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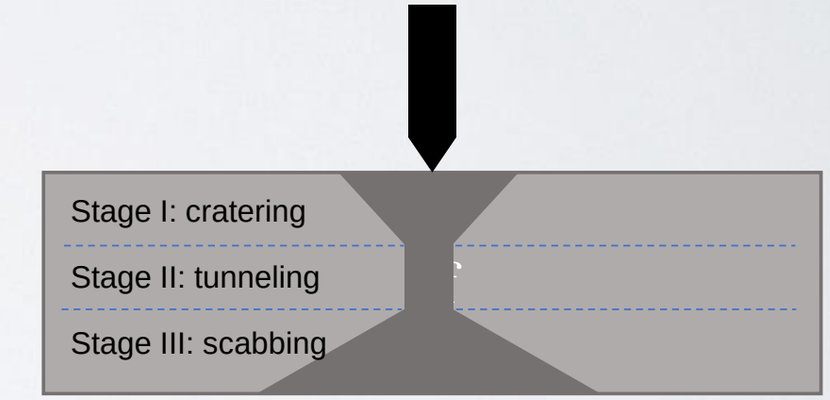
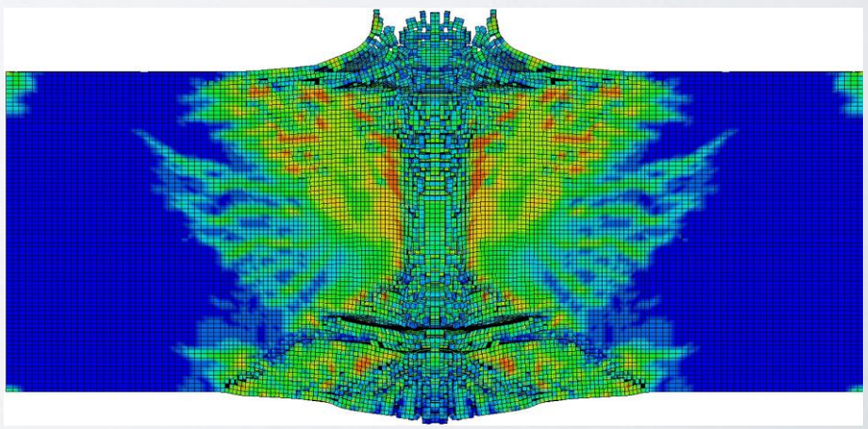
Constitutive modelling of concrete material subjected to low-velocity projectile impact: insights into damage mechanism and target resistance

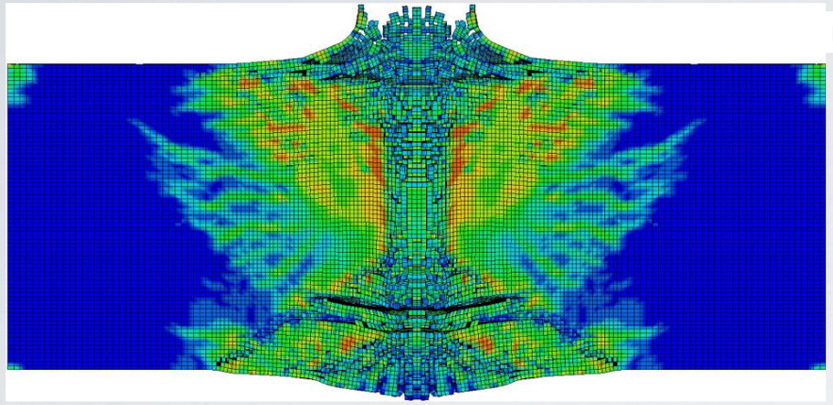
Key words:

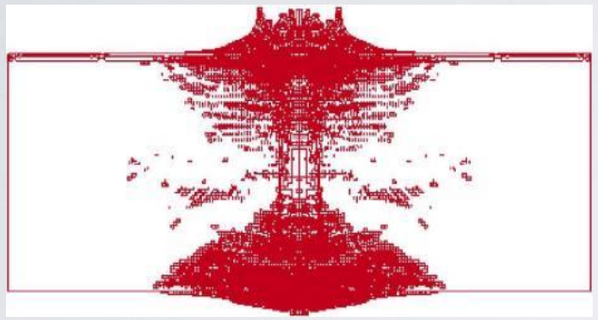
Penetration; Perforation; Damage mechanism; Target resistance; Projectile impact; Pore collapse

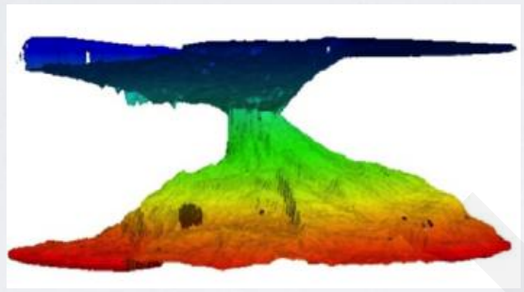


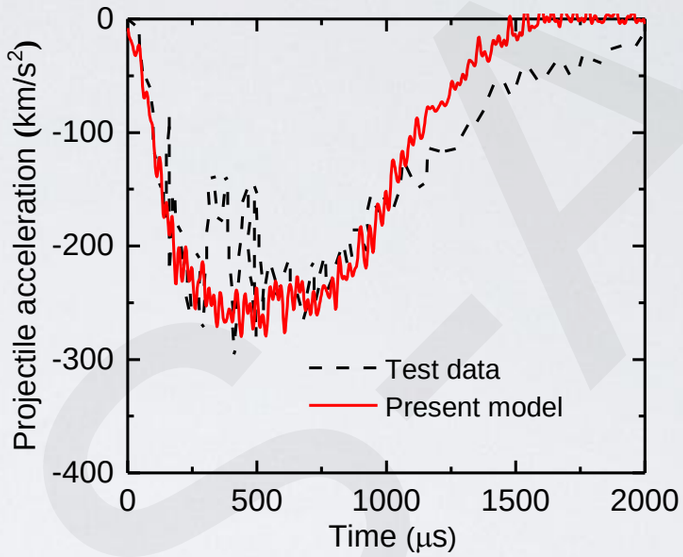


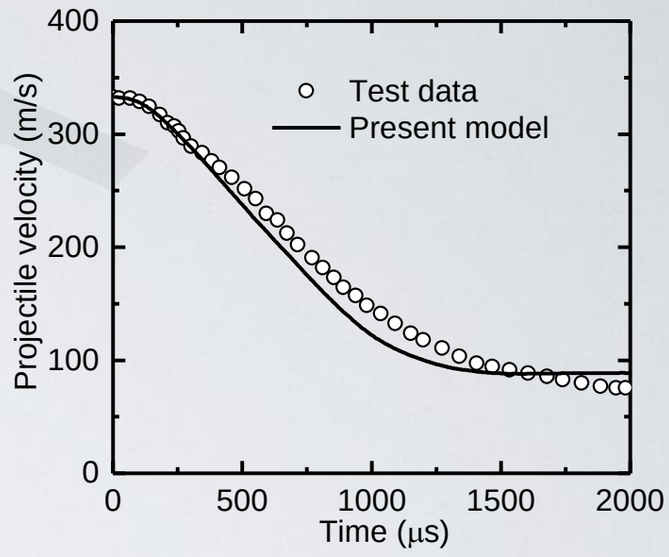
Validation of numerical model



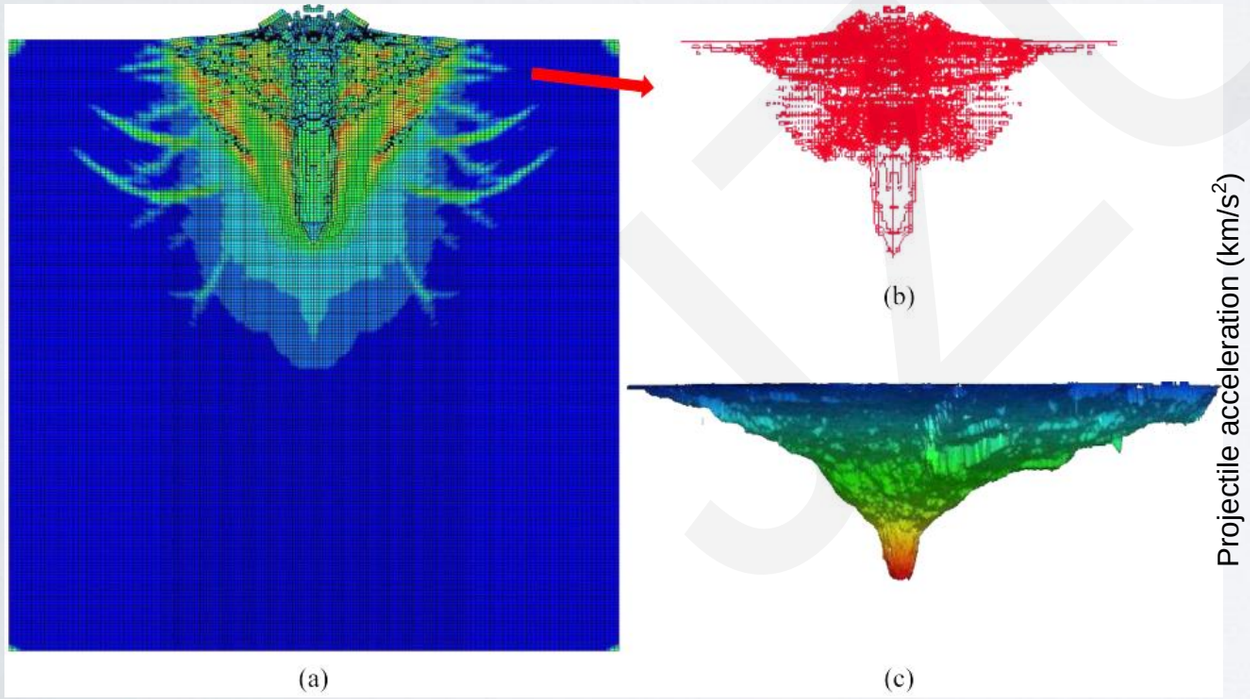


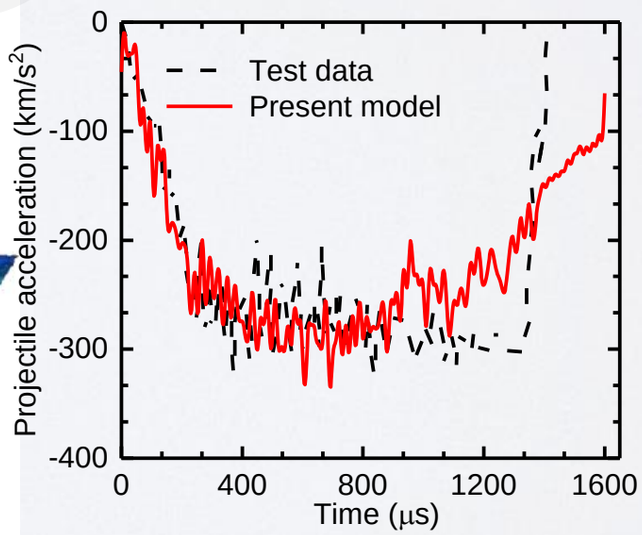


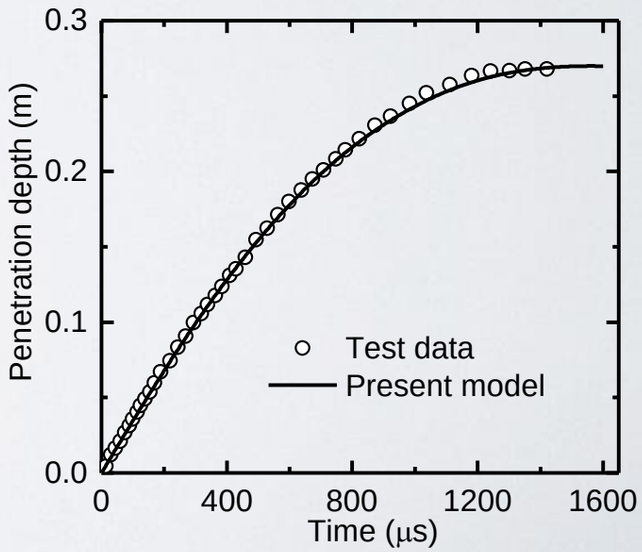




a 300-mm thin concrete target perforated by a projectile at 333 m/s



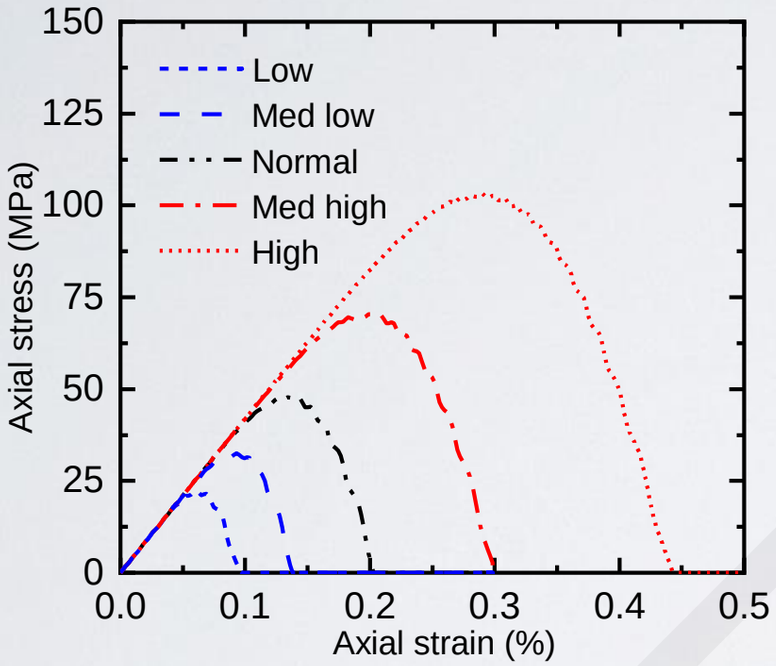


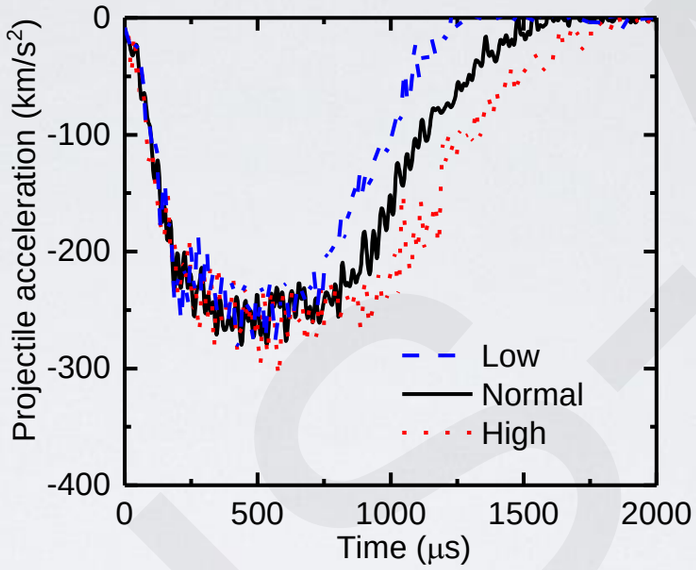


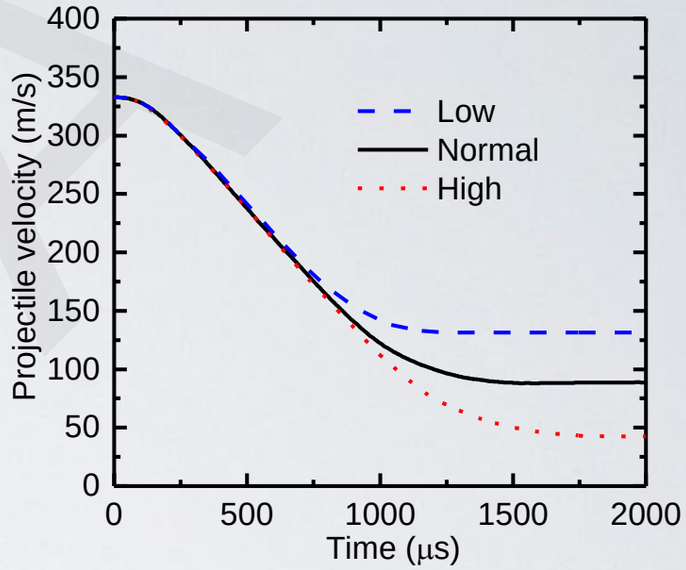
an 800-mm thick concrete target penetrated by a projectile at 347 m/s

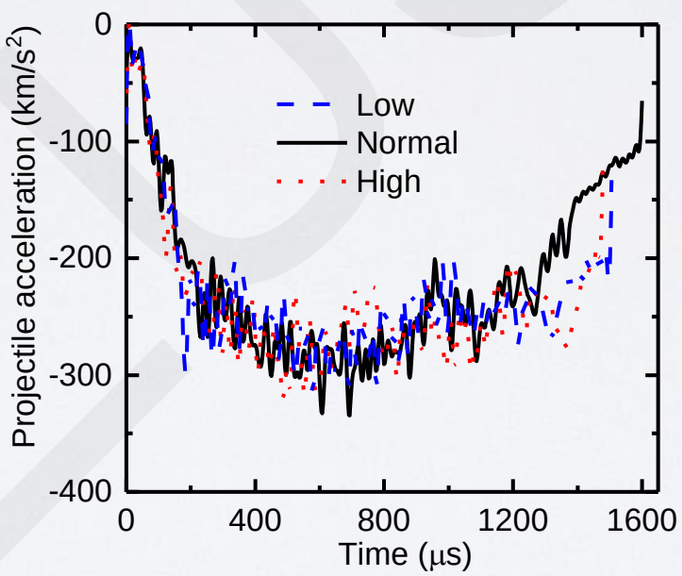
Main results

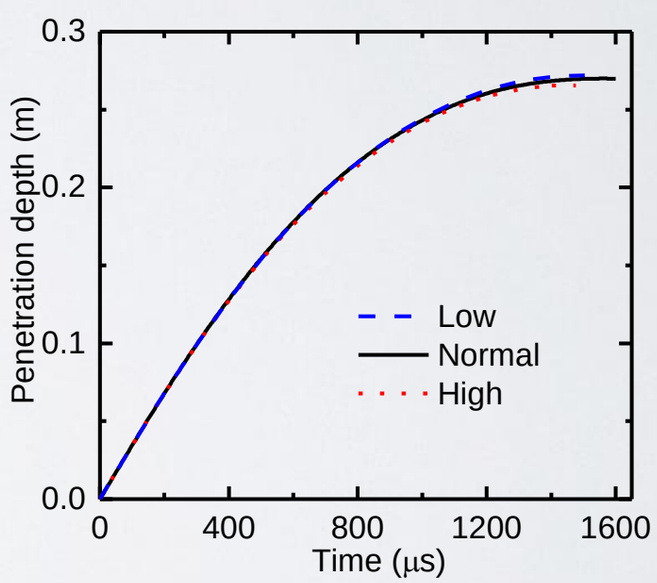
- Influence of concrete tensile behavior on its ballistic performances

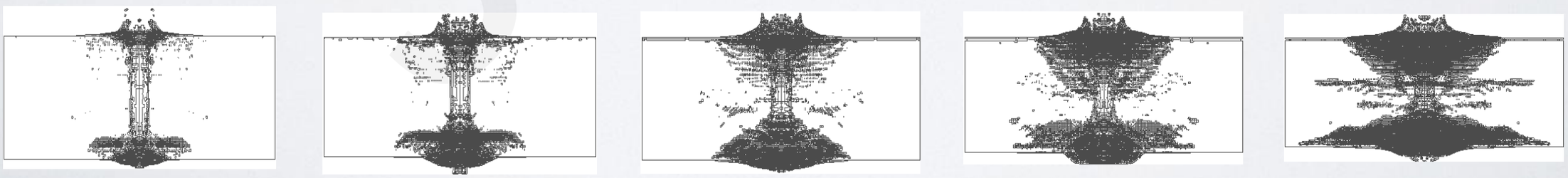








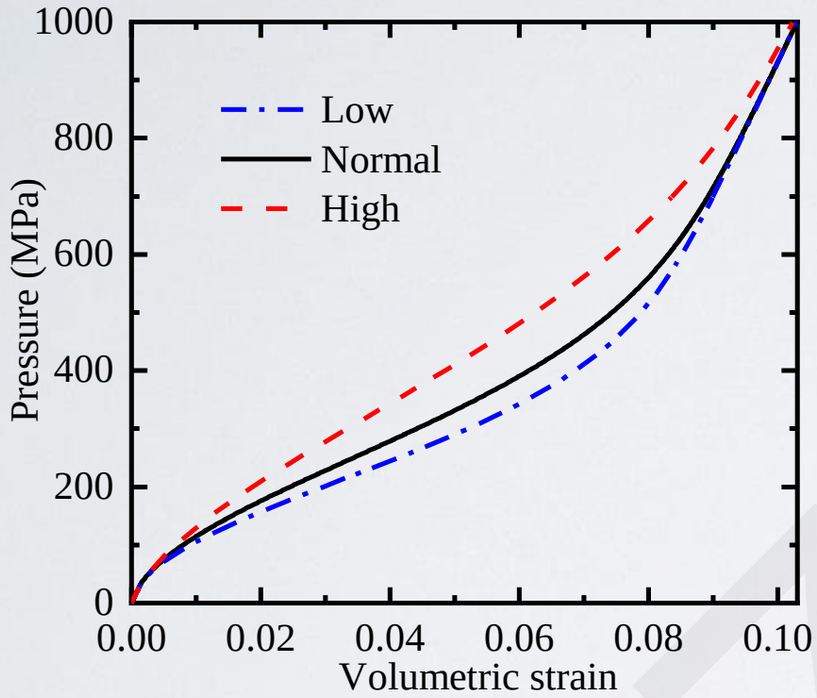


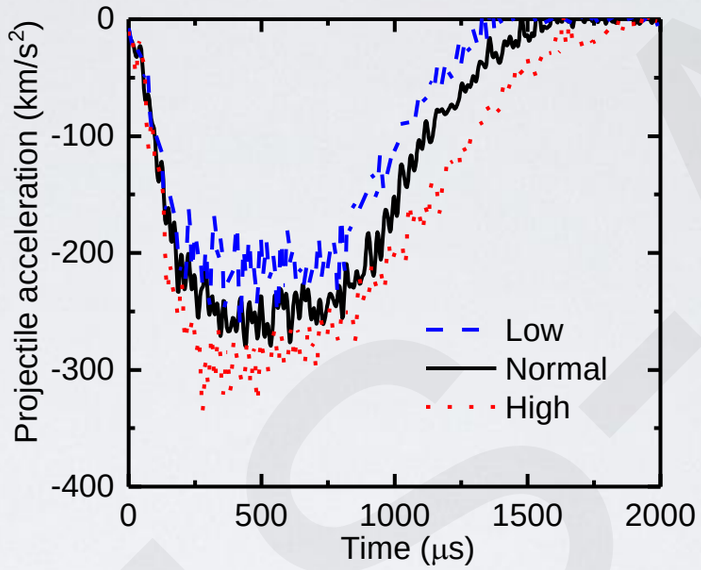


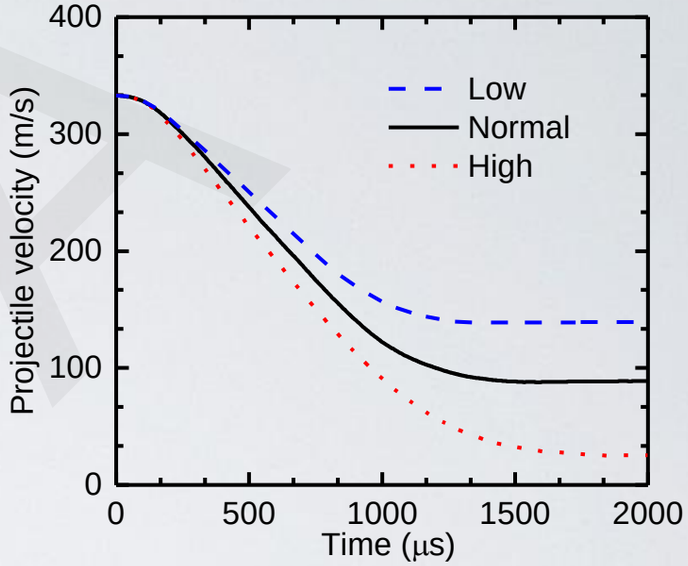
Low | Med low | Normal | Med high | High

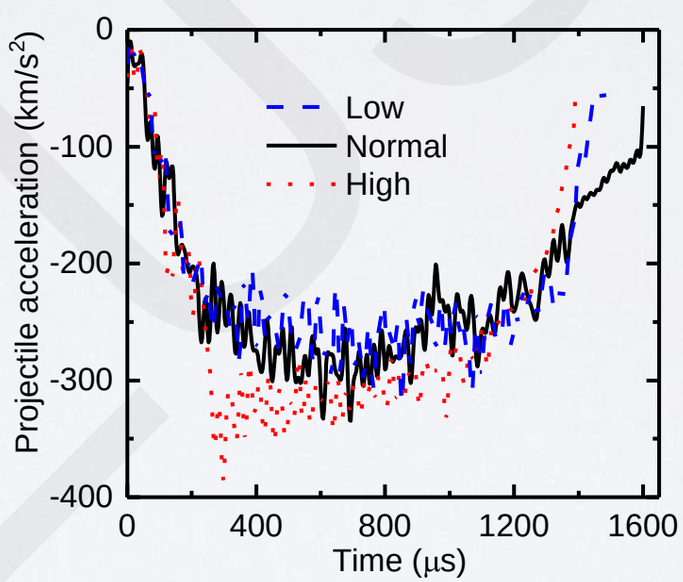
Main results

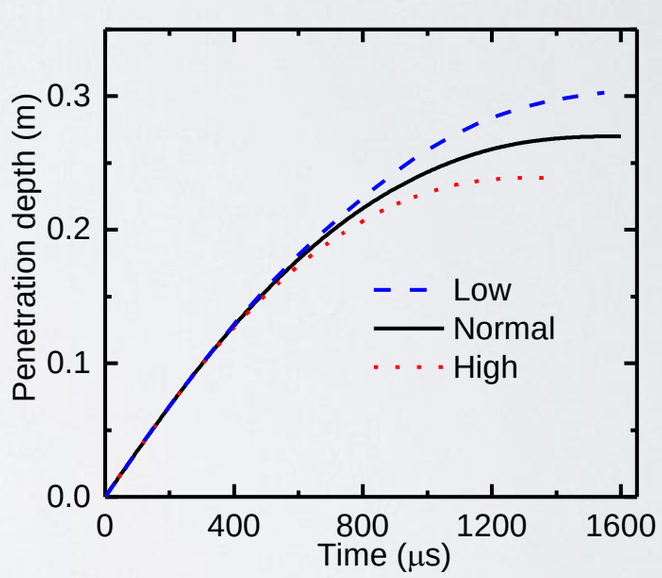
- Influence of concrete volumetric behavior on its ballistic performances

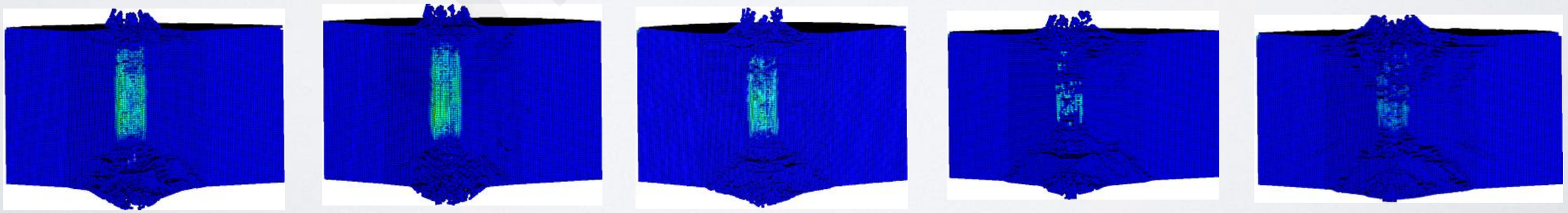








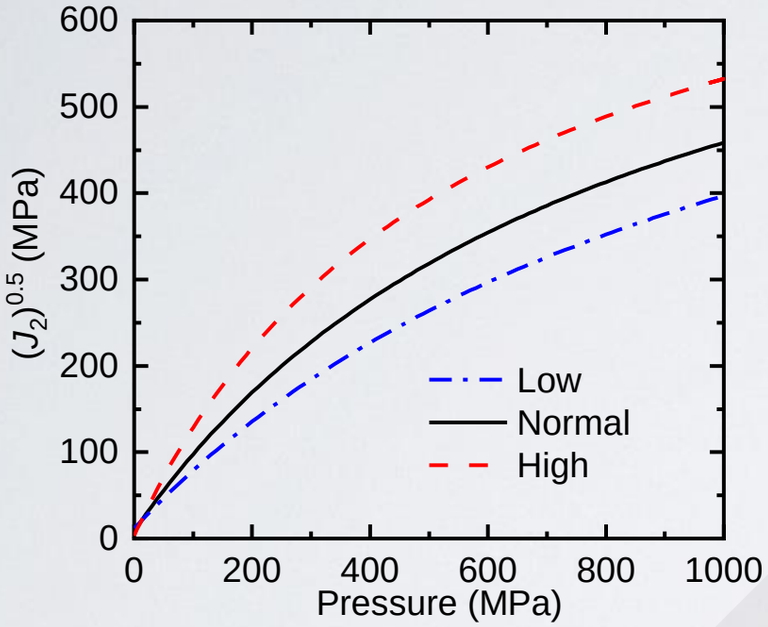


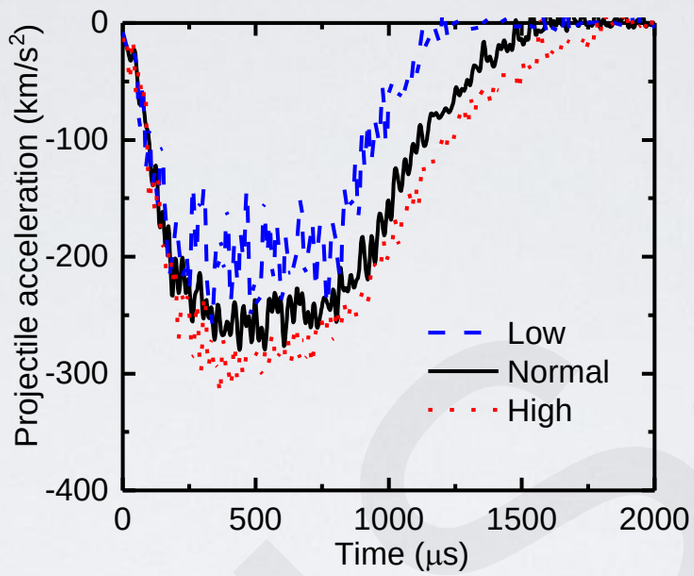


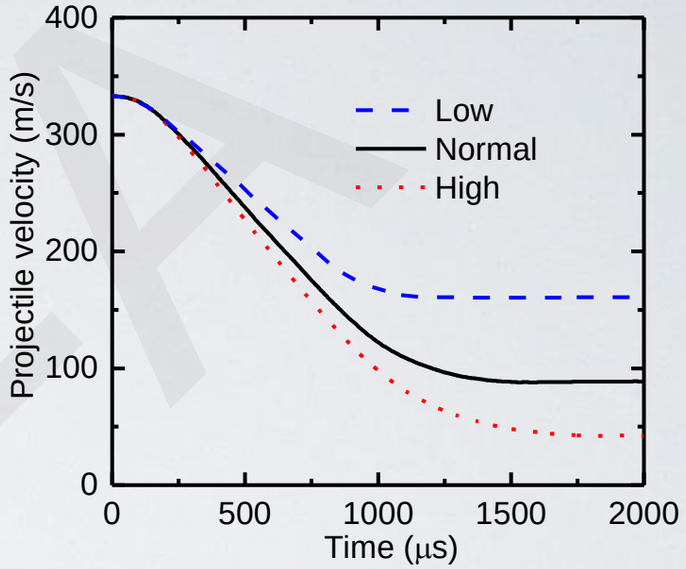
Low | Med low | Normal | Med high | High

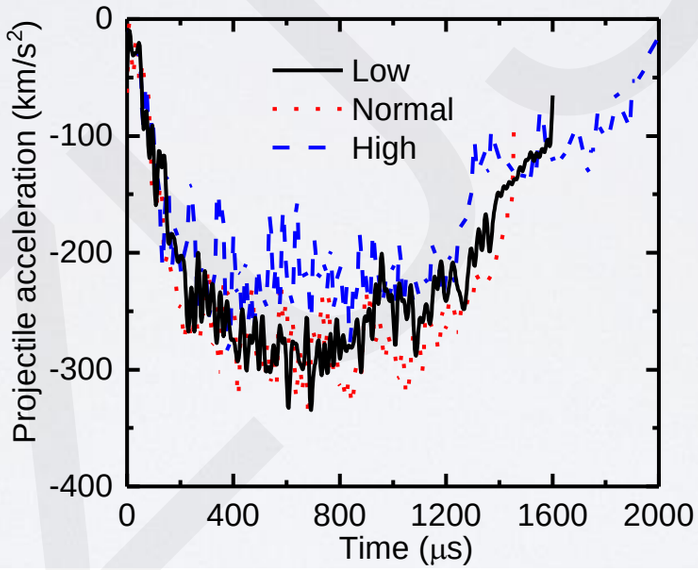
Main results

- Influence of concrete volumetric behavior on its ballistic performances









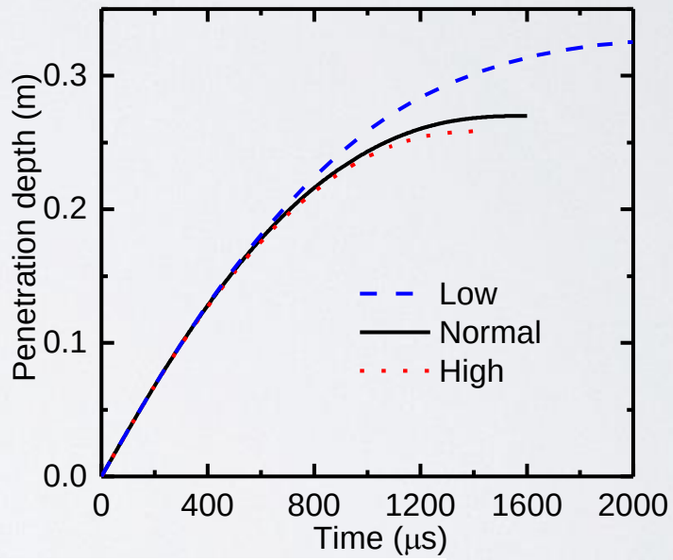


Table 7 Influence of concrete shear behavior on its impact resistance and failure modes

Scheme	300-mm thin concrete targets perforated by 333-m/s projectile			800-mm thick concrete targets penetrated by 347-m/s projectile	
	Residual velocity (m/s)	Cratering size (mm)	Scabbing size (mm)	Penetration depth (mm)	Cratering size (mm)
Low	160.9 (+81.4%)	373.3 (−0.4%)	401.2 (−0.6%)	0.3253 (+21%)	416.7 (+3.9%)
Med low	134.3 (+51.4%)	391.4 (+4.4%)	416.5(+3.2%)	0.3033 (+11%)	391.4 (−2.2%)
Normal	88.7 (baseline)	374.8	403.6	0.2699	400.3
Med high	81.1 (−8.6%)	404.2 (+7.8%)	371.2 (−8.0%)	0.2600 (−3.7%)	403.1 (+0.7%)
High	42.2 (−52.4%)	414.2 (+10.5%)	421.1 (+4.3%)	0.2584 (−4.3%)	406.7 (+1.6%)

Note: values given in brackets above refer to the difference relative to the 'Normal' scheme

Conclusions

Damage mechanisms:

- The formation of the cratering on the front face and the scabbing on the rear face is mainly determined by its tensile mechanical behavior, while the middle high-pressure tunnelling process is determined by concrete shear and volume compression behavior.
- Damage due to pore collapse during the high-pressure tunnelling process is clearly captured by the proposed hydrostatic damage.

Target resistances:

- The unconfined compression strength is not the main factor affecting the penetration resistance of concrete target, but the shear and volumetric behaviors under high pressure play a decisive role, and the middle high pressure tunneling stage is the main process of the concrete target anti-projectile body penetration.
- The influence of concrete tensile behavior on its penetration resistance is commonly neglected previously, but this study finds that the tensile behavior can significantly affect the residual velocity of the projectile, thus its effect on target resistance cannot be ignored.