

Chengzeng Yan, Xun Wang

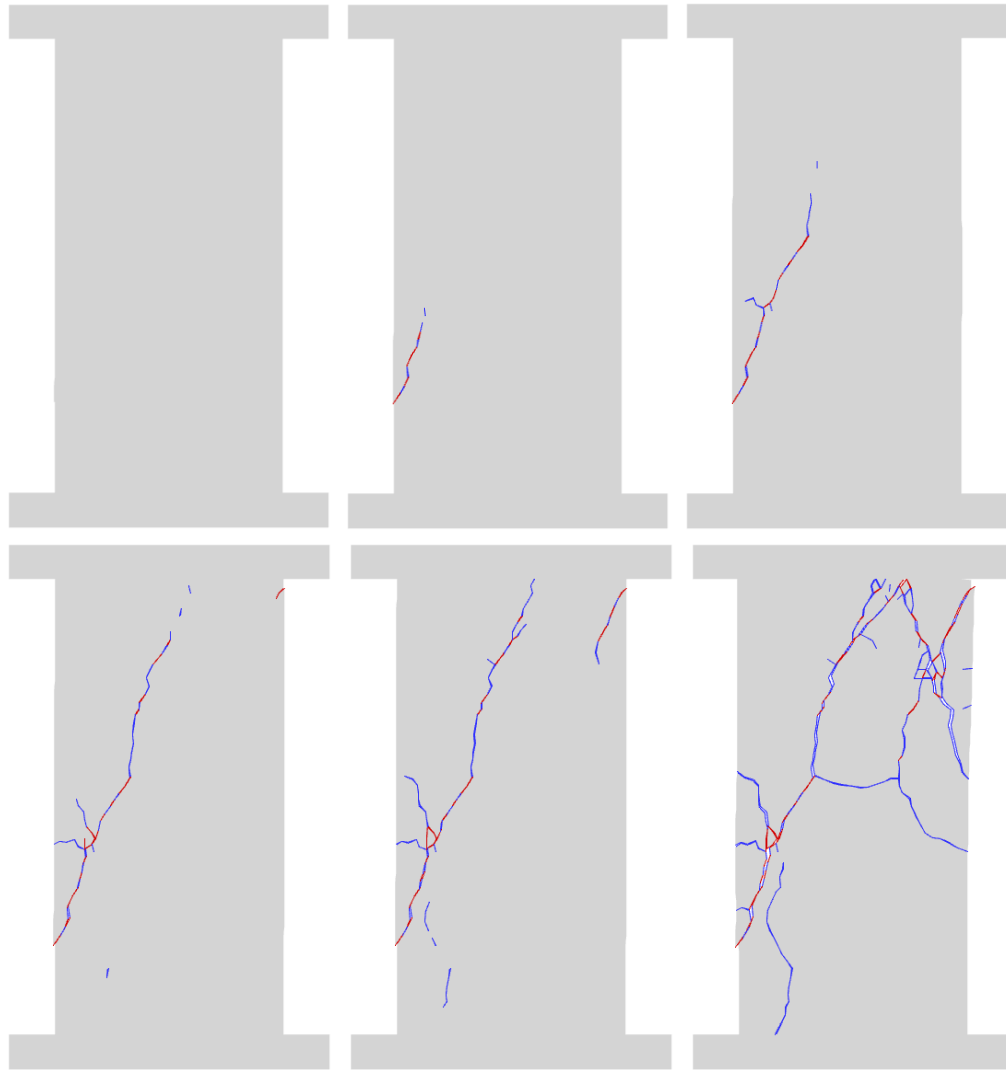
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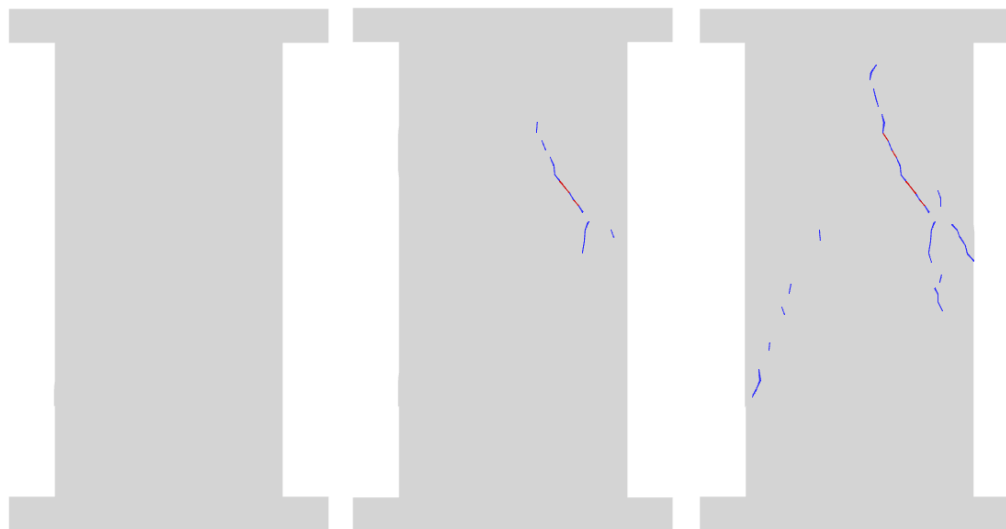
UCS and BD

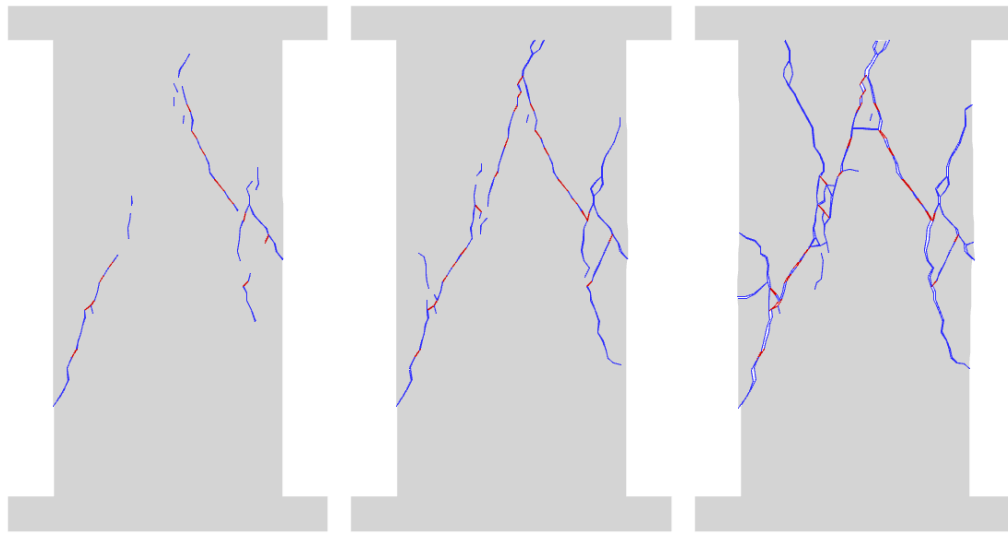
Parameters	Rock types		
	Granite	Marble	Red-sandstone
Density (g/cm ³)	2.63	2.85	2.43
Friction angle, Φ (°)	35	35	30
Cohesion, C (MPa)	36.8	25.5	31.0
Poisson's ratio	0.265	0.274	0.225
Young's modulus (Gpa)	42.25	59.70	21.09
Tensile strength, (MPa)	6.0	4.84	5.3
Normal penalty parameter ,P _n (Gpa)	4225	5970	2109
Tangential penalty parameter ,P _t (Gpa)	4225	5970	2109
Model I fracture energy release rate , G _{fI} (J/m ²)	0.005	0.004	0.002
Model II fracture energy release rate , G _{fII} (J/m ²)	0.02	0.02	0.02
Boundary conditions	free	free	free
Loading rate (m/s)	0.1(up)	0.1(up)	0.1(up)
element number(UCS)	3486	3486	3486
element number(BD)	1855	1855	1855

Ucs-G

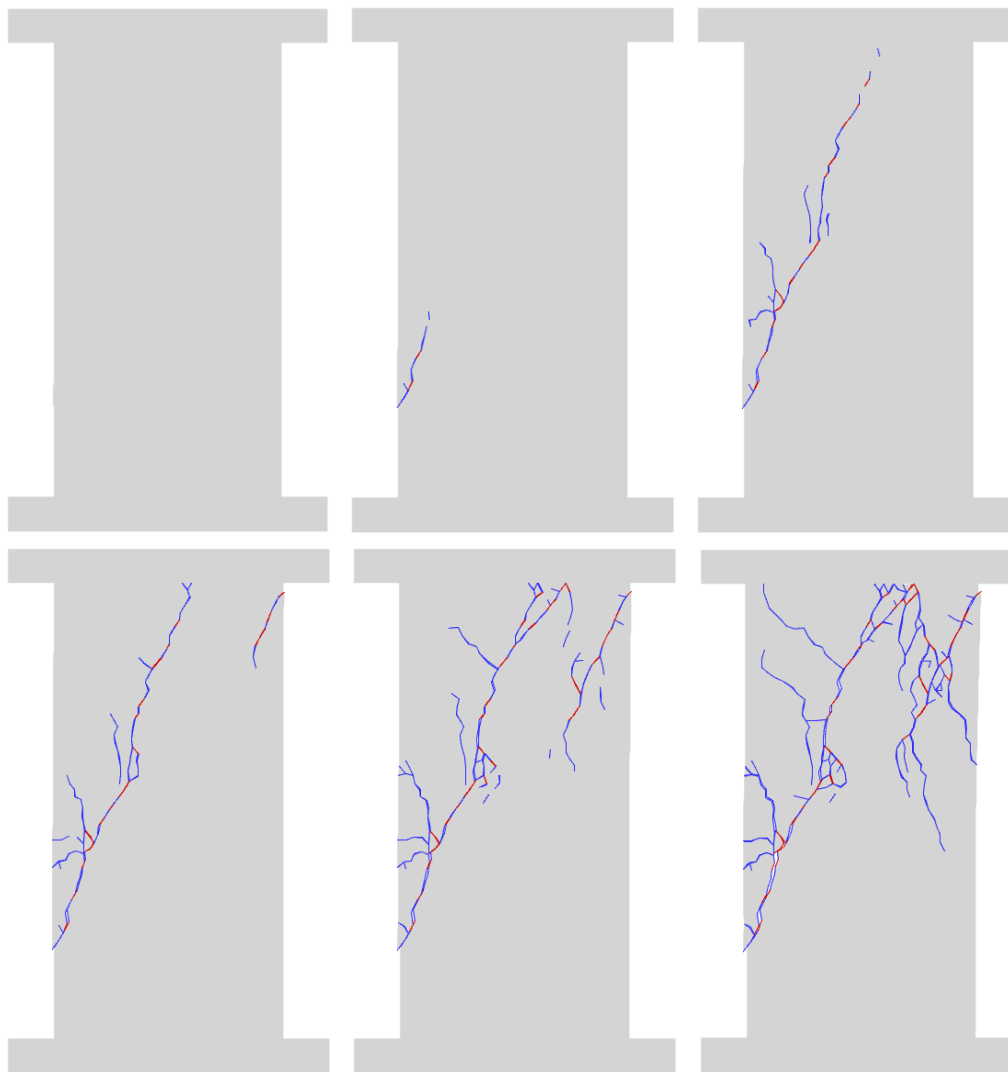


Ucs-M

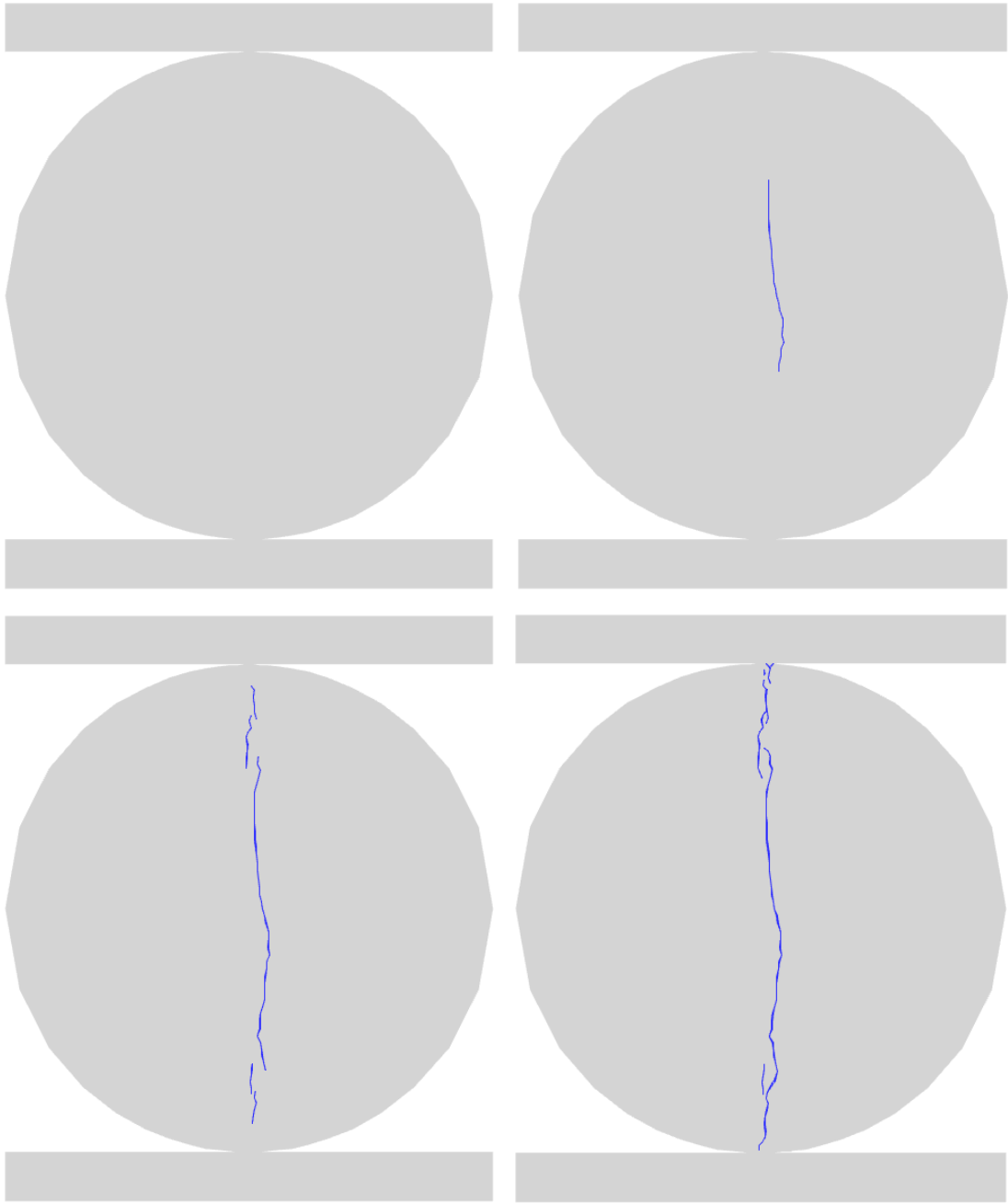




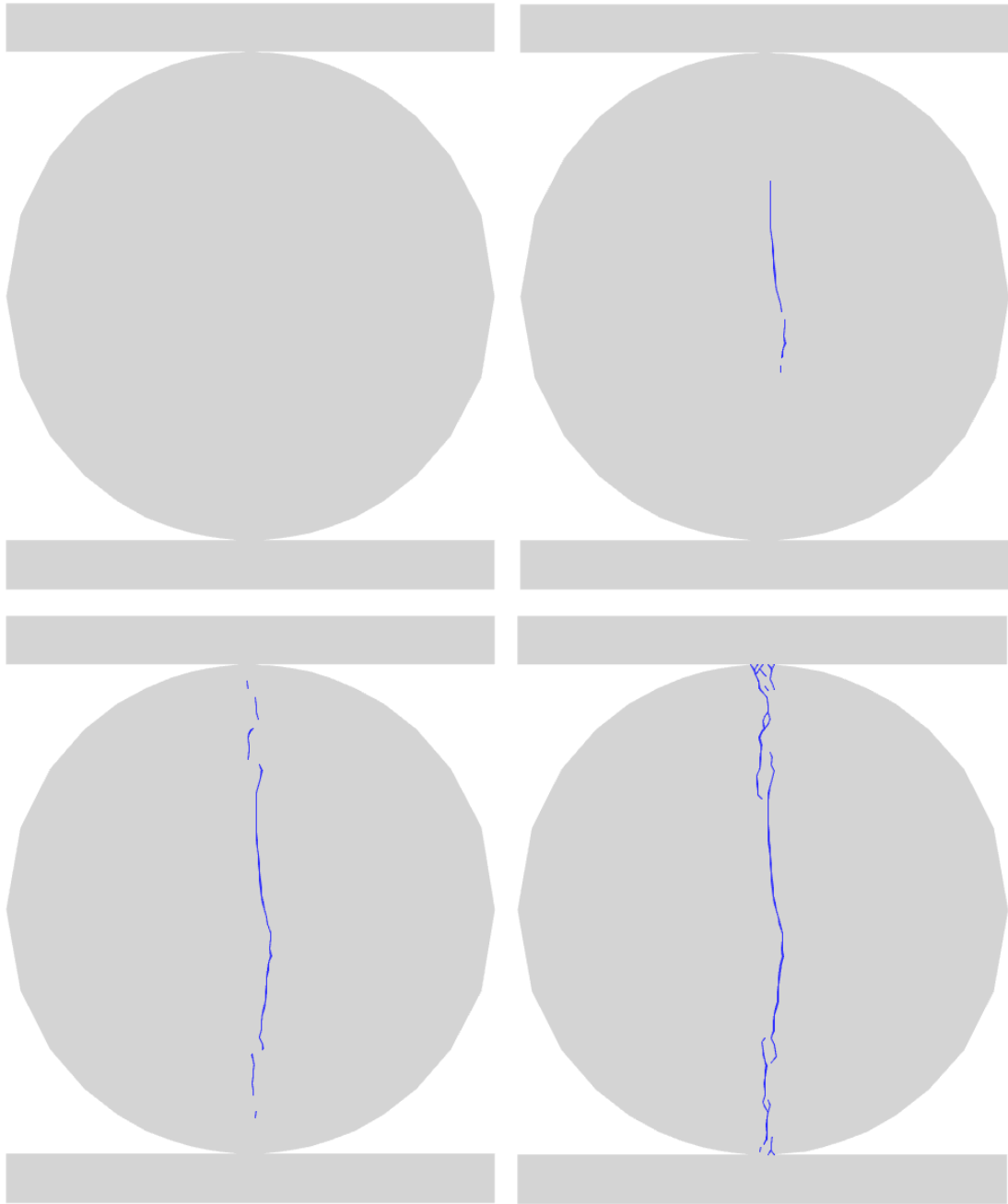
Ucs-R



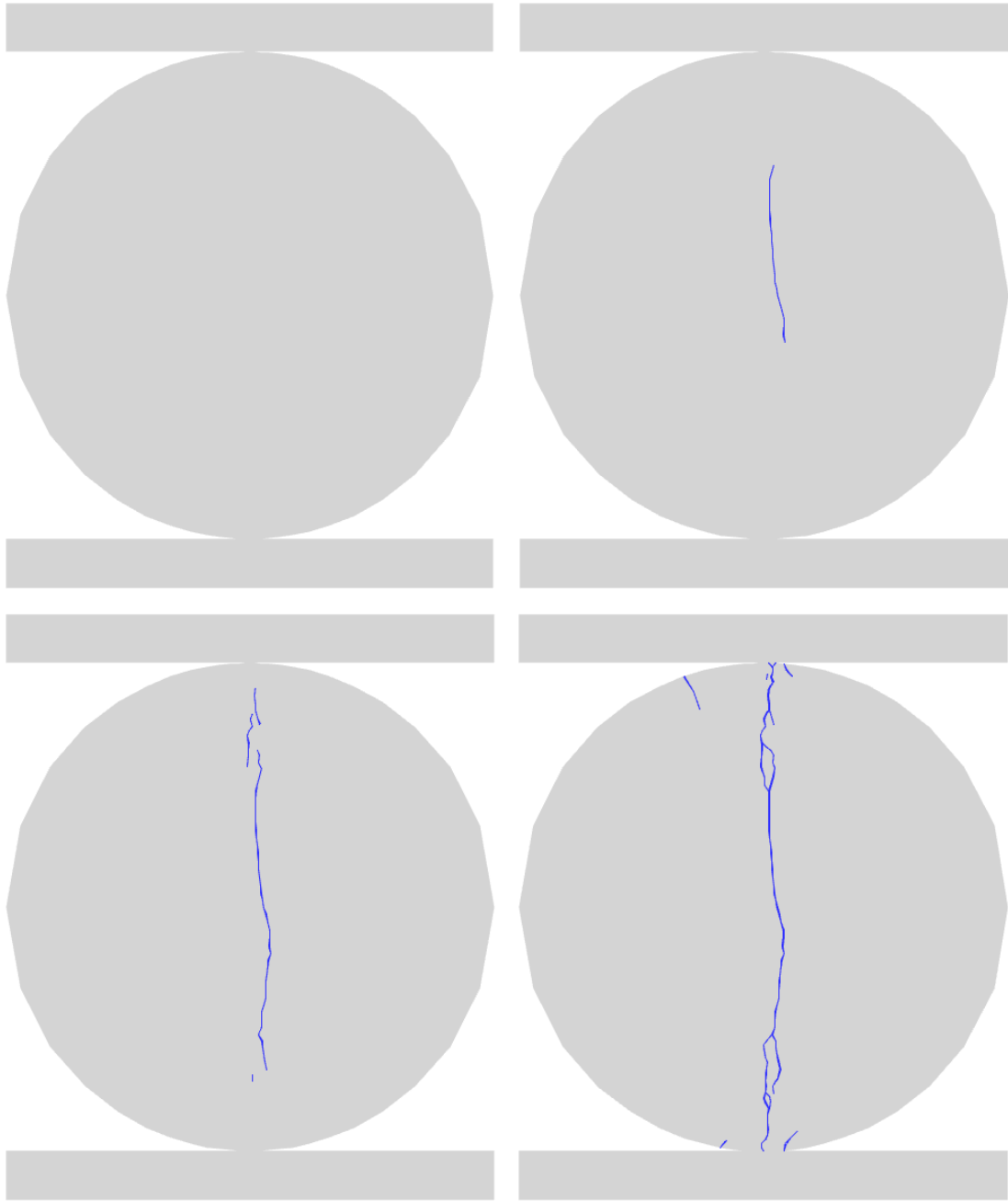
BD-G



BD-M



BD-R



Parameters	Unconfined compressive strength (MPa)	Tensile strength (kN)
Granite	159.65	14.11
Marble	119.78	12.00
Red-sandstone	116.23	11.01

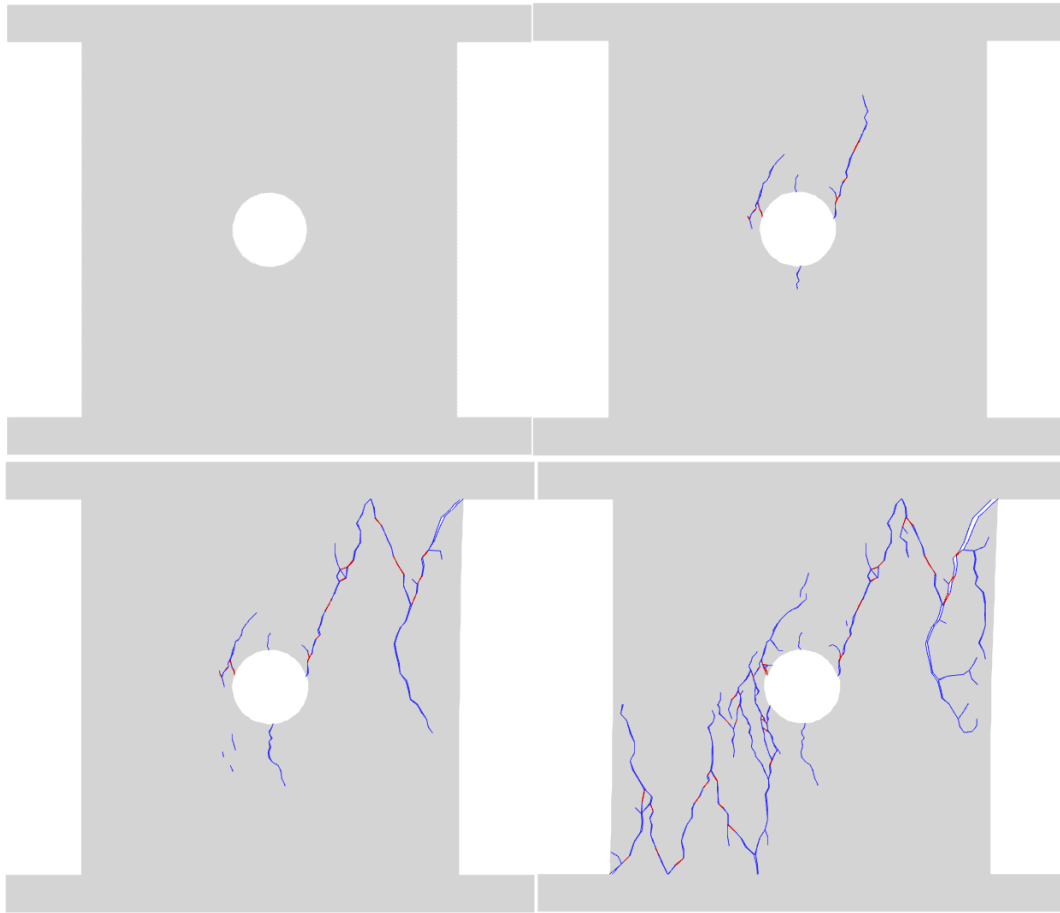
UCS-hollow

Parameters	Rock types		
	Granite	Marble	Red-sandstone
Density (g/cm ³)	2.63	2.85	2.43
Friction angle, Φ (°)	35	35	30
Cohesion, C (MPa)	36.8	25.5	31.0
Poisson's ratio	0.265	0.274	0.225
Young's modulus (Gpa)	42.25	59.70	21.09
Tensile strength, (MPa)	6.0	4.84	5.3
Normal penalty parameter ,P _n (Gpa)	4225	5970	2109
Tangential penalty parameter ,P _t (Gpa)	4225	5970	2109
Model I fracture energy release rate , G _{fI} (J/m ²)	0.005	0.004	0.002
Model II fracture energy release rate , G _{fII} (J/m ²)	0.02	0.02	0.02
Boundary conditions	free	free	free
Loading rate (m/s)	0.1(up-down)	0.1(up-down)	0.1(up-down)
element number	4465	4465	4465

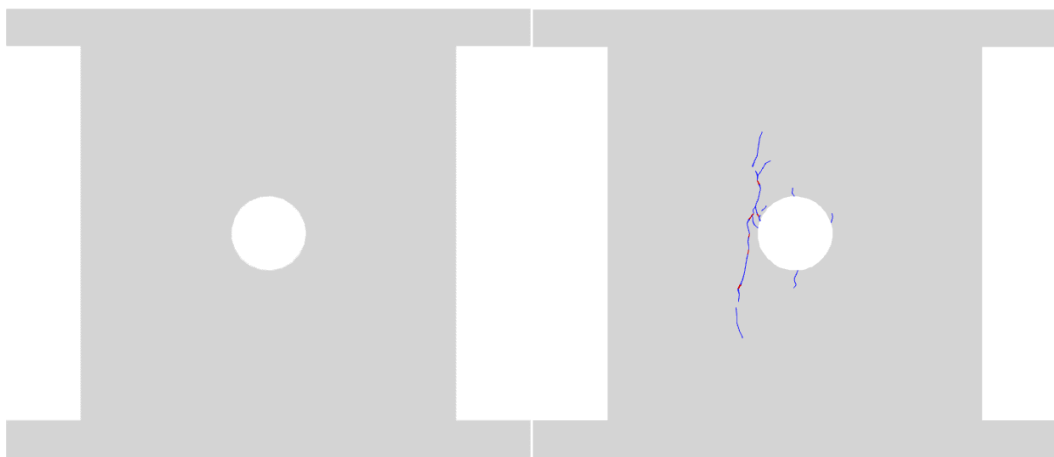
UCS-hollow

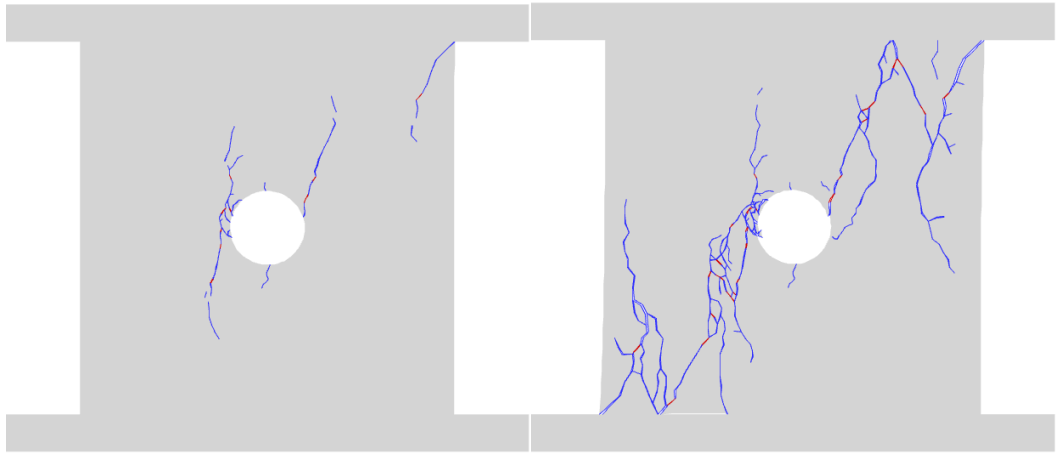
Parameters	Rock types		
	Granite	Marble	Red-sandstone
Density (g/cm ³)	2.63	2.85	2.43
Friction angle, Φ (°)	35	35	30
Cohesion, C (MPa)	36.8	25.5	31.0
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Model II fracture energy release rate , G _{fII} (J/m ²)	0.02	0.02	0.02
Boundary conditions	free	free	free
Loading rate (m/s)	0.1(up-down)	0.1(up-down)	0.1(up-down)
element number	6895	6895	6895

UCS-hollow-G

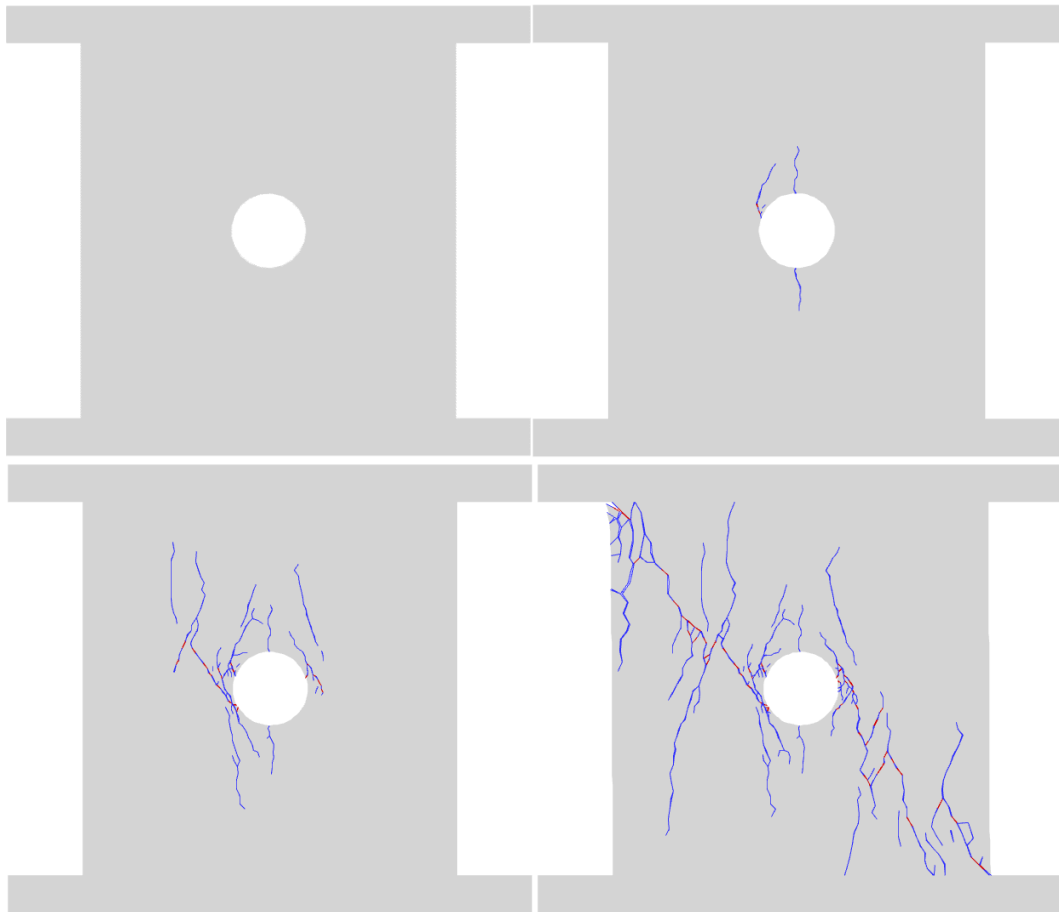


UCS-hollow-M





UCS-hollow-R



Parameters	Peak compressive load (kN)
Granite	621.38
Marble	485.91
Red-sandstone	404.60

References

- Yan Chengzeng, Tong Y. Calibration of microscopic penalty parameters in the combined finite-discrete element method. *International Journal of Geomechanics*. 2020, doi:10.1061/(ASCE)GM.1943-5622.0001686.
- Yan Chengzeng, Jiao YY, Zheng H. A fully coupled three-dimensional hydro-mechanical finite discrete element approach with real porous seepage for simulating 3D hydraulic fracturing. *Computers and Geotechnics*. 2018;96:73-89.
- Yan Chengzeng, Zheng H, Sun GH, Ge XR. Combined finite-discrete element method for simulation of hydraulic fracturing. *Rock Mechanics and Rock Engineering*. 2016;49(4):1389-1410.
- Yan Chengzeng, Jiao YY, Zheng H. A three - dimensional heat transfer and thermal cracking model considering the effect of cracks on heat transfer. *International Journal for Numerical and Analytical Methods in Geomechanics*. 2019;43(10):1825- 1853.