Electronic supplementary materials

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Evolution mechanism and quantitative characterization of initial micro-cracks in marble under triaxial compression

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S1 Marble material and experimental procedures

S1.1 Marble material

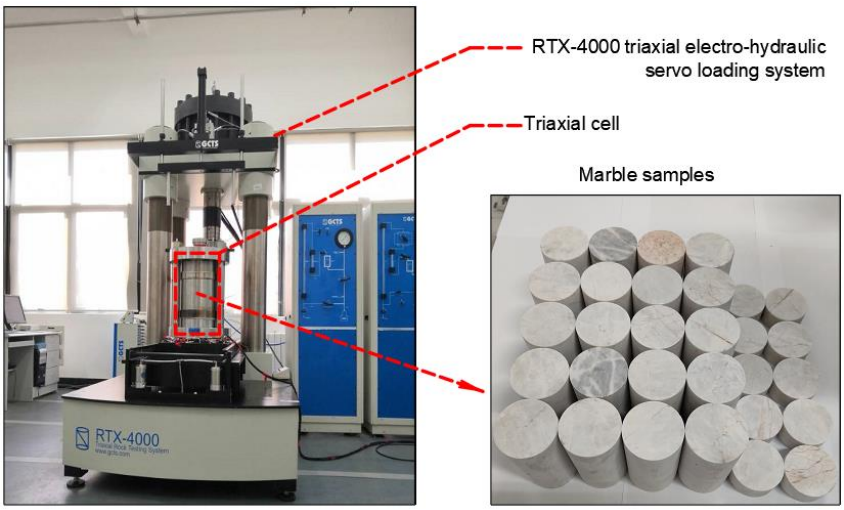

Fig. S1 Photos of triaxial compression device and marble samples

A series of triaxial tests were carried out on the RTX-4000 triaxial electro-hydraulic servo loading system at the China University of Mining and Technology (Fig. S1). The marble used in the test was taken from Jinping II Hydropower Station, Sichuan Province, China, and the average principal stress at the sampling site was between 35 and 50 MPa. X-ray diffraction (XRD) test results showed that the mineral composition of the marble material was mainly dolomite (69.31%), calcite (20.35%), and quartz (5.44%). Each marble sample was taken from the same rock block and processed into a standard cylinder with 50 mm in diameter and 100 mm in height. The sample was polished according to the recommendations of the International Society of Rock Mechanics (ISRM) until it met the test requirements (e.g., end face parallelism less than ±0.05 mm) (Fairhurst and Hudson, 1999). A photo of marble samples is shown in Fig. S1.

S1.2 Experimental procedures

Before the triaxial compression experiment, the longitudinal wave velocity and density were measured for each sample. Based on the measurement results, the samples differing greatly from the average were discarded to eliminate the discreteness among the samples as far as possible. Among the samples in the triaxial compression test, the average wave velocity and density were 3700 m/s and 2800 kg/m^3, respectively. The detailed steps of the triaxial compression test and corresponding control conditions (confining pressure loading rate and axial pressure loading rate) are given in (Wang et al., 2022).

$$\sigma_3 = 0 \text{ MPa}, \quad \varepsilon = (1-9.10\times10^{-4})\frac{\sigma}{36817.90} + 9.10\times10^{-4}\left(1-\mathrm{e}^{-\frac{\sigma}{22.81}}\right), \tag{S1}$$

$$\sigma_3 = 10 \text{ MPa}, \quad \varepsilon = (1-2.79\times10^{-4})\frac{\sigma}{37029.14} + 2.79\times10^{-4}\left(1-\mathrm{e}^{-\frac{\sigma}{22.85}}\right), \tag{S2}$$

$$\sigma_3 = 20 \text{ MPa}, \quad \varepsilon = (1-3.34\times10^{-4})\frac{\sigma}{41081.38} + 3.34\times10^{-4}\left(1-\mathrm{e}^{-\frac{\sigma}{28.48}}\right), \tag{S3}$$

$$\sigma_3 = 30 \text{ MPa}, \quad \varepsilon = (1-3.55\times10^{-5})\frac{\sigma}{44940.03} + 3.55\times10^{-5}\left(1-\mathrm{e}^{-\frac{\sigma}{29.13}}\right), \tag{S4}$$

$$\sigma_3 = 40 \text{ MPa}, \quad \varepsilon = (1-1.85\times10^{-4})\frac{\sigma}{43163.70} + 1.85\times10^{-4}\left(1-\mathrm{e}^{-\frac{\sigma}{38.95}}\right), \tag{S5}$$

$$\sigma_3 = 50 \text{ MPa}, \quad \varepsilon = (1-6.96\times10^{-5})\frac{\sigma}{43110.75} + 6.96\times10^{-5}\left(1-\mathrm{e}^{-\frac{\sigma}{54.89}}\right). \tag{S6}$$

Table S1 Variation of deformation parameters for rock matrix and crack with confining pressure

σ_3 (MPa)	V_C/V	E_c (MPa)	E_m (GPa)	E_s (GPa)	μ_s
0	9.10×10^{-4}	22.81	36.82	33.33	0.34
10	2.79×10^{-4}	22.85	37.03	36.87	0.19
20	3.34×10^{-4}	28.48	41.08	40.18	0.15
30	3.55×10^{-5}	29.13	44.94	46.18	0.17
40	1.85×10^{-4}	38.95	43.16	42.33	0.17
50	6.96×10^{-5}	54.89	43.11	42.91	0.14

S2 Comparison between the quantitative crack analysis model curves and marble test results

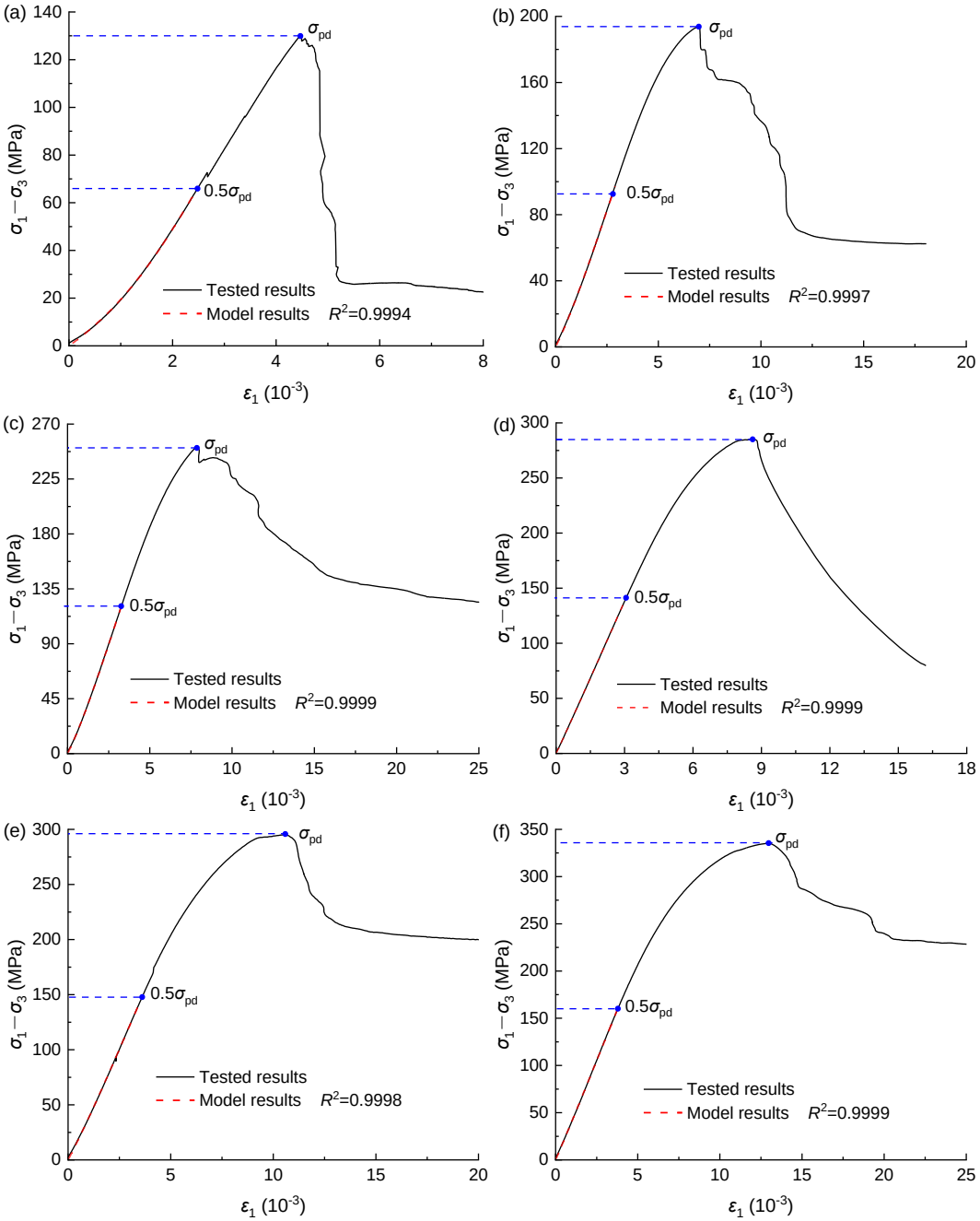

Fig. S2 Comparison between the quantitative crack analysis model curves and marble test results: (a) σ_3=0 MPa; (b) σ_3=10 MPa; (c) σ_3=20 MPa; (d) σ_3=30 MPa; (e) σ_3=40 MPa; (f) σ_3=50 MPa

S3 CT scanning of triaxial compression marble samples

To explore the relationship between internal crack propagation and failure characteristics, CT scanning was performed on the samples (σ_3 was as taken as 0, 30, or 50 MPa) after the aforementioned triaxial compression experiment. A 3D reconstruction of sample failure was carried out, and sections of typical axial positions were selected to illustrate the internal failure characteristics. Typical axial section positions were taken as (diameter d=) 7, 14, 21, 28, 35, and 42 mm, respectively.

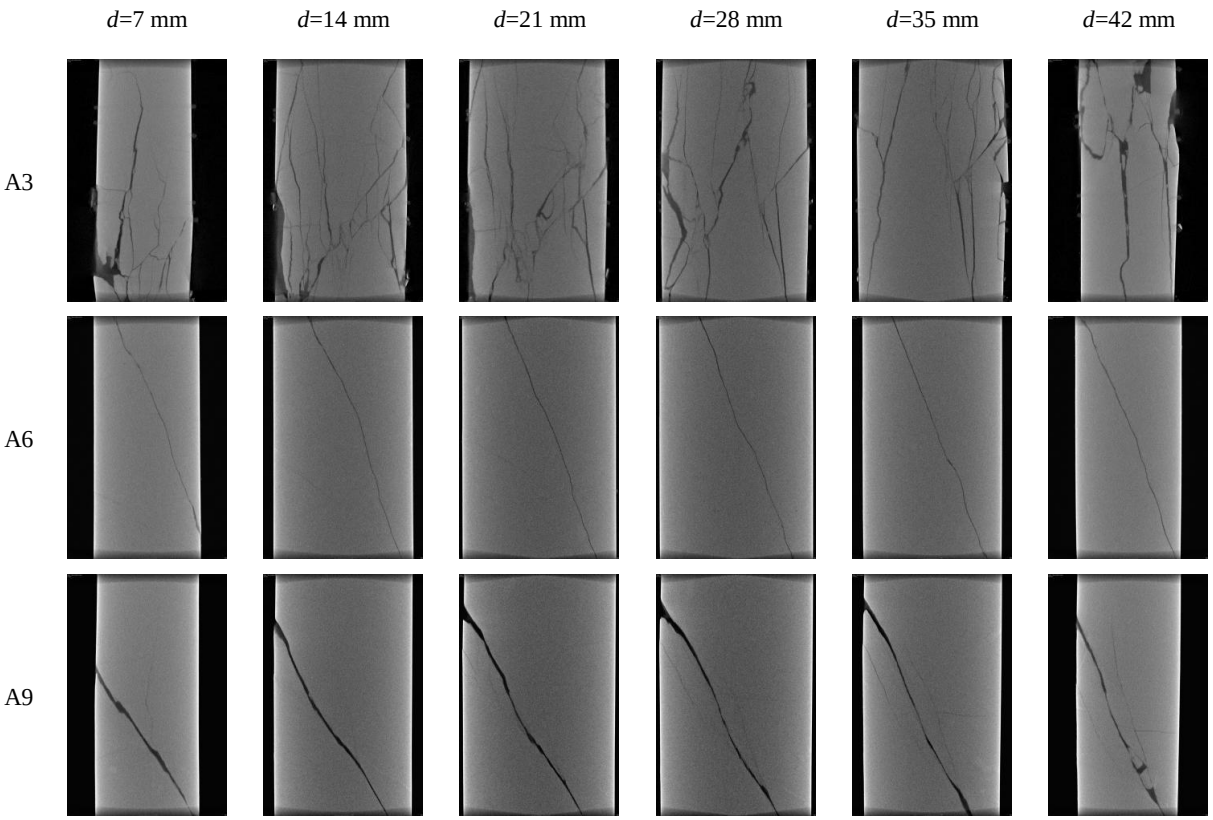

Fig. S3 CT scanning sections of triaxial compression marble samples with different axial positions

References

Fairhurst CE, Hudson JA, 1999. Draft ISRM suggested method for the complete stress–strain curve for intact rock in uniaxial compression. *International Journal of Rock Mechanics and Mining Sciences*, 36(3):279-289.

Wang ZL, Li SY, Wang JG, et al., 2022. Mechanical behavior, mesoscopic properties and energy evolution of deeply buried marble during triaxial loading. *International Journal of Damage Mechanics*, 31(10):1592-1612.