APPENDIX B BOLT RUPTURE OF 16ES CONNECTION

B.1 PROCEDURE

In order to determine the number of bolts that are effective, n_{eff}, for the 16ES moment end-plate connection, numerous connections were modeled using the finite element method. A total of 25 connections were analyzed, which includes eight connections for W30x173 beams, eight connections for W24x162 beams, and nine connections for W21x101 beams. Beam dimensions are given in Table B-1. Based on the yield line solution for end-plate bending presented in Chapter 6, it was determined that 1 ¼ inch thick end-plates were required to develop the W30x173 and W24x162 beams and a 1 inch thick plate was needed to develop the W21x101 beam. The beams and end-plates have nominal yield stresses of 50 and 36 ksi, respectively. Only A325 bolts were considered. Various bolt sizes were used in the analysis, and the resulting end-plate geometry is detailed in Tables B-2 through B-4 with reference to Fig. 6-1.

B.2 RESULTS

The connections are loaded until failure occurs via bolt rupture. The ultimate applied moment M_u is given in Tables B-2 through B-4 for each of the beam connections considered. This moment is divided by the center-to-center distance between beam flanges and the nominal yield stress of a bolt to determine the number of effective bolts. The procedure is described in Section 6.4 of this dissertation.

TABLE B-1. Beam dimensions.

Dimension	W30x173	W24x162	W21x101
d (beam depth)	30.44 in.	25.00 in.	21.36 in.
b_f (flange width)	14.985 in.	12.955 in.	12.29 in.
t_f (flange thickness)	1.065 in.	1.22 in.	0.80 in.
t_w (web thickness)	0.655 in.	0.705 in.	0.50 in.

TABLE B-2. 16ES geometry for W30x173 beam.

Connection Number	1	2	3	4	5	6	7	8
g_1 (in.)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
g_2 (in.)	1.67	2.00	2.33	2.67	3.00	4.50	4.75	4.25
b_{ext} (in.)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
p_{ext} (in.)	6.00	6.00	6.00	7.00	7.00	7.00	7.00	7.00
p_f (in.)	1.125	1.25	1.375	1.50	1.625	1.75	1.75	1.75
p_b (in.)	1.67	2.00	2.33	2.66	3.00	3.33	3.33	3.33
$[b_f-(g_1+2g_2)]/2$ (in.)	3.33	2.99	2.67	2.33	1.99	0.49	0.24	0.74
Bolt diameter (in.)	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/4	1 1/4
M_u (k-ft)	770	1100	1490	1910	2300	2300	2000	2510
n_{eff}	11.4	11.3	11.3	11.0	10.5	8.5	7.4	9.3

TABLE B-3. 16ES geometry for W24x162 beam.

Connection Number	9	10	11	12	13	14	15	16
g_1 (in.)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
g_2 (in.)	1.67	2.00	2.33	2.67	3.00	3.33	3.50	3.50
b_{ext} (in.)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
p_{ext} (in.)	6.00	6.00	6.00	7.00	7.00	7.00	7.00	6.00
p_f (in.)	1.125	1.25	1.375	1.50	1.625	1.75	1.75	1.25
p_b (in.)	1.67	2.00	2.33	2.67	3.00	3.33	3.33	2.00
$[b_f-(g_1+2g_2)]/2$ (in.)	2.31	1.98	1.64	1.31	0.98	0.64	0.48	0.48
Bolt diameter (in.)	5/8	3/4	7/8	1	1 1/8	1 1/4	1 1/4	3/4
M_u (k-ft)	630	900	1200	1540	1650	1960	1900	740
n_{eff}	11.5	11.4	11.2	11.0	9.3	8.9	8.7	9.4

TABLE B-4. 16ES geometry for W21x101 beam.

Connection	17	18	19	20	21	22	23	24	25
g_1 (in.)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
g_2 (in.)	1.67	2.00	2.33	2.67	2.75	3.00	3.25	3.00	3.25
b_{ext} (in.)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
p_{ext} (in.)	6.00	6.00	6.00	7.00	6.00	6.00	6.00	7.00	7.00
p_f (in.)	1.125	1.25	1.375	1.50	1.125	1.25	1.25	1.50	1.50
p_b (in.)	1.67	2.00	2.33	2.67	2.00	2.00	2.00	2.67	2.67
$[b_f-(g_1+2g_2)]/2$ (in.)	1.98	1.65	1.31	0.98	0.90	0.65	0.40	0.65	0.40
Bolt diameter (in.)	5/8	3/4	7/8	1	3/4	3/4	3/4	1	1
M_u (k-ft)	550	790	1020	1200	730	710	620	1150	980
n_{eff}	11.6	11.6	11.0	9.9	10.7	10.4	9.1	9.5	8.0