warwick and Course Leader for the MSc Tunnelling and Underground Space. His research interests are chiefly in reinforced concrete structures and tunnel lining design. He is a member of the Concrete Society Design Committee, the fib Working Group on Fibre-reinforced Sprayed Concrete and the International Tunnelling Association ITAtech Activity Group on Lining and Waterproofing.

Wednesday 6 March 2019, 1pm-2:00pm
Room A401 Engineering Building

The seminar is open to all.
For more information, contact Dr Rezania (m.rezania@warwick.ac.uk).