

High Performance Concrete for Protective Structures – Part B: Characterisation and Constitutive Modelling of Dynamic Response of HSC and Establishment of a High-Capacity Ballistic Testing Facility

This project focuses on the dynamic properties of high-strength concretes (HSCs) and their performance in protection against projectile impact. It encompasses experimental characterisation and constitutive modelling of the dynamic material response of HSC, and ballistic tests on HSC targets. Tensile and compressive static and dynamic tests were performed on three HSCs with different strengths, to examine the effects of strain rate on their mechanical properties – i.e. stress-strain relationship, compressive/tensile strength – and how these vary with concrete strength. A 3D finite element (FE) model for HSC was also developed; the model incorporates details of the HSC meso-structure – i.e. random distribution of coarse aggregate particles within the mortar matrix, and a cohesive surface between the aggregate particles and the mortar matrix via an interfacial transition zone. This meso-scale FE model yields reasonable estimates of the HSC response, based on the properties of the constituent mortar and coarse aggregate prescribed to it. The model was employed to investigate the effect of aggregate size and volume fraction on HSC properties. With respect to ballistic testing, a 30mm-calibre high-capacity gas gun was procured and installed in the NUS Impact Mechanics Lab. It was utilised to propel 250g ogival-nose projectiles with a diameter around three times the maximum size of the coarse aggregates, to impact HSC targets at velocities of ~300-640m/s. The variation of penetration depth and crater size with impact velocity was determined and analysed in relation to HSC strength. Finite element simulation of penetration tests was also undertaken, and the computational model provides reasonable accuracy in predicting the penetration resistance of HSCs.

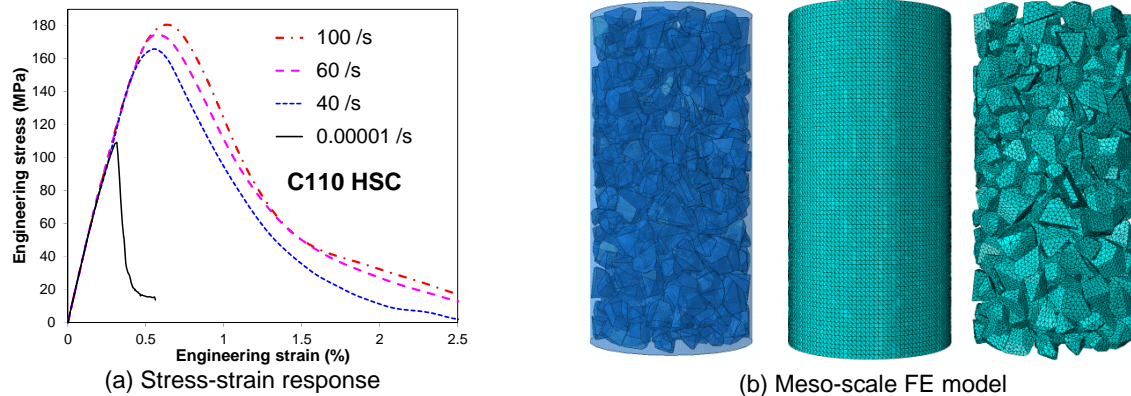


Figure 1: Experimental characterisation and constitutive modelling of HSC

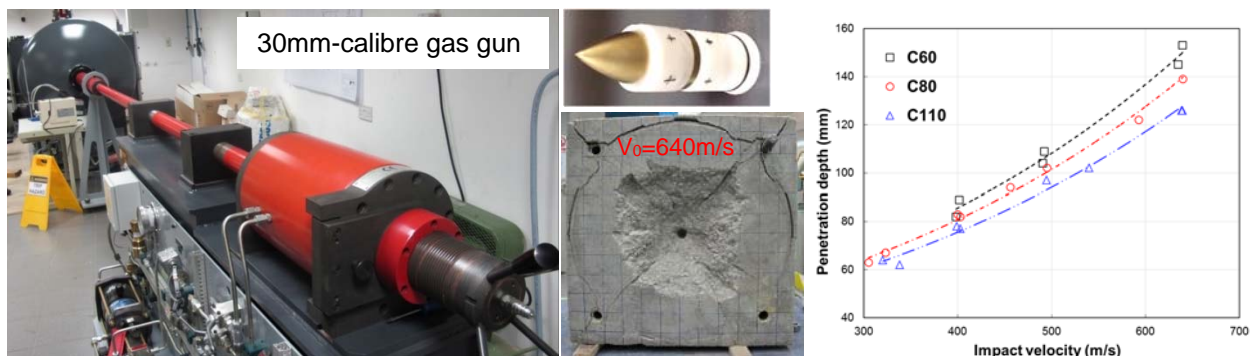


Figure 2: Projectile penetration tests on HSC targets

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