



Supplementary Material

10.1302/2046-3758.99.BJR2019-0237.R2

Table i. Estimated maximum loads in fatigue tests of type II and III plates.

Plate type	Load, N	Maximum principal stress, MPa	Maximum deformation, mm
I	2,100*	1,033.0	1.80
II	1,000	856.2	1.72
	1,250	1,070.3	2.15
	1,300*	1,113.1	2.24
III	800	1,093.3	1.93
	900	1,229.9	2.17
	1,000*	1,366.6	2.41

*Final testing loads. The type I plates failed at a load of 2,100 N. The stress was 1,033 MPa according to finite element analyses. Using similar models, the loads on the type II and III plates were estimated. To ensure plate breakage, 1,300 N and 1,000 N were selected.

Table ii. Fatigue lives of the plates.

Test	Type IA, 10³ cycles	Type IB, 10³ cycles	Type IIA, 10³ cycles	Type IIB, 10³ cycles	Type IIIA, 10³ cycles	Type IIIB, 10³ cycles
1	217.9	2,890.2	67.8	1,757.0	44.2	589.7
2	119.0	2,749.8	101.9	1,341.7	44.8	652.8
3	814.3	1,995.5	90.1	1,553.7	58.2	569.4
4	82.5	1,786.4	85.0	1,588.4	48.2	585.6
5	88.5	2,912.1	69.8	1,625.9	43.9	581.2
6	122.6	2,106.9	73.9	1,358.3	49.1	614.3
7	95.4	2,317.7	64.7	1,581.3	48.1	555.0
8	184.0	1,998.8	85.9	1,269.3	52.9	565.4
9	114.7	1,985.0	117.9	2,028.1	63.3	618.3
10	93.5	2,337.2	203.9	1,505.9	68.3	627.0
Mean	193.2	2,307.0	96.1	1,561.0	52.1	595.9
SD	211.2	388.7	39.2	209.6	8.1	29.6

Table iii. Removal torque before cycling loading.

Test	Type IA, Nm	Type IB, Nm	Type IIA, Nm	Type IIB, Nm	Type IIIA, Nm	Type IIIB, Nm
1	4.10	4.10	4.20	4.40	2.18	2.10
2	4.19	4.30	4.38	4.30	2.03	2.00
3	4.41	4.40	4.25	4.60	2.06	2.01
4	4.61	4.30	4.50	4.60	2.00	2.08
5	4.00	4.30	4.20	4.50	2.16	2.02
6	4.10	4.41	4.25	4.50	2.05	2.18
7	4.18	4.35	4.10	4.50	2.05	2.01
8	4.18	4.30	4.25	4.66	2.15	1.99
9	4.00	4.45	4.30	4.20	2.19	1.95
10	4.00	4.75	4.20	4.10	2.19	2.01
11	3.62	4.55	4.10	4.48	2.19	2.19
12	4.22	4.45	4.30	4.40	2.18	2.00
13	4.20	4.59	3.60	4.30	2.15	2.02
14	4.45	4.65	3.90	4.36	2.10	1.99
15	4.15	4.10	4.00	4.40	2.21	2.05
16	4.68	4.10	4.21	4.20	2.15	1.96
17	4.41	4.50	4.00	4.20	1.60	2.09
18	4.59	4.21	4.25	4.25	2.02	2.02
19	3.98	4.41	4.10	4.30	2.21	2.10
20	4.22	4.42	4.30	4.21	2.18	1.79
Mean	4.21	4.38	4.17	4.37	2.10	2.03
SD	0.25	0.17	0.19	0.15	0.13	0.08

Table iv. Removal torque after cycling loading (intact holes).

Test	Type IA, Nm	Type IB, Nm	Type IIA, Nm	Type IIB, Nm	Type IIIA, Nm	Type IIIB, Nm
1	3.58	3.70	3.50	3.82	1.70	1.80
2	3.59	4.00	3.40	3.75	1.45	1.62
3	2.97	4.21	3.41	3.75	1.41	1.78
4	3.60	4.16	3.21	3.78	1.82	1.60
5	3.66	4.10	3.58	3.54	1.88	1.61
6	3.59	3.80	2.98	3.51	1.90	1.62
7	3.80	4.38	3.85	3.70	2.18	1.82
8	4.00	3.98	4.22	3.83	1.79	1.71
9	3.52	4.00	3.80	3.80	2.00	1.80
10	3.88	3.62	3.18	3.59	1.78	1.70
11	3.79	4.00	3.20	3.78	1.59	1.62
12	3.61	3.88	2.63	3.52	1.61	1.70
13	3.65	3.80	2.98	3.40	1.80	1.61
14	3.60	4.10	2.60	3.81	1.47	1.62
15	3.75	4.02	3.42	3.65	1.80	1.72
16	3.71	4.12	3.58	3.60	1.58	1.61
17	3.81	4.08	3.00	3.61	1.92	1.60
18	4.17	3.94	3.34	4.11	2.00	1.64
19	3.59	4.20	3.62	3.61	1.98	1.61
20	3.89	4.18	3.92	3.88	2.00	1.62
Mean	3.69	4.01	3.37	3.70	1.78	1.67
SD	0.23	0.18	0.41	0.16	0.21	0.07

Table v. Removal torque after cycling loading (broken holes).

Test	Type IA, Nm	Type IB, Nm	Type IIA, Nm	Type IIB, Nm	Type IIIA, Nm	Type IIIB, Nm
1	0.42	0.30	1.38	1.95	0.38	0.83
2	0.40	0.25	0.32	2.34	1.53	0.82
3	0.85	0.10	2.49	0.87	1.18	1.00
4	0.53	0.25	0.23	2.28	0.52	1.52
5	0.31	0.60	1.01	1.03	2.85	1.00
6	0.63	0.50	0.38	2.62	1.28	1.00
7	0.20	0.20	3.69	1.04	0.67	0.20
8	0.62	0.20	0.85	1.01	0.92	0.62
9	0.28	0.50	0.70	0.98	0.63	0.65
10	0.62	0.60	1.45	1.03	0.72	1.18
Mean	0.49	0.35	1.25	1.52	1.07	0.88
SD	0.19	0.17	1.04	0.66	0.69	0.34

Table vi. Bending strengths of the screws.

Test	Type IA, N	Type IB, N	Type IIA, N	Type IIB, N	Type IIIA, N	Type IIIB, N
1	920.4	921.2	969.9	925.3	711.5	806.2
2	914.9	937.4	976.4	965.3	790.6	721.4
3	937.4	919.7	962.0	946.6	809.1	751.9
4	914.5	914.6	957.6	947.7	735.9	748.3
5	919.4	950.3	989.1	947.6	716.7	746.9
6	929.1	954.9	1039.2	939.0	725.9	750.2
7	904.9	935.3	995.4	940.7	796.0	778.8
8	963.7	938.4	903.0	941.5	793.2	803.2
9	927.6	951.0	940.0	944.8	734.1	804.1
10	921.8	934.3	891.9	1018.6	689.0	722.0
Mean	925.3	935.7	962.4	951.7	750.2	763.3
SD	15.3	13.2	41.2	24.2	40.6	31.0

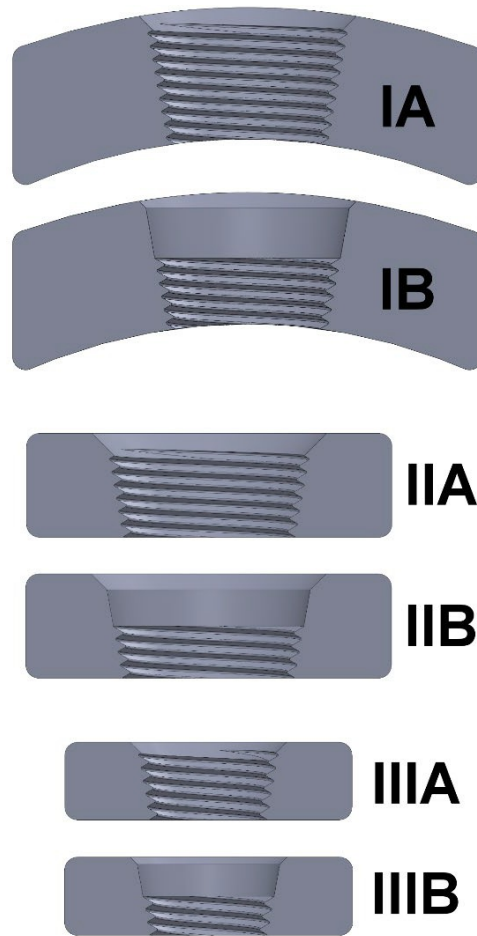


Fig. a. Plate cross-sections. 'A' indicates fully threaded holes and 'B' indicates half-threaded holes.

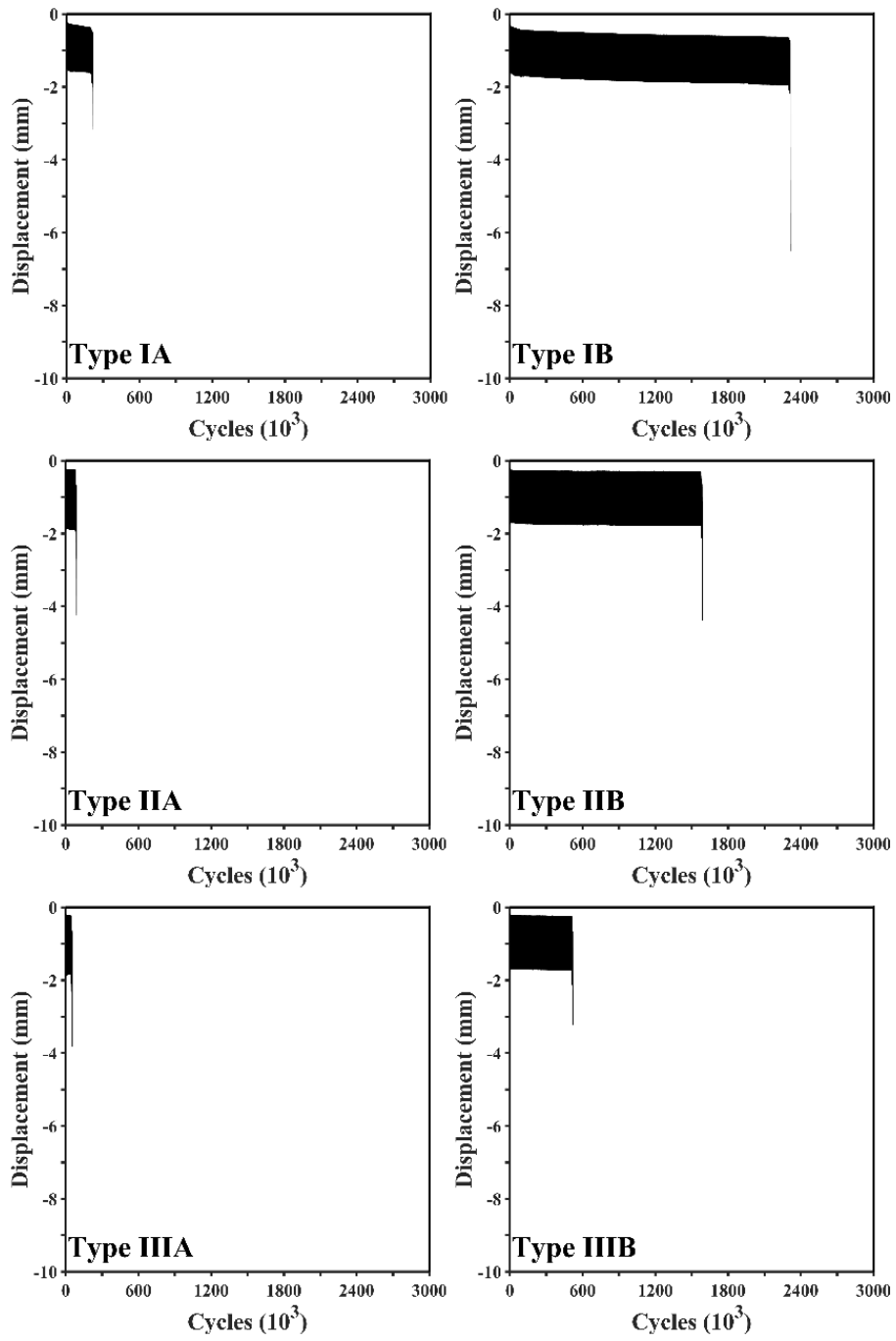


Fig. b. Fatigue lives of plates during four-point bending test.

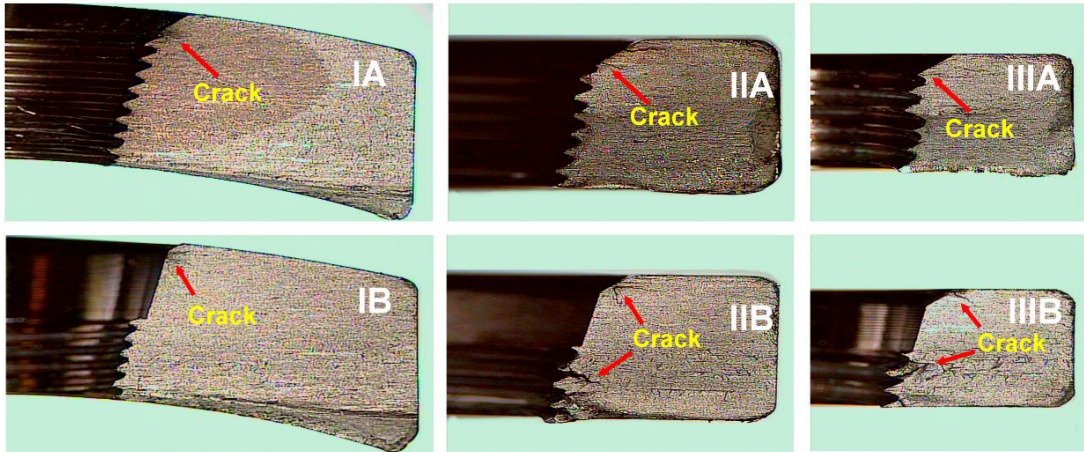


Fig. c. Crack initiation lines observed under an optical microscope in all plates. More thread deformation was observed in the half-threaded holes, especially for types II and III.

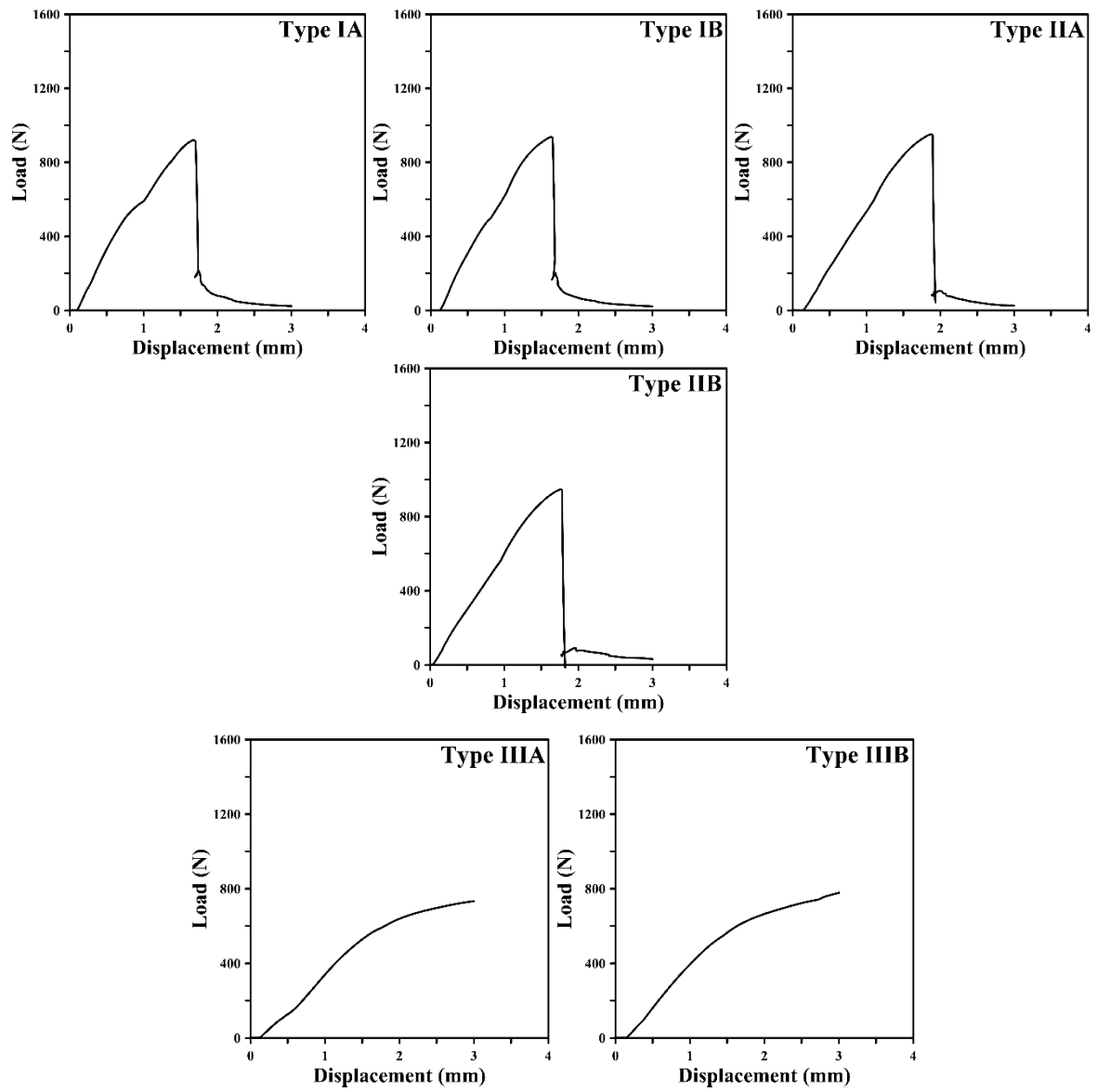


Fig. d. Load–deformation curves obtained from screw stability tests.