PFC

Calibration results

1. Granite

The uniaxial compressive strength is 161.40MPa, and the Poisson's ratio is 0.261, the tensile strength is 19.87MPa, the total particle number of models for uniaxial compression is 35190, and the number for Brazilian splitting test is 13720, the strain rate of model is 1e-3/s.

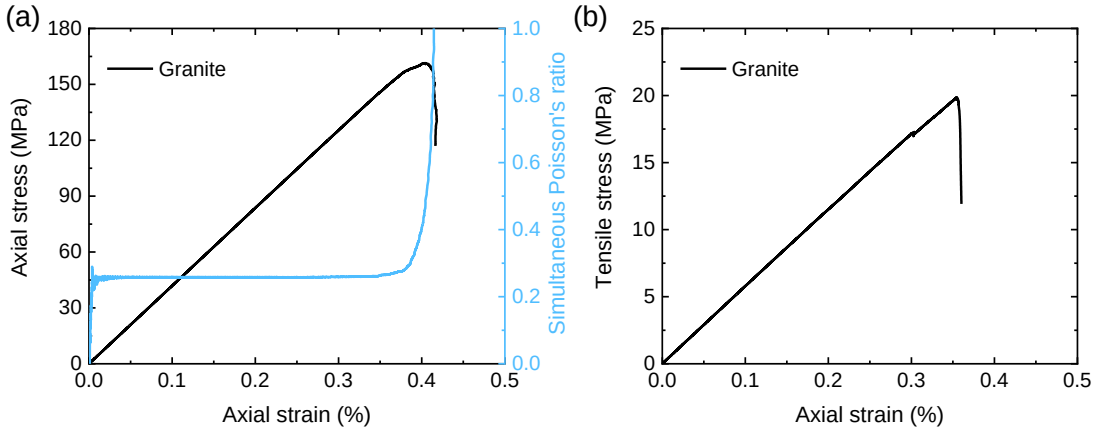

Fig. 1 Numerical results of intact granite sample, (a) Uniaxial compression test, (b) Brazilian splitting test

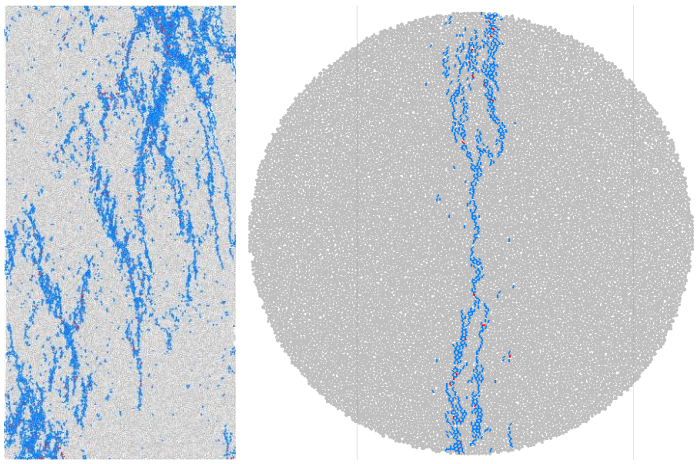

Fig. 2 Numerical models after uniaxial compression and Brazilian splitting tests

Table 1. Microparameters of the granite sample

Micro parameters	values
Minimum particle radius R_{min}	0.15(mm)
Particle radius ratio R_{max}/R_{min}	1.66
Particle elastic modulus E_b	20.6(GPa)
Particle stiffness ratio k_n/k_s	2.2
Parallel bond elastic modulus E_P	20.6(GPa)
Parallel bond elastic modulus $\bar{k}_n/\bar{k}_s$	2.2
Friction coefficient μ	0.76
Tension strength *Pb_ten*(ave±std.dev)	47.8±2(MPa)
Shear strength *Pb_coh*(ave±std.dev)	61.85±2(MPa)

2. Marble

The uniaxial compressive strength is 119.11MPa and the Poisson's ratio is 0.269, the tensile strength is 13.87MPa, the total particle number of models for uniaxial compression is 35190, and the number for Brazilian splitting test is 13720, the strain rate of model is 1e-3/s.

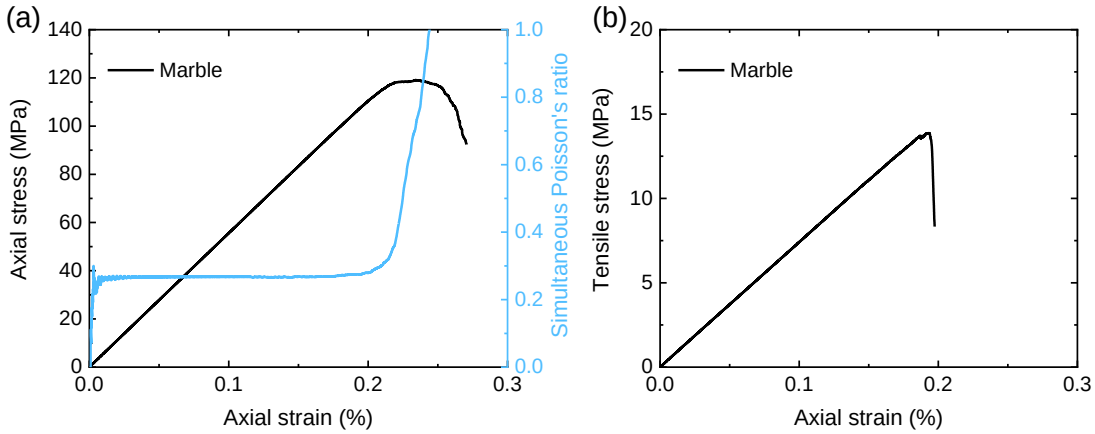

Fig. 3 Numerical results of intact marble sample, (a) Uniaxial compression test, (b) Brazilian splitting test

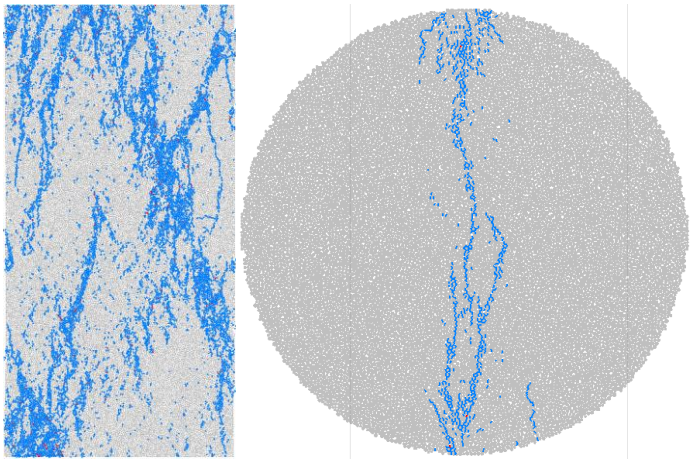

Fig. 4 Numerical models after uniaxial compression and Brazilian splitting tests

Table 2. Microparameters of the marble sample

Micro parameters	values
Minimum particle radius R_{min}	0.15(mm)
Particle radius ratio R_{max}/R_{min}	1.66
Particle elastic modulus E_b	27.6(GPa)
Particle stiffness ratio k_n/k_s	2.3
Parallel bond elastic modulus E_P	27.6(GPa)
Parallel bond elastic modulus $\bar{k}_n/\bar{k}_s$	2.3
Friction coefficient μ	0.76
Tension strength *Pb_ten*(ave±std.dev)	32.8±2(MPa)
Shear strength *Pb_coh*(ave±std.dev)	49.5±2(MPa)

3. Sandstone

The uniaxial compressive strength is 118MPa and the Poisson's ratio is 0.215, the tensile strength is 14.57MPa, the total particle number of models for uniaxial compression is 35190, and the number for Brazilian splitting test is 13720, the strain rate of model is 1e-3/s.

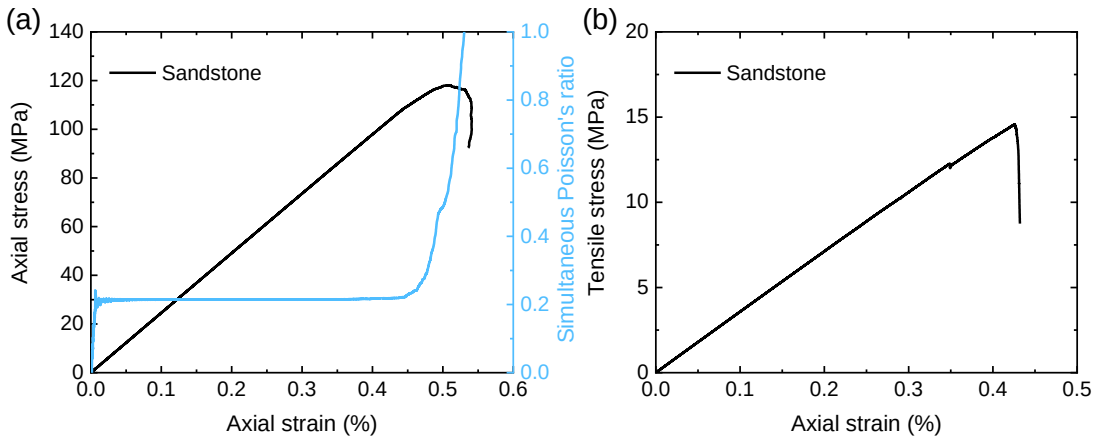

Fig. 5 Numerical results of intact sandstone sample, (a) Uniaxial compression test, (b) Brazilian splitting test

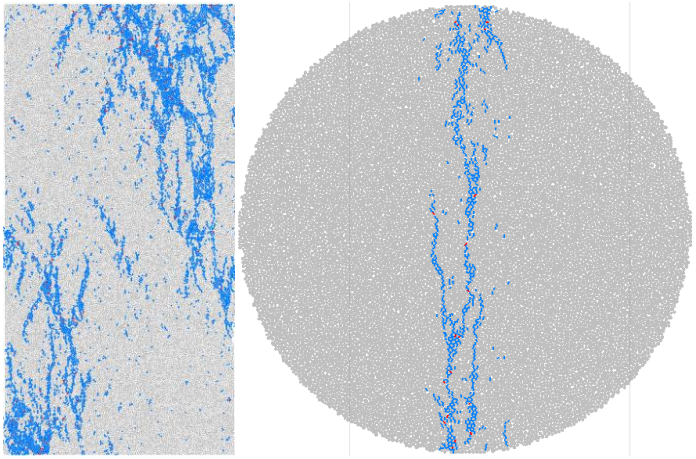

Fig. 6 Numerical models after uniaxial compression and Brazilian splitting tests

Table 3. Microparameters of the sandstone sample

Micro parameters	values
Minimum particle radius R_{min}	0.15(mm)
Particle radius ratio R_{max}/R_{min}	1.66
Particle elastic modulus E_b	11.6 (GPa)
Particle stiffness ratio k_n/k_s	1.8
Parallel bond elastic modulus E_P	11.6(GPa)
Parallel bond elastic modulus $\bar{k}_n/\bar{k}_s$	1.8
Friction coefficient μ	0.76
Tension strength *Pb_ten*(ave±std.dev)	32.8±2(MPa)
Shear strength *Pb_coh*(ave±std.dev)	48.85±2(MPa)

Prediction results

The compressive mechanical characteristics for three materials are shown in Table 4, and the total particle number of models with a hole for uniaxial compression test is 68197, the strain rate of model is 1e-3/s.

Table 4. Prediction results of uniaxial compressive tests

Materials	Peak compressive load (KN)	Peak compressive strength (MPa)
Granite	13152	131.52
Marble	9047	90.47
Sandstone	8768	87.68

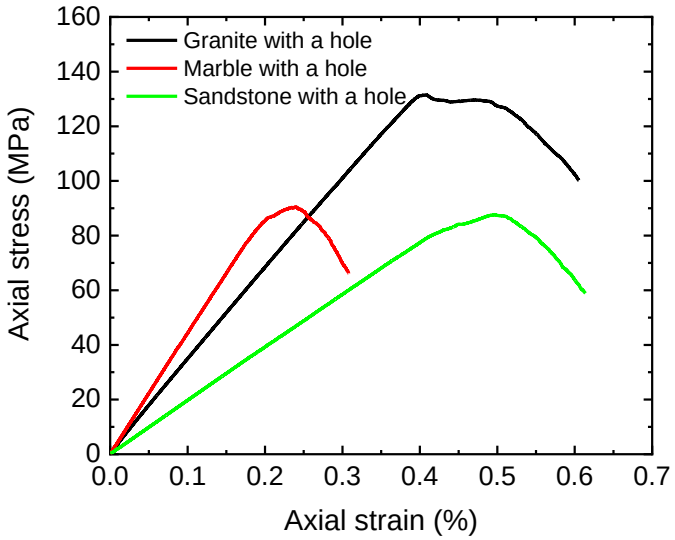

Fig. 7 stress-strain curves of samples with a hole

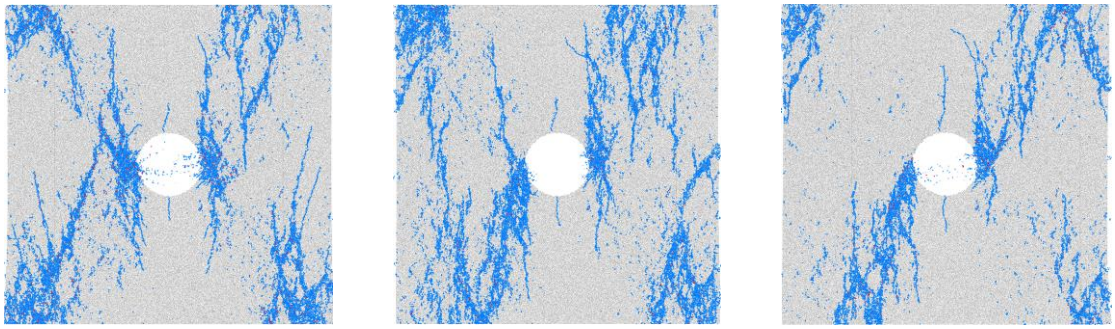

Fig. 8 Numerical models after uniaxial compression tests, (a) Granite, (b) Marble, (c) Sandstone