Supplementary materials

Table S1 Morphology parameters and direct shear test results (performed on 3D rough DDJCS) presented by this study

Group	No.	A_0	θ^*_{max}/(°)	C	JCS_{Low}/MPa	λ	σ_n/MPa	φ_b/(°)	$\tau_{experimental}$/MPa	$\tau_{predicted}$/MPa (This study)	δ/% (This study)	$\tau_{predicted}$/MPa (TANG et al [21])	δ/% (TANG et al [21])
M1		0.4414	83.74	4.646	28.48	1.37	0.5	34.1	1.853	1.448	21.846	1.688	8.894
	HM-M1	0.4414	83.74	4.646	28.48	1.37	1.5	34.1	3.165	2.798	11.607	3.013	4.798
		0.4414	83.74	4.646	28.48	1.37	3	34.1	4.057	4.452	9.744	5.330	31.372
		0.4414	83.74	4.646	11.69	2.44	0.5	33.2	1.62	1.310	19.109	1.277	21.200
	ML-M1	0.4414	83.74	4.646	11.69	2.44	1.5	33.2	2.822	2.594	8.067	2.535	10.179
		0.4414	83.74	4.646	11.69	2.44	3	33.2	4.034	4.158	3.078	4.737	17.416
M2		0.4828	65.24	5.798	28.48	1.37	0.5	34.1	1.421	1.171	17.583	1.059	25.476
	HM-M2	0.4828	65.24	5.798	28.48	1.37	1.5	34.1	2.65	2.471	6.754	2.376	10.323
		0.4828	65.24	5.798	28.48	1.37	3	34.1	3.711	4.070	9.669	4.108	10.690
		0.4828	65.24	5.798	11.69	2.44	0.5	33.2	1.139	1.079	5.224	0.878	22.895
	ML-M2	0.4828	65.24	5.798	11.69	2.44	1.5	33.2	2.457	2.310	5.965	1.990	18.993
		0.4828	65.24	5.798	11.69	2.44	3	33.2	3.652	3.822	4.658	3.563	2.436
M3		0.4983	54.95	5.109	28.48	1.37	0.5	34.1	0.962	1.117	16.133	1.032	7.284
	HM-M3	0.4983	54.95	5.109	28.48	1.37	1.5	34.1	2.294	2.400	4.624	2.361	2.902
		0.4983	54.95	5.109	28.48	1.37	3	34.1	3.521	3.983	13.129	4.065	15.443
		0.4983	54.95	5.109	11.69	2.44	0.5	33.2	0.905	1.033	14.191	0.861	4.891
	ML-M3	0.4983	54.95	5.109	11.69	2.44	1.5	33.2	2.155	2.248	4.319	1.976	8.324
		0.4983	54.95	5.109	11.69	2.44	3	33.2	3.366	3.746	11.275	3.509	4.259
B1		0.4652	62.75	6.375	28.48	1.37	0.5	34.1	0.98	1.085	10.701	0.881	10.062
	HM-B1	0.4652	62.75	6.375	28.48	1.37	1.5	34.1	2.567	2.356	8.209	2.111	17.753
		0.4652	62.75	6.375	28.48	1.37	3	34.1	3.685	3.929	6.627	3.720	0.937
		0.4652	62.75	6.375	11.69	2.44	0.5	33.2	0.92	1.006	9.309	0.744	19.127
	ML-B1	0.4652	62.75	6.375	11.69	2.44	1.5	33.2	2.088	2.209	5.816	1.781	14.707
		0.4652	62.75	6.375	11.69	2.44	3	33.2	3.662	3.698	0.971	3.219	12.095
B2		0.4344	85.99	5.534	28.48	1.37	0.5	34.1	1.615	1.389	14.002	1.315	18.548
	HM-B2	0.4344	85.99	5.534	28.48	1.37	1.5	34.1	2.617	2.733	4.417	2.632	0.574
		0.4344	85.99	5.534	28.48	1.37	3	34.1	3.79	4.378	15.519	4.674	23.330
		0.4344	85.99	5.534	11.69	2.44	0.5	33.2	1.565	1.262	19.376	1.045	33.216
	ML-B2	0.4344	85.99	5.534	11.69	2.44	1.5	33.2	2.304	2.538	10.166	2.222	3.549
		0.4344	81.76	5.534	11.69	2.44	3	33.2	3.868	4.058	4.910	3.961	2.401

to be continued

Continued

Group	No.	A_0	θ^*_{max}/(°)	C	JCS_{Low}/MPa	λ	σ_n/MPa	φ_b/(°)	$\tau_{experimental}$/MPa	$\tau_{predicted}$/MPa (This study)	δ/% (This study)	$\tau_{predicted}$/MPa (TANG et al [21])	δ/% (TANG et al [21])
B3		0.56	89.07	7.919	28.48	1.37	0.5	34.1	1.755	1.212	30.912	1.536	12.464
	HM-B3	0.56	89.07	7.919	28.48	1.37	1.5	34.1	2.506	2.524	0.705	3.045	21.499
		0.56	89.07	7.919	28.48	1.37	3	34.1	4.997	4.133	17.286	4.942	1.094
		0.56	89.07	7.919	11.69	2.44	0.5	33.2	0.822	1.115	35.591	1.221	48.584
	ML-B3	0.56	89.07	7.919	11.69	2.44	1.5	33.2	2.161	2.357	9.050	2.486	15.020
		0.56	89.07	7.919	11.69	2.44	3	33.2	3.948	3.878	1.770	4.232	7.201
S1		0.5791	73.59	4.732	28.48	1.37	0.5	34.1	1.831	1.368	25.279	4.059	121.684
	HM-S1	0.5791	73.59	4.732	28.48	1.37	1.5	34.1	3.273	2.709	17.224	4.494	37.313
		0.5791	73.59	4.732	28.48	1.37	3	34.1	3.602	4.351	20.803	6.687	85.637
		0.5791	73.59	4.732	11.69	2.44	0.5	33.2	1.519	1.245	18.060	2.447	61.099
	ML-S1	0.5791	73.59	4.732	11.69	2.44	1.5	33.2	2.813	2.518	10.485	3.476	23.568
		0.5791	73.59	4.732	11.69	2.44	3	33.2	3.522	4.070	15.556	5.717	62.335
S2		0.5805	43.74	2.702	28.48	1.37	0.5	34.1	1.578	1.286	18.476	2.780	76.171
	HM-S2	0.5805	43.74	2.702	28.48	1.37	1.5	34.1	2.485	2.614	5.201	3.992	60.650
		0.5805	43.74	2.702	28.48	1.37	3	34.1	3.064	4.241	38.404	6.083	98.547
		0.5805	43.74	2.702	11.69	2.44	0.5	33.2	1.498	1.177	21.445	1.923	28.354
	ML-S2	0.5805	43.74	2.702	11.69	2.44	1.5	33.2	2.375	2.436	2.551	3.143	32.345
		0.5805	43.74	2.702	11.69	2.44	3	33.2	3.002	3.973	32.338	5.196	73.097
S3		0.4709	54.06	5.197	28.48	1.37	0.5	34.1	1.2	1.095	8.751	0.918	23.511
	HM-S3	0.4709	54.06	5.197	28.48	1.37	1.5	34.1	2.251	2.370	5.290	2.170	3.589
		0.4709	54.06	5.197	28.48	1.37	3	34.1	3.402	3.946	16.000	3.805	11.849
		0.4709	54.06	5.197	11.69	2.44	0.5	33.2	1.197	1.014	15.258	0.772	35.479
	ML-S3	0.4709	54.06	5.197	11.69	2.44	1.5	33.2	2.261	2.222	1.741	1.828	19.166
		0.4709	54.06	5.197	11.69	2.44	3	33.2	3.104	3.713	19.611	3.294	6.115

Table S2 Morphology parameters and direct shear test results (performed on 3D rough DDJCS) of this study and published by TANG et al [21]

Group	No.	A_0	θ^*_{max}/(°)	C	JCS_{Low}/MPa	λ	σ_n/MPa	φ_b/(°)	$\tau_{experimental}$/MPa	$\tau_{predicted}$/MPa (This study)	δ/% (This study)	$\tau_{predicted}$/MPa (TANG et al [21])	δ/% (TANG et al [21])
A	J-I/J-V	0.486	55.4	13.6	10.30	1.00	0.3	35.3	0.35	0.357	1.976	0.318	9.143
	J-I/J-V	0.486	55.4	13.6	10.30	1.00	0.6	35.3	0.65	0.645	0.735	0.628	3.385
	J-I/J-V	0.486	55.4	13.6	10.30	1.00	0.9	35.3	0.94	0.913	2.910	0.929	1.170
	J-I/J-V	0.486	55.4	13.6	10.30	1.00	1.5	35.3	1.47	1.413	3.898	1.508	2.585
	J-I/J-V	0.486	55.4	13.6	10.30	1.00	3	35.3	2.85	2.554	10.379	2.861	0.386
	J-I/J-V	0.486	55.4	13.6	10.30	1.00	4	35.3	3.74	3.265	12.713	3.716	0.642
	J-II/J-V	0.486	55.4	13.6	10.30	1.63	0.3	35.8	0.38	0.397	4.590	0.343	9.737
	J-II/J-V	0.486	55.4	13.6	10.30	1.63	0.6	35.8	0.71	0.717	1.002	0.678	4.507
	J-II/J-V	0.486	55.4	13.6	10.30	1.63	0.9	35.8	1.02	1.014	0.614	1.004	1.569
	J-II/J-V	0.486	55.4	13.6	10.30	1.63	1.5	35.8	1.62	1.569	3.159	1.629	0.556
	J-II/J-V	0.486	55.4	13.6	10.30	1.63	3	35.8	2.99	2.838	5.076	3.090	3.344
	J-II/J-V	0.486	55.4	13.6	10.30	1.63	4	35.8	3.98	3.630	8.804	4.015	0.879
	J-III/J-V	0.486	55.4	13.6	10.30	2.66	0.3	36.5	0.41	0.453	10.474	0.356	13.171
	J-III/J-V	0.486	55.4	13.6	10.30	2.66	0.6	36.5	0.75	0.814	8.549	0.704	6.133
	J-III/J-V	0.486	55.4	13.6	10.30	2.66	0.9	36.5	1.08	1.149	6.394	1.042	3.519
	J-III/J-V	0.486	55.4	13.6	10.30	2.66	1.5	36.5	1.71	1.776	3.851	1.691	1.111
	J-III/J-V	0.486	55.4	13.6	10.30	2.66	3	36.5	3.08	3.211	4.237	3.208	4.156
	J-III/J-V	0.486	55.4	13.6	10.30	2.66	4	36.5	4.13	4.106	0.581	4.167	0.896
	J-IV/J-V	0.486	55.4	13.6	10.30	3.29	0.3	37.6	0.42	0.497	18.301	0.371	11.667
	J-IV/J-V	0.486	55.4	13.6	10.30	3.29	0.6	37.6	0.78	0.890	14.064	0.732	6.154
	J-IV/J-V	0.486	55.4	13.6	10.30	3.29	0.9	37.6	1.12	1.254	11.931	1.083	3.304
	J-IV/J-V	0.486	55.4	13.6	10.30	3.29	1.5	37.6	1.77	1.934	9.286	1.758	0.678
	J-IV/J-V	0.486	55.4	13.6	10.30	3.29	3	37.6	3.5	3.492	0.220	3.335	4.714
	J-IV/J-V	0.486	55.4	13.6	10.30	3.29	4	37.6	4.42	4.465	1.018	4.333	1.968
	J-V/J-V	0.486	55.4	13.6	10.30	4.40	0.3	38.1	0.44	0.545	23.920	0.390	11.364
	J-V/J-V	0.486	55.4	13.6	10.30	4.40	0.6	38.1	0.81	0.972	19.974	0.770	4.938
	J-V/J-V	0.486	55.4	13.6	10.30	4.40	0.9	38.1	1.17	1.366	16.784	1.140	2.564
	J-V/J-V	0.486	55.4	13.6	10.30	4.40	1.5	38.1	1.81	2.104	16.233	1.810	0.000
	J-V/J-V	0.486	55.4	13.6	10.30	4.40	3	38.1	3.62	3.790	4.707	3.510	3.039
	J-V/J-V	0.486	55.4	13.6	10.30	4.40	4	38.1	4.62	4.843	4.834	4.560	1.299

to be continued

Continued

Group	No.	A_0	θ^*_{max}/(°)	C	JCS_{Low}/MPa	λ	σ_n/MPa	φ_b/(°)	$\tau_{experimental}$/MPa	$\tau_{predicted}$/MPa (This study)	δ/% (This study)	$\tau_{predicted}$/MPa (TANG et al [21])	δ/% (TANG et al [21])
B	J-I/J-V	0.502	64.3	9.4	10.30	1.00	0.3	35.3	0.54	0.450	16.746	0.456	15.556
	J-I/J-V	0.502	64.3	9.4	10.30	1.00	0.6	35.3	0.98	0.773	21.151	0.872	11.020
	J-I/J-V	0.502	64.3	9.4	10.30	1.00	0.9	35.3	1.35	1.064	21.208	1.263	6.444
	J-I/J-V	0.502	64.3	9.4	10.30	1.00	1.5	35.3	2.11	1.594	24.472	1.972	6.540
	J-I/J-V	0.502	64.3	9.4	10.30	1.00	3	35.3	3.72	2.761	25.790	3.529	5.134
	J-I/J-V	0.502	64.3	9.4	10.30	1.00	4	35.3	4.63	3.467	25.129	4.483	3.175
	J-II/J-V	0.502	64.3	9.4	10.30	1.63	0.3	35.8	0.58	0.527	9.069	0.493	15.000
	J-II/J-V	0.502	64.3	9.4	10.30	1.63	0.6	35.8	1.04	0.898	13.644	0.942	9.423
	J-II/J-V	0.502	64.3	9.4	10.30	1.63	0.9	35.8	1.43	1.232	13.856	1.365	4.545
	J-II/J-V	0.502	64.3	9.4	10.30	1.63	1.5	35.8	2.24	1.840	17.846	2.131	4.866
	J-II/J-V	0.502	64.3	9.4	10.30	1.63	3	35.8	4.01	3.184	20.602	3.812	4.938
	J-II/J-V	0.502	64.3	9.4	10.30	1.63	4	35.8	4.84	3.999	17.368	4.842	0.041
	J-III/J-V	0.502	64.3	9.4	10.30	2.66	0.3	36.5	0.6	0.647	7.809	0.512	14.667
	J-III/J-V	0.502	64.3	9.4	10.30	2.66	0.6	36.5	1.08	1.083	0.247	0.978	9.444
	J-III/J-V	0.502	64.3	9.4	10.30	2.66	0.9	36.5	1.51	1.474	2.358	1.416	6.225
	J-III/J-V	0.502	64.3	9.4	10.30	2.66	1.5	36.5	2.33	2.188	6.092	2.212	5.064
	J-III/J-V	0.502	64.3	9.4	10.30	2.66	3	36.5	4.15	3.765	9.268	3.957	4.651
	J-III/J-V	0.502	64.3	9.4	10.30	2.66	4	36.5	5.05	4.725	6.445	5.026	0.475
	J-IV/J-V	0.502	64.3	9.4	10.30	3.29	0.3	37.6	0.63	0.745	18.297	0.532	15.556
	J-IV/J-V	0.502	64.3	9.4	10.30	3.29	0.6	37.6	1.12	1.228	9.643	1.017	9.196
	J-IV/J-V	0.502	64.3	9.4	10.30	3.29	0.9	37.6	1.55	1.661	7.181	1.473	4.968
	J-IV/J-V	0.502	64.3	9.4	10.30	3.29	1.5	37.6	2.39	2.450	2.507	2.299	3.808
	J-IV/J-V	0.502	64.3	9.4	10.30	3.29	3	37.6	4.32	4.192	2.969	4.114	4.769
	J-IV/J-V	0.502	64.3	9.4	10.30	3.29	4	37.6	5.33	5.251	1.481	5.226	1.951
	J-V/J-V	0.502	64.3	9.4	10.30	4.40	0.3	38.1	0.64	0.879	37.347	0.560	12.500
	J-V/J-V	0.502	64.3	9.4	10.30	4.40	0.6	38.1	1.15	1.416	23.168	1.070	6.957
	J-V/J-V	0.502	64.3	9.4	10.30	4.40	0.9	38.1	1.59	1.898	19.402	1.550	2.516
	J-V/J-V	0.502	64.3	9.4	10.30	4.40	1.5	38.1	2.48	2.775	11.885	2.420	2.419
	J-V/J-V	0.502	64.3	9.4	10.30	4.40	3	38.1	4.41	4.707	6.746	4.330	1.814
	J-V/J-V	0.502	64.3	9.4	10.30	4.40	4	38.1	5.61	5.882	4.854	5.500	1.961

to be continued

Continued

Group	No.	A_0	θ^*_{max}/(°)	C	JCS_{Low}/MPa	λ	σ_n/MPa	φ_b/(°)	$\tau_{experimental}$/MPa	$\tau_{predicted}$/MPa (This study)	δ/% (This study)	$\tau_{predicted}$/MPa (TANG et al [21])	δ/% (TANG et al [21])
C	J-I/J-V	0.491	75.8	7.3	10.30	1.00	0.3	35.3	0.98	0.543	44.568	0.734	25.102
	J-I/J-V	0.491	75.8	7.3	10.30	1.00	0.6	35.3	1.49	0.891	40.221	1.304	12.483
	J-I/J-V	0.491	75.8	7.3	10.30	1.00	0.9	35.3	2.01	1.198	40.412	1.785	11.194
	J-I/J-V	0.491	75.8	7.3	10.30	1.00	1.5	35.3	2.85	1.747	38.697	2.592	9.053
	J-I/J-V	0.491	75.8	7.3	10.30	1.00	3	35.3	4.78	2.927	38.761	4.279	10.481
	J-I/J-V	0.491	75.8	7.3	10.30	1.00	4	35.3	5.67	3.627	36.035	5.355	5.556
	J-II/J-V	0.491	75.8	7.3	10.30	1.63	0.3	35.8	1.07	0.674	37.045	0.792	25.981
	J-II/J-V	0.491	75.8	7.3	10.30	1.63	0.6	35.8	1.56	1.080	30.789	1.409	9.679
	J-II/J-V	0.491	75.8	7.3	10.30	1.63	0.9	35.8	2.11	1.439	31.789	1.928	8.626
	J-II/J-V	0.491	75.8	7.3	10.30	1.63	1.5	35.8	2.99	2.084	30.300	2.800	6.355
	J-II/J-V	0.491	75.8	7.3	10.30	1.63	3	35.8	5	3.476	30.489	4.622	7.560
	J-II/J-V	0.491	75.8	7.3	10.30	1.63	4	35.8	5.92	4.305	27.284	5.784	2.297
	J-III/J-V	0.491	75.8	7.3	10.30	2.66	0.3	36.5	1.16	0.906	21.924	0.822	29.138
	J-III/J-V	0.491	75.8	7.3	10.30	2.66	0.6	36.5	1.62	1.388	14.341	1.462	9.753
	J-III/J-V	0.491	75.8	7.3	10.30	2.66	0.9	36.5	2.17	1.818	16.229	2.001	7.788
	J-III/J-V	0.491	75.8	7.3	10.30	2.66	1.5	36.5	3.08	2.591	15.869	2.906	5.649
	J-III/J-V	0.491	75.8	7.3	10.30	2.66	3	36.5	5.17	4.265	17.500	4.798	7.195
	J-III/J-V	0.491	75.8	7.3	10.30	2.66	4	36.5	6.21	5.266	15.199	6.004	3.317
	J-IV/J-V	0.491	75.8	7.3	10.30	3.29	0.3	37.6	1.19	1.124	5.571	0.855	28.151
	J-IV/J-V	0.491	75.8	7.3	10.30	3.29	0.6	37.6	1.66	1.648	0.711	1.520	8.434
	J-IV/J-V	0.491	75.8	7.3	10.30	3.29	0.9	37.6	2.23	2.124	4.738	2.081	6.682
	J-IV/J-V	0.491	75.8	7.3	10.30	3.29	1.5	37.6	3.14	2.984	4.961	3.022	3.758
	J-IV/J-V	0.491	75.8	7.3	10.30	3.29	3	37.6	5.31	4.850	8.672	4.988	6.064
	J-IV/J-V	0.491	75.8	7.3	10.30	3.29	4	37.6	6.39	5.966	6.633	6.243	2.300
	J-V/J-V	0.491	75.8	7.3	10.30	4.40	0.3	38.1	1.22	1.505	23.354	0.900	26.230
	J-V/J-V	0.491	75.8	7.3	10.30	4.40	0.6	38.1	1.71	2.048	19.763	1.600	6.433
	J-V/J-V	0.491	75.8	7.3	10.30	4.40	0.9	38.1	2.28	2.572	12.803	2.190	3.947
	J-V/J-V	0.491	75.8	7.3	10.30	4.40	1.5	38.1	3.24	3.532	9.002	3.180	1.852
	J-V/J-V	0.491	75.8	7.3	10.30	4.40	3	38.1	5.44	5.626	3.421	5.250	3.493
	J-V/J-V	0.491	75.8	7.3	10.30	4.40	4	38.1	6.49	6.882	6.041	6.570	1.233

Table S3 Morphology parameters and direct shear test results (performed on 2D regular-shaped DDJCS) presented by this study

Group	A_0	θ^*_r/(°)	θ^*_{max}/(C+1)/(°)	JCS_{low}/MPa	λ	JSC	σ_n/MPa	$\tau_{experimental}$/MPa	$\tau_{predicted}$/MPa (This study)	δ/% (This study)	$\tau_{predicted}$/MPa (TANG et al [21])	δ/% (TANG et al [21])
G1	0.5	15	15	28.48	1.37	0.69	0.5	1.069	1.29	21.11	3.00	180.79
	0.5	15	15	28.48	1.37	0.69	1.5	2.756	2.62	4.79	3.89	41.19
	0.5	15	15	28.48	1.37	0.69	3.0	3.968	4.25	7.16	6.41	61.46
	0.5	15	15	11.69	2.44	0.39	0.5	1.05	1.18	12.72	1.95	86.14
	0.5	15	15	11.69	2.44	0.39	1.5	2.588	2.44	5.56	3.15	21.72
	0.5	15	15	11.69	2.44	0.39	3.0	3.9	3.98	2.12	5.63	44.43
G2	0.5	22.5	22.5	28.48	1.37	0.69	0.5	1.473	1.51	2.54	−3.90	—
	0.5	22.5	22.5	28.48	1.37	0.69	1.5	3.22	2.86	11.08	11.11	245.09
	0.5	22.5	22.5	28.48	1.37	0.69	3.0	5.263	4.53	14.00	16.50	213.44
	0.5	22.5	22.5	11.69	2.44	0.39	0.5	1.474	1.36	7.66	−22.42	—
	0.5	22.5	22.5	11.69	2.44	0.39	1.5	2.9	2.65	8.59	7.66	164.02
	0.5	22.5	22.5	11.69	2.44	0.39	3.0	5.115	4.22	17.45	13.75	168.80
G3	0.5	22.5	22.5	28.48	1.37	0.69	0.5	1.472	1.51	2.61	−3.90	—
	0.5	22.5	22.5	28.48	1.37	0.69	1.5	3.316	2.86	13.65	11.11	235.10
	0.5	22.5	22.5	28.48	1.37	0.69	3	4.971	4.53	8.95	16.50	231.85
	0.5	22.5	22.5	11.69	2.44	0.39	0.5	1.403	1.36	2.99	−22.42	—
	0.5	22.5	22.5	11.69	2.44	0.39	1.5	2.95	2.65	10.14	7.66	159.55
	0.5	22.5	22.5	11.69	2.44	0.39	3	4.858	4.22	13.08	13.75	183.02

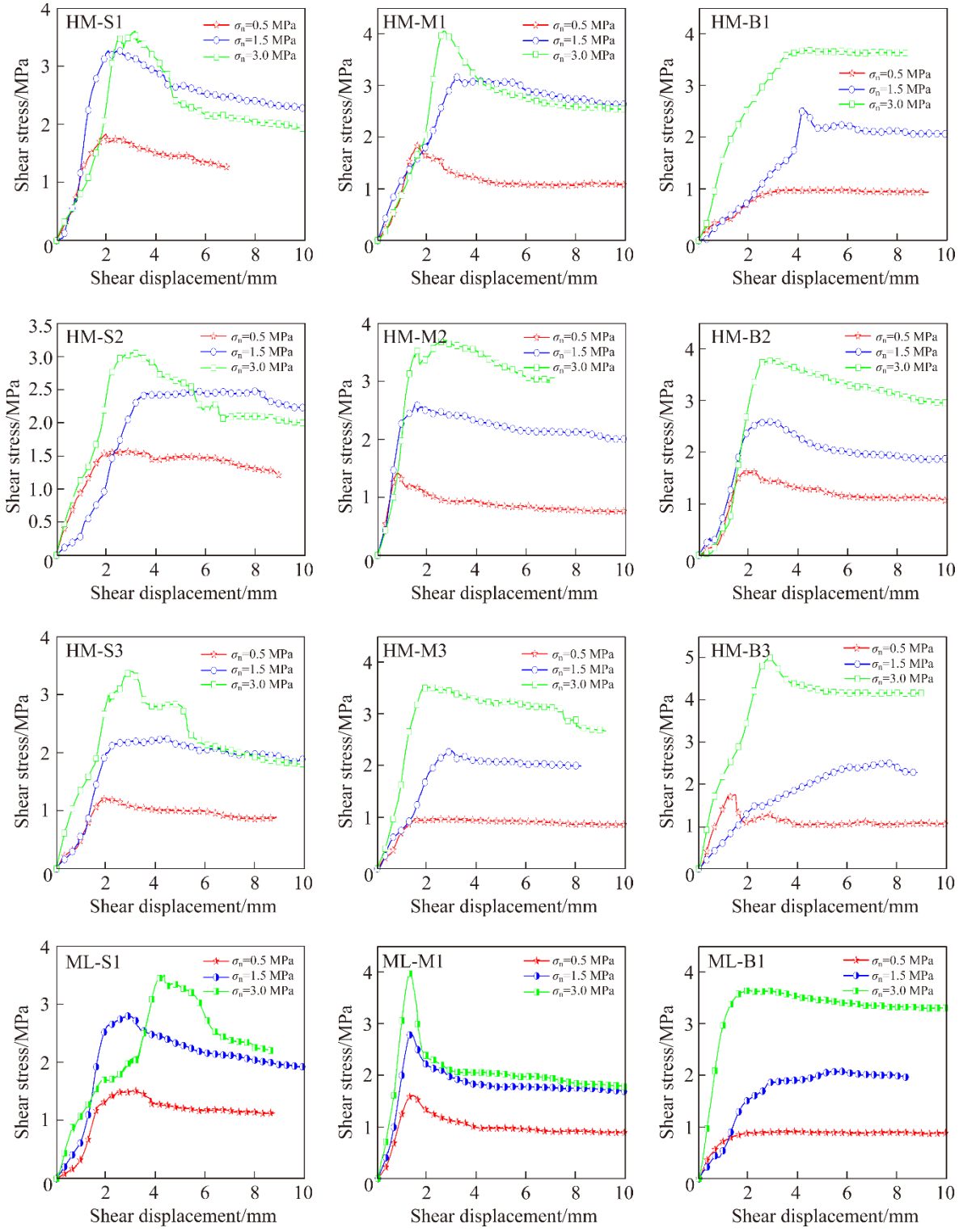
Table S4 Morphology parameters and direct shear test results (performed on 3D rough DIJCS)

Data source	No.	Type	A_0	C	θ^*_{max}/(°)	σ_n/MPa	σ_c/MPa	σ_t/MPa	φ_b/(°)	$\tau_{experimental}$/ MPa	$\tau_{predicted}$/ MPa	δ/%
XIA et al [15]	JI	Mortar	0.499	10.5	59	0.5	27.5	1.54	35	0.85	0.740	12.967
	JI	Mortar	0.499	10.5	59	1	27.5	1.54	35	1.19	1.295	8.817
	JI	Mortar	0.499	10.5	59	1.5	27.5	1.54	35	1.77	1.801	1.729
	JI	Mortar	0.499	10.5	59	2	27.5	1.54	35	2.24	2.277	1.632
	JI	Mortar	0.499	10.5	59	3	27.5	1.54	35	2.84	3.170	11.629
	JII	Mortar	0.504	8.01	69.3	0.5	27.5	1.54	35	1.13	0.939	16.904
	JII	Mortar	0.504	8.01	69.3	1	27.5	1.54	35	1.75	1.558	10.987
	JII	Mortar	0.504	8.01	69.3	1.5	27.5	1.54	35	2.2	2.109	4.156
	JII	Mortar	0.504	8.01	69.3	2	27.5	1.54	35	2.78	2.619	5.778
	JII	Mortar	0.504	8.01	69.3	3	27.5	1.54	35	3.34	3.564	6.697
	JIII	Mortar	0.688	7.48	68.7	0.5	27.5	1.54	35	1.78	0.967	45.681
	JIII	Mortar	0.688	7.48	68.7	1	27.5	1.54	35	2.42	1.592	34.198
	JIII	Mortar	0.688	7.48	68.7	1.5	27.5	1.54	35	2.89	2.148	25.671
	JIII	Mortar	0.688	7.48	68.7	2	27.5	1.54	35	3.51	2.663	24.142
	JIII	Mortar	0.688	7.48	68.7	3	27.5	1.54	35	4.2	3.612	13.994
GRASSELLI [12]	C1	Limestone	0.491	7.03	80	1.07	25	2.4	36	2.2	1.837	16.491
	C2	Limestone	0.462	5.64	80	1.07	25	2.4	36	2.1	1.945	7.398
	C3	Limestone	0.46	4.6	57	3.72	25	2.4	36	5.5	4.492	18.335
	C4	Limestone	0.508	4.74	65	2.45	25	2.4	36	4.6	3.394	26.207
	C5	Limestone	0.495	5.26	74	3.11	25	2.4	36	5	4.060	18.793
	C6	Limestone	0.546	5.19	68	1.02	25	2.4	36	2.1	1.828	12.944
	C8	Limestone	0.555	5.71	74	3.11	25	2.4	36	4.9	4.014	18.078
	G1	Granite	0.493	7.17	90	2.3	173	8.8	34	5.7	5.625	1.313
	G2	Granite	0.498	5.6	80	2.3	173	8.8	34	5.6	5.861	4.654
	G4	Granite	0.498	5.48	65	2.19	173	8.8	34	4.8	5.134	6.964
	G5	Granite	0.46	5.33	57	1.12	173	8.8	34	2.4	3.123	30.120
	G6	Granite	0.477	7.39	84	1.12	173	8.8	34	2.9	3.476	19.871
	G7	Granite	0.47	7.15	81	1.12	173	8.8	34	2.8	3.450	23.219
	G9	Granite	0.508	5.85	75	1.12	173	8.8	34	3	3.705	23.493
	M1	Marble	0.513	9.64	76	0.87	87	9.2	37	1.7	2.037	19.830
	M2	Marble	0.492	5.6	39	1.73	87	9.2	37	2.3	2.901	26.113
	M3	Marble	0.471	10.5	65	0.87	87	9.2	37	1.2	1.693	41.071
	M4	Marble	0.513	8.12	61	3.78	87	9.2	37	5.8	5.708	1.590
	M5	Marble	0.533	8.92	59	2.6	87	9.2	37	4.4	4.046	8.042
	M6	Marble	0.45	10.18	68	2.6	87	9.2	37	4.3	4.105	4.533
	M7	Marble	0.502	13.33	86	3.78	87	9.2	37	5.6	5.479	2.161

to be continued

Continued

Data source	No.	Type	A_0	C	θ^*_{max}/(°)	σ_n/MPa	σ_c/MPa	σ_t/MPa	φ_b/(°)	$\tau_{experimental}$/ MPa	$\tau_{predicted}$/ MPa	δ/%
GRASSELLI [12]	M8	Marble	0.459	10.52	72	3.83	87	9.2	37	6.4	5.618	12.221
	M9	Marble	0.494	10.36	59	2.6	87	9.2	37	4.5	3.784	15.908
	M10	Marble	0.515	10.79	67	0.87	87	9.2	37	1.5	1.701	13.413
	M12	Marble	0.429	7.28	55	1.79	87	9.2	37	3	3.223	7.435
	ML1	Sandstone	0.573	7.25	66	1.02	10	0.7	37	1.4	1.336	4.562
	ML2	Sandstone	0.505	5.44	45	4.13	10	0.7	37	4.5	3.794	15.685
	ML3	Sandstone	0.523	7.81	66	2.09	10	0.7	37	2.3	2.271	1.255
TANG et al [52]	J-IV+B	Mortar	0.513	9.27	44.7	0.4	16.1	1.37	31	0.418	0.443	6.098
	J-IV+B	Mortar	0.513	9.27	44.7	0.8	16.1	1.37	31	0.793	0.794	0.082
	J-IV+B	Mortar	0.513	9.27	44.7	1.2	16.1	1.37	31	1.106	1.116	0.864
	J-IV+B	Mortar	0.513	9.27	44.7	1.6	16.1	1.37	31	1.442	1.420	1.516
	J-IV+B	Mortar	0.513	9.27	44.7	2	16.1	1.37	31	1.709	1.712	0.192
	J-IV-	Mortar	0.501	9.82	43.9	0.4	16.1	1.37	31	0.391	0.430	9.858
	J-IV-	Mortar	0.501	9.82	43.9	0.8	16.1	1.37	31	0.726	0.773	6.527
	J-IV-	Mortar	0.501	9.82	43.9	1.2	16.1	1.37	31	1.117	1.091	2.345
	J-IV-	Mortar	0.501	9.82	43.9	1.6	16.1	1.37	31	1.406	1.392	1.000
	J-IV-	Mortar	0.501	9.82	43.9	2	16.1	1.37	31	1.669	1.681	0.742
	J-V+B	Mortar	0.534	9.05	78.4	0.4	16.1	1.37	31	0.601	0.596	0.884
	J-V+B	Mortar	0.534	9.05	78.4	0.8	16.1	1.37	31	0.984	1.002	1.869
	J-V+B	Mortar	0.534	9.05	78.4	1.2	16.1	1.37	31	1.483	1.364	8.054
	J-V+B	Mortar	0.534	9.05	78.4	1.6	16.1	1.37	31	1.857	1.698	8.585
	J-V+B	Mortar	0.534	9.05	78.4	2	16.1	1.37	31	2.23	2.012	9.755
	J-V-	Mortar	0.506	9.38	75.6	0.4	16.1	1.37	31	0.552	0.576	4.344
	J-V-	Mortar	0.506	9.38	75.6	0.8	16.1	1.37	31	0.934	0.977	4.565
	J-V-	Mortar	0.506	9.38	75.6	1.2	16.1	1.37	31	1.367	1.334	2.438
	J-V-	Mortar	0.506	9.38	75.6	1.6	16.1	1.37	31	1.706	1.665	2.425
	J-V-	Mortar	0.506	9.38	75.6	2	16.1	1.37	31	2.008	1.977	1.534
	J-IV+C	Mortar	0.513	9.27	44.7	0.2	4.7	0.64	24.8	0.154	0.164	6.233
	J-IV+C	Mortar	0.513	9.27	44.7	0.4	4.7	0.64	24.8	0.288	0.292	1.291
	J-IV+C	Mortar	0.513	9.27	44.7	0.6	4.7	0.64	24.8	0.442	0.408	7.598
	J-IV+C	Mortar	0.513	9.27	44.7	0.8	4.7	0.64	24.8	0.568	0.518	8.802
	J-IV+C	Mortar	0.513	9.27	44.7	1	4.7	0.64	24.8	0.703	0.622	11.460
	J-V+C	Mortar	0.534	9.05	78.4	0.2	4.7	0.64	24.8	0.208	0.209	0.482
	J-V+C	Mortar	0.534	9.05	78.4	0.4	4.7	0.64	24.8	0.379	0.354	6.465
	J-V+C	Mortar	0.534	9.05	78.4	0.6	4.7	0.64	24.8	0.514	0.482	6.170
	J-V+C	Mortar	0.534	9.05	78.4	0.8	4.7	0.64	24.8	0.622	0.599	3.652
	J-V+C	Mortar	0.534	9.05	78.4	1	4.7	0.64	24.8	0.749	0.709	5.398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HM-M1
HM-B1
HM-S2
HM-M2
HM-B2
HM-S3
HM-M3
HM-B3
ML-S1
ML-M1
ML-B1
σn=0.5 MPa
σn=1.5 MPa
σn=3.0 MPa
Shear stress/MPa
Shear displacement/mm

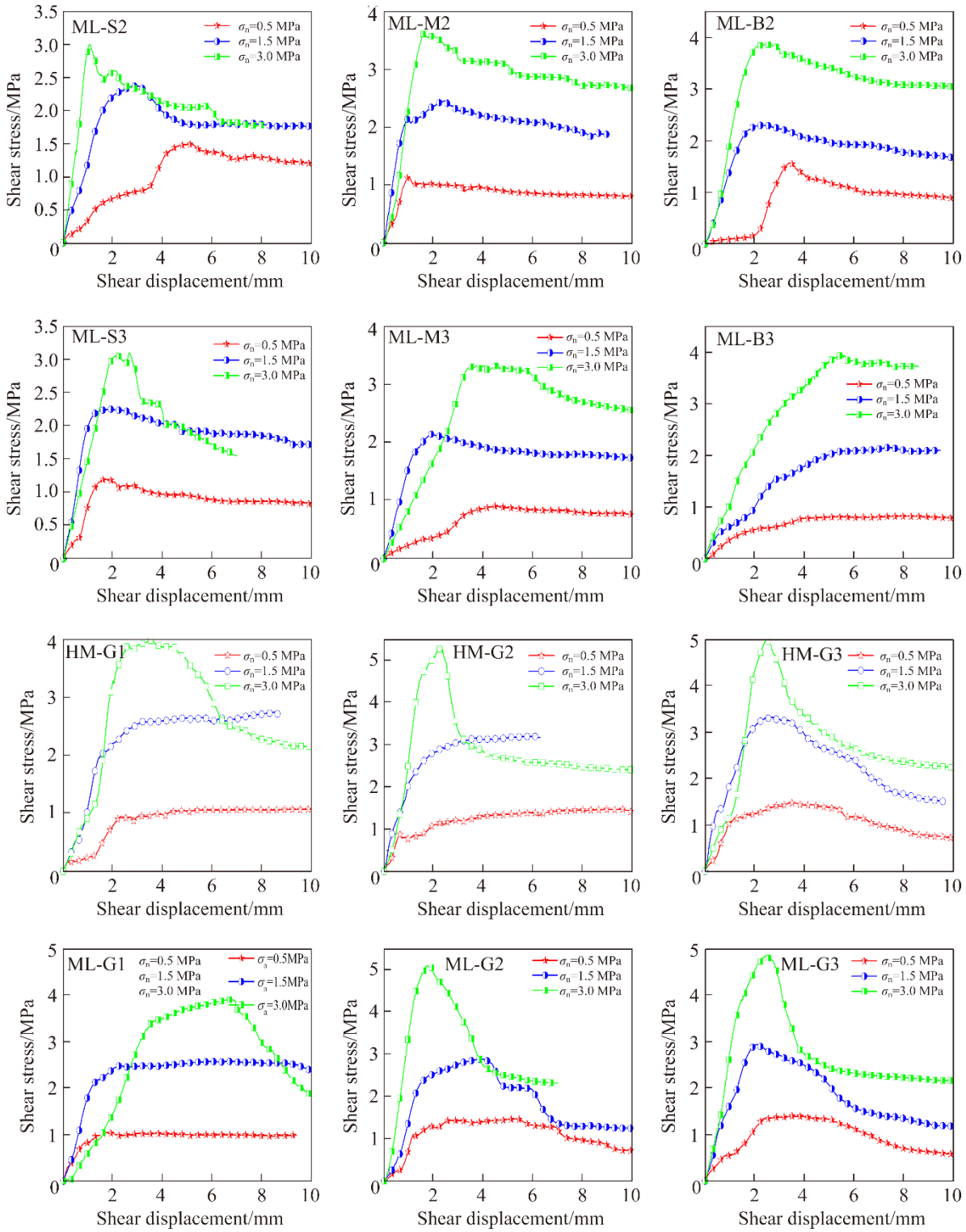

Figure S1 Shear stress−shear displacement curve of rough DDJCS (S1−S3, M1−M3, B1−B3) and regular-shaped DDJCS (G1−G3)