Verification Report

ILX Connection v1.0.0 · all connection types: shear (single plate, single angle, double angle, end plate, seated, tee, skewed bent plate), FR moment, splices (shear, compression), truss connections, hangers, beam bearing plates, HSS strut end plates, column base plates, components and calculators (bracket plates, bolt groups, weld groups, bolted joints, welded joints)

Code basis	AISC 360-22; AISC Steel Construction Manual 16th Ed.; AISC Design Examples v16.0; AISC Design Guide 1; AISC Design Guide 29; ACI 318-19 Chapter 17
Generated	2026-10-30T23:18:05+00:00 · commit 916211c-dirty · Python 3.14.5
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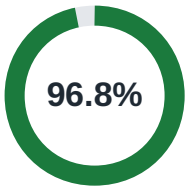
Tests	tests/test_verification_examples.py, tests/test_verification_components.py, tests/test_single_angle.py::test_published_angle_examples_identical_to_the_single_plate_angle_path, tests/test_shear_end_plate_verification.py, tests/test_seated_verification.py, tests/test_double_angle_examples.py, tests/test_shear_tee.py::test_design_examples, tests/test_shear_tee.py::test_ii_a_30_details, tests/test_shear_tee.py::test_ii_a_31_and_k_details, tests/test_moment_fr.py::test_IIB1_bolted_flange_plate, tests/test_moment_fr.py::test_IIB1_plate_weld_size, tests/test_moment_fr.py::test_IIB2_welded_flange_plate, tests/test_moment_fr.py::test_IIB3_directly_welded, tests/test_moment_fr.py::test_J7_web_local_yielding_and_crippling, tests/test_moment_fr.py::test_J10_flange_local_bending_IIB1, tests/test_moment_fr.py::test_F13_tension_flange, tests/test_moment_fr.py::test_weld_group_J26, tests/test_verification_base_plate.py, tests/test_verification_hss.py, tests/test_verification_hanger_bearing.py, tests/test_verification_truss.py, tests/test_verification_splices.py, tests/test_verification_skewed.py, tests/test_verification_calculators.py, tests/test_verification_pin_eyebar.py, tests/test_verification_tension_member.py, tests/test_verification_column_on_beam.py, tests/test_verification_built_up.py, tests/test_verification_bracing_gusset.py, tests/test_verification_web_opening.py, tests/test_verification_dg1_3rd.py, tests/test_verification_dg29.py, tests/test_verification_embedded_base.py, tests/test_verification_braced_base.py, tests/test_verification_moment_ep.py: 4414 passed, 142 xfailed, 56 skipped

Summary



limit states within tolerance

187 published examples (348 LRFD/ASD runs)

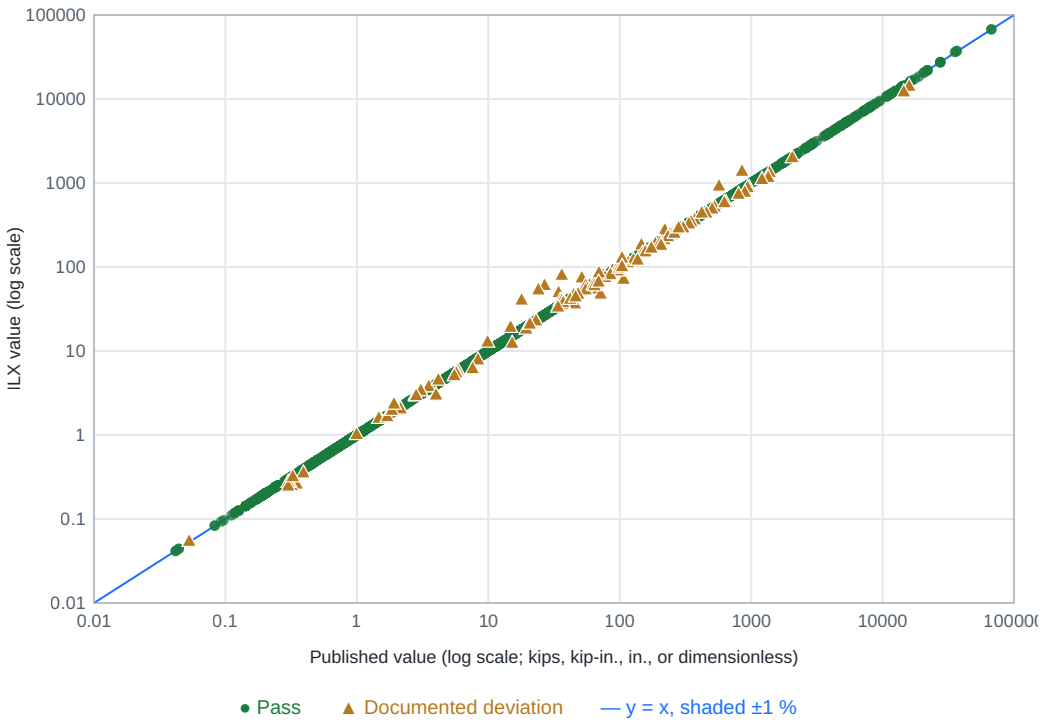
4127 limit-state comparisons

3994 pass

133 documented deviations

0 not checked (coverage gaps)

ILX's overall OK/NG matches the published conclusion in 261 of 312 comparable runs (the exception is Muir & Hewitt 2009, explained under D15). 85 of 85 component benchmarks (IC coefficients, bearing/tearout, slip) are within tolerance.



Results by example

Example	Connection	Method	Limit states	Pass	Deviation	Not checked	ILX	Published
II.A-6	Coped beam	LRFD	54	52	2	0	–	NG
II.A-6	Coped beam	ASD	54	52	2	0	–	NG
II.A-7	Coped beam	LRFD	8	8	0	0	–	OK
II.A-7	Coped beam	ASD	8	8	0	0	–	OK
II.A-17A	Single plate, conventional	LRFD	14	14	0	0	OK	OK
II.A-17A	Single plate, conventional	ASD	14	14	0	0	OK	OK
II.A-17B	Single plate, conventional	LRFD	25	24	1	0	OK	OK
II.A-17B	Single plate, conventional	ASD	25	24	1	0	OK	OK
II.A-17C	Single plate, conventional	LRFD	14	14	0	0	OK	OK
II.A-17C	Single plate, conventional	ASD	14	14	0	0	OK	OK
II.A-18	Single plate, conventional	LRFD	11	10	1	0	OK	OK
II.A-18	Single plate, conventional	ASD	11	10	1	0	OK	OK
SDS2 II.A-18	Single plate, conventional	LRFD	17	17	0	0	OK	OK
SDS2 II.A-18	Single plate, conventional	ASD	17	17	0	0	OK	OK
II.A-19A	Single plate, extended	LRFD	18	18	0	0	OK	OK
II.A-19A	Single plate, extended	ASD	18	18	0	0	OK	OK

Example	Connection	Method	Limit states	Pass	Deviation	Not checked	ILX	Published
II.A-19B	Single plate, extended	LRFD	33	29	4	0	NG	NG
II.A-19B	Single plate, extended	ASD	33	29	4	0	NG	NG
M&T 2011	Single plate, conventional	LRFD	12	12	0	0	OK	OK
M&H 2009	Single plate, extended	LRFD	12	8	4	0	NG	OK
Dowswell 2018	Coped beam	LRFD	10	10	0	0	–	OK
K.6	Single plate, conventional	LRFD	14	14	0	0	OK	OK
K.6	Single plate, conventional	ASD	14	14	0	0	OK	OK
K.7	Through plate (HSS)	LRFD	19	19	0	0	OK	OK
K.7	Through plate (HSS)	ASD	19	19	0	0	OK	OK
K.8	Single plate, conventional	LRFD	8	8	0	0	OK	OK
K.8	Single plate, conventional	ASD	8	8	0	0	OK	OK
II.A-28A	Single angle	LRFD	20	16	4	0	OK	OK
II.A-28A	Single angle	ASD	20	16	4	0	OK	OK
II.A-28B	Single angle	LRFD	18	18	0	0	OK	OK
II.A-28B	Single angle	ASD	18	18	0	0	OK	OK
II.A-29	Single angle	LRFD	16	13	3	0	OK	OK
II.A-29	Single angle	ASD	16	13	3	0	OK	OK
II.A-1A	Double angle	LRFD	5	5	0	0	–	OK
II.A-1A	Double angle	ASD	5	5	0	0	–	OK
II.A-1B	Double angle	LRFD	15	14	1	0	–	OK
II.A-1B	Double angle	ASD	14	14	0	0	–	OK
II.A-1C	Double angle	LRFD	10	10	0	0	–	OK
II.A-1C	Double angle	ASD	8	8	0	0	–	OK
II.A-2A	Double angle	LRFD	5	5	0	0	–	OK
II.A-2A	Double angle	ASD	5	5	0	0	–	OK
II.A-2B	Double angle	LRFD	11	10	1	0	–	OK
II.A-2B	Double angle	ASD	10	10	0	0	–	OK
II.A-3	Double angle	LRFD	4	4	0	0	–	OK
II.A-3	Double angle	ASD	4	4	0	0	–	OK
II.A-4	Double angle	LRFD	6	6	0	0	–	OK
II.A-4	Double angle	ASD	6	6	0	0	–	OK
II.A-5	Double angle	LRFD	4	4	0	0	–	OK
II.A-5	Double angle	ASD	4	4	0	0	–	OK
K.3	Double angle	LRFD	3	3	0	0	–	OK
K.3	Double angle	ASD	2	2	0	0	–	OK
II.A-8	Double angle	LRFD	6	6	0	0	–	OK
II.A-8	Double angle	ASD	6	6	0	0	–	OK
II.A-9	Double angle	LRFD	2	2	0	0	–	OK

Example	Connection	Method	Limit states	Pass	Deviation	Not checked	ILX	Published
II.A-9	Double angle	ASD	2	2	0	0	–	OK
II.A-11A	Shear end plate	LRFD	19	19	0	0	OK	OK
II.A-11A	Shear end plate	ASD	19	19	0	0	OK	OK
II.A-11B	Shear end plate	LRFD	32	31	1	0	OK	OK
II.A-11B	Shear end plate	ASD	32	31	1	0	OK	OK
II.A-11C	Shear end plate	LRFD	12	12	0	0	OK	OK
II.A-11C	Shear end plate	ASD	12	12	0	0	OK	OK
II.A-12A	Seated	LRFD	8	7	1	0	OK	OK
II.A-12A	Seated	ASD	6	5	1	0	OK	OK
II.A-12B	Seated	LRFD	8	8	0	0	OK	OK
II.A-12B	Seated	ASD	2	2	0	0	OK	OK
II.A-13	Seated	LRFD	4	4	0	0	OK	OK
II.A-13	Seated	ASD	2	2	0	0	OK	OK
II.A-14	Seated	LRFD	12	12	0	0	OK	OK
II.A-14	Seated	ASD	8	8	0	0	OK	OK
II.A-15	Seated	LRFD	3	3	0	0	OK	OK
II.A-15	Seated	ASD	1	1	0	0	OK	OK
II.A-16	Seated	LRFD	8	8	0	0	OK	OK
II.A-16	Seated	ASD	7	7	0	0	OK	OK
K.4	Seated	LRFD	5	5	0	0	OK	OK
K.4	Seated	ASD	2	2	0	0	OK	OK
K.5	Seated	LRFD	9	9	0	0	OK	OK
K.5	Seated	ASD	5	5	0	0	OK	OK
E&S 1999	Seated	LRFD	8	8	0	0	–	OK
II.A-30	Shear tee	LRFD	14	14	0	0	OK	OK
II.A-30	Shear tee	ASD	7	7	0	0	OK	OK
II.A-31	Shear tee	LRFD	9	9	0	0	OK	OK
II.A-31	Shear tee	ASD	7	7	0	0	OK	OK
K.1	Shear tee	LRFD	11	11	0	0	OK	OK
K.1	Shear tee	ASD	8	8	0	0	OK	OK
K.2	Shear tee	LRFD	3	3	0	0	OK	OK
K.2	Shear tee	ASD	1	1	0	0	OK	OK
II.A-10	Skewed double bent plate	LRFD	17	16	1	0	OK	OK
II.A-10	Skewed double bent plate	ASD	17	16	1	0	OK	OK
II.B-1	FR moment	LRFD	36	36	0	0	OK	OK
II.B-1	FR moment	ASD	33	33	0	0	OK	OK
II.B-2	FR moment	LRFD	16	16	0	0	OK	OK
II.B-2	FR moment	ASD	15	15	0	0	OK	OK
II.B-3	FR moment	LRFD	2	2	0	0	OK	OK
II.B-3	FR moment	ASD	2	2	0	0	OK	OK
J.7	FR moment	LRFD	3	3	0	0	–	OK
J.7	FR moment	ASD	1	1	0	0	–	OK
DG39-5.2-1	End-plate moment	LRFD	27	27	0	0	OK	OK

Example	Connection	Method	Limit states	Pass	Deviation	Not checked	ILX	Published
DG39-5.2-1	End-plate moment	ASD	27	27	0	0	OK	OK
DG39-5.2-2	End-plate moment	LRFD	16	16	0	0	OK	OK
DG39-5.2-2	End-plate moment	ASD	16	16	0	0	OK	OK
DG39-5.2-3	End-plate moment	LRFD	20	20	0	0	OK	OK
DG39-5.2-3	End-plate moment	ASD	20	20	0	0	OK	OK
DG39-5.2-4	End-plate moment	LRFD	20	20	0	0	OK	OK
DG39-5.2-4	End-plate moment	ASD	20	20	0	0	OK	OK
DG39-5.2-5	End-plate moment	LRFD	16	16	0	0	OK	OK
DG39-5.2-5	End-plate moment	ASD	16	16	0	0	OK	OK
DG39-5.2-6	End-plate moment	LRFD	16	16	0	0	OK	OK
DG39-5.2-6	End-plate moment	ASD	16	16	0	0	OK	OK
DG39-5.3-1	End-plate moment	LRFD	21	21	0	0	OK	OK
DG39-5.3-1	End-plate moment	ASD	21	21	0	0	OK	OK
DG39-5.3-2	End-plate moment	LRFD	29	29	0	0	OK	OK
DG39-5.3-2	End-plate moment	ASD	29	29	0	0	OK	OK
DG39-5.3-3	End-plate moment	LRFD	16	16	0	0	OK	OK
DG39-5.3-3	End-plate moment	ASD	16	16	0	0	OK	OK
DG39-5.3-4	End-plate moment	LRFD	16	16	0	0	OK	OK
DG39-5.3-4	End-plate moment	ASD	16	16	0	0	OK	OK
DG39-5.3-5	End-plate moment	LRFD	17	17	0	0	OK	OK
DG39-5.3-5	End-plate moment	ASD	17	17	0	0	OK	OK
DG39-5.3-6	End-plate moment	LRFD	16	16	0	0	OK	OK
DG39-5.3-6	End-plate moment	ASD	16	16	0	0	OK	OK
DG39-5.3-7	End-plate moment	LRFD	17	17	0	0	OK	OK
DG39-5.3-7	End-plate moment	ASD	17	17	0	0	NG	OK
DG39-5.3-8	End-plate moment	LRFD	16	16	0	0	OK	OK
DG39-5.3-8	End-plate moment	ASD	16	16	0	0	OK	OK
DG39-5.3-9	End-plate moment	LRFD	17	17	0	0	OK	OK
DG39-5.3-9	End-plate moment	ASD	17	17	0	0	OK	OK
DG39-B.2-1	End-plate moment	LRFD	7	7	0	0	OK	OK
DG39-B.2-1	End-plate moment	ASD	7	7	0	0	OK	OK
DG39-B.2-2	End-plate moment	LRFD	5	5	0	0	OK	OK
DG39-B.2-2	End-plate moment	ASD	5	5	0	0	OK	OK
DG39-B.2-3	End-plate moment	LRFD	5	5	0	0	OK	OK
DG39-B.2-3	End-plate moment	ASD	5	5	0	0	OK	OK
DG39-B.2-4	End-plate moment	LRFD	5	5	0	0	OK	OK
DG39-B.2-4	End-plate moment	ASD	5	5	0	0	NG	OK
DG39-B.2-5	End-plate moment	LRFD	5	5	0	0	OK	OK
DG39-B.2-5	End-plate moment	ASD	5	5	0	0	OK	OK
DG39-B.2-6	End-plate moment	LRFD	5	5	0	0	OK	OK
DG39-B.2-6	End-plate moment	ASD	5	5	0	0	OK	OK
DG39-B.3-1	End-plate moment	LRFD	10	10	0	0	OK	OK
DG39-B.3-1	End-plate moment	ASD	10	10	0	0	OK	OK
DG39-B.3-2	End-plate moment	LRFD	7	7	0	0	OK	OK
DG39-B.3-2	End-plate moment	ASD	7	7	0	0	OK	OK

Example	Connection	Method	Limit states	Pass	Deviation	Not checked	ILX	Published
DG39-B.3-3	End-plate moment	LRFD	8	8	0	0	OK	OK
DG39-B.3-3	End-plate moment	ASD	8	8	0	0	OK	OK
DG39-B.3-4	End-plate moment	LRFD	8	8	0	0	OK	OK
DG39-B.3-4	End-plate moment	ASD	8	8	0	0	OK	OK
DG39-B.3-5	End-plate moment	LRFD	5	5	0	0	OK	OK
DG39-B.3-5	End-plate moment	ASD	5	5	0	0	OK	OK
DG39-B.3-6	End-plate moment	LRFD	8	8	0	0	OK	OK
DG39-B.3-6	End-plate moment	ASD	8	8	0	0	OK	OK
DG39-B.3-7	End-plate moment	LRFD	5	5	0	0	OK	OK
DG39-B.3-7	End-plate moment	ASD	5	5	0	0	OK	OK
DG39-B.3-8	End-plate moment	LRFD	8	8	0	0	OK	OK
DG39-B.3-8	End-plate moment	ASD	8	8	0	0	OK	OK
DG39-B.3-9	End-plate moment	LRFD	5	5	0	0	OK	OK
DG39-B.3-9	End-plate moment	ASD	5	5	0	0	NG	OK
II.A-20	Beam shear splice	LRFD	14	14	0	0	OK	OK
II.A-20	Beam shear splice	ASD	14	14	0	0	OK	OK
II.A-21	Beam shear splice	LRFD	18	15	3	0	OK	OK
II.A-21	Beam shear splice	ASD	18	15	3	0	OK	OK
II.C-3 diagonal	Compression splice (flange plates)	LRFD	11	11	0	0	OK	OK
II.C-3 diagonal	Compression splice (flange plates)	ASD	11	11	0	0	OK	OK
II.C-3 chord	Compression splice (flange plates)	LRFD	6	6	0	0	OK	OK
II.C-3 chord	Compression splice (flange plates)	ASD	6	6	0	0	OK	OK
II.C-3 vertical	Compression splice (flange plates)	LRFD	5	5	0	0	OK	OK
II.C-3 vertical	Compression splice (flange plates)	ASD	5	5	0	0	OK	OK
II.C-1	Truss connection	LRFD	44	44	0	0	OK	OK
II.C-1	Truss connection	ASD	42	42	0	0	OK	OK
II.C-2 (L1)	Truss connection	LRFD	10	10	0	0	OK	OK
II.C-2 (L1)	Truss connection	ASD	10	10	0	0	OK	OK
II.C-2 (U1)	Truss connection	LRFD	9	9	0	0	OK	OK
II.C-2 (U1)	Truss connection	ASD	9	9	0	0	OK	OK
II.D-1	WT hanger	LRFD	30	30	0	0	OK	OK
II.D-1	WT hanger	ASD	30	30	0	0	OK	OK
II.D-2A	Beam bearing plate	LRFD	11	11	0	0	NG	NG
II.D-2A	Beam bearing plate	ASD	11	11	0	0	NG	NG
II.D-2B	Beam bearing plate	LRFD	4	4	0	0	OK	OK
II.D-2B	Beam bearing plate	ASD	4	4	0	0	OK	OK
II.D-2C	Beam bearing plate	LRFD	6	6	0	0	OK	OK
II.D-2C	Beam bearing plate	ASD	6	6	0	0	OK	OK
K.10	HSS strut end plate	LRFD	14	14	0	0	OK	OK
K.10	HSS strut end plate	ASD	14	14	0	0	OK	OK

Example	Connection	Method	Limit states	Pass	Deviation	Not checked	ILX	Published
J.6	Base plate	LRFD	6	6	0	0	–	OK
J.6	Base plate	ASD	3	3	0	0	–	OK
K.9	Base plate	LRFD	5	5	0	0	–	OK
K.9	Base plate	ASD	2	2	0	0	–	OK
STI 2024 Ex. 1	Base plate	LRFD	3	3	0	0	–	OK
STI 2024 Ex. 2	Base plate	LRFD	4	4	0	0	–	OK
DG1-3 4.7-1	Base plate	LRFD	8	8	0	0	OK	OK
DG1-3 4.7-1	Base plate	ASD	8	8	0	0	OK	OK
DG1-3 4.7-2	Base plate	LRFD	9	8	1	0	OK	OK
DG1-3 4.7-2	Base plate	ASD	8	8	0	0	OK	OK
DG1-3 4.7-3	Base plate	LRFD	15	15	0	0	OK	OK
DG1-3 4.7-3	Base plate	ASD	7	7	0	0	OK	OK
DG1-3 4.7-4	Base plate	LRFD	6	6	0	0	NG	OK
DG1-3 4.7-5	Base plate	LRFD	33	32	1	0	NG	OK
DG1-3 4.7-5	Base plate	ASD	19	18	1	0	NG	OK
DG1-3 4.7-6	Base plate	LRFD	7	7	0	0	NG	NG
DG1-3 4.7-6	Base plate	ASD	7	7	0	0	NG	NG
DG1-3 4.7-6b	Base plate	LRFD	7	7	0	0	NG	OK
DG1-3 4.7-6b	Base plate	ASD	7	7	0	0	NG	OK
DG1-3 4.7-7	Base plate	LRFD	18	17	1	0	NG	OK
DG1-3 4.7-7	Base plate	ASD	9	8	1	0	NG	OK
DG1-3 4.7-8	Base plate	LRFD	12	12	0	0	NG	OK
DG1-3 4.7-8	Base plate	ASD	11	11	0	0	NG	OK
DG1-3 4.7-9	Base plate	LRFD	18	17	1	0	NG	OK
DG1-3 4.7-9	Base plate	ASD	12	11	1	0	NG	OK
DG1-3 4.7-10	Base plate	LRFD	11	11	0	0	OK	OK
DG1-3 4.7-10	Base plate	ASD	11	11	0	0	OK	OK
DG1-3 4.7-11	Base plate	LRFD	26	24	2	0	NG	OK
DG1-3 4.7-11	Base plate	ASD	19	18	1	0	NG	OK
DG1-3 4.7-12	Base plate	LRFD	4	2	2	0	NG	OK
DG1-3 4.7-12	Base plate	ASD	4	2	2	0	NG	OK
DG1-3 4.7-13	Base plate	LRFD	2	2	0	0	NG	OK
DG1-3 4.7-13	Base plate	ASD	2	2	0	0	NG	OK
DG1-3 4.7-14	Base plate	LRFD	23	19	4	0	NG	OK
DG1-3 4.7-15	Base plate	LRFD	15	15	0	0	OK	OK
DG1-3 6.4-1	Base plate	LRFD	24	22	2	0	NG	OK
DG1-3 6.4-1b	Base plate	LRFD	5	3	2	0	NG	OK
DG1-3 B.2-1	Base plate	LRFD	14	14	0	0	NG	OK
DG1-3 B.2-1	Base plate	ASD	14	14	0	0	NG	OK
DG1-3 B.2-2	Base plate	LRFD	11	11	0	0	NG	OK
DG1-3 B.2-2	Base plate	ASD	11	11	0	0	NG	OK
DG1-3 B.3-1	Base plate	LRFD	3	3	0	0	NG	OK
DG1-Ex5.3-1	Embedded column base	LRFD	14	14	0	0	OK	OK

Example	Connection	Method	Limit states	Pass	Deviation	Not checked	ILX	Published
HK2023-1	Embedded column base (Type II)	LRFD	1	1	0	0	NG	NG
HK2023-2	Embedded column base (Type II)	LRFD	1	1	0	0	NG	NG
HK2023-3	Embedded column base (Type II)	LRFD	1	1	0	0	NG	NG
HK2023-4	Embedded column base (Type II)	LRFD	1	0	1	0	NG	NG
HK2023-5	Embedded column base (Type II)	LRFD	1	0	1	0	NG	NG
HK2023-1G	Embedded column base (Type II)	LRFD	1	1	0	0	NG	NG
HK2023-2G	Embedded column base (Type II)	LRFD	1	1	0	0	NG	NG
HK2023-3G	Embedded column base (Type II)	LRFD	1	1	0	0	NG	NG
HK2023-4G	Embedded column base (Type II)	LRFD	1	1	0	0	NG	NG
HK2023-5G	Embedded column base (Type II)	LRFD	1	1	0	0	NG	NG
DG29 5.12.1	Braced-frame column base	LRFD	40	39	1	0	OK	OK
DG29 5.12.1	Braced-frame column base	ASD	40	40	0	0	OK	OK
DG29 5.12.2	Braced-frame column base	LRFD	22	22	0	0	NG	OK
DG29 5.12.2	Braced-frame column base	ASD	22	22	0	0	NG	OK
DG1-3 4.7-7 (braced base)	Braced-frame column base	LRFD	18	18	0	0	NG	OK
DG1-3 4.7-7 (braced base)	Braced-frame column base	ASD	9	9	0	0	NG	OK
DG1-3 4.7-8 (braced base)	Braced-frame column base	LRFD	12	12	0	0	NG	OK
DG1-3 4.7-8 (braced base)	Braced-frame column base	ASD	11	11	0	0	NG	OK
II.A-22	Bracket plate	LRFD	24	22	2	0	OK	OK
II.A-22	Bracket plate	ASD	24	22	2	0	OK	OK
II.A-23	Bracket plate	LRFD	21	21	0	0	OK	OK
II.A-23	Bracket plate	ASD	21	21	0	0	OK	OK
II.A-24A	Bolt group	LRFD	4	4	0	0	OK	OK
II.A-24A	Bolt group	ASD	4	4	0	0	OK	OK
II.A-24B	Bolt group	LRFD	4	4	0	0	OK	OK
II.A-24B	Bolt group	ASD	4	4	0	0	OK	OK
II.A-25	Bolt group	LRFD	5	5	0	0	OK	OK
II.A-25	Bolt group	ASD	5	5	0	0	OK	OK
II.A-26A	Weld group	LRFD	6	6	0	0	OK	OK
II.A-26A	Weld group	ASD	6	6	0	0	OK	OK
II.A-26B	Weld group	LRFD	3	3	0	0	OK	OK
II.A-26B	Weld group	ASD	3	3	0	0	OK	OK

Example	Connection	Method	Limit states	Pass	Deviation	Not checked	ILX	Published
II.A-27	Weld group	LRFD	5	5	0	0	OK	OK
II.A-27	Weld group	ASD	5	5	0	0	OK	OK
J.3	Bolted joint	LRFD	5	5	0	0	OK	OK
J.3	Bolted joint	ASD	5	5	0	0	OK	OK
J.4A	Bolted joint	LRFD	4	4	0	0	OK	OK
J.4A	Bolted joint	ASD	4	4	0	0	OK	OK
J.4B	Bolted joint	LRFD	3	3	0	0	OK	OK
J.4B	Bolted joint	ASD	3	3	0	0	OK	OK
J.5	Bolted joint	LRFD	7	7	0	0	OK	OK
J.5	Bolted joint	ASD	7	7	0	0	OK	OK
II.D-3	Bolted joint	LRFD	14	14	0	0	OK	OK
II.D-3	Bolted joint	ASD	14	14	0	0	OK	OK
J.1	Welded joint	LRFD	9	9	0	0	OK	OK
J.1	Welded joint	ASD	9	9	0	0	OK	OK
J.2A	Welded joint	LRFD	5	5	0	0	OK	OK
J.2A	Welded joint	ASD	5	5	0	0	OK	OK
J.2B	Welded joint	LRFD	9	9	0	0	OK	OK
J.2B	Welded joint	ASD	9	9	0	0	OK	OK
II.D-3 weld	Welded joint	LRFD	4	4	0	0	OK	OK
II.D-3 weld	Welded joint	ASD	4	4	0	0	OK	OK
D.7	Pin-connected member / eyebar	LRFD	17	17	0	0	OK	OK
D.7	Pin-connected member / eyebar	ASD	17	17	0	0	OK	OK
D.8	Pin-connected member / eyebar	LRFD	10	10	0	0	OK	OK
D.8	Pin-connected member / eyebar	ASD	10	10	0	0	OK	OK
D.1	Tension member end connection	LRFD	11	11	0	0	OK	OK
D.1	Tension member end connection	ASD	11	11	0	0	OK	OK
D.2	Tension member end connection	LRFD	11	11	0	0	OK	OK
D.2	Tension member end connection	ASD	11	11	0	0	OK	OK
D.3	Tension member end connection	LRFD	9	9	0	0	OK	OK
D.3	Tension member end connection	ASD	9	9	0	0	OK	OK
D.4	Tension member end connection	LRFD	9	9	0	0	OK	OK
D.4	Tension member end connection	ASD	9	9	0	0	OK	OK
D.5	Tension member end connection	LRFD	10	10	0	0	OK	OK
D.5	Tension member end connection	ASD	10	10	0	0	OK	OK

Example	Connection	Method	Limit states	Pass	Deviation	Not checked	ILX	Published
D.6	Tension member end connection	LRFD	10	10	0	0	OK	OK
D.6	Tension member end connection	ASD	10	10	0	0	OK	OK
D.9	Tension member end connection	LRFD	8	8	0	0	OK	OK
D.9	Tension member end connection	ASD	8	8	0	0	OK	OK
J.7 (girder web)	Column bearing on beam	LRFD	8	8	0	0	OK	OK
J.7 (girder web)	Column bearing on beam	ASD	8	8	0	0	OK	OK
II.D-3 (V14.1)	Column bearing on beam	LRFD	3	3	0	0	NG	NG
II.D-3 (V14.1)	Column bearing on beam	ASD	3	3	0	0	NG	NG
F.14	Built-up member connectors	LRFD	6	6	0	0	OK	OK
F.14	Built-up member connectors	ASD	6	6	0	0	OK	OK
F.14-int	Built-up member connectors	LRFD	3	3	0	0	OK	OK
F.14-int	Built-up member connectors	ASD	3	3	0	0	OK	OK
E.5	Built-up member connectors	LRFD	7	7	0	0	OK	OK
E.5	Built-up member connectors	ASD	7	7	0	0	OK	OK
E.6	Built-up member connectors	LRFD	6	6	0	0	OK	OK
E.6	Built-up member connectors	ASD	6	6	0	0	OK	OK
E.13	Built-up member connectors	LRFD	8	8	0	0	OK	OK
E.13	Built-up member connectors	ASD	8	8	0	0	OK	OK
II.C-3a (V14.1)	Vertical bracing gusset (UFM)	LRFD	11	11	0	0	OK	OK
II.C-3a (V14.1)	Vertical bracing gusset (UFM)	ASD	11	11	0	0	OK	OK
II.C-3b (V14.1)	Vertical bracing gusset (UFM)	LRFD	8	8	0	0	OK	OK
II.C-3b (V14.1)	Vertical bracing gusset (UFM)	ASD	8	8	0	0	OK	OK
II.C-3c (V14.1)	Vertical bracing gusset (UFM)	LRFD	11	11	0	0	OK	OK
II.C-3c (V14.1)	Vertical bracing gusset (UFM)	ASD	11	11	0	0	OK	OK
II.C-3d (V14.1)	Vertical bracing gusset (UFM)	LRFD	7	7	0	0	OK	OK
II.C-3d (V14.1)	Vertical bracing gusset (UFM)	ASD	7	7	0	0	OK	OK

Example	Connection	Method	Limit states	Pass	Deviation	Not checked	ILX	Published
II.C-2 (V14.1)	Vertical bracing gusset (UFM)	LRFD	25	24	1	0	OK	OK
II.C-2 (V14.1)	Vertical bracing gusset (UFM)	ASD	25	24	1	0	OK	OK
DG29 5.1	Vertical bracing gusset (UFM)	LRFD	28	25	3	0	NG	OK
DG29 5.1	Vertical bracing gusset (UFM)	ASD	28	25	3	0	NG	OK
DG29 5.2	Vertical bracing gusset (UFM)	LRFD	15	15	0	0	NOT FEASIBLE	OK
DG29 5.2	Vertical bracing gusset (UFM)	ASD	15	15	0	0	NOT FEASIBLE	OK
DG29 5.3	Vertical bracing gusset (UFM)	LRFD	9	9	0	0	NG	OK
DG29 5.3	Vertical bracing gusset (UFM)	ASD	9	9	0	0	NG	OK
DG29 5.4	Vertical bracing gusset (UFM)	LRFD	26	23	3	0	OK	OK
DG29 5.4	Vertical bracing gusset (UFM)	ASD	26	23	3	0	OK	OK
DG29 5.5	Vertical bracing gusset (UFM)	LRFD	27	21	6	0	NG	OK
DG29 5.5	Vertical bracing gusset (UFM)	ASD	27	21	6	0	NG	OK
DG29 5.7	Vertical bracing gusset (UFM)	LRFD	14	13	1	0	NG	OK
DG29 5.7	Vertical bracing gusset (UFM)	ASD	14	13	1	0	NG	OK
DG29 5.8	Vertical bracing gusset (UFM)	LRFD	14	12	2	0	OK	OK
DG29 5.8	Vertical bracing gusset (UFM)	ASD	14	12	2	0	OK	OK
DG29 5.11	Vertical bracing gusset (UFM)	LRFD	31	28	3	0	NG	OK
DG29 5.11	Vertical bracing gusset (UFM)	ASD	31	28	3	0	NG	OK
DG29 6.1a	Vertical bracing gusset (UFM)	LRFD	31	27	4	0	NG	OK
DG29 6.1a	Vertical bracing gusset (UFM)	ASD	31	27	4	0	NG	OK
DG29 6.1b	Vertical bracing gusset (UFM)	LRFD	26	21	5	0	NG	OK
DG29 6.1b	Vertical bracing gusset (UFM)	ASD	26	21	5	0	NG	OK
DG2-Ex1-6ft	Beam web opening	LRFD	3	3	0	0	OK	OK
DG2-Ex1-6ft	Beam web opening	ASD	3	3	0	0	OK	OK
DG2-Ex1-12ft	Beam web opening	LRFD	19	19	0	0	OK	OK
DG2-Ex1-12ft	Beam web opening	ASD	19	19	0	0	OK	OK
DG2-Ex1-15ft	Beam web opening	LRFD	3	3	0	0	NG	NG
DG2-Ex1-15ft	Beam web opening	ASD	3	3	0	0	NG	NG
DG2-Ex2-unreinforced	Beam web opening	LRFD	14	14	0	0	NG	NG

Example	Connection	Method	Limit states	Pass	Deviation	Not checked	ILX	Published
DG2-Ex2-trial	Beam web opening	LRFD	18	18	0	0	OK	OK
DG2-Ex2-bar	Beam web opening	LRFD	13	13	0	0	OK	OK

Acceptance tolerances

Quantity	Relative	Absolute (at least)
Force (kips)	±1 %	±0.5
Moment (kip-in.)	±1 %	–
Length (in.)	±1 %	±0.005
Coef	±1 %	–
Ratio	±2 %	±0.005
Angle (deg)	–	±0.1
Stress (ksi)	±1 %	±0.05
Area (in.²)	±1 %	±0.005

II.A-6: Beam end coped at the top flange only

Source: AISC Design Examples v16.0, Example II.A-6, pp. IIA-80 to IIA-96. Connection: Coped beam, support Column flange.

> Surrogate model: The example gives the beam end only (shear connection welded to the beam web); ILX models it with a single plate welded to the beam web with a ½ in. setback (cope and beam-web checks only).

II.A-6 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
A: e = c + setback	in.	9.500	9.500	+0.00		Pass
A: Sc (Manual Table 9-2a)		17.80	17.86	+0.35		Pass
A: Zc (Manual Table 9-2b)		32.20	32.24	+0.11		Pass
A: f = 2c/d (Eq. 9-20a)		0.858	0.857	-0.12		Pass
A: k = 2.2 (ho/c)^1.65 (Eq. 9-19a)		4.040	4.036	-0.10		Pass
A: k1 = f k ≥ 1.61 (Eq. 9-14)		3.470	3.459	-0.32		Pass
A: λ = ho/tw (Eq. 9-17)		32.50	32.50	+0.00		Pass
A: λp = 0.475 √(k1 E/Fy) (Eq. 9-18)		21.30	21.30	+0.00		Pass
A: Mn (Manual Eq. 9-11)	kip-in.	1,230	1,233	+0.22		Pass
A: coped section φRn = φMn / e	kips	116.0	116.8	+0.67		Pass
A: beam web shear yielding (Agv = 5.20)	kips	156.0	156.0	+0.00		Pass
A: beam web shear rupture (welded, no holes)	kips	152.0	152.1	+0.07		Pass
B: required strength Ru / Ra	kips	135.0	134.8	-0.15		Pass
B: k1 (W21x73)		3.520	3.514	-0.17		Pass
B: λ = ho/tw (W21x73)		29.00	29.00	+0.00		Pass
B: λp (W21x73)		21.50	21.40	-0.47		Pass
B: Mn (W21x73, Zc = 37.6, Sc = 21.0)	kip-in.	1,590	1,585	-0.31		Pass
B: coped section φRn = φMn / e (W21x73)	kips	150.0	150.2	+0.11		Pass
B: beam web shear yielding (W21x73)	kips	180.0	180.2	+0.10		Pass
B: beam web shear rupture (W21x73, welded)	kips	176.0	175.7	-0.18		Pass
C: doubler dp ≤ 1.12 tp √(E/Fy)	in.	6.740	6.743	+0.05		Pass
C: Sc of the reinforced section		25.50	25.45	-0.18		Pass
C: Zc of the reinforced section		44.80	44.84	+0.09		Pass
C: Mp = Fy Zc (Manual Eq. 9-15)	kip-in.	2,240	2,242	+0.09		Pass
C: My = Fy Sc (Manual Eq. 9-16)	kip-in.	1,280	1,273	-0.57		Pass
C: Mn (Manual Eq. 9-11, unreinforced λ, λp)	kip-in.	1,740	1,731	-0.53		Pass
C: doubler-reinforced coped section φRn	kips	165.0	164.0	-0.63		Pass
C: web + doubler shear yielding	kips	205.0	204.8	-0.12		Pass
C: web + doubler shear rupture	kips	200.0	199.6	-0.18		Pass
C: force in the doubler plate	kips	51.40	52.08	+1.33		Deviation D18
D18 II.A-6 C computes the doubler force from rounded intermediate strengths, F = φFy tp dp × (116 / 165) = 51.4 kips; ILX carries the unrounded 116.8 / 164.0 kips (ratio 0.712 vs 0.703), so F is 1.4 % higher and the required weld length 1.60 vs 1.50 in. (conservative, rounding only).						
C: required longitudinal weld length (Eq. J2-6)	in.	1.500	1.601	+6.71		Deviation D18
D18 II.A-6 C computes the doubler force from rounded intermediate strengths, F = φFy tp dp × (116 / 165) = 51.4 kips; ILX carries the unrounded 116.8 / 164.0 kips (ratio 0.712 vs 0.703), so F is 1.4 % higher and the required weld length 1.60 vs 1.50 in. (conservative, rounding only).						
C: doubler length ≥ c + dc	in.	17.00	17.00	+0.00		Pass
D: yo (elastic neutral axis)	in.	4.380	4.392	+0.28		Pass
D: Zx		44.30	44.25	-0.10		Pass
D: Ix		253.0	253.2	+0.08		Pass
D: Sxc		28.60	28.58	-0.05		Pass
D: Sxt		57.70	57.65	-0.09		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
D: hc = 2(d − dc − yo)	in.	17.20	17.22	+0.09		Pass
D: hp = 2(d − dc − yp − tf)	in.	22.50	22.55	+0.24		Pass
D: stiffener λpf = 0.38 √(E/Fy) (Case 11)		9.150	9.152	+0.02		Pass
D: stiffener b/t		8.000	8.000	+0.00		Pass
D: λr = 5.70 √(E/Fy) (Case 16)		137.0	137.3	+0.20		Pass
D: web λ = hc/tw		43.00	43.04	+0.09		Pass
D: λpw (Table B4.1b Case 16)		32.90	33.00	+0.30		Pass
D: Lp = 1.1 rt √(E/Fy) (Eq. F4-7)	in.	20.90	20.87	-0.13		Pass
D: Mp = Fy Zx	kip-in.	2,220	2,213	-0.33		Pass
D: Iyc / Iy		0.044	0.044	+0.23		Pass
D: Mn = Rpc Myc (Eq. F4-1)	kip-in.	1,430	1,429	-0.05		Pass
D: longitudinal-stiffener reinforced section φRn	kips	136.0	135.4	-0.44		Pass
D: first moment Q of the stiffener		8.740	8.733	-0.08		Pass
D: weld shear flow in the cope, V Q / (2 I)		2.330	2.325	-0.23		Pass
D: weld force per length (controls), V e Q / (2 I (l − c))		2.770	2.760	-0.34		Pass
D: ¼ in. fillet strength per inch		5.570	5.568	-0.03		Pass
D: web shear rupture per weld		5.850	5.850	+0.00		Pass

ILX result: **– (surrogate)**; published: **NG**.

II.A-6 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
A: e = c + setback	in.	9.500	9.500	+0.00		Pass
A: Sc (Manual Table 9-2a)		17.80	17.86	+0.35		Pass
A: Zc (Manual Table 9-2b)		32.20	32.24	+0.11		Pass
A: f = 2c/d (Eq. 9-20a)		0.858	0.857	-0.12		Pass
A: k = 2.2 (ho/c)^1.65 (Eq. 9-19a)		4.040	4.036	-0.10		Pass
A: k1 = f k ≥ 1.61 (Eq. 9-14)		3.470	3.459	-0.32		Pass
A: λ = ho/tw (Eq. 9-17)		32.50	32.50	+0.00		Pass
A: λp = 0.475 √(k1 E/Fy) (Eq. 9-18)		21.30	21.30	+0.00		Pass
A: Mn (Manual Eq. 9-11)	kip-in.	1,230	1,233	+0.22		Pass
A: coped section φRn = φMn / e	kips	77.20	77.70	+0.64		Pass
A: beam web shear yielding (Agv = 5.20)	kips	104.0	104.0	+0.00		Pass
A: beam web shear rupture (welded, no holes)	kips	102.0	101.4	-0.59		Pass
B: required strength Ru / Ra	kips	90.00	90.00	+0.00		Pass
B: k1 (W21x73)		3.520	3.514	-0.17		Pass
B: λ = ho/tw (W21x73)		29.00	29.00	+0.00		Pass
B: λp (W21x73)		21.50	21.40	-0.47		Pass
B: Mn (W21x73, Zc = 37.6, Sc = 21.0)	kip-in.	1,590	1,585	-0.31		Pass
B: coped section φRn = φMn / e (W21x73)	kips	100.0	99.91	-0.09		Pass
B: beam web shear yielding (W21x73)	kips	120.0	120.1	+0.10		Pass
B: beam web shear rupture (W21x73, welded)	kips	117.0	117.1	+0.10		Pass
C: doubler dp ≤ 1.12 tp √(E/Fy)	in.	6.740	6.743	+0.05		Pass
C: Sc of the reinforced section		25.50	25.45	-0.18		Pass
C: Zc of the reinforced section		44.80	44.84	+0.09		Pass
C: Mp = Fy Zc (Manual Eq. 9-15)	kip-in.	2,240	2,242	+0.09		Pass
C: My = Fy Sc (Manual Eq. 9-16)	kip-in.	1,280	1,273	-0.57		Pass
C: Mn (Manual Eq. 9-11, unreinforced λ, λp)	kip-in.	1,740	1,731	-0.53		Pass
C: doubler-reinforced coped section φRn	kips	110.0	109.1	-0.83		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
C: web + doubler shear yielding	kips	137.0	136.5	-0.36		Pass
C: web + doubler shear rupture	kips	133.0	133.1	+0.07		Pass
C: force in the doubler plate	kips	34.10	34.65	+1.62		Deviation D18
D18 II.A-6 C computes the doubler force from rounded intermediate strengths, F = φFy tp dp × (116 / 165) = 51.4 kips; ILX carries the unrounded 116.8 / 164.0 kips (ratio 0.712 vs 0.703), so F is 1.4 % higher and the required weld length 1.60 vs 1.50 in. (conservative, rounding only).						
C: required longitudinal weld length (Eq. J2-6)	in.	1.470	1.586	+7.89		Deviation D18
D18 II.A-6 C computes the doubler force from rounded intermediate strengths, F = φFy tp dp × (116 / 165) = 51.4 kips; ILX carries the unrounded 116.8 / 164.0 kips (ratio 0.712 vs 0.703), so F is 1.4 % higher and the required weld length 1.60 vs 1.50 in. (conservative, rounding only).						
C: doubler length ≥ c + dc	in.	17.00	17.00	+0.00		Pass
D: yo (elastic neutral axis)	in.	4.380	4.392	+0.28		Pass
D: Zx		44.30	44.25	-0.10		Pass
D: Ix		253.0	253.2	+0.08		Pass
D: Sxc		28.60	28.58	-0.05		Pass
D: Sxt		57.70	57.65	-0.09		Pass
D: hc = 2(d − dc − yo)	in.	17.20	17.22	+0.09		Pass
D: hp = 2(d − dc − yp − tf)	in.	22.50	22.55	+0.24		Pass
D: stiffener λpf = 0.38 √(E/Fy) (Case 11)		9.150	9.152	+0.02		Pass
D: stiffener b/t		8.000	8.000	+0.00		Pass
D: λr = 5.70 √(E/Fy) (Case 16)		137.0	137.3	+0.20		Pass
D: web λ = hc/tw		43.00	43.04	+0.09		Pass
D: λpw (Table B4.1b Case 16)		32.90	33.00	+0.30		Pass
D: Lp = 1.1 rt √(E/Fy) (Eq. F4-7)	in.	20.90	20.87	-0.13		Pass
D: Mp = Fy Zx	kip-in.	2,220	2,213	-0.33		Pass
D: Iyc / Iy		0.044	0.044	+0.23		Pass
D: Mn = Rpc Myc (Eq. F4-1)	kip-in.	1,430	1,429	-0.05		Pass
D: longitudinal-stiffener reinforced section φRn	kips	90.40	90.09	-0.35		Pass
D: first moment Q of the stiffener		8.740	8.733	-0.08		Pass
D: weld shear flow in the cope, V Q / (2 I)		1.550	1.552	+0.13		Pass
D: weld force per length (controls), V e Q / (2 I (l − c))		1.850	1.843	-0.38		Pass
D: ¼ in. fillet strength per inch		3.710	3.712	+0.06		Pass
D: web shear rupture per weld		3.900	3.900	+0.00		Pass

ILX result: **– (surrogate)**; published: **NG**.

II.A-7: Beam end coped at the top and bottom flanges

Source: AISC Design Examples v16.0, Example II.A-7, pp. IIA-97 to IIA-99. Connection: Coped beam, support Column flange.

> Surrogate model: The example gives the beam end only; ILX models it with a single plate welded to the beam web with a ½ in. setback (cope checks only).

II.A-7 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
e = c + setback	in.	10.00	10.00	+0.00		Pass
Cb (Manual Eq. 9-21, Lb = ct)		1.940	1.936	-0.18		Pass
Lb hc / tw²		1,070	1,072	+0.19		Pass
My = Fy Sc (Sc = 5.60)	kip-in.	280.0	280.2	+0.08		Pass
Mp = Fy Zc (Zc = 8.41)	kip-in.	421.0	420.3	-0.16		Pass
Mn = min(F11-3, Mp) ILX caps F11-3 at Mpv = Mp [1 − (V/Vc)²] (Dowswell & Whyte 2014); the example gives no load, so the run uses V = 1 kip and Mpv = Mp within 0.02 %.	kip-in.	421.0	420.3	-0.17		Pass
Rn = Mn / e	kips	42.10	42.03	-0.17		Pass
Coped section φRn = φMn / e	kips	37.90	37.83	-0.20		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-7 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
e = c + setback	in.	10.00	10.00	+0.00		Pass
Cb (Manual Eq. 9-21, Lb = ct)		1.940	1.936	-0.18		Pass
Lb hc / tw²		1,070	1,072	+0.19		Pass
My = Fy Sc (Sc = 5.60)	kip-in.	280.0	280.2	+0.08		Pass
Mp = Fy Zc (Zc = 8.41)	kip-in.	421.0	420.3	-0.16		Pass
Mn = min(F11-3, Mp) ILX caps F11-3 at Mpv = Mp [1 − (V/Vc)²] (Dowswell & Whyte 2014); the example gives no load, so the run uses V = 1 kip and Mpv = Mp within 0.02 %.	kip-in.	421.0	420.2	-0.18		Pass
Rn = Mn / e	kips	42.10	42.02	-0.18		Pass
Coped section φRn = φMn / e	kips	25.20	25.16	-0.15		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-17A: Conventional single plate to column flange

Source: AISC Design Examples v16.0, Example II.A-17A, pp. IIA-171 to IIA-179. Connection: Single plate, conventional, support Column flange.

II.A-17A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	49.60	49.60	+0.00		Pass
Eccentricity e = a/2 (Table 10-9, n = 4, STD)	in.	1.500	1.500	+0.00		Pass
Bolt shear per bolt	kips	17.90	17.89	-0.04		Pass
Plate bearing/tearout, edge bolt (le = 1¼)	kips	12.40	12.34	-0.49		Pass
Plate bearing, non-edge bolt	kips	22.00	21.94	-0.28		Pass
Beam web bearing, non-edge bolt	kips	33.40	33.34	-0.16		Pass
C (Table 7-6, n = 4, e = 1.50)		3.540	3.556	+0.46		Pass
Shear transfer at bolt holes (ILX default, (C/n) Σ rn,i)	kips	58.50	58.70	+0.33		Pass
tmax = d/2 + 1/16	in.	0.438	0.438	-0.11		Pass
Weld w ≥ 5/8 tp	in.	0.156	0.156	+0.16		Pass
Support tmin = 3.09 D/Fu	in.	0.143	0.143	-0.15		Pass
Plate shear yielding	kips	86.40	86.25	-0.17		Pass
Plate shear rupture	kips	58.50	58.50	+0.00		Pass
Plate block shear	kips	65.30	65.51	+0.32		Pass

ILX governing check: `plate_shear_rupture_beam` (Plate shear rupture (beam-side bolt line)), ratio 0.848. ILX result: **OK**; published: **OK**.

II.A-17A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	33.00	33.00	+0.00		Pass
Eccentricity e = a/2 (Table 10-9, n = 4, STD)	in.	1.500	1.500	+0.00		Pass
Bolt shear per bolt	kips	11.90	11.93	+0.24		Pass
Plate bearing/tearout, edge bolt (le = 1¼)	kips	8.230	8.227	-0.04		Pass
Plate bearing, non-edge bolt	kips	14.60	14.62	+0.17		Pass
Beam web bearing, non-edge bolt	kips	22.20	22.23	+0.14		Pass
C (Table 7-6, n = 4, e = 1.50)		3.540	3.556	+0.46		Pass
Shear transfer at bolt holes (ILX default, (C/n) Σ rn,i)	kips	38.90	39.13	+0.59		Pass
tmax = d/2 + 1/16	in.	0.438	0.438	-0.11		Pass
Weld w ≥ 5/8 tp	in.	0.156	0.156	+0.16		Pass
Support tmin = 3.09 D/Fu	in.	0.143	0.143	-0.15		Pass
Plate shear yielding	kips	57.60	57.50	-0.17		Pass
Plate shear rupture	kips	39.00	39.00	+0.00		Pass
Plate block shear	kips	43.60	43.67	+0.16		Pass

ILX governing check: `plate_shear_rupture_beam` (Plate shear rupture (beam-side bolt line)), ratio 0.846. ILX result: **OK**; published: **OK**.

II.A-17B: Conventional single plate, axial + shear, to column flange

Source: AISC Design Examples v16.0, Example II.A-17B, pp. IIA-180 to IIA-193. Connection: Single plate, conventional, support Column flange.

II.A-17B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Resultant R	kips	96.00	96.05	+0.05		Pass
Resultant angle θ from vertical	deg	38.7	38.7	-0.10		Pass
C (e = a = 2½) AISC: Table 7-6 at 30° (conservative); ILX: IC at 38.7°.		4.070	4.060	-0.26		Pass
Bolt shear per bolt	kips	24.30	24.35	+0.22		Pass
Beam web bearing 3.0 d t Fu	kips	45.50	45.43	-0.16		Pass
Beam web tearout (lc = 1.03, worst case)	kips	26.80	60.55	+125.95		Deviation D9
D9 tearout lc: ILX ray-casts along the resultant (app/connections/single_plate.py, _clear_distance); AISC II.A-17B/19B conservatively uses the smaller edge distance less a ¼ in. underrun (method difference, AISC permits the exact lc).						
Bolt group φRn = C φrn	kips	98.90	98.86	-0.04		Pass
Weld w = 5/8 tp	in.	0.312	0.312	+0.00		Pass
Column flange shear rupture	kips	602.0	602.3	+0.04		Pass
Plate shear yielding	kips	218.0	217.5	-0.23		Pass
Plate tensile yielding	kips	327.0	326.2	-0.23		Pass
Plate flexural yielding φMn	kip-in.	1,180	1,183	+0.23		Pass
Plate yield interaction (Eq. 12-2)		0.181	0.182	+0.36		Pass
Plate shear rupture	kips	139.0	138.9	-0.04		Pass
Plate tensile rupture	kips	232.0	231.6	-0.19		Pass
Plate flexural rupture φMn (Znet = 17.2)	kip-in.	840.0	836.4	-0.43		Pass
Plate rupture interaction (Eq. 12-3)		0.500	0.502	+0.30		Pass
Plate block shear, shear direction	kips	177.0	176.7	-0.16		Pass
Plate block shear, axial L-shape	kips	242.0	241.4	-0.25		Pass
Plate block shear, axial U-shape	kips	251.0	251.2	+0.10		Pass
Plate block shear interaction (Eq. 12-1)		0.241	0.242	+0.37		Pass
Beam web shear yielding	kips	192.0	191.7	-0.16		Pass
Beam tensile yielding	kips	662.0	661.5	-0.08		Pass
Beam tensile rupture (U = 0.407)	kips	256.0	256.6	+0.22		Pass
Beam web block shear, axial U-shape (leh = 1¾ − ¼ = 1½) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	159.0	159.2	+0.14		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 0.972. ILX result: **OK**; published: **OK**.

II.A-17B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Resultant R	kips	64.00	64.03	+0.05		Pass
Resultant angle θ from vertical	deg	38.7	38.7	-0.10		Pass
C (e = a = 2½) AISC: Table 7-6 at 30° (conservative); ILX: IC at 38.7°.		4.070	4.060	-0.26		Pass
Bolt shear per bolt	kips	16.20	16.24	+0.22		Pass
Beam web bearing 3.0 d t Fu	kips	30.30	30.29	-0.05		Pass
Beam web tearout (lc = 1.03, worst case)	kips	17.90	40.37	+125.52		Deviation D9
D9 tearout lc: ILX ray-casts along the resultant (app/connections/single_plate.py, _clear_distance); AISC II.A-17B/19B conservatively uses the smaller edge distance less a ¼ in. underrun (method difference, AISC permits the exact lc).						
Bolt group φRn = C φrn	kips	65.90	65.91	+0.01		Pass
Weld w = 5/8 tp	in.	0.312	0.312	+0.00		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Column flange shear rupture	kips	402.0	401.5	-0.12		Pass
Plate shear yielding	kips	145.0	145.0	+0.00		Pass
Plate tensile yielding	kips	217.0	217.1	+0.03		Pass
Plate flexural yielding φMn	kip-in.	784.0	786.9	+0.37		Pass
Plate yield interaction (Eq. 12-2)		0.182	0.182	-0.05		Pass
Plate shear rupture	kips	92.50	92.62	+0.14		Pass
Plate tensile rupture	kips	155.0	154.4	-0.40		Pass
Plate flexural rupture φMn (Znet = 17.2)	kip-in.	560.0	557.6	-0.43		Pass
Plate rupture interaction (Eq. 12-3)		0.501	0.502	+0.10		Pass
Plate block shear, shear direction	kips	118.0	117.8	-0.16		Pass
Plate block shear, axial L-shape	kips	161.0	160.9	-0.04		Pass
Plate block shear, axial U-shape	kips	168.0	167.5	-0.30		Pass
Plate block shear interaction (Eq. 12-1)		0.241	0.242	+0.37		Pass
Beam web shear yielding	kips	128.0	127.8	-0.16		Pass
Beam tensile yielding	kips	440.0	440.1	+0.03		Pass
Beam tensile rupture (U = 0.407)	kips	171.0	171.0	+0.02		Pass
Beam web block shear, axial U-shape (leh = 1¾ − ¼ = 1½) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	106.0	106.1	+0.14		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 0.972. ILX result: **OK**; published: **OK**.

II.A-17C: Single plate, structural integrity check (II.A-17A connection)

Source: AISC Design Examples v16.0, Example II.A-17C, pp. IIA-194 to IIA-199. Connection: Single plate, conventional, support Column flange.

II.A-17C · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required shear strength (from II.A-17A)	kips	49.60	49.60	+0.00		Pass
Integrity tension T = max(2/3 Vu or Va, 10 kips)	kips	33.10	33.07	-0.10		Pass
Bolt shear Tn = n Fnv Ab	kips	95.50	95.43	-0.08		Pass
Plate bearing Tn = n 3.0 d t Fu	kips	146.0	146.2	+0.17		Pass
Plate tearout lc = leh − dh/2	in.	1.090	1.094	+0.34		Pass
Plate tearout Tn = n 1.5 lc t Fu	kips	106.0	106.6	+0.60		Pass
Plate tensile yielding	kips	144.0	143.8	-0.17		Pass
Plate tensile rupture (An = 2.00, U = 1.0)	kips	130.0	130.0	+0.00		Pass
Plate block shear, axial U-shape	kips	124.0	124.3	+0.25		Pass
Plate block shear, axial L-shape	kips	127.0	127.2	+0.12		Pass
Beam web block shear, axial (leh = 2½ − ¼ = 2¼) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	209.0	208.8	-0.11		Pass
Weld tension (1.5 directional increase)	kips	192.0	192.1	+0.06		Pass
Controlling nominal tension Tn (bolt shear)	kips	95.50	95.43	-0.08		Pass
Column brace: maximum Pu / Pa braced (150 Tn / 100 Tn, B3.9(c))	kips	14,300	14,314	+0.10		Pass

ILX governing check: `plate_shear_rupture_beam` (Plate shear rupture (beam-side bolt line)), ratio 0.848. ILX result: **OK**; published: **OK**.

II.A-17C · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required shear strength (from II.A-17A)	kips	33.00	33.00	+0.00		Pass
Integrity tension T = max(2/3 Vu or Va, 10 kips)	kips	33.00	33.00	+0.00		Pass
Bolt shear Tn = n Fnv Ab	kips	95.50	95.43	-0.08		Pass
Plate bearing Tn = n 3.0 d t Fu	kips	146.0	146.2	+0.17		Pass
Plate tearout lc = leh − dh/2	in.	1.090	1.094	+0.34		Pass
Plate tearout Tn = n 1.5 lc t Fu	kips	106.0	106.6	+0.60		Pass
Plate tensile yielding	kips	144.0	143.8	-0.17		Pass
Plate tensile rupture (An = 2.00, U = 1.0)	kips	130.0	130.0	+0.00		Pass
Plate block shear, axial U-shape	kips	124.0	124.3	+0.25		Pass
Plate block shear, axial L-shape	kips	127.0	127.2	+0.12		Pass
Beam web block shear, axial (leh = 2½ − ¼ = 2¼) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	209.0	208.8	-0.11		Pass
Weld tension (1.5 directional increase)	kips	192.0	192.1	+0.06		Pass
Controlling nominal tension Tn (bolt shear)	kips	95.50	95.43	-0.08		Pass
Column brace: maximum Pu / Pa braced (150 Tn / 100 Tn, B3.9(c))	kips	9,550	9,543	-0.07		Pass

ILX governing check: `plate_shear_rupture_beam` (Plate shear rupture (beam-side bolt line)), ratio 0.846. ILX result: **OK**; published: **OK**.

II.A-18: Single plate to girder web, top-coped beam

Source: AISC Design Examples v16.0, Example II.A-18, pp. IIA-200 to IIA-204. Connection: Single plate, conventional, support Girder web.

II.A-18 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	39.80	39.80	+0.00		Pass
Bolt shear per bolt	kips	17.90	17.89	-0.04		Pass
Plate edge bolt (lev = 1¼)	kips	12.40	12.34	-0.49		Pass
Plate non-edge bolt	kips	22.00	21.94	-0.28		Pass
Beam web edge bolt (lev = 1½ below cope)	kips	19.20	19.20	-0.02		Pass
Beam web non-edge bolt	kips	26.30	26.32	+0.10		Pass
C (C/n = 0.885)		3.540	3.556	+0.46		Pass
Shear transfer at bolt holes (ILX default, (C/n) Σ rn,i)	kips	58.50	58.70	+0.33		Pass
Beam web block shear, Table 10-10c (leh = 2¼ stated)	kips	88.20	91.77	+4.05		Deviation D14
D14 AISC Table 10-10c beam-web block shear: the tabulated bottom-edge value (76.2 kips/in.) back-calculates to leh = 2.0 in. although the text says leh = 2¼ in. (the table carries a further ¼ in. length tolerance). ILX at leh = 2.0 reproduces 88.2 kips (see the following row).						
Beam web block shear, Table 10-10c (effective leh = 2.0)	kips	88.20	88.12	-0.10		Pass
Girder web tmin = 3.09 D/Fu	in.	0.143	0.143	-0.15		Pass

ILX governing check: `plate_shear_rupture_beam` (Plate shear rupture (beam-side bolt line)), ratio 0.680. ILX result: **OK**; published: **OK**.

II.A-18 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	26.50	26.50	+0.00		Pass
Bolt shear per bolt	kips	11.90	11.93	+0.24		Pass
Plate edge bolt (lev = 1¼)	kips	8.230	8.227	-0.04		Pass
Plate non-edge bolt	kips	14.60	14.62	+0.17		Pass
Beam web edge bolt (lev = 1½ below cope)	kips	12.80	12.80	-0.02		Pass
Beam web non-edge bolt	kips	17.60	17.55	-0.28		Pass
C (C/n = 0.885)		3.540	3.556	+0.46		Pass
Shear transfer at bolt holes (ILX default, (C/n) Σ rn,i)	kips	38.90	39.13	+0.59		Pass
Beam web block shear, Table 10-10c (leh = 2¼ stated)	kips	58.70	61.18	+4.23		Deviation D14
D14 AISC Table 10-10c beam-web block shear: the tabulated bottom-edge value (76.2 kips/in.) back-calculates to leh = 2.0 in. although the text says leh = 2¼ in. (the table carries a further ¼ in. length tolerance). ILX at leh = 2.0 reproduces 88.2 kips (see the following row).						
Beam web block shear, Table 10-10c (effective leh = 2.0)	kips	58.70	58.74	+0.07		Pass
Girder web tmin = 3.09 D/Fu	in.	0.143	0.143	-0.15		Pass

ILX governing check: `plate_shear_rupture_beam` (Plate shear rupture (beam-side bolt line)), ratio 0.679. ILX result: **OK**; published: **OK**.

SDS2 II.A-18: SDS2 v2025.01 verification of AISC II.A-18 (SDS2 column)

Source: SDS2 Engineering, AISC 16th Ed. Verification Problem II.A-18 (techsupport.sds2.com) and its LRFD/ASD reports. Connection: Single plate, conventional, support Girder web.

SDS2 II.A-18 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Plate shear rupture	kips	58.50	58.50	+0.00		Pass
Plate block shear rupture	kips	65.40	65.51	+0.16		Pass
Bolt shear per bolt	kips	17.90	17.89	-0.04		Pass
C (SDS2 IC)		3.560	3.556	-0.10		Pass
Tearout, plate edge bolt	kips	12.30	12.34	+0.32		Pass
Bearing, plate non-edge bolt	kips	21.90	21.94	+0.17		Pass
Tearout, web edge bolt	kips	19.20	19.20	-0.02		Pass
Bearing, web non-edge bolt	kips	26.30	26.32	+0.10		Pass
Bolt group shear C × φrnv	kips	63.70	63.63	-0.11		Pass
Shear transfer at bolts (SDS2: C rnv, concentric bearing = ILX 'split')	kips	63.70	63.63	-0.11		Pass
Block shear, beam web (leh = 2.5)	kips	95.40	95.43	+0.03		Pass
Flexure of coped beam, as shear φMn/e	kips	254.3	253.6	-0.27		Pass
Shear of support (girder web at weld)	kips	269.1	269.1	+0.00		Pass
Shear yield, plate	kips	86.30	86.25	-0.06		Pass
Flexure, plate (as shear φMn/e, e = a/2)	kips	249.0	248.0	-0.41		Pass
Shear rupture, beam web (coped)	kips	107.1	107.1	-0.04		Pass
Shear yield, beam web (coped)	kips	141.3	141.3	+0.00		Pass

ILX governing check: `plate_shear_rupture_beam` (Plate shear rupture (beam-side bolt line)), ratio 0.680. ILX result: **OK**; published: **OK**.

SDS2 II.A-18 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Plate shear rupture	kips	39.00	39.00	+0.00		Pass
Plate block shear rupture	kips	43.60	43.67	+0.16		Pass
Bolt shear per bolt	kips	11.90	11.93	+0.24		Pass
C (SDS2 IC)		3.560	3.556	-0.10		Pass
Tearout, plate edge bolt	kips	8.230	8.227	-0.04		Pass
Bearing, plate non-edge bolt	kips	14.60	14.62	+0.17		Pass
Tearout, web edge bolt	kips	12.80	12.80	-0.02		Pass
Bearing, web non-edge bolt	kips	17.60	17.55	-0.28		Pass
Bolt group shear C × φrnv	kips	42.50	42.42	-0.19		Pass
Shear transfer at bolts (SDS2: C rnv, concentric bearing = ILX 'split')	kips	42.50	42.42	-0.19		Pass
Block shear, beam web (leh = 2.5)	kips	63.60	63.62	+0.03		Pass
Flexure of coped beam, as shear φMn/e	kips	169.2	168.7	-0.28		Pass
Shear of support (girder web at weld)	kips	179.4	179.4	+0.00		Pass
Shear yield, plate	kips	57.50	57.50	+0.00		Pass
Flexure, plate (as shear φMn/e, e = a/2)	kips	165.7	165.0	-0.43		Pass
Shear rupture, beam web (coped)	kips	71.40	71.37	-0.04		Pass
Shear yield, beam web (coped)	kips	94.20	94.20	+0.00		Pass

ILX governing check: `plate_shear_rupture_beam` (Plate shear rupture (beam-side bolt line)), ratio 0.679. ILX result: **OK**; published: **OK**.

II.A-19A: Extended single plate to column web

Source: AISC Design Examples v16.0, Example II.A-19A, pp. IIA-205 to IIA-212. Connection: Single plate, extended, support Column web.

II.A-19A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Eccentricity e = a + s/2	in.	10.50	10.50	+0.00		Pass
C (Table 7-7, 2 × 4)		2.330	2.318	-0.53		Pass
Bolt shear per bolt	kips	17.90	17.89	-0.04		Pass
Beam web bearing per bolt	kips	25.90	25.89	-0.05		Pass
Bolt group φRn = C φrn	kips	41.70	41.47	-0.56		Pass
C' (Table 7-7, moment only)		26.00	26.03	+0.12		Pass
Mmax = (Fnv/0.90) Ab C'	kip-in.	690.0	690.0	+0.00		Pass
tmax = 6 Mmax / (Fy l²)	in.	0.575	0.575	+0.00		Pass
Plate bearing per bolt	kips	43.90	43.88	-0.06		Pass
Plate tearout, bottom edge bolt (lc = 1.09)	kips	31.90	31.99	+0.29		Pass
Plate shear yielding	kips	180.0	180.0	+0.00		Pass
Plate shear rupture	kips	125.0	124.3	-0.55		Pass
Plate block shear (Ubs = 0.5)	kips	145.0	144.6	-0.29		Pass
Mr = Vr a	kip-in.	324.0	324.0	+0.00		Pass
Plate flexural yielding φMn	kip-in.	810.0	810.0	+0.00		Pass
Interaction (Eq. 10-8)		0.200	0.200	+0.00		Pass
Plate flexural rupture φMn (Znet = 12.8)	kip-in.	624.0	621.6	-0.39		Pass
Column web tmin = 3.09 D/Fu	in.	0.238	0.238	-0.01		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 0.868. ILX result: **OK**; published: **OK**.

II.A-19A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Eccentricity e = a + s/2	in.	10.50	10.50	+0.00		Pass
C (Table 7-7, 2 × 4)		2.330	2.318	-0.53		Pass
Bolt shear per bolt	kips	11.90	11.93	+0.24		Pass
Beam web bearing per bolt	kips	17.30	17.26	-0.25		Pass
Bolt group φRn = C φrn	kips	27.70	27.64	-0.20		Pass
C' (Table 7-7, moment only)		26.00	26.03	+0.12		Pass
Mmax = (Fnv/0.90) Ab C'	kip-in.	690.0	690.0	+0.00		Pass
tmax = 6 Mmax / (Fy l²)	in.	0.575	0.575	+0.00		Pass
Plate bearing per bolt	kips	29.30	29.25	-0.17		Pass
Plate tearout, bottom edge bolt (lc = 1.09)	kips	21.30	21.33	+0.13		Pass
Plate shear yielding	kips	120.0	120.0	+0.00		Pass
Plate shear rupture	kips	83.00	82.88	-0.15		Pass
Plate block shear (Ubs = 0.5)	kips	96.50	96.38	-0.12		Pass
Mr = Vr a	kip-in.	216.0	216.0	+0.00		Pass
Plate flexural yielding φMn	kip-in.	539.0	538.9	-0.01		Pass
Interaction (Eq. 10-8)		0.201	0.201	-0.18		Pass
Plate flexural rupture φMn (Znet = 12.8)	kip-in.	416.0	414.4	-0.39		Pass
Column web tmin = 3.09 D/Fu	in.	0.238	0.238	-0.01		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 0.868. ILX result: **OK**; published: **OK**.

II.A-19B: Extended single plate, axial + shear, to column web

Source: AISC Design Examples v16.0, Example II.A-19B, pp. IIA-213 to IIA-229. Connection: Single plate, extended, support Column web.

II.A-19B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Resultant R	kips	96.00	96.05	+0.05		Pass
Resultant angle θ	deg	38.7	38.7	-0.10		Pass
C' (Table 7-7, 2 × 5)		38.70	38.67	-0.08		Pass
Mmax	kip-in.	1,820	1,822	+0.12		Pass
tmax	in.	0.971	0.972	+0.09		Pass
ex = a + s/2	in.	11.30	11.25	-0.44		Pass
C (Table 7-7 at 30°)		3.530	3.767	+6.71		Deviation D10
D10 AISC interpolates Manual Table 7-6/7-7 at 30° (conservative, as AISC notes); ILX solves the IC at the true resultant angle 38.7° (method difference).						
Bolt shear per bolt	kips	31.80	31.81	+0.03		Pass
Beam web bearing per bolt	kips	60.70	60.69	-0.01		Pass
Beam web tearout (lc = 1.19, worst case)	kips	36.20	80.09	+121.24		Deviation D9
D9 tearout lc: ILX ray-casts along the resultant (app/connections/single_plate.py, _clear_distance); AISC II.A-17B/19B conservatively uses the smaller edge distance less a ¼ in. underrun (method difference, AISC permits the exact lc).						
Plate bearing per bolt	kips	110.0	109.7	-0.28		Pass
Plate tearout (lc = 0.938, worst case)	kips	51.50	74.50	+44.66		Deviation D9
D9 tearout lc: ILX ray-casts along the resultant (app/connections/single_plate.py, _clear_distance); AISC II.A-17B/19B conservatively uses the smaller edge distance less a ¼ in. underrun (method difference, AISC permits the exact lc).						
Bolt group φRn = C φrn	kips	112.0	119.8	+6.98		Deviation D10
D10 AISC interpolates Manual Table 7-6/7-7 at 30° (conservative, as AISC notes); ILX solves the IC at the true resultant angle 38.7° (method difference).						
Beam tensile yielding	kips	792.0	792.0	+0.00		Pass
Beam tensile rupture (U = 0.610)	kips	449.0	450.0	+0.22		Pass
Beam web block shear (leh = 2 − ¼ = 1¾) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	219.0	218.8	-0.11		Pass
Mr = Vr a	kip-in.	731.0	731.2	+0.03		Pass
Plate flexural yielding φMn	kip-in.	1,900	1,898	-0.08		Pass
Plate shear yielding	kips	339.0	337.5	-0.44		Pass
Plate tensile yielding	kips	509.0	506.2	-0.54		Pass
Plate yield interaction (Eq. 12-2)		0.246	0.247	+0.37		Pass
Plate tensile rupture	kips	332.0	331.3	-0.20		Pass
Plate flexural rupture φMn (Znet = 25.9)	kip-in.	1,260	1,262	+0.18		Pass
Plate shear rupture	kips	199.0	198.8	-0.10		Pass
Plate rupture interaction (Eq. 12-2)		0.592	0.591	-0.16		Pass
Plate block shear, shear direction	kips	237.0	237.8	+0.33		Pass
Plate block shear, axial L-shape	kips	369.0	368.8	-0.05		Pass
Plate block shear, axial U-shape	kips	407.0	406.3	-0.17		Pass
Plate block shear interaction		0.127	0.126	-0.82		Pass
Column web shear rupture at weld	kips	386.0	386.1	+0.03		Pass
Column web yield line, w = d − 2kdes	in.	11.40	11.38	-0.18		Pass
Column web yield line (Manual Eq. 9-45)	kips	42.40	42.33	-0.18		Pass
Plate compression (K = 1.2, Lc/r = 54.0)	kips	410.0	408.9	-0.26		Pass

ILX governing check: `web_yield_line` (Support web yield-line strength (column web)), ratio 1.418. ILX result: **NG**; published: **NG**.

II.A-19B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Resultant R	kips	64.00	64.03	+0.05		Pass
Resultant angle θ	deg	38.7	38.7	-0.10		Pass
C' (Table 7-7, 2 × 5)		38.70	38.67	-0.08		Pass
Mmax	kip-in.	1,820	1,822	+0.12		Pass
tmax	in.	0.971	0.972	+0.09		Pass
ex = a + s/2	in.	11.30	11.25	-0.44		Pass
C (Table 7-7 at 30°)		3.530	3.767	+6.71		Deviation D10
D10 AISC interpolates Manual Table 7-6/7-7 at 30° (conservative, as AISC notes); ILX solves the IC at the true resultant angle 38.7° (method difference).						
Bolt shear per bolt	kips	21.20	21.21	+0.03		Pass
Beam web bearing per bolt	kips	40.50	40.46	-0.09		Pass
Beam web tearout (lc = 1.19, worst case)	kips	24.10	53.39	+121.54		Deviation D9
D9 tearout lc: ILX ray-casts along the resultant (app/connections/single_plate.py, _clear_distance); AISC II.A-17B/19B conservatively uses the smaller edge distance less a ¼ in. underrun (method difference, AISC permits the exact lc).						
Plate bearing per bolt	kips	73.00	73.12	+0.17		Pass
Plate tearout (lc = 0.938, worst case)	kips	34.30	49.67	+44.80		Deviation D9
D9 tearout lc: ILX ray-casts along the resultant (app/connections/single_plate.py, _clear_distance); AISC II.A-17B/19B conservatively uses the smaller edge distance less a ¼ in. underrun (method difference, AISC permits the exact lc).						
Bolt group φRn = C φrn	kips	74.80	79.88	+6.79		Deviation D10
D10 AISC interpolates Manual Table 7-6/7-7 at 30° (conservative, as AISC notes); ILX solves the IC at the true resultant angle 38.7° (method difference).						
Beam tensile yielding	kips	527.0	526.9	-0.01		Pass
Beam tensile rupture (U = 0.610)	kips	300.0	300.0	-0.00		Pass
Beam web block shear (leh = 2 − ¼ = 1¾) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	146.0	145.8	-0.11		Pass
Mr = Vr a	kip-in.	488.0	487.5	-0.10		Pass
Plate flexural yielding φMn	kip-in.	1,260	1,263	+0.25		Pass
Plate shear yielding	kips	226.0	225.0	-0.44		Pass
Plate tensile yielding	kips	338.0	336.8	-0.35		Pass
Plate yield interaction (Eq. 12-2)		0.248	0.248	-0.12		Pass
Plate tensile rupture	kips	221.0	220.9	-0.05		Pass
Plate flexural rupture φMn (Znet = 25.9)	kip-in.	840.0	841.5	+0.18		Pass
Plate shear rupture	kips	133.0	132.5	-0.35		Pass
Plate rupture interaction (Eq. 12-2)		0.592	0.591	-0.16		Pass
Plate block shear, shear direction	kips	158.0	158.5	+0.33		Pass
Plate block shear, axial L-shape	kips	246.0	245.9	-0.05		Pass
Plate block shear, axial U-shape	kips	271.0	270.9	-0.05		Pass
Plate block shear interaction		0.127	0.126	-0.82		Pass
Column web shear rupture at weld	kips	258.0	257.4	-0.23		Pass
Column web yield line, w = d − 2kdes	in.	11.40	11.38	-0.18		Pass
Column web yield line (Manual Eq. 9-45)	kips	28.30	28.22	-0.29		Pass
Plate compression (K = 1.2, Lc/r = 54.0)	kips	272.0	272.1	+0.02		Pass

ILX governing check: `web_yield_line` (Support web yield-line strength (column web)), ratio 1.418. ILX result: **NG**; published: **NG**.

M&T 2011: Muir & Thornton (2011) conventional single plate design example

Source: Muir, L.S. and Thornton, W.A. (2011), Engineering Journal 48(2), Design Example, pp. 149-150. Connection: Single plate, conventional, support Column flange.

M&T 2011 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
tmax = d/2 − 1/16 (n = 6, STD)	in.	0.375	0.375	+0.00		Pass
Leh ≥ 2d	in.	1.750	1.750	+0.00		Pass
Bolt shear φrv	kips	24.40	24.35	-0.19		Pass
Plate bearing 2.4 d t Fu	kips	38.40	38.39	-0.02		Pass
Plate tearout (Lc = 1.03)	kips	22.60	22.62	+0.10		Pass
Eccentricity e = a (n = 6, STD)	in.	3.000	3.000	+0.00		Pass
C (Table 7-6)		4.980	4.984	+0.08		Pass
Bolt group C × min(φrv, φrbrg)	kips	113.0	112.8	-0.22		Pass
Plate shear yielding	kips	203.0	202.5	-0.25		Pass
Plate shear rupture	kips	132.0	131.6	-0.28		Pass
Plate flexure φFy Zg / e	kips	456.0	455.6	-0.08		Pass
Weld w = 5/8 tp	in.	0.234	0.234	+0.16		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 0.887. ILX result: **OK**; published: **OK**.

M&H 2009: Muir & Hewitt (2009) extended single plate design example

Source: Muir, L.S. and Hewitt, C.M. (2009), Engineering Journal 46(2), Design Example, pp. 77-78. Connection: Single plate, extended, support Column flange.

M&H 2009 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Bolt shear φrv (A490-N)	kips	35.30	40.06	+13.47		Deviation D13
D13 code edition: Muir & Hewitt (2009) used 360-05 A490-N Fnv = 60 ksi (φrv = 35.3 kips); 360-22 Group 150-N Fnv = 68 ksi (φrv = 40.1 kips). ILX is correct for 360-22.						
C (3 × 4, g = 4, e = 13.5)		3.440	3.436	-0.11		Pass
Beam web bearing per bolt	kips	29.30	29.25	-0.17		Pass
Bolt group C × φrbrg (3.44 × 29.3)	kips	100.8	94.22	-6.52		Deviation D15
D15 Muir & Hewitt (2009) took 2.4 d t Fu for every bolt; per 360-22 J3.11a the tearout between holes, 1.2 lc t Fu with lc = s − dh = 1.875 in. (36.6 < 39.0 kips nominal), governs. ILX is correct.						
C' (pure moment)		50.70	50.67	-0.05		Pass
Mmax = C' Rn 1.2 % band: 360-05 1.25 Fv vs. 360-22 Fnv/0.90 (D13).	kip-in.	2,980	3,007	+0.91		Pass
tmax Same edition note (D13).	in.	2.480	2.506	+1.04		Pass
Shear + bending (von Mises) φRn	kips	154.0	154.1	+0.07		Pass
Plate net shear rupture	kips	219.0	212.1	-3.17		Deviation D16
D16 Muir & Hewitt (2009) net areas use dh = 1⅛ in.; 360-22 B4.3b adds 1/16 in. (dh + 1/16 = 1 3/16 in.). ILX is correct.						
Plate block shear (Ubs = 0.5)	kips	355.0	344.8	-2.89		Deviation D16
D16 Muir & Hewitt (2009) net areas use dh = 1⅛ in.; 360-22 B4.3b adds 1/16 in. (dh + 1/16 = 1 3/16 in.). ILX is correct.						
Plate buckling λ		0.279	0.279	+0.17		Pass
Weld w = 0.625 tp	in.	0.625	0.625	+0.00		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 1.061. ILX result: **NG**; published: **OK**.
ILX reports NG where the paper finds OK: D15 (bolt group 94.2 < 100 kips) and the 15th/16th Ed. flexural-rupture interaction the 2009 paper does not check (ratio 1.025).

Dowswell 2018: Dowswell (2018) single-coped beam design example

Source: Dowswell, B. (2018), Engineering Journal 55(4), Design Example, pp. 238-239. Connection: Coped beam, support Column flange.

> Surrogate model: The paper's beam is on clip angles; ILX models the cope with a single plate (cope checks only).

Dowswell 2018 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Snet		18.20	18.20	+0.01		Pass
Znet		32.10	32.10	-0.01		Pass
f = 2c/d		0.847	0.847	+0.00		Pass
k = 2.2 (ho/c)^1.65		7.440	7.444	+0.05		Pass
k1 = f k		6.300	6.308	+0.13		Pass
λ = ho/tw		52.30	52.30	+0.00		Pass
λp = 0.475 √(k1 E/Fy)		28.70	28.70	+0.00		Pass
Mn (Manual Eq. 9-11)	kip-in.	1,030	1,034	+0.40		Pass
e (support face to cope end)	in.	8.000	8.000	+0.00		Pass
φRn = φMn / e	kips	116.0	116.3	+0.30		Pass

ILX result: **– (surrogate)**; published: **OK**.

K.6: Single plate to a rectangular HSS column

Source: AISC Design Examples v16.0, Example K.6, pp. K-28 to K-32. Connection: Single plate, conventional, support HSS wall.

K.6 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	39.00	39.00	+0.00		Pass
HSS wall b/t (not slender)		14.20	14.20	+0.00		Pass
Limit 1.40√(E/Fy)		33.70	33.72	+0.05		Pass
Punching shear demand Ru e (Manual Eq. 10-10)	kip-in.	117.0	117.0	+0.00		Pass
Punching shear strength φ Fu t lp² / 5	kip-in.	235.0	234.5	-0.21		Pass
tmax = d/2 + 1/16 (Table 10-9)	in.	0.438	0.438	-0.11		Pass
Table 10-10a: plate shear rupture (governs weld and plate)	kips	53.70	53.70	+0.00		Pass
Bolt shear per bolt	kips	17.90	17.89	-0.04		Pass
Plate bearing/tearout, edge bolt (lev = 1¼)	kips	15.40	15.42	+0.16		Pass
Plate bearing, non-edge bolt	kips	27.40	27.42	+0.08		Pass
Beam web bearing, non-edge bolt	kips	26.30	26.32	+0.10		Pass
C = n × (C/n) = 3 × 0.823 (Table 10-10b)		2.469	2.481	+0.49		Pass
Shear transfer at bolt holes (C/n) Σ rn,i	kips	42.10	42.35	+0.60		Pass
HSS tmin = 3.09 D/Fu (Manual Eq. 9-6)	in.	0.199	0.200	+0.29		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 0.921. ILX result: **OK**; published: **OK**.

K.6 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	26.00	26.00	+0.00		Pass
HSS wall b/t (not slender)		14.20	14.20	+0.00		Pass
Limit 1.40√(E/Fy)		33.70	33.72	+0.05		Pass
Punching shear demand Ru e (Manual Eq. 10-10)	kip-in.	78.00	78.00	+0.00		Pass
Punching shear strength φ Fu t lp² / 5	kip-in.	156.0	156.3	+0.21		Pass
tmax = d/2 + 1/16 (Table 10-9)	in.	0.438	0.438	-0.11		Pass
Table 10-10a: plate shear rupture (governs weld and plate)	kips	35.80	35.80	+0.00		Pass
Bolt shear per bolt	kips	11.90	11.93	+0.24		Pass
Plate bearing/tearout, edge bolt (lev = 1¼)	kips	10.30	10.28	-0.16		Pass
Plate bearing, non-edge bolt	kips	18.30	18.28	-0.10		Pass
Beam web bearing, non-edge bolt	kips	17.60	17.55	-0.28		Pass
C = n × (C/n) = 3 × 0.823 (Table 10-10b)		2.469	2.481	+0.49		Pass
Shear transfer at bolt holes (C/n) Σ rn,i	kips	28.10	28.24	+0.48		Pass
HSS tmin = 3.09 D/Fu (Manual Eq. 9-6)	in.	0.199	0.200	+0.29		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 0.921. ILX result: **OK**; published: **OK**.

K.7: Through plate to a rectangular HSS column

Source: AISC Design Examples v16.0, Example K.7, pp. K-33 to K-38. Connection: Through plate (HSS), support HSS wall.

K.7 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	19.80	19.80	+0.00		Pass
HSS wall h/t (slender: through plate)		48.70	48.70	+0.00		Pass
Limit 1.40√(E/Fy)		33.70	33.72	+0.05		Pass
Plate length ≥ T/2	in.	7.750	7.750	+0.00		Pass
tmax = d/2 + 1/16 (Table 10-9)	in.	0.438	0.438	-0.11		Pass
Table 10-10a: plate shear rupture (governs weld and plate)	kips	43.00	42.96	-0.09		Pass
Bolt shear per bolt	kips	17.90	17.89	-0.04		Pass
Plate bearing/tearout, edge bolt (lev = 1¼)	kips	12.40	12.34	-0.49		Pass
Plate bearing, non-edge bolt	kips	22.00	21.94	-0.28		Pass
Beam web bearing, non-edge bolt	kips	26.30	26.32	+0.10		Pass
C = n × (C/n) = 3 × 0.823 (Table 10-10b)		2.469	2.481	+0.49		Pass
Shear transfer at bolt holes (C/n) Σ rn,i	kips	39.70	39.80	+0.26		Pass
Near-wall weld reaction Vf = R (B + a) / B	kips	34.70	34.65	-0.14		Pass
Required weld size D (sixteenths)		1.470	1.464	-0.40		Pass
HSS Agv = 2 l t (in.²)		1.970	1.972	+0.10		Pass
HSS shear yielding Rn = 0.60 Fy Agv (nominal)	kips	59.10	59.16	+0.10		Pass
HSS shear yielding, available	kips	59.10	59.16	+0.10		Pass
HSS shear rupture Rn = 0.60 Fu Anv (nominal)	kips	73.30	73.36	+0.08		Pass
HSS shear rupture, available	kips	55.00	55.02	+0.03		Pass

ILX governing check: `hss_tp_shear_rupture` (HSS wall shear rupture at the through-plate welds), ratio 0.630. ILX result: **OK**; published: **OK**.

K.7 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	13.20	13.20	+0.00		Pass
HSS wall h/t (slender: through plate)		48.70	48.70	+0.00		Pass
Limit 1.40√(E/Fy)		33.70	33.72	+0.05		Pass
Plate length ≥ T/2	in.	7.750	7.750	+0.00		Pass
tmax = d/2 + 1/16 (Table 10-9)	in.	0.438	0.438	-0.11		Pass
Table 10-10a: plate shear rupture (governs weld and plate)	kips	28.60	28.64	+0.14		Pass
Bolt shear per bolt	kips	11.90	11.93	+0.24		Pass
Plate bearing/tearout, edge bolt (lev = 1¼)	kips	8.230	8.227	-0.04		Pass
Plate bearing, non-edge bolt	kips	14.60	14.62	+0.17		Pass
Beam web bearing, non-edge bolt	kips	17.60	17.55	-0.28		Pass
C = n × (C/n) = 3 × 0.823 (Table 10-10b)		2.469	2.481	+0.49		Pass
Shear transfer at bolt holes (C/n) Σ rn,i	kips	26.40	26.53	+0.51		Pass
Near-wall weld reaction Vf = R (B + a) / B	kips	23.10	23.10	-0.00		Pass
Required weld size D (sixteenths)		1.460	1.464	+0.28		Pass
HSS Agv = 2 l t (in.²)		1.970	1.972	+0.10		Pass
HSS shear yielding Rn = 0.60 Fy Agv (nominal)	kips	59.10	59.16	+0.10		Pass
HSS shear yielding, available	kips	39.40	39.44	+0.10		Pass
HSS shear rupture Rn = 0.60 Fu Anv (nominal)	kips	73.30	73.36	+0.08		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
HSS shear rupture, available	kips	36.70	36.68	-0.06		Pass

ILX governing check: `hss_tp_shear_rupture` (HSS wall shear rupture at the through-plate welds), ratio 0.630. ILX result: **OK**; published: **OK**.

K.8: Longitudinal plate on a round HSS, load perpendicular to the HSS axis

Source: AISC Design Examples v16.0, Example K.8, pp. K-39 to K-41. Connection: Single plate, conventional, support HSS wall.

K.8 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa	kips	24.00	24.00	+0.00		Pass
HSS D/t		17.20	17.20	+0.00		Pass
D/t limit for T-connections (Table K2.1A)		50.00	50.00	+0.00		Pass
Fy ≤ 52 ksi (Table K2.1A)		50.00	50.00	+0.00		Pass
β = Bb / D		0.042	0.042	-0.08		Pass
Minimum end distance lend = D (1.25 − β/2) (Eq. K1-8)	in.	7.370	7.375	+0.07		Pass
HSS plastification Rn = 5.5 Fy t² (1 + 0.25 lb/D) Qf (Eq. K2-2a)	kips	39.10	39.08	-0.06		Pass
HSS plastification, available	kips	35.20	35.17	-0.09		Pass

ILX governing check: `hss_plast` (Round HSS wall plastification (longitudinal plate)), ratio 0.682. ILX result: **OK**; published: **OK**.

K.8 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa	kips	16.00	16.00	+0.00		Pass
HSS D/t		17.20	17.20	+0.00		Pass
D/t limit for T-connections (Table K2.1A)		50.00	50.00	+0.00		Pass
Fy ≤ 52 ksi (Table K2.1A)		50.00	50.00	+0.00		Pass
β = Bb / D		0.042	0.042	-0.08		Pass
Minimum end distance lend = D (1.25 − β/2) (Eq. K1-8)	in.	7.370	7.375	+0.07		Pass
HSS plastification Rn = 5.5 Fy t² (1 + 0.25 lb/D) Qf (Eq. K2-2a)	kips	39.10	39.08	-0.06		Pass
HSS plastification, available	kips	23.40	23.40	-0.00		Pass

ILX governing check: `hss_plast` (Round HSS wall plastification (longitudinal plate)), ratio 0.684. ILX result: **OK**; published: **OK**.

II.A-28A: All-bolted single angle to girder web

Source: AISC Design Examples v16.0, Example II.A-28A, pp. IIA-266 to IIA-275. Connection: Single angle, support Girder web.

II.A-28A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Support-leg eccentricity e = g + tw/2	in.	1.900	1.900	+0.00		Pass
C, support leg (Table 10-11 Case I)		3.070	3.369	+9.74		Deviation D11
D11 single angle: AISC uses Table 10-11 C = 3.07 (tabulated at e = 2½ in.) for the support leg and neglects eccentricity on the 4-in. beam leg (Manual Fig. 10-15); ILX solves e = g + tw/2 = 1.90 in. on the support leg and applies e = a on the beam leg (method difference).						
C at e = 2½ in. (the Table 10-11 tabulated eccentricity)		3.070	3.065	-0.15		Pass
Bolt shear per bolt	kips	17.90	17.89	-0.04		Pass
Angle edge bolt (le = 1¼)	kips	18.50	18.51	+0.05		Pass
Angle interior bolt	kips	32.90	32.91	+0.02		Pass
Angle bolt group (support leg)	kips	55.00	60.28	+9.60		Deviation D11
D11 single angle: AISC uses Table 10-11 C = 3.07 (tabulated at e = 2½ in.) for the support leg and neglects eccentricity on the 4-in. beam leg (Manual Fig. 10-15); ILX solves e = g + tw/2 = 1.90 in. on the support leg and applies e = a on the beam leg (method difference).						
Beam web edge bolt	kips	14.80	19.20	+29.70		Deviation D12
D12 AISC conservatively uses le = 1¼ in. for the beam-web top bolt; the actual lev is 1½ in.						
Beam web interior bolt	kips	26.30	26.32	+0.10		Pass
Beam web bolt group (concentric)	kips	68.50	54.85	-19.93		Deviation D11
D11 single angle: AISC uses Table 10-11 C = 3.07 (tabulated at e = 2½ in.) for the support leg and neglects eccentricity on the 4-in. beam leg (Manual Fig. 10-15); ILX solves e = g + tw/2 = 1.90 in. on the support leg and applies e = a on the beam leg (method difference).						
Girder web bearing	kips	35.10	35.10	-0.00		Pass
Angle shear yielding	kips	129.0	129.4	+0.29		Pass
Angle shear rupture	kips	87.80	87.75	-0.06		Pass
Angle block shear, 3-in. leg	kips	93.60	93.69	+0.10		Pass
Angle flexural yielding φMn	kip-in.	558.0	557.9	-0.01		Pass
Angle flexural rupture φMn (Znet = 8.46)	kip-in.	413.0	412.5	-0.13		Pass
Coped beam Mr (e = 4.75)	kip-in.	189.0	189.1	+0.03		Pass
Coped beam φMn (Dowswell; k1 = 9.49, λp = 35.2)	kip-in.	1,140	1,141	+0.11		Pass
Coped web shear yielding	kips	141.0	141.3	+0.21		Pass
Beam web block shear (leh = 1¾ − ¼ = 1½) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	80.90	80.80	-0.12		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 0.726. ILX result: **OK**; published: **OK**.
D11 single angle: AISC uses Table 10-11 C = 3.07 (tabulated at e = 2½ in.) for the support leg and neglects eccentricity on the 4-in. beam leg (Manual Fig. 10-15); ILX solves e = g + tw/2 = 1.90 in. on the support leg and applies e = a on the beam leg (method difference). ILX governs on the beam-leg group instead.

II.A-28A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Support-leg eccentricity e = g + tw/2	in.	1.900	1.900	+0.00		Pass
C, support leg (Table 10-11 Case I)		3.070	3.369	+9.74		Deviation D11
D11 single angle: AISC uses Table 10-11 C = 3.07 (tabulated at e = 2½ in.) for the support leg and neglects eccentricity on the 4-in. beam leg (Manual Fig. 10-15); ILX solves e = g + tw/2 = 1.90 in. on the support leg and applies e = a on the beam leg (method difference).						
C at e = 2½ in. (the Table 10-11 tabulated eccentricity)		3.070	3.065	-0.15		Pass
Bolt shear per bolt	kips	11.90	11.93	+0.24		Pass
Angle edge bolt (le = 1¼)	kips	12.30	12.34	+0.32		Pass
Angle interior bolt	kips	21.90	21.94	+0.17		Pass
Angle bolt group (support leg)	kips	36.50	40.19	+10.10		Deviation D11
D11 single angle: AISC uses Table 10-11 C = 3.07 (tabulated at e = 2½ in.) for the support leg and neglects eccentricity on the 4-in. beam leg (Manual Fig. 10-15); ILX solves e = g + tw/2 = 1.90 in. on the support leg and applies e = a on the beam leg (method difference).						
Beam web edge bolt	kips	9.870	12.80	+29.65		Deviation D12
D12 AISC conservatively uses le = 1¼ in. for the beam-web top bolt; the actual lev is 1½ in.						

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam web interior bolt	kips	17.60	17.55	-0.28		Pass
Beam web bolt group (concentric)	kips	45.60	36.56	-19.81		Deviation D11
D11 single angle: AISC uses Table 10-11 C = 3.07 (tabulated at e = 2½ in.) for the support leg and neglects eccentricity on the 4-in. beam leg (Manual Fig. 10-15); ILX solves e = g + tw/2 = 1.90 in. on the support leg and applies e = a on the beam leg (method difference).						
Girder web bearing	kips	23.40	23.40	+0.00		Pass
Angle shear yielding	kips	86.00	86.25	+0.29		Pass
Angle shear rupture	kips	58.50	58.50	+0.00		Pass
Angle block shear, 3-in. leg	kips	62.40	62.46	+0.10		Pass
Angle flexural yielding φMn	kip-in.	371.0	371.2	+0.06		Pass
Angle flexural rupture φMn (Znet = 8.46)	kip-in.	275.0	275.0	-0.01		Pass
Coped beam Mr (e = 4.75)	kip-in.	126.0	125.9	-0.10		Pass
Coped beam φMn (Dowswell; k1 = 9.49, λp = 35.2)	kip-in.	760.0	759.3	-0.09		Pass
Coped web shear yielding	kips	94.00	94.20	+0.21		Pass
Beam web block shear (leh = 1¾ − ¼ = 1½) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	53.90	53.87	-0.06		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 0.725. ILX result: **OK**; published: **OK**.
D11 single angle: AISC uses Table 10-11 C = 3.07 (tabulated at e = 2½ in.) for the support leg and neglects eccentricity on the 4-in. beam leg (Manual Fig. 10-15); ILX solves e = g + tw/2 = 1.90 in. on the support leg and applies e = a on the beam leg (method difference). ILX governs on the beam-leg group instead.

II.A-28B: All-bolted single angle, structural integrity check (II.A-28A connection)

Source: AISC Design Examples v16.0, Example II.A-28B, pp. IIA-276 to IIA-283. Connection: Single angle, support Girder web.

II.A-28B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required shear strength (from II.A-28A)	kips	39.80	39.80	+0.00		Pass
Integrity tension T = max(2/3 Vu or Va, 10 kips)	kips	26.50	26.53	+0.13		Pass
Bolt shear Tn = n Fnv Ab	kips	95.50	95.43	-0.08		Pass
Bolt tension Tn = n Fnt Ab (support leg)	kips	159.0	159.0	+0.03		Pass
Angle bearing Tn = n 3.0 d t Fu	kips	219.0	219.4	+0.17		Pass
Beam web bearing Tn = n 3.0 d tw Fu	kips	176.0	175.5	-0.28		Pass
Angle tearout Tn = n 1.5 lc t Fu (lc = 1.09)	kips	159.0	160.0	+0.60		Pass
Beam web tearout (leh = 1¾ − ¼, lc = 1.09) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	128.0	128.0	-0.02		Pass
Prying: tc (Manual Eq. 9-30, nominal)	in.	1.010	1.005	-0.46		Pass
Prying: Q (Manual Eq. 9-39c)		0.237	0.239	+0.83		Pass
Angle bending with prying, Tn = n Q Tc	kips	37.70	38.01	+0.81		Pass
Angle block shear, axial U-shape	kips	186.0	186.5	+0.25		Pass
Angle block shear, axial L-shape	kips	191.0	190.7	-0.14		Pass
Angle tensile yielding	kips	216.0	215.6	-0.17		Pass
Angle tensile rupture (Ae = 3.00)	kips	195.0	195.0	+0.00		Pass
Beam web block shear, axial U-shape (leh = 1¾ − ¼) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	149.0	149.2	+0.12		Pass
Beam web block shear, axial L-shape (leh = 1¾ − ¼) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	157.0	157.5	+0.29		Pass
Controlling nominal tension Tn (angle prying)	kips	37.70	38.01	+0.81		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 0.726. ILX result: **OK**; published: **OK**.

II.A-28B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required shear strength (from II.A-28A)	kips	26.50	26.50	+0.00		Pass
Integrity tension T = max(2/3 Vu or Va, 10 kips)	kips	26.50	26.50	+0.00		Pass
Bolt shear Tn = n Fnv Ab	kips	95.50	95.43	-0.08		Pass
Bolt tension Tn = n Fnt Ab (support leg)	kips	159.0	159.0	+0.03		Pass
Angle bearing Tn = n 3.0 d t Fu	kips	219.0	219.4	+0.17		Pass
Beam web bearing Tn = n 3.0 d tw Fu	kips	176.0	175.5	-0.28		Pass
Angle tearout Tn = n 1.5 lc t Fu (lc = 1.09)	kips	159.0	160.0	+0.60		Pass
Beam web tearout (leh = 1¾ − ¼, lc = 1.09) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	128.0	128.0	-0.02		Pass
Prying: tc (Manual Eq. 9-30, nominal)	in.	1.010	1.005	-0.46		Pass
Prying: Q (Manual Eq. 9-39c)		0.237	0.239	+0.83		Pass
Angle bending with prying, Tn = n Q Tc	kips	37.70	38.01	+0.81		Pass
Angle block shear, axial U-shape	kips	186.0	186.5	+0.25		Pass
Angle block shear, axial L-shape	kips	191.0	190.7	-0.14		Pass
Angle tensile yielding	kips	216.0	215.6	-0.17		Pass
Angle tensile rupture (Ae = 3.00)	kips	195.0	195.0	+0.00		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam web block shear, axial U-shape (leh = 1¾ − ¼) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	149.0	149.2	+0.12		Pass
Beam web block shear, axial L-shape (leh = 1¾ − ¼) AISC applies a ¼ in. beam-length underrun to leh for this limit state.	kips	157.0	157.5	+0.29		Pass
Controlling nominal tension Tn (angle prying)	kips	37.70	38.01	+0.81		Pass

ILX governing check: `bolts_beam` (Beam-side bolts: shear, bearing and tearout), ratio 0.725. ILX result: **OK**; published: **OK**.

II.A-29: Single angle welded to a column flange, bolted to the beam web

Source: AISC Design Examples v16.0, Example II.A-29, pp. IIA-284 to IIA-292. Connection: Single angle, support Column flange.

II.A-29 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	54.00	54.00	+0.00		Pass
Beam-leg eccentricity neglected, e = a = 2¾ ≤ 3 in. (Fig. 10-15)	in.	0.000	0.000	–		Pass
Bolt shear per bolt	kips	17.90	17.89	-0.04		Pass
Angle edge bolt (le = 1¼)	kips	18.50	18.51	+0.05		Pass
Angle interior bolt	kips	32.90	32.91	+0.02		Pass
Beam web bolt (s = 3 in.)	kips	33.40	33.34	-0.16		Pass
Shear transfer at the bolt holes, n × 17.9	kips	71.60	71.57	-0.04		Pass
Weld return kl (Table 8-10)	in.	4.000	3.000	-25.00		Deviation D17
D17 AISC II.A-29 takes the weld return kl = 4 in. (k = 0.348) although the 3-in. leg of the L4×3×3/8 is welded to the column; ILX returns the weld across the welded leg's width, kl = 3 in. (k = 0.261, a = 0.250). The weld group coefficient is nearly insensitive to this (C = 2.20 vs. 2.19, both rows below pass).						
Weld k = kl / l		0.348	0.261	-25.04		Deviation D17
D17 AISC II.A-29 takes the weld return kl = 4 in. (k = 0.348) although the 3-in. leg of the L4×3×3/8 is welded to the column; ILX returns the weld across the welded leg's width, kl = 3 in. (k = 0.261, a = 0.250). The weld group coefficient is nearly insensitive to this (C = 2.20 vs. 2.19, both rows below pass).						
Weld a = (kl + tw/2) / l − x		0.319	0.250	-21.50		Deviation D17
D17 AISC II.A-29 takes the weld return kl = 4 in. (k = 0.348) although the 3-in. leg of the L4×3×3/8 is welded to the column; ILX returns the weld across the welded leg's width, kl = 3 in. (k = 0.261, a = 0.250). The weld group coefficient is nearly insensitive to this (C = 2.20 vs. 2.19, both rows below pass).						
Weld C (Table 8-10, Angle = 0°)		2.190	2.203	+0.57		Pass
Weld, L-shape φRn = φ C C1 D l (Eq. 8-30)	kips	56.70	56.99	+0.51		Pass
Angle shear yielding	kips	129.0	129.4	+0.29		Pass
Angle shear rupture	kips	87.80	87.75	-0.06		Pass
Angle block shear (Agv 3.84, Anv 2.69, Ant 0.305)	kips	93.80	93.69	-0.12		Pass
Support tmin = 3.09 D / Fu (Manual Eq. 9-6)	in.	0.143	0.143	-0.15		Pass

ILX governing check: `weld_support` (Weld to support (L-shape: toe of the support leg + top return)), ratio 0.948. ILX result: **OK**; published: **OK**.

II.A-29 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	36.00	36.00	+0.00		Pass
Beam-leg eccentricity neglected, e = a = 2¾ ≤ 3 in. (Fig. 10-15)	in.	0.000	0.000	–		Pass
Bolt shear per bolt	kips	11.90	11.93	+0.24		Pass
Angle edge bolt (le = 1¼)	kips	12.30	12.34	+0.32		Pass
Angle interior bolt	kips	21.90	21.94	+0.17		Pass
Beam web bolt (s = 3 in.)	kips	22.20	22.23	+0.14		Pass
Shear transfer at the bolt holes, n × 17.9	kips	47.60	47.71	+0.24		Pass
Weld return kl (Table 8-10)	in.	4.000	3.000	-25.00		Deviation D17
D17 AISC II.A-29 takes the weld return kl = 4 in. (k = 0.348) although the 3-in. leg of the L4×3×3/8 is welded to the column; ILX returns the weld across the welded leg's width, kl = 3 in. (k = 0.261, a = 0.250). The weld group coefficient is nearly insensitive to this (C = 2.20 vs. 2.19, both rows below pass).						
Weld k = kl / l		0.348	0.261	-25.04		Deviation D17
D17 AISC II.A-29 takes the weld return kl = 4 in. (k = 0.348) although the 3-in. leg of the L4×3×3/8 is welded to the column; ILX returns the weld across the welded leg's width, kl = 3 in. (k = 0.261, a = 0.250). The weld group coefficient is nearly insensitive to this (C = 2.20 vs. 2.19, both rows below pass).						
Weld a = (kl + tw/2) / l − x		0.319	0.250	-21.50		Deviation D17
D17 AISC II.A-29 takes the weld return kl = 4 in. (k = 0.348) although the 3-in. leg of the L4×3×3/8 is welded to the column; ILX returns the weld across the welded leg's width, kl = 3 in. (k = 0.261, a = 0.250). The weld group coefficient is nearly insensitive to this (C = 2.20 vs. 2.19, both rows below pass).						
Weld C (Table 8-10, Angle = 0°)		2.190	2.203	+0.57		Pass
Weld, L-shape φRn = φ C C1 D l (Eq. 8-30)	kips	37.80	37.99	+0.51		Pass
Angle shear yielding	kips	86.00	86.25	+0.29		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Angle shear rupture	kips	58.50	58.50	+0.00		Pass
Angle block shear (Agv 3.84, Anv 2.69, Ant 0.305)	kips	62.50	62.46	-0.06		Pass
Support tmin = 3.09 D / Fu (Manual Eq. 9-6)	in.	0.143	0.143	-0.15		Pass

ILX governing check: `weld_support` (Weld to support (L-shape: toe of the support leg + top return)), ratio 0.948. ILX result: **OK**; published: **OK**.

II.A-1A: All-bolted double angle, W36×231 to W14×90 column flange

Source: AISC Design Examples v16.0, Example II.A-1A. Connection: Double angle, support Column flange.

II.A-1A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	281.0	281.4	+0.14		Pass
Outstanding-leg bolts: shear transfer at bolt holes	kips	281.0	281.4	+0.14		Pass
Angles: shear yielding (both angles)	kips	441.0	441.3	+0.07		Pass
Angles: shear rupture (beam legs)	kips	302.0	302.1	+0.04		Pass
Angles: block shear (beam legs, both angles)	kips	315.0	315.9	+0.27		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-1A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	187.0	187.6	+0.32		Pass
Outstanding-leg bolts: shear transfer at bolt holes	kips	187.0	187.6	+0.32		Pass
Angles: shear yielding (both angles)	kips	294.0	294.2	+0.07		Pass
Angles: shear rupture (beam legs)	kips	201.0	201.4	+0.21		Pass
Angles: block shear (beam legs, both angles)	kips	210.0	210.6	+0.27		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-1B: All-bolted double angle under shear and axial tension

Source: AISC Design Examples v16.0, Example II.A-1B. Connection: Double angle, support Column flange.

II.A-1B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	182.0	181.7	-0.16		Pass
Angles: shear yielding (both angles)	kips	543.0	543.8	+0.14		Pass
Angles: shear rupture (beam legs)	kips	348.0	347.3	-0.19		Pass
Angles: tension yielding	kips	815.0	815.6	+0.08		Pass
Angles: tension rupture (beam legs, U = 1.0)	kips	581.0	578.9	-0.36		Pass
Angles: block shear (beam legs, both angles)	kips	368.0	365.6	-0.65		Pass
Angles: block shear, axial L-shape (beam legs)	kips	559.0	560.6	+0.29		Pass
Angles: block shear, axial U-shape (beam legs)	kips	542.0	542.3	+0.06		Pass
Angles: block shear (outstanding legs, both angles)	kips	379.0	376.4	-0.68		Pass
Beam web shear	kips	192.0	191.7	-0.16		Pass
Beam tensile yielding	kips	662.0	661.5	-0.08		Pass
Beam tensile rupture (shear lag)	kips	256.0	256.6	+0.22		Pass
Beam web block shear, axial U-shape	kips	159.0	159.2	+0.14		Pass
Outstanding-leg bolts: tension with shear and prying	kips	9.810	9.842	+0.33		Pass
Angles: block shear interaction (shear and axial)		0.053	0.054	+2.29		Deviation A2
Documented deviation: II.A-1B combines the shear block (368) with the L-shape axial block (559) although the U-shape (542) is smaller; the engine uses the smaller axial block (0.0543 vs 0.0531, +2.3 %).						

ILX result: **– (surrogate)**; published: **OK**.

II.A-1B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	122.0	121.1	-0.70		Pass
Angles: shear yielding (both angles)	kips	362.0	362.5	+0.14		Pass
Angles: shear rupture (beam legs)	kips	232.0	231.6	-0.19		Pass
Angles: tension yielding	kips	542.0	542.7	+0.12		Pass
Angles: tension rupture (beam legs, U = 1.0)	kips	387.0	385.9	-0.27		Pass
Angles: block shear (beam legs, both angles)	kips	245.0	243.8	-0.51		Pass
Angles: block shear, axial L-shape (beam legs)	kips	373.0	373.8	+0.20		Pass
Angles: block shear, axial U-shape (beam legs)	kips	362.0	361.6	-0.12		Pass
Angles: block shear (outstanding legs, both angles)	kips	253.0	251.0	-0.81		Pass
Beam web shear	kips	128.0	127.8	-0.16		Pass
Beam tensile yielding	kips	440.0	440.1	+0.03		Pass
Beam tensile rupture (shear lag)	kips	171.0	171.0	+0.02		Pass
Beam web block shear, axial U-shape	kips	106.0	106.1	+0.14		Pass
Outstanding-leg bolts: tension with shear and prying	kips	6.540	6.548	+0.13		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-1C: Structural integrity check of II.A-1B (B3.9)

Source: AISC Design Examples v16.0, Example II.A-1C. Connection: Double angle, support Column flange.

II.A-1C · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Integrity: beam-leg bolt shear (double shear)	kips	325.0	324.7	-0.09		Pass
Integrity: outstanding-leg bolt tension	kips	541.0	541.2	+0.03		Pass
Integrity: beam web bearing (3.0 d t Fu)	kips	303.0	302.9	-0.05		Pass
Integrity: beam web tearout toward the beam end (1.5 lc t Fu)	kips	178.0	178.5	+0.26		Pass
Integrity: angle bending / prying at the outstanding-leg bolts (per bolt)	kips	10.90	10.94	+0.33		Pass
Integrity: angle tension yielding	kips	905.0	906.2	+0.14		Pass
Integrity: angle tension rupture (beam legs)	kips	774.0	771.9	-0.27		Pass
Integrity: beam web block shear (axial)	kips	212.0	212.3	+0.14		Pass
Integrity: governing Tn = 10 × angle bending / prying per bolt	kips	109.0	109.4	+0.33		Pass
Integrity: required tension T	kips	50.00	50.00	+0.00		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-1C · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Integrity: beam-leg bolt shear (double shear)	kips	325.0	324.7	-0.09		Pass
Integrity: outstanding-leg bolt tension	kips	541.0	541.2	+0.03		Pass
Integrity: beam web bearing (3.0 d t Fu)	kips	303.0	302.9	-0.05		Pass
Integrity: beam web tearout toward the beam end (1.5 lc t Fu)	kips	178.0	178.5	+0.26		Pass
Integrity: angle bending / prying at the outstanding-leg bolts (per bolt)	kips	10.90	10.94	+0.33		Pass
Integrity: angle tension yielding	kips	905.0	906.2	+0.14		Pass
Integrity: angle tension rupture (beam legs)	kips	774.0	771.9	-0.27		Pass
Integrity: beam web block shear (axial)	kips	212.0	212.3	+0.14		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-2A: Bolted/welded double angle (Welds B to the column flange)

Source: AISC Design Examples v16.0, Example II.A-2A. Connection: Double angle, support Column flange.

II.A-2A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	286.0	286.3	+0.10		Pass
Welds B: outstanding legs to the support (shear)	kips	318.0	318.6	+0.20		Pass
Angles: shear yielding (both angles)	kips	528.0	528.8	+0.14		Pass
Angles: shear rupture (beam legs)	kips	363.0	362.0	-0.28		Pass
Angles: block shear (beam legs, both angles)	kips	380.0	378.4	-0.42		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-2A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	190.0	190.9	+0.45		Pass
Welds B: outstanding legs to the support (shear)	kips	212.0	212.4	+0.20		Pass
Angles: shear yielding (both angles)	kips	352.0	352.5	+0.14		Pass
Angles: shear rupture (beam legs)	kips	242.0	241.3	-0.28		Pass
Angles: block shear (beam legs, both angles)	kips	253.0	252.3	-0.28		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-2B: Welded/bolted double angle under shear and axial tension (Welds A to the beam web)

Source: AISC Design Examples v16.0, Example II.A-2B. Connection: Double angle, support Column flange.

II.A-2B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Outstanding-leg bolts: shear transfer at bolt holes	kips	241.0	240.5	-0.19		Pass
Outstanding-leg bolts: tension with shear and prying	kips	9.370	9.432	+0.66		Pass
Angles: shear yielding (both angles)	kips	435.0	435.0	+0.00		Pass
Angles: shear rupture (outstanding legs)	kips	278.0	277.9	-0.04		Pass
Angles: tension yielding	kips	653.0	652.5	-0.08		Pass
Angles: block shear (outstanding legs, both angles)	kips	303.0	301.2	-0.61		Pass
Beam web shear	kips	192.0	191.7	-0.16		Pass
Beam web block shear around Welds A, axial U-shape	kips	295.0	294.9	-0.04		Pass
Beam tensile yielding	kips	662.0	661.5	-0.08		Pass
Beam tensile rupture (shear lag)	kips	422.0	422.4	+0.08		Pass
Welds A (3/16 in.), φRn = 0.75 (2.69)(3)(14.5)(2), Table 8-8 at 30°	kips	175.5	180.2	+2.69		Deviation A1
Documented deviation: II.A-2B evaluates Welds A at 30° (Table 8-8 row) instead of the actual 38.7° load angle; the engine uses the actual angle (+2.7 %).						

ILX result: **– (surrogate)**; published: **OK**.

II.A-2B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Outstanding-leg bolts: shear transfer at bolt holes	kips	161.0	160.4	-0.40		Pass
Outstanding-leg bolts: tension with shear and prying	kips	6.240	6.275	+0.56		Pass
Angles: shear yielding (both angles)	kips	290.0	290.0	+0.00		Pass
Angles: shear rupture (outstanding legs)	kips	186.0	185.2	-0.40		Pass
Angles: tension yielding	kips	434.0	434.1	+0.03		Pass
Angles: block shear (outstanding legs, both angles)	kips	202.0	200.8	-0.61		Pass
Beam web shear	kips	128.0	127.8	-0.16		Pass
Beam web block shear around Welds A, axial U-shape	kips	197.0	196.6	-0.21		Pass
Beam tensile yielding	kips	440.0	440.1	+0.03		Pass
Beam tensile rupture (shear lag)	kips	282.0	281.6	-0.15		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-3: All-welded double angle (Table 10-3)

Source: AISC Design Examples v16.0, Example II.A-3. Connection: Double angle, support Column flange.

II.A-3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Welds A: angles to the beam web (C-shaped)	kips	257.0	257.8	+0.29		Pass
Welds B: outstanding legs to the support (shear)	kips	260.0	261.0	+0.40		Pass
Angles: shear yielding (both angles)	kips	450.0	450.7	+0.16		Pass
Angles: shear rupture (welded legs, gross section)	kips	439.0	439.5	+0.10		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Welds A: angles to the beam web (C-shaped)	kips	171.0	171.8	+0.49		Pass
Welds B: outstanding legs to the support (shear)	kips	173.0	174.0	+0.59		Pass
Angles: shear yielding (both angles)	kips	300.0	300.5	+0.16		Pass
Angles: shear rupture (welded legs, gross section)	kips	293.0	293.0	-0.01		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-4: All-bolted double angle, top-coped W18×50 to W21×62 girder web

Source: AISC Design Examples v16.0, Example II.A-4. Connection: Double angle, support Girder web.

II.A-4 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	73.50	73.35	-0.20		Pass
Outstanding-leg bolts: shear transfer at bolt holes	kips	96.40	96.25	-0.16		Pass
Coped beam: flexural local buckling (single cope, Manual Part 9) (published Rn × e)	kip-in.	1,683	1,679	-0.22		Pass
Beam web shear yielding (coped section)	kips	170.0	170.4	+0.24		Pass
Beam web block shear (top coped, Table 10-1c form)	kips	68.60	68.79	+0.28		Pass
Angles: shear rupture (beam legs)	kips	85.90	85.92	+0.03		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-4 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	49.00	48.90	-0.20		Pass
Outstanding-leg bolts: shear transfer at bolt holes	kips	64.10	64.17	+0.10		Pass
Coped beam: flexural local buckling (single cope, Manual Part 9) (published Rn × e)	kip-in.	1,120	1,117	-0.28		Pass
Beam web shear yielding (coped section)	kips	113.0	113.6	+0.53		Pass
Beam web block shear (top coped, Table 10-1c form)	kips	45.80	45.86	+0.13		Pass
Angles: shear rupture (beam legs)	kips	57.30	57.28	-0.03		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-5: Welded/bolted double angle to a girder web, top-coped beam

Source: AISC Design Examples v16.0, Example II.A-5. Connection: Double angle, support Girder web.

II.A-5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Outstanding-leg bolts: shear transfer at bolt holes	kips	96.40	96.25	-0.16		Pass
Beam web block shear around Welds A (top coped)	kips	119.0	118.5	-0.44		Pass
Beam web shear yielding (coped section)	kips	170.0	170.4	+0.24		Pass
Angles: shear rupture (outstanding legs)	kips	85.90	85.92	+0.03		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-5 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Outstanding-leg bolts: shear transfer at bolt holes	kips	64.10	64.17	+0.10		Pass
Beam web block shear around Welds A (top coped)	kips	79.00	78.99	-0.02		Pass
Beam web shear yielding (coped section)	kips	113.0	113.6	+0.53		Pass
Angles: shear rupture (outstanding legs)	kips	57.30	57.28	-0.03		Pass

ILX result: **– (surrogate)**; published: **OK**.

K.3: Double angle of II.A-2A to an HSS14×14×½ column

Source: AISC Design Examples v16.0, Example K.3. Connection: Double angle, support HSS wall.

K.3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	286.0	286.3	+0.10		Pass
Welds B: outstanding legs to the support (shear)	kips	318.0	318.6	+0.20		Pass
Minimum HSS wall thickness, tmin = 0.238 (65/62)	in.	0.250	0.249	-0.21		Pass

ILX result: **– (surrogate)**; published: **OK**.

K.3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	190.0	190.9	+0.45		Pass
Welds B: outstanding legs to the support (shear)	kips	212.0	212.4	+0.20		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-8: Double angles on both sides of a girder web, shared bolts (Beam B)

Source: AISC Design Examples v16.0, Example II.A-8. Connection: Double angle, support Girder web.

II.A-8 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	158.0	158.1	+0.04		Pass
Angles: shear rupture (beam legs)	kips	148.0	148.1	+0.05		Pass
Shared bolts: girder web bearing/tearout under both reactions	kips	45.70	45.63	-0.15		Pass
Coped beam: flexural local buckling (single cope, Manual Part 9) (published Rn × e)	kip-in.	2,106	2,099	-0.38		Pass
Shared bolt: force per bolt from both connections (required)	kips	17.30	17.25	-0.29		Pass
Shared bolt: double-shear strength	kips	35.80	35.78	-0.04		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-8 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-leg bolts: shear transfer at bolt holes (bolt shear, bearing, tearout)	kips	105.0	105.4	+0.36		Pass
Angles: shear rupture (beam legs)	kips	98.70	98.72	+0.02		Pass
Shared bolts: girder web bearing/tearout under both reactions	kips	30.40	30.42	+0.07		Pass
Coped beam: flexural local buckling (single cope, Manual Part 9) (published Rn × e)	kip-in.	1,397	1,396	-0.05		Pass
Shared bolt: force per bolt from both connections (required)	kips	11.50	11.51	+0.04		Pass
Shared bolt: double-shear strength	kips	23.90	23.86	-0.18		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-9: Offset double angles on both sides of a girder web, shared bolts

Source: AISC Design Examples v16.0, Example II.A-9. Connection: Double angle, support Girder web.

II.A-9 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Shared bolt: force per bolt from both connections (required)	kips	20.00	20.00	+0.00		Pass
Shared bolt: double-shear strength	kips	35.80	35.78	-0.04		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-9 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Shared bolt: force per bolt from both connections (required)	kips	13.30	13.33	+0.25		Pass
Shared bolt: double-shear strength	kips	23.90	23.86	-0.18		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-11A: Shear end plate to a girder web (top-coped W18X50 to W21X62)

Source: AISC Design Examples v16.0, Example II.A-11A, pp. IIA-122 to IIA-129. Connection: Shear end plate, support Girder web.

II.A-11A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	60.00	60.00	+0.00		Pass
Bolt shear per bolt (Table 10-4b)	kips	17.90	17.89	-0.04		Pass
End-plate bearing per bolt (2.4 d t Fu)	kips	22.00	21.94	-0.28		Pass
End-plate tearout, edge bolt (lc = 0.844)	kips	12.40	12.34	-0.49		Pass
End-plate tearout, non-edge bolt (lc = 2.19)	kips	32.00	31.99	-0.02		Pass
Edge clear distance lc	in.	0.844	0.844	-0.03		Pass
Shear transfer at the bolt holes	kips	96.40	96.25	-0.16		Pass
Table 10-4a end plate (shear rupture, block shear)	kips	85.90	85.92	+0.03		Pass
End-plate shear yielding (Agv = 4.25)	kips	128.0	127.5	-0.39		Pass
End-plate shear rupture (Anv = 2.94)	kips	86.30	85.92	-0.44		Pass
Anv	in.²	2.940	2.938	-0.09		Pass
End-plate block shear	kips	93.80	93.84	+0.05		Pass
Block shear Agv	in.²	3.630	3.625	-0.14		Pass
Block shear Anv	in.²	2.540	2.531	-0.34		Pass
Block shear Ant	in.²	0.406	0.406	+0.06		Pass
Weld effective length lw = L − 2w	in.	8.130	8.125	-0.06		Pass
Weld strength (Part B)	kips	67.90	67.87	-0.05		Pass
Table 10-4c weld and beam web	kips	67.90	67.87	-0.05		Pass
Table 10-4c minimum beam web thickness (6.19 D/Fu)	in.	0.286	0.286	-0.15		Pass

ILX governing check: `weld_beam` (Fillet welds to the beam web (both sides)), ratio 0.884. ILX result: **OK**; published: **OK**.

II.A-11A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	40.00	40.00	+0.00		Pass
Bolt shear per bolt (Table 10-4b)	kips	11.90	11.93	+0.24		Pass
End-plate bearing per bolt (2.4 d t Fu)	kips	14.70	14.62	-0.51		Pass
End-plate tearout, edge bolt (lc = 0.844)	kips	8.250	8.227	-0.28		Pass
End-plate tearout, non-edge bolt (lc = 2.19)	kips	21.40	21.33	-0.34		Pass
Edge clear distance lc	in.	0.844	0.844	-0.03		Pass
Shear transfer at the bolt holes	kips	64.10	64.17	+0.10		Pass
Table 10-4a end plate (shear rupture, block shear)	kips	57.30	57.28	-0.03		Pass
End-plate shear yielding (Agv = 4.25)	kips	85.30	85.00	-0.35		Pass
End-plate shear rupture (Anv = 2.94)	kips	57.50	57.28	-0.38		Pass
Anv	in.²	2.940	2.938	-0.09		Pass
End-plate block shear	kips	62.50	62.56	+0.10		Pass
Block shear Agv	in.²	3.630	3.625	-0.14		Pass
Block shear Anv	in.²	2.540	2.531	-0.34		Pass
Block shear Ant	in.²	0.406	0.406	+0.06		Pass
Weld effective length lw = L − 2w	in.	8.130	8.125	-0.06		Pass
Weld strength (Part B)	kips	45.30	45.24	-0.13		Pass
Table 10-4c weld and beam web	kips	45.20	45.24	+0.10		Pass
Table 10-4c minimum beam web thickness (6.19 D/Fu)	in.	0.286	0.286	-0.15		Pass

ILX governing check: `weld_beam` (Fillet welds to the beam web (both sides)), ratio 0.884. ILX result: **OK**; published: **OK**.

II.A-11B: End plate with axial tension and shear (prying)

Source: AISC Design Examples v16.0, Example II.A-11B, pp. IIA-130 to IIA-140. Connection: Shear end plate, support Column flange.

II.A-11B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Resultant √(V² + N²)	kips	96.00	96.05	+0.05		Pass
Bolt shear per pair	kips	48.70	48.71	+0.01		Pass
Plate bearing per pair	kips	102.0	102.4	+0.37		Pass
Top edge tearout per pair (lc = 0.781)	kips	45.80	45.70	-0.21		Pass
Interior tearout per pair (lc = 2.06)	kips	120.0	120.7	+0.55		Pass
Shear strength of the bolted connection	kips	241.0	240.5	-0.19		Pass
frv	ksi	12.50	12.47	-0.22		Pass
F'nt (J3.8)	ksi	89.20	89.28	+0.09		Pass
Available tension per bolt	kips	40.20	40.27	+0.16		Pass
Bolt tension, 10 bolts	kips	402.0	402.7	+0.16		Pass
b = (g − tw)/2	in.	2.570	2.572	+0.10		Pass
a = (W − g)/2 ≤ 1.25 b	in.	1.500	1.500	+0.00		Pass
a'	in.	1.940	1.938	-0.13		Pass
b'	in.	2.130	2.135	+0.23		Pass
ρ = b'/a'		1.100	1.102	+0.18		Pass
p = L/n (average pitch)	in.	2.900	2.900	+0.00		Pass
δ = 1 − d'/p		0.677	0.677	-0.04		Pass
tc	in.	1.420	1.424	+0.26		Pass
α'		4.970	4.997	+0.54		Pass
Q (Manual Eq. 9-39c)		0.208	0.207	-0.57		Pass
Tc,adj = Q Tc per bolt	kips	8.360	8.327	-0.39		Pass
Bolt tension with prying, 10 bolts	kips	83.60	83.27	-0.39		Pass
Weld effective length lw = L − 2w	in.	14.10	14.12	+0.18		Pass
Resultant angle θ		38.70	38.66	-0.10		Pass
Required weld size Dmin (sixteenths)		2.080	1.959	-5.83		Deviation E1
E1 weld: AISC II.A-11B reads Manual Table 8-4 at 30° ("which will lead to a conservative result"); ILX applies the directional increase at the true resultant angle 38.7° (method difference, ILX is exact).						
End-plate shear yielding (Agv = 14.5)	kips	435.0	435.0	+0.00		Pass
End-plate shear rupture (Anv = 9.50)	kips	278.0	277.9	-0.04		Pass
End-plate block shear (L-shaped)	kips	306.0	304.7	-0.43		Pass
Beam shear yielding (d tw)	kips	192.0	191.7	-0.16		Pass
Beam tensile yielding	kips	662.0	661.5	-0.08		Pass
Beam tensile rupture (An = lw tw, U = 1)	kips	245.0	244.5	-0.22		Pass
Beam An = lw tw	in.²	5.010	5.014	+0.09		Pass

ILX result: **OK**; published: **OK**.

II.A-11B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Resultant √(V² + N²)	kips	64.00	64.03	+0.05		Pass
Bolt shear per pair	kips	32.50	32.47	-0.09		Pass
Plate bearing per pair	kips	68.30	68.25	-0.07		Pass
Top edge tearout per pair (lc = 0.781)	kips	30.50	30.47	-0.10		Pass
Interior tearout per pair (lc = 2.06)	kips	80.30	80.44	+0.17		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Shear strength of the bolted connection	kips	161.0	160.4	-0.40		Pass
frv	ksi	8.320	8.315	-0.06		Pass
F'nt (J3.8)	ksi	89.30	89.28	-0.02		Pass
Available tension per bolt	kips	26.80	26.84	+0.16		Pass
Bolt tension, 10 bolts	kips	268.0	268.4	+0.16		Pass
b = (g − tw)/2	in.	2.570	2.572	+0.10		Pass
a = (W − g)/2 ≤ 1.25 b	in.	1.500	1.500	+0.00		Pass
a'	in.	1.940	1.938	-0.13		Pass
b'	in.	2.130	2.135	+0.23		Pass
ρ = b'/a'		1.100	1.102	+0.18		Pass
p = L/n (average pitch)	in.	2.900	2.900	+0.00		Pass
δ = 1 − d'/p		0.677	0.677	-0.04		Pass
tc	in.	1.420	1.425	+0.36		Pass
α'		4.970	5.008	+0.77		Pass
Q (Manual Eq. 9-39c)		0.208	0.206	-0.77		Pass
Tc,adj = Q Tc per bolt	kips	5.570	5.540	-0.53		Pass
Bolt tension with prying, 10 bolts	kips	55.70	55.40	-0.53		Pass
Weld effective length lw = L − 2w	in.	14.10	14.12	+0.18		Pass
Resultant angle θ		38.70	38.66	-0.10		Pass
Required weld size Dmin (sixteenths)		2.080	1.959	-5.83		Deviation E1
E1 weld: AISC II.A-11B reads Manual Table 8-4 at 30° ("which will lead to a conservative result"); ILX applies the directional increase at the true resultant angle 38.7° (method difference, ILX is exact).						
End-plate shear yielding (Agv = 14.5)	kips	290.0	290.0	+0.00		Pass
End-plate shear rupture (Anv = 9.50)	kips	186.0	185.2	-0.40		Pass
End-plate block shear (L-shaped)	kips	204.0	203.1	-0.43		Pass
Beam shear yielding (d tw)	kips	128.0	127.8	-0.16		Pass
Beam tensile yielding	kips	440.0	440.1	+0.03		Pass
Beam tensile rupture (An = lw tw, U = 1)	kips	163.0	163.0	-0.02		Pass
Beam An = lw tw	in.²	5.010	5.014	+0.09		Pass

ILX result: **OK**; published: **OK**.

II.A-11C: Structural integrity check of II.A-11B (B3.9)

Source: AISC Design Examples v16.0, Example II.A-11C, pp. IIA-141 to IIA-146. Connection: Shear end plate, support Column flange.

II.A-11C · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
T = max(2/3 Vu or Va, 10 kips)	kips	50.00	50.00	+0.00		Pass
Bolt tension Tn = n Fnt Ab	kips	541.0	541.2	+0.03		Pass
Tc = Fnt Ab (nominal)	kips	54.10	54.12	+0.03		Pass
tc (nominal)	in.	1.560	1.566	+0.37		Pass
α' (nominal)		6.140	6.192	+0.84		Pass
Q (nominal)		0.172	0.171	-0.60		Pass
End plate with prying Tn = n Q Tc	kips	93.10	92.52	-0.62		Pass
Weld Fnw at 90°	ksi	63.00	63.00	+0.00		Pass
Weld Awe	in.²	3.740	3.745	+0.14		Pass
Weld tension Tn	kips	236.0	236.0	-0.02		Pass
Beam web at the weld Tn	kips	326.0	325.9	-0.02		Pass
Column braced, Pu ≤ 150 Tn / Pa ≤ 100 Tn	kips	14,000	13,879	-0.86		Pass

ILX governing check: `integrity_prying` (Integrity: end-plate bending with prying (nominal)), ratio 0.540. ILX result: **OK**; published: **OK**.

II.A-11C · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
T = max(2/3 Vu or Va, 10 kips)	kips	50.00	50.00	+0.00		Pass
Bolt tension Tn = n Fnt Ab	kips	541.0	541.2	+0.03		Pass
Tc = Fnt Ab (nominal)	kips	54.10	54.12	+0.03		Pass
tc (nominal)	in.	1.560	1.566	+0.37		Pass
α' (nominal)		6.140	6.192	+0.84		Pass
Q (nominal)		0.172	0.171	-0.60		Pass
End plate with prying Tn = n Q Tc	kips	93.10	92.52	-0.62		Pass
Weld Fnw at 90°	ksi	63.00	63.00	+0.00		Pass
Weld Awe	in.²	3.740	3.745	+0.14		Pass
Weld tension Tn	kips	236.0	236.0	-0.02		Pass
Beam web at the weld Tn	kips	326.0	325.9	-0.02		Pass
Column braced, Pu ≤ 150 Tn / Pa ≤ 100 Tn	kips	9,310	9,252	-0.62		Pass

ILX governing check: `integrity_prying` (Integrity: end-plate bending with prying (nominal)), ratio 0.540. ILX result: **OK**; published: **OK**.

II.A-12A: All-bolted unstiffened seated connection, W16×50 to W14×90 column web

Source: AISC Design Examples v16.0, Example II.A-12A. Connection: Seated, support Column web.

II.A-12A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ru	kips	54.80	54.80	+0.00		Pass
lb,yielding (Eq. 10-1a)	in.	0.309	0.309	+0.07		Pass
lb,min = kdes	in.	1.030	1.030	+0.00		Pass
(lb/d)max = 3.25/16.3		0.199	0.199	+0.19		Pass
OSL available strength (Table 10-5)	kips	113.0	112.5	-0.44		Pass
Bolt shear, Type B (Table 10-5)	kips	107.0	71.57	-33.11		Deviation S1
D-S1 II.A-12A quotes Table 10-5 bolt shear 107 / 71.6 kips for 'Connection Type B (four bolts)'. Four 3/4 in. Group 120-N bolts give 4 × 17.9 = 71.6 kips (LRFD) and 4 × 11.9 = 47.7 kips (ASD); 107 / 71.6 are six-bolt values (the next Table 10-5 column). ILX is correct; the conclusion (o.k.) is unchanged.						
Bolt shear = 4 × 17.9 (Specification)	kips	71.60	71.57	-0.04		Pass
tmin for bolt shear to govern (Table 10-5)	in.	0.204	0.204	-0.05		Pass

ILX result: **OK**; published: **OK**.

II.A-12A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ra	kips	36.50	36.50	+0.00		Pass
lb,yielding (Eq. 10-1b)	in.	0.307	0.307	-0.14		Pass
lb,min = kdes	in.	1.030	1.030	+0.00		Pass
OSL available strength (Table 10-5)	kips	74.90	74.85	-0.07		Pass
Bolt shear, Type B (Table 10-5)	kips	71.60	47.71	-33.36		Deviation S1
D-S1 II.A-12A quotes Table 10-5 bolt shear 107 / 71.6 kips for 'Connection Type B (four bolts)'. Four 3/4 in. Group 120-N bolts give 4 × 17.9 = 71.6 kips (LRFD) and 4 × 11.9 = 47.7 kips (ASD); 107 / 71.6 are six-bolt values (the next Table 10-5 column). ILX is correct; the conclusion (o.k.) is unchanged.						
Bolt shear = 4 × 11.9 (Specification)	kips	47.70	47.71	+0.03		Pass

ILX result: **OK**; published: **OK**.

II.A-12B: Structural integrity check of II.A-12A (B3.9)

Source: AISC Design Examples v16.0, Example II.A-12B. Connection: Seated, support Column web.

II.A-12B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
B3.9 T = 2/3 Vu	kips	36.50	36.53	+0.09		Pass
Bolt shear Tn = 2 Fnv Ab	kips	47.70	47.71	+0.03		Pass
Bolt tension Tn = 2 Fnt Ab	kips	79.60	79.52	-0.10		Pass
Bearing 3.0 d t Fu	kips	183.0	182.8	-0.10		Pass
Tearout 1.5 lc t Fu	kips	133.0	133.3	+0.23		Pass
Angle bending with prying	kips	65.40	65.41	+0.01		Pass
Beam flange block shear	kips	92.80	92.96	+0.17		Pass
Column bracing Pu ≤ 100 (3/2) Tn	kips	7,160	7,157	-0.04		Pass

ILX result: **OK**; published: **OK**.

II.A-12B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
B3.9 T = Va	kips	36.50	36.50	+0.00		Pass
Column bracing Pa ≤ 100 Tn	kips	4,770	4,771	+0.03		Pass

ILX result: **OK**; published: **OK**.

II.A-13: Bolted/welded unstiffened seated connection, W21×62 to W14×61 column flange (Table 10-6)

Source: AISC Design Examples v16.0, Example II.A-13. Connection: Seated, support Column flange.

II.A-13 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
lb,min = kdes	in.	1.120	1.120	+0.00		Pass
(lb/d)max		0.155	0.155	-0.15		Pass
OSL available strength (Table 10-6)	kips	113.0	112.5	-0.44		Pass
Weld L8×4, 5/16 (Table 10-6)	kips	66.70	66.74	+0.06		Pass

ILX result: **OK**; published: **OK**.

II.A-13 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
OSL available strength (Table 10-6)	kips	74.90	74.85	-0.07		Pass
Weld L8×4, 5/16 (Table 10-6)	kips	44.50	44.49	-0.02		Pass

ILX result: **OK**; published: **OK**.

II.A-14: Stiffened seated connection, W21×68 to W14×90 column flange (Table 10-8)

Source: AISC Design Examples v16.0, Example II.A-14. Connection: Seated, support Column flange.

II.A-14 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ru	kips	125.0	125.2	+0.16		Pass
φR5 (Table 9-4)	kips	75.90	75.92	+0.03		Pass
φR6 (Table 9-4)	kip/in.	7.950	7.949	-0.02		Pass
φR1	kips	64.00	63.96	-0.06		Pass
φR2	kip/in.	21.50	21.50	+0.00		Pass
Wmin, crippling	in.	6.930	6.950	+0.29		Pass
Wmin, yielding	in.	3.590	3.598	+0.23		Pass
lb/d = (7 − 3/4)/21.1		0.296	0.296	+0.07		Pass
Weld, W = 7, l = 15, 5/16 (Table 10-8)	kips	139.0	139.4	+0.31		Pass
Seat plate weld min length 0.2 l	in.	3.000	3.000	+0.00		Pass
Stiffener tmin = 1.5w	in.	0.469	0.469	-0.05		Pass
Stiffener tmin = (Fyb/Fys) tw	in.	0.430	0.430	+0.00		Pass

ILX result: **OK**; published: **OK**.

II.A-14 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ra	kips	83.50	83.50	+0.00		Pass
R5/Ω	kips	50.60	50.61	+0.03		Pass
R6/Ω	kip/in.	5.300	5.299	-0.02		Pass
R1/Ω	kips	42.60	42.64	+0.10		Pass
R2/Ω	kip/in.	14.30	14.33	+0.23		Pass
Wmin, crippling	in.	6.960	6.956	-0.06		Pass
Wmin, yielding	in.	3.610	3.601	-0.26		Pass
Weld, W = 7, l = 15, 5/16 (Table 10-8)	kips	93.00	92.95	-0.05		Pass

ILX result: **OK**; published: **OK**.

II.A-15: Stiffened seated connection, W21×68 to W14×90 column web (seats on one and on both sides)

Source: AISC Design Examples v16.0, Example II.A-15. Connection: Seated, support Column web.

II.A-15 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Weld (Table 10-8)	kips	139.0	139.4	+0.31		Pass
Column web tmin, one side (Eq. 9-6)	in.	0.238	0.238	-0.13		Pass
Column web tmin, both sides (Eq. 9-7) Seats on both sides of the column web.	in.	0.476	0.476	+0.03		Pass

ILX result: **OK**; published: **OK**.

II.A-15 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Weld (Table 10-8)	kips	93.00	92.95	-0.05		Pass

ILX result: **OK**; published: **OK**.

II.A-16: Offset welded unstiffened seated connection, W14×38 to W12×65 column flange

Source: AISC Design Examples v16.0, Example II.A-16. Connection: Seated, support Column flange.

II.A-16 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
φR1 (W14×38)	kips	35.50	35.46	-0.12		Pass
φR2	kip/in.	15.50	15.50	+0.00		Pass
φR3	kips	44.70	44.75	+0.10		Pass
φR4	kip/in.	4.450	4.446	-0.09		Pass
lb,min = kdes	in.	0.915	0.915	+0.00		Pass
Seat design force 2 RuR	kips	51.40	51.43	+0.06		Pass
OSL available strength (Table 10-6, 6 in.)	kips	113.0	112.5	-0.44		Pass
Weld L7×4, 5/16 (Table 10-6)	kips	53.40	53.39	-0.01		Pass

ILX result: **OK**; published: **OK**.

II.A-16 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
R1/Ω	kips	23.60	23.64	+0.16		Pass
R2/Ω	kip/in.	10.30	10.33	+0.32		Pass
R3/Ω	kips	29.80	29.83	+0.10		Pass
R4/Ω	kip/in.	2.960	2.964	+0.14		Pass
Seat design force 2 RaR	kips	34.20	34.29	+0.25		Pass
OSL available strength (Table 10-6, 6 in.)	kips	75.00	75.00	+0.00		Pass
Weld L7×4, 5/16 (Table 10-6)	kips	35.60	35.59	-0.01		Pass

ILX result: **OK**; published: **OK**.

K.4: Unstiffened seated connection to an HSS12×12×½ column

Source: AISC Design Examples v16.0, Example K.4. Connection: Seated, support HSS wall.

K.4 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ru	kips	54.00	54.00	+0.00		Pass
lb,min	in.	1.120	1.120	+0.00		Pass
OSL (Table 10-6)	kips	113.0	112.5	-0.44		Pass
Weld (Table 10-6)	kips	66.70	66.74	+0.06		Pass
HSS tmin = 3.09 D / Fu	in.	0.249	0.249	+0.08		Pass

ILX result: **OK**; published: **OK**.

K.4 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
OSL (Table 10-6)	kips	74.90	74.85	-0.07		Pass
Weld (Table 10-6)	kips	44.50	44.49	-0.02		Pass

ILX result: **OK**; published: **OK**.

K.5: Stiffened seated connection to an HSS14×14×½ column (Table 10-15)

Source: AISC Design Examples v16.0, Example K.5. Connection: Seated, support HSS wall.

K.5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ru	kips	120.0	120.0	+0.00		Pass
Wmin, crippling	in.	6.300	6.296	-0.07		Pass
Wmin, yielding	in.	3.350	3.356	+0.19		Pass
Weld, W = 7, l = 24, 5/16 (Table 10-8)	kips	293.0	293.1	+0.03		Pass
Seat plate weld min length 0.2 l	in.	4.800	4.800	+0.00		Pass
HSS tmin	in.	0.249	0.249	+0.08		Pass
(Ru W / t²) required	kip/in.	3,880	3,885	+0.12		Pass
HSS wall strength factor (Table 10-15)	kip/in.	4,250	4,250	+0.00		Pass
HSS width check, required	in.	12.90	12.88	-0.19		Pass

ILX result: **OK**; published: **OK**.

K.5 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Wmin, crippling	in.	6.300	6.296	-0.07		Pass
Wmin, yielding	in.	3.370	3.356	-0.40		Pass
Weld, W = 7, l = 24, 5/16 (Table 10-8)	kips	195.0	195.4	+0.20		Pass
(Ra W / t²) required	kip/in.	2,590	2,590	-0.00		Pass
HSS wall strength factor (Table 10-15)	kip/in.	2,830	2,830	+0.00		Pass

ILX result: **OK**; published: **OK**.

E&S 1999: Ellifritt & Sputo (1999) stiffened seats on column webs, Examples 1, 3, 4

Source: Ellifritt, D.S. and Sputo, T. (1999), Engineering Journal 36(4), pp. 160-168. Connection: Seated, support Column web.

E&S 1999 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ex. 1: stiffener weld φPn (L = 8, W = 6, 5/16 E70, e = 0.8W)	kips	51.40	51.40	+0.00		Pass
Ex. 3: web yield line k (W14×61)		14.76	14.76	+0.02		Pass
Ex. 3: web yield line m (W14×61)		2.225	2.227	+0.07		Pass
Ex. 3: web yield line e (W14×61)	in.	1.750	1.750	+0.00		Pass
Ex. 3: web yield line Pn (W14×61) Nominal value (the paper's yield-line strength).	kips	150.0	150.3	+0.17		Pass
Ex. 4: web yield line k (W16×31)		14.25	14.25	-0.01		Pass
Ex. 4: web yield line m (W16×31)		1.197	1.197	+0.03		Pass
Ex. 4: web yield line Pn (W16×31) Nominal value (the paper's yield-line strength).	kips	78.00	77.99	-0.01		Pass

ILX result: **– (surrogate)**; published: **OK**.

II.A-30: All-bolted shear tee, W16×50 to W14×90 column flange

Source: AISC Design Examples v16.0, Example II.A-30, pp. IIA-293 to IIA-300. Connection: Shear tee, support Column flange.

II.A-30 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Stem bolts (eccentric, e = a): shear, bearing and tearout	kips	43.50	43.41	-0.21		Pass
Tee stem shear yielding	kips	121.0	120.8	-0.21		Pass
Tee stem shear rupture (beam-side bolt line)	kips	81.80	81.90	+0.12		Pass
Tee stem block shear (beam-side bolts)	kips	87.40	87.45	+0.05		Pass
Flange-to-support bolts: shear, bearing and tearout	kips	143.0	143.1	+0.10		Pass
Tee stem flexural yielding	kip-in.	521.0	520.7	-0.05		Pass
Tee stem flexural rupture	kip-in.	386.0	385.0	-0.27		Pass
Total eccentricity of the stem bolt group	in.	3.800	3.800	+0.00		Pass
C, Manual Table 7-6 interpolated at ex = 3.80 in.		2.450	2.447	-0.12		Pass
Required strength Ru	kips	36.00	36.00	+0.00		Pass
Stem required moment Mr	kip-in.	137.0	136.8	-0.15		Pass
Rotational ductility dmin (Manual Eq. 9-52)	in.	0.481	0.481	+0.02		Pass
Stem thickness limit (Manual Eq. 9-53)	in.	0.438	0.438	-0.11		Pass
Flange edge distance (accepted by Table J3.4 footnote [a])	in.	0.895	0.895	+0.00		Pass

ILX result: **OK**; published: **OK**.

II.A-30 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Stem bolts (eccentric, e = a): shear, bearing and tearout	kips	28.90	28.94	+0.13		Pass
Tee stem shear yielding	kips	80.70	80.50	-0.25		Pass
Tee stem shear rupture (beam-side bolt line)	kips	54.50	54.60	+0.18		Pass
Tee stem block shear (beam-side bolts)	kips	58.20	58.30	+0.17		Pass
Flange-to-support bolts: shear, bearing and tearout	kips	95.20	95.43	+0.24		Pass
Tee stem flexural yielding	kip-in.	346.0	346.5	+0.13		Pass
Tee stem flexural rupture	kip-in.	257.0	256.6	-0.14		Pass

ILX result: **OK**; published: **OK**.

II.A-31: Bolted/welded shear tee to a column flange

Source: AISC Design Examples v16.0, Example II.A-31, pp. IIA-301 to IIA-307. Connection: Shear tee, support Column flange.

II.A-31 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Stem bolts (eccentric, e = a): shear, bearing and tearout	kips	43.50	43.41	-0.21		Pass
Tee stem shear yielding	kips	121.0	120.8	-0.21		Pass
Tee stem shear rupture (beam-side bolt line)	kips	81.80	81.90	+0.12		Pass
Tee stem block shear (beam-side bolts)	kips	87.40	87.45	+0.05		Pass
Flange-to-support welds	kips	99.70	99.77	+0.07		Pass
Tee stem flexural yielding	kip-in.	521.0	520.7	-0.05		Pass
Tee stem flexural rupture	kip-in.	386.0	385.0	-0.27		Pass
Minimum flange weld wmin (Manual Eq. 9-51)	in.	0.193	0.194	+0.28		Pass
Minimum support thickness (Table 10-2)	in.	0.190	0.190	+0.20		Pass

ILX result: **OK**; published: **OK**.

II.A-31 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Stem bolts (eccentric, e = a): shear, bearing and tearout	kips	28.90	28.94	+0.13		Pass
Tee stem shear yielding	kips	80.70	80.50	-0.25		Pass
Tee stem shear rupture (beam-side bolt line)	kips	54.50	54.60	+0.18		Pass
Tee stem block shear (beam-side bolts)	kips	58.20	58.30	+0.17		Pass
Flange-to-support welds	kips	66.50	66.51	+0.02		Pass
Tee stem flexural yielding	kip-in.	346.0	346.5	+0.13		Pass
Tee stem flexural rupture	kip-in.	257.0	256.6	-0.14		Pass

ILX result: **OK**; published: **OK**.

K.1: Welded/bolted wide tee to an HSS column

Source: AISC Design Examples v16.0, Example K.1, pp. K-2 to K-10. Connection: Shear tee, support HSS wall.

K.1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Stem bolts (eccentric, e = a): shear, bearing and tearout	kips	47.21	47.22	+0.03		Pass
Tee stem shear yielding	kips	117.0	117.3	+0.26		Pass
Tee stem shear rupture (beam-side bolt line)	kips	79.50	79.56	+0.08		Pass
Tee stem block shear (beam-side bolts)	kips	97.30	97.21	-0.09		Pass
Flange-to-support welds	kips	106.0	105.5	-0.47		Pass
Tee stem flexural yielding	kip-in.	504.0	505.9	+0.37		Pass
Tee stem lateral-torsional buckling (rectangular bar)	kip-in.	465.0	465.1	+0.01		Pass
Tee stem flexural rupture	kip-in.	374.0	374.0	-0.01		Pass
Minimum flange weld wmin (Manual Eq. 9-51)	in.	0.158	0.158	+0.22		Pass
Flare-bevel weld as an equivalent fillet (3.30 sixteenths)	in.	0.206	0.206	-0.15		Pass
Minimum HSS wall thickness	in.	0.164	0.164	+0.25		Pass

ILX result: **OK**; published: **OK**.

K.1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Stem bolts (eccentric, e = a): shear, bearing and tearout	kips	31.47	31.48	+0.03		Pass
Tee stem shear yielding	kips	78.00	78.20	+0.26		Pass
Tee stem shear rupture (beam-side bolt line)	kips	53.00	53.04	+0.08		Pass
Tee stem block shear (beam-side bolts)	kips	64.90	64.81	-0.14		Pass
Flange-to-support welds	kips	70.50	70.34	-0.23		Pass
Tee stem flexural yielding	kip-in.	335.0	336.6	+0.47		Pass
Tee stem lateral-torsional buckling (rectangular bar)	kip-in.	310.0	309.4	-0.19		Pass
Tee stem flexural rupture	kip-in.	250.0	249.3	-0.27		Pass

ILX result: **OK**; published: **OK**.

K.2: Welded/bolted narrow tee to an HSS column

Source: AISC Design Examples v16.0, Example K.2, pp. K-11 to K-13. Connection: Shear tee, support HSS wall.

K.2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Flange-to-support welds	kips	128.0	128.1	+0.06		Pass
Minimum flange weld wmin, capped at 5/8 tsw	in.	0.213	0.212	-0.23		Pass
Minimum HSS wall thickness	in.	0.199	0.200	+0.29		Pass

ILX result: **OK**; published: **OK**.

K.2 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Flange-to-support welds	kips	85.50	85.38	-0.14		Pass

ILX result: **OK**; published: **OK**.

II.A-10: Skewed double bent plate, beam to girder web

Source: AISC Design Examples v16.0, Example II.A-10, pp. IIA-115 to IIA-121. Connection: Skewed double bent plate, support Girder web.

II.A-10 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	80.00	79.96	-0.05		Pass
Required strength, bent plate A (acute)	kips	30.00	29.98	-0.05		Pass
Required strength, bent plate B (obtuse)	kips	50.00	49.98	-0.05		Pass
Weld k = kl / l		0.294	0.294	+0.04		Pass
Weld xl	in.	0.462	0.463	+0.21		Pass
Weld a		0.372	0.372	+0.00		Pass
Weld C (Table 8-8, θ = 0°)		2.520	2.518	-0.07		Pass
Required weld size Dreq (sixteenths)		3.110	3.113	+0.10		Pass
Beam web tmin = 6.19 D / Fu	in.	0.296	0.296	+0.15		Pass
Bolt shear per bolt	kips	24.30	24.35	+0.22		Pass
Plate bearing/tearout, edge bolt (lev = 1¼)	kips	14.30	14.28	-0.12		Pass
Plate bearing, non-edge bolt	kips	31.90	31.99	+0.29		Pass
Girder web bearing, non-edge bolt	kips	50.00	50.16	+0.33		Pass
Shear transfer at bolt holes, plate B	kips	62.90	62.99	+0.14		Pass
Plate B shear yielding	kips	79.80	79.69	-0.14		Pass
Plate B shear rupture	kips	50.30	50.27	-0.05		Pass
Plate B block shear	kips	55.00	53.42	-2.88		Deviation D40

D40 block shear Ant: AISC II.A-10 deducts the slot width (15/16 + 1/16 in.) across the horizontal tension plane; the plates have short slots with the long dimension horizontal (SSLT, 1 1/8 in.), so ILX deducts the slot length per AISC 360-22 B4.3b (app/connections/skewed_bent_plate.py). ILX is conservative by 2.9 %.

ILX governing check: `plate_shear_rupture_obtuse` (Obtuse-side plate: shear rupture), ratio 0.994. ILX result: **OK**; published: **OK**.

II.A-10 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	53.30	53.30	+0.00		Pass
Required strength, bent plate A (acute)	kips	20.00	19.99	-0.06		Pass
Required strength, bent plate B (obtuse)	kips	33.30	33.31	+0.04		Pass
Weld k = kl / l		0.294	0.294	+0.04		Pass
Weld xl	in.	0.462	0.463	+0.21		Pass
Weld a		0.372	0.372	+0.00		Pass
Weld C (Table 8-8, θ = 0°)		2.520	2.518	-0.07		Pass
Required weld size Dreq (sixteenths)		3.110	3.113	+0.08		Pass
Beam web tmin = 6.19 D / Fu	in.	0.296	0.296	+0.14		Pass
Bolt shear per bolt	kips	16.20	16.24	+0.22		Pass
Plate bearing/tearout, edge bolt (lev = 1¼)	kips	9.530	9.521	-0.09		Pass
Plate bearing, non-edge bolt	kips	21.30	21.33	+0.13		Pass
Girder web bearing, non-edge bolt	kips	33.50	33.44	-0.17		Pass
Shear transfer at bolt holes, plate B	kips	41.90	41.99	+0.22		Pass
Plate B shear yielding	kips	53.20	53.12	-0.14		Pass
Plate B shear rupture	kips	33.60	33.52	-0.25		Pass
Plate B block shear	kips	36.70	35.61	-2.97		Deviation D40

D40 block shear Ant: AISC II.A-10 deducts the slot width (15/16 + 1/16 in.) across the horizontal tension plane; the plates have short slots with the long dimension horizontal (SSLT, 1 1/8 in.), so ILX deducts the slot length per AISC 360-22 B4.3b (app/connections/skewed_bent_plate.py). ILX is conservative by 2.9 %.

ILX governing check: `plate_shear_rupture_obtuse` (Obtuse-side plate: shear rupture), ratio 0.994. ILX result: **OK**; published: **OK**.

II.B-1: Bolted flange-plate FR moment connection, W18×50 to W14×99 column flange

Source: AISC Design Examples v16.0, Example II.B-1. Connection: FR moment, support Column flange.

II.B-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Flange bolts, top (tension flange): shear, bearing and tearout	kips	194.0	194.8	+0.43		Pass
Flange bolts, top (tension flange): shear, bearing and tearout (required)	kips	168.0	168.0	+0.00		Pass
Flange plate (top): tensile yielding	kips	237.0	236.2	-0.32		Pass
Flange plate (top): tensile yielding (required)	kips	161.0	161.3	+0.17		Pass
Flange plate (top): tensile rupture	kips	183.0	182.8	-0.10		Pass
Flange plate (top): tensile rupture (required)	kips	161.0	161.3	+0.17		Pass
Flange plate (top): block shear rupture	kips	300.0	299.8	-0.06		Pass
Flange plate (top): block shear rupture (required)	kips	161.0	161.3	+0.17		Pass
Beam flange (top): block shear rupture	kips	294.0	294.5	+0.19		Pass
Beam flange (top): block shear rupture (required)	kips	168.0	168.0	+0.00		Pass
Flange plate (bottom): compression (J4.4)	kips	237.0	236.2	-0.32		Pass
Flange plate (bottom): compression (J4.4) (required)	kips	161.0	161.3	+0.17		Pass
Web plate bolts: shear, bearing and tearout (direct shear)	kips	71.20	71.33	+0.18		Pass
Web plate bolts: shear, bearing and tearout (direct shear) (required)	kips	42.00	42.00	+0.00		Pass
Web plate to column flange: fillet welds (direct shear)	kips	100.0	100.2	+0.23		Pass
Web plate to column flange: fillet welds (direct shear) (required)	kips	42.00	42.00	+0.00		Pass
Web plate: plate shear yielding	kips	101.0	101.2	+0.25		Pass
Web plate: plate shear yielding (required)	kips	42.00	42.00	+0.00		Pass
Web plate: plate shear rupture (beam-side bolt line)	kips	65.90	65.81	-0.13		Pass
Web plate: plate shear rupture (beam-side bolt line) (required)	kips	42.00	42.00	+0.00		Pass
Web plate: plate block shear (beam-side bolts)	kips	82.20	82.27	+0.08		Pass
Web plate: plate block shear (beam-side bolts) (required)	kips	42.00	42.00	+0.00		Pass
Web plate: support shear rupture along the welds (column flange)	kips	410.0	410.7	+0.16		Pass
Web plate: support shear rupture along the welds (column flange) (required)	kips	42.00	42.00	+0.00		Pass
Column flange local bending, top flange force (J10.1)	kips	171.0	171.1	+0.07		Pass
Column flange local bending, top flange force (J10.1) (required)	kips	161.0	161.3	+0.17		Pass
Column web local yielding, top flange force (J10.2)	kips	186.0	185.5	-0.26		Pass
Column web local yielding, top flange force (J10.2) (required)	kips	161.0	161.3	+0.17		Pass
Column web crippling, bottom flange force (J10.3)	kips	233.0	232.3	-0.31		Pass
Column web crippling, bottom flange force (J10.3) (required)	kips	161.0	161.3	+0.17		Pass
Beam flexural rupture at the flange holes (F13.1)	kip-ft	318.0	317.8	-0.06		Pass
Flange force Puf at the faying surface (bolts, dm = d)	kips	168.0	168.0	+0.00		Pass
Flange force Puf at the plate centroid (plates, dm = d + tp)	kips	161.0	161.3	+0.17		Pass
Plate-to-column fillet weld, Dmin (sixteenths)	sixteenths	5.510	5.517	+0.14		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Column flange local bending Rn = 6.25 Fy tf² (J10-1, nominal)	kips	190.0	190.1	+0.07		Pass
Beam tension flange rupture Mn (F13-1, nominal)	kip-ft	353.0	353.1	+0.04		Pass

ILX result: **OK**; published: **OK**.

II.B-1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Flange bolts, top (tension flange): shear, bearing and tearout	kips	130.0	129.9	-0.09		Pass
Flange bolts, top (tension flange): shear, bearing and tearout (required)	kips	112.0	112.0	+0.00		Pass
Flange plate (top): tensile yielding	kips	157.0	157.2	+0.12		Pass
Flange plate (top): tensile yielding (required)	kips	108.0	107.5	-0.44		Pass
Flange plate (top): tensile rupture	kips	122.0	121.9	-0.10		Pass
Flange plate (top): tensile rupture (required)	kips	108.0	107.5	-0.44		Pass
Flange plate (top): block shear rupture	kips	200.0	199.9	-0.06		Pass
Flange plate (top): block shear rupture (required)	kips	108.0	107.5	-0.44		Pass
Beam flange (top): block shear rupture	kips	197.0	196.4	-0.32		Pass
Beam flange (top): block shear rupture (required)	kips	112.0	112.0	+0.00		Pass
Flange plate (bottom): compression (J4.4)	kips	157.0	157.2	+0.12		Pass
Flange plate (bottom): compression (J4.4) (required)	kips	108.0	107.5	-0.44		Pass
Web plate bolts: shear, bearing and tearout (direct shear)	kips	47.50	47.55	+0.11		Pass
Web plate bolts: shear, bearing and tearout (direct shear) (required)	kips	28.00	28.00	+0.00		Pass
Web plate to column flange: fillet welds (direct shear)	kips	66.80	66.82	+0.03		Pass
Web plate to column flange: fillet welds (direct shear) (required)	kips	28.00	28.00	+0.00		Pass
Web plate: plate shear yielding	kips	67.30	67.50	+0.30		Pass
Web plate: plate shear yielding (required)	kips	28.00	28.00	+0.00		Pass
Web plate: plate shear rupture (beam-side bolt line)	kips	43.90	43.88	-0.06		Pass
Web plate: plate shear rupture (beam-side bolt line) (required)	kips	28.00	28.00	+0.00		Pass
Web plate: plate block shear (beam-side bolts)	kips	54.90	54.84	-0.10		Pass
Web plate: plate block shear (beam-side bolts) (required)	kips	28.00	28.00	+0.00		Pass
Web plate: support shear rupture along the welds (column flange)	kips	273.0	273.8	+0.29		Pass
Web plate: support shear rupture along the welds (column flange) (required)	kips	28.00	28.00	+0.00		Pass
Column flange local bending, top flange force (J10.1)	kips	114.0	113.8	-0.13		Pass
Column flange local bending, top flange force (J10.1) (required)	kips	108.0	107.5	-0.44		Pass
Column web local yielding, top flange force (J10.2)	kips	124.0	123.7	-0.26		Pass
Column web local yielding, top flange force (J10.2) (required)	kips	108.0	107.5	-0.44		Pass
Column web crippling, bottom flange force (J10.3)	kips	155.0	154.8	-0.10		Pass
Column web crippling, bottom flange force (J10.3) (required)	kips	108.0	107.5	-0.44		Pass
Beam flexural rupture at the flange holes (F13.1)	kip-ft	211.0	211.5	+0.22		Pass
Flange force Puf at the faying surface (bolts, dm = d)	kips	112.0	112.0	+0.00		Pass
Flange force Puf at the plate centroid (plates, dm = d + tp)	kips	108.0	107.5	-0.44		Pass

ILX result: **OK**; published: **OK**.

II.B-2: Welded flange-plate FR moment connection, W18×50 to W14×99 column flange

Source: AISC Design Examples v16.0, Example II.B-2. Connection: FR moment, support Column flange.

II.B-2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Flange plate (top): tensile yielding	kips	270.0	270.0	+0.00		Pass
Flange plate (top): tensile yielding (required)	kips	160.0	160.2	+0.13		Pass
Fillet welds, top plate to beam flange	kips	169.0	168.4	-0.35		Pass
Fillet welds, top plate to beam flange (required)	kips	168.0	168.0	+0.00		Pass
Flange plate (bottom): compression (J4.4)	kips	295.0	295.3	+0.11		Pass
Flange plate (bottom): compression (J4.4) (required)	kips	160.0	160.2	+0.13		Pass
Fillet welds, bottom plate to beam flange	kips	174.0	174.0	+0.01		Pass
Fillet welds, bottom plate to beam flange (required)	kips	168.0	168.0	+0.00		Pass
Beam flange (bottom): shear rupture at the welds	kips	419.0	416.8	-0.52		Pass
Beam flange (bottom): shear rupture at the welds (required)	kips	168.0	168.0	+0.00		Pass
Top plate-to-beam weld length lw = 10.5 − 1 − ¼ − 5/16	in.	8.940	8.938	-0.03		Pass
Moment arm dm between the plates	in.	18.90	18.88	-0.13		Pass
Base metal tmin = 3.09 D / Fu	in.	0.238	0.238	-0.13		Pass
Plate-to-column fillet Dmin, top plate (sixteenths)	sixteenths	6.390	6.394	+0.06		Pass
Plate-to-column fillet Dmin, bottom plate (sixteenths)	sixteenths	4.380	4.384	+0.10		Pass
Top plate weld group, longitudinal + transverse (J2-6, nominal)	kips	225.0	224.5	-0.21		Pass

ILX result: **OK**; published: **OK**.

II.B-2 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Flange plate (top): tensile yielding	kips	180.0	179.6	-0.20		Pass
Flange plate (top): tensile yielding (required)	kips	107.0	106.8	-0.18		Pass
Fillet welds, top plate to beam flange	kips	113.0	112.3	-0.65		Pass
Fillet welds, top plate to beam flange (required)	kips	112.0	112.0	+0.00		Pass
Flange plate (bottom): compression (J4.4)	kips	196.0	196.5	+0.25		Pass
Flange plate (bottom): compression (J4.4) (required)	kips	107.0	106.8	-0.18		Pass
Fillet welds, bottom plate to beam flange	kips	116.0	116.0	+0.01		Pass
Fillet welds, bottom plate to beam flange (required)	kips	112.0	112.0	+0.00		Pass
Beam flange (bottom): shear rupture at the welds	kips	279.0	277.9	-0.40		Pass
Beam flange (bottom): shear rupture at the welds (required)	kips	112.0	112.0	+0.00		Pass
Top plate-to-beam weld length lw = 10.5 − 1 − ¼ − 5/16	in.	8.940	8.938	-0.03		Pass
Moment arm dm between the plates	in.	18.90	18.88	-0.13		Pass
Base metal tmin = 3.09 D / Fu	in.	0.238	0.238	-0.13		Pass
Plate-to-column fillet Dmin, top plate (sixteenths)	sixteenths	6.390	6.394	+0.06		Pass
Plate-to-column fillet Dmin, bottom plate (sixteenths)	sixteenths	4.380	4.384	+0.10		Pass

ILX result: **OK**; published: **OK**.

II.B-3: Directly welded flange FR moment connection, W18×50 to W14×99 column flange

Source: AISC Design Examples v16.0, Example II.B-3. Connection: FR moment, support Column flange.

II.B-3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Web plate bolts: shear, bearing and tearout (direct shear)	kips	71.20	71.33	+0.18		Pass
Flange force Puf = Mu / (d − tf)	kips	173.5	173.5	-0.00		Pass

ILX result: **OK**; published: **OK**.

II.B-3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Web plate bolts: shear, bearing and tearout (direct shear)	kips	47.50	47.55	+0.11		Pass
Flange force Puf = Mu / (d − tf)	kips	115.7	115.7	-0.03		Pass

ILX result: **OK**; published: **OK**.

J.7: Web local yielding and crippling of a W24×55 girder, lb = 7.50 in. (J10)

Source: AISC Design Examples v16.0, Example J.7, pp. J-24 to J-26. Connection: FR moment.

J.7 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Web local yielding Rn (J10-2, nominal)	kips	248.0	247.9	-0.06		Pass
Web local crippling Rn (J10-4, nominal)	kips	282.0	282.0	+0.01		Pass
Web local crippling φRn	kips	212.0	211.5	-0.22		Pass

ILX result: **– (surrogate)**; published: **OK**.

J.7 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Web local crippling Rn/Ω	kips	141.0	141.0	+0.01		Pass

ILX result: **– (surrogate)**; published: **OK**.

DG39-5.2-1: Two-bolt flush unstiffened, thick end plate

Source: AISC Design Guide 39 (2023), Example 5.2-1, pp. 66-77. Connection: End-plate moment.

DG39-5.2-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.470	2.475	+0.20		Pass
Yield-line parameter Yp	in.	93.90	93.67	-0.25		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	829.0	828.5	-0.06		Pass
db,reqd (Eq. 5-3)	in.	0.708	0.709	+0.08		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.519	0.520	+0.17		Pass
Shear transfer, compression bolts	kips	35.90	35.78	-0.32		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	48.00	47.96	-0.08		Pass
Flange weld demand (Eq. 3-38)	kips	76.50	76.50	+0.00		Pass
Flange fillet length lw	in.	10.50	10.50	+0.00		Pass
Flange weld strength	kips	87.80	87.70	-0.11		Pass
Web tension zone length	in.	7.500	7.500	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	48.00	47.96	-0.08		Pass
Web tension yielding	kips	102.0	101.2	-0.74		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	67.80	67.50	-0.44		Pass
Web weld strength near the tension bolts	kips	93.80	93.97	+0.18		Pass
Shear weld length lwv	in.	8.430	8.425	-0.06		Pass
Web weld strength for shear	kips	70.40	70.37	-0.04		Pass
Web shear rupture at the weld	kips	74.00	73.93	-0.10		Pass
Column flange Yc (Appendix A)	in.	91.20	91.10	-0.10		Pass
Column flange Mcf (Eq. 3-43)	kip-in.	1,230	1,232	+0.14		Pass
Column web local yielding (Eq. 3-46)	kips	99.90	100.2	+0.34		Pass
Column web crippling (J10-4)	kips	101.0	101.5	+0.47		Pass
Panel-zone shear demand (Eq. 3-34)	kips	48.00	47.96	-0.08		Pass
Panel-zone shear strength	kips	102.0	101.2	-0.74		Pass
Cap plate to column flange weld	kips	83.30	83.53	+0.27		Pass
Cap plate to column web weld	kips	128.0	127.6	-0.29		Pass
Column web rupture at the cap plate	kips	101.0	100.6	-0.43		Pass

ILX governing check: (Cap plate to column flange weld (Example 5.2-1)), ratio 0.916. ILX result: **OK**; published: **OK**.

DG39-5.2-1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.470	2.475	+0.20		Pass
Yield-line parameter Yp	in.	93.90	93.67	-0.25		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	552.0	552.0	+0.00		Pass
db,reqd (Eq. 5-3)	in.	0.708	0.708	+0.05		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.520	0.520	+0.04		Pass
Shear transfer, compression bolts	kips	23.90	23.86	-0.18		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	32.00	31.95	-0.14		Pass
Flange weld demand (Eq. 3-38)	kips	51.00	51.00	+0.00		Pass
Flange fillet length lw	in.	10.50	10.50	+0.00		Pass
Flange weld strength	kips	58.50	58.47	-0.05		Pass
Web tension zone length	in.	7.500	7.500	+0.00		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Web tension demand (Eq. 3-40)	kips	32.00	31.95	-0.14		Pass
Web tension yielding	kips	67.70	67.37	-0.49		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	45.20	45.00	-0.44		Pass
Web weld strength near the tension bolts	kips	62.50	62.65	+0.23		Pass
Shear weld length lwv	in.	8.430	8.425	-0.06		Pass
Web weld strength for shear	kips	47.00	46.91	-0.18		Pass
Web shear rupture at the weld	kips	49.30	49.29	-0.03		Pass
Column flange Yc (Appendix A)	in.	91.20	91.10	-0.10		Pass
Column flange Mcf (Eq. 3-43)	kip-in.	1,230	1,232	+0.14		Pass
Column web local yielding (Eq. 3-46)	kips	66.60	66.83	+0.34		Pass
Column web crippling (J10-4)	kips	67.50	67.65	+0.22		Pass
Panel-zone shear demand (Eq. 3-34)	kips	32.00	31.95	-0.14		Pass
Panel-zone shear strength	kips	67.70	67.37	-0.49		Pass
Cap plate to column flange weld	kips	55.50	55.68	+0.33		Pass
Cap plate to column web weld	kips	85.00	85.09	+0.10		Pass
Column web rupture at the cap plate	kips	67.00	67.04	+0.06		Pass

ILX governing check: (Cap plate to column flange weld (Example 5.2-1)), ratio 0.916. ILX result: **OK**; published: **OK**.

DG39-5.2-2: Four-bolt flush unstiffened, thick end plate

Source: AISC Design Guide 39 (2023), Example 5.2-2, pp. 77-83. Connection: End-plate moment.

DG39-5.2-2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.120	2.121	+0.06		Pass
Yield-line parameter Yp	in.	114.0	113.3	-0.57		Pass
db,reqd (Eq. 5-3)	in.	0.708	0.709	+0.17		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.634	0.636	+0.30		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	86.80	86.83	+0.04		Pass
Flange weld demand (Eq. 3-38)	kips	86.80	86.83	+0.04		Pass
Flange fillet length lw	in.	10.50	10.50	+0.00		Pass
Flange weld strength	kips	110.0	109.6	-0.34		Pass
Web tension zone length	in.	10.50	10.50	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	86.80	86.83	+0.04		Pass
Web tension yielding	kips	142.0	141.8	-0.18		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	94.80	94.50	-0.32		Pass
Web weld strength near the tension bolts	kips	131.0	131.6	+0.42		Pass
Shear weld length lwv	in.	6.350	6.350	-0.00		Pass
Web weld strength for shear	kips	53.00	53.04	+0.07		Pass
Web shear rupture at the weld	kips	55.70	55.72	+0.04		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.894. ILX result: **OK**; published: **OK**.

DG39-5.2-2 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.120	2.121	+0.06		Pass
Yield-line parameter Yp	in.	114.0	113.3	-0.57		Pass
db,reqd (Eq. 5-3)	in.	0.708	0.709	+0.17		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.635	0.637	+0.24		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	57.90	57.89	-0.02		Pass
Flange weld demand (Eq. 3-38)	kips	57.90	57.89	-0.02		Pass
Flange fillet length lw	in.	10.50	10.50	+0.00		Pass
Flange weld strength	kips	73.00	73.09	+0.12		Pass
Web tension zone length	in.	10.50	10.50	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	57.90	57.89	-0.02		Pass
Web tension yielding	kips	94.60	94.31	-0.31		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	63.20	63.00	-0.32		Pass
Web weld strength near the tension bolts	kips	87.50	87.70	+0.23		Pass
Shear weld length lwv	in.	6.350	6.350	-0.00		Pass
Web weld strength for shear	kips	35.40	35.36	-0.11		Pass
Web shear rupture at the weld	kips	37.20	37.15	-0.14		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.894. ILX result: **OK**; published: **OK**.

DG39-5.2-3: Four-bolt flush, web stiffeners between the tension rows, thick end plate

Source: AISC Design Guide 39 (2023), Example 5.2-3, pp. 83-91. Connection: End-plate moment.

DG39-5.2-3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.290	2.291	+0.06		Pass
Yield-line parameter Yp	in.	181.0	180.8	-0.10		Pass
db,reqd (Eq. 5-3)	in.	0.854	0.855	+0.12		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.650	0.650	-0.01		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	128.0	128.2	+0.16		Pass
Flange weld demand (Eq. 3-38)	kips	128.0	128.2	+0.16		Pass
Flange fillet length lw	in.	11.40	11.38	-0.22		Pass
Flange weld strength	kips	143.0	142.5	-0.34		Pass
Web weld length near the tension bolts	in.	23.60	23.58	-0.07		Pass
Web tension area Awt	in.²	2.950	2.948	-0.07		Pass
Web tension demand (Eq. 3-40)	kips	128.0	128.2	+0.16		Pass
Web tension yielding	kips	133.0	132.7	-0.26		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	128.0	128.2	+0.16		Pass
Web weld strength near the tension bolts	kips	148.0	147.7	-0.18		Pass
Shear weld length lwv	in.	9.500	9.500	+0.00		Pass
Web weld strength for shear	kips	79.50	79.35	-0.19		Pass
Web shear rupture at the weld	kips	69.50	69.47	-0.04		Pass
Web stiffener weld demand	kips	51.60	51.65	+0.09		Pass
Web stiffener weld strength	kips	75.00	75.17	+0.23		Pass
Web base metal rupture at the stiffener welds	kips	65.90	65.81	-0.13		Pass

ILX governing check: (Beam web tension yielding near the tension bolts (DG39 Eq. 3-40; J4.1(a))), ratio 0.966. ILX result: **OK**; published: **OK**.

DG39-5.2-3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.290	2.291	+0.06		Pass
Yield-line parameter Yp	in.	181.0	180.8	-0.10		Pass
db,reqd (Eq. 5-3)	in.	0.855	0.856	+0.11		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.651	0.651	+0.04		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	85.60	85.64	+0.05		Pass
Flange weld demand (Eq. 3-38)	kips	85.60	85.64	+0.05		Pass
Flange fillet length lw	in.	11.40	11.38	-0.22		Pass
Flange weld strength	kips	95.00	95.01	+0.01		Pass
Web weld length near the tension bolts	in.	23.60	23.58	-0.07		Pass
Web tension area Awt	in.²	2.950	2.948	-0.07		Pass
Web tension demand (Eq. 3-40)	kips	85.60	85.64	+0.05		Pass
Web tension yielding	kips	88.60	88.26	-0.39		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	85.60	85.64	+0.05		Pass
Web weld strength near the tension bolts	kips	98.50	98.49	-0.01		Pass
Shear weld length lwv	in.	9.500	9.500	+0.00		Pass
Web weld strength for shear	kips	53.00	52.90	-0.19		Pass
Web shear rupture at the weld	kips	46.30	46.31	+0.03		Pass
Web stiffener weld demand	kips	34.50	34.50	-0.00		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Web stiffener weld strength	kips	50.00	50.12	+0.23		Pass
Web base metal rupture at the stiffener welds	kips	43.90	43.88	-0.06		Pass

ILX governing check: (Beam web tension yielding near the tension bolts (DG39 Eq. 3-40; J4.1(a))), ratio 0.970. ILX result: **OK**; published: **OK**.

DG39-5.2-4: Four-bolt flush, web stiffeners below the tension rows, thick end plate

Source: AISC Design Guide 39 (2023), Example 5.2-4, pp. 91-98. Connection: End-plate moment.

DG39-5.2-4 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.290	2.291	+0.06		Pass
Yield-line parameter Yp	in.	124.0	123.8	-0.20		Pass
db,reqd (Eq. 5-3)	in.	0.850	0.852	+0.21		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.785	0.786	+0.09		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	128.0	128.2	+0.16		Pass
Flange weld demand (Eq. 3-38)	kips	128.0	128.2	+0.16		Pass
Flange fillet length lw	in.	11.40	11.38	-0.22		Pass
Flange weld strength	kips	143.0	142.5	-0.34		Pass
Web weld length near the tension bolts	in.	22.10	22.12	+0.11		Pass
Web tension area Awt	in.²	3.070	3.062	-0.24		Pass
Web tension demand (Eq. 3-40)	kips	128.0	128.2	+0.16		Pass
Web tension yielding	kips	139.0	137.8	-0.85		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	128.0	128.2	+0.16		Pass
Web weld strength near the tension bolts	kips	139.0	138.6	-0.29		Pass
Shear weld length lwv	in.	9.500	9.500	+0.00		Pass
Web weld strength for shear	kips	79.50	79.35	-0.19		Pass
Web shear rupture at the weld	kips	69.50	69.47	-0.04		Pass
Web stiffener weld demand	kips	62.10	62.14	+0.06		Pass
Web stiffener weld strength	kips	75.00	75.17	+0.23		Pass
Web base metal rupture at the stiffener welds	kips	65.80	65.81	+0.02		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.948. ILX result: **OK**; published: **OK**.

DG39-5.2-4 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.290	2.291	+0.06		Pass
Yield-line parameter Yp	in.	124.0	123.8	-0.20		Pass
db,reqd (Eq. 5-3)	in.	0.851	0.853	+0.19		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.786	0.787	+0.16		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	85.60	85.64	+0.05		Pass
Flange weld demand (Eq. 3-38)	kips	85.60	85.64	+0.05		Pass
Flange fillet length lw	in.	11.40	11.38	-0.22		Pass
Flange weld strength	kips	95.00	95.01	+0.01		Pass
Web weld length near the tension bolts	in.	22.10	22.12	+0.11		Pass
Web tension area Awt	in.²	3.070	3.062	-0.24		Pass
Web tension demand (Eq. 3-40)	kips	85.60	85.64	+0.05		Pass
Web tension yielding	kips	92.20	91.69	-0.55		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	85.60	85.64	+0.05		Pass
Web weld strength near the tension bolts	kips	92.50	92.40	-0.11		Pass
Shear weld length lwv	in.	9.500	9.500	+0.00		Pass
Web weld strength for shear	kips	53.00	52.90	-0.19		Pass
Web shear rupture at the weld	kips	46.30	46.31	+0.03		Pass
Web stiffener weld demand	kips	41.50	41.51	+0.02		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Web stiffener weld strength	kips	50.00	50.12	+0.23		Pass
Web base metal rupture at the stiffener welds	kips	43.90	43.88	-0.06		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.949. ILX result: **OK**; published: **OK**.

DG39-5.2-5: Six-bolt flush unstiffened (three rows), thick end plate

Source: AISC Design Guide 39 (2023), Example 5.2-5, pp. 99-105. Connection: End-plate moment.

DG39-5.2-5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.710	3.708	-0.05		Pass
Yield-line parameter Yp	in.	391.0	391.4	+0.11		Pass
db,reqd (Eq. 5-3)	in.	0.925	0.925	-0.04		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	1.050	1.045	-0.44		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	298.0	297.9	-0.04		Pass
Flange weld demand (Eq. 3-38)	kips	300.0	300.0	+0.00		Pass
Flange fillet length lw	in.	18.90	18.88	-0.13		Pass
Flange weld strength	kips	316.0	315.3	-0.22		Pass
Web tension zone length	in.	15.00	15.00	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	298.0	297.9	-0.04		Pass
Web tension yielding	kips	338.0	337.5	-0.15		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	298.0	297.9	-0.04		Pass
Web weld strength near the tension bolts	kips	314.0	313.2	-0.25		Pass
Shear weld length lwv	in.	23.00	23.00	+0.00		Pass
Web weld strength for shear	kips	192.0	192.1	+0.06		Pass
Web shear rupture at the weld	kips	337.0	336.4	-0.19		Pass

ILX governing check: (Beam flange to end-plate fillet welds (DG39 Eq. 3-38)), ratio 0.951. ILX result: **OK**; published: **OK**.

DG39-5.2-5 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.710	3.708	-0.05		Pass
Yield-line parameter Yp	in.	391.0	391.4	+0.11		Pass
db,reqd (Eq. 5-3)	in.	0.924	0.924	+0.05		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	1.050	1.046	-0.35		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	199.0	198.5	-0.25		Pass
Flange weld demand (Eq. 3-38)	kips	200.0	200.0	+0.00		Pass
Flange fillet length lw	in.	18.90	18.88	-0.13		Pass
Flange weld strength	kips	211.0	210.2	-0.37		Pass
Web tension zone length	in.	15.00	15.00	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	199.0	198.5	-0.25		Pass
Web tension yielding	kips	225.0	224.6	-0.20		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	199.0	198.5	-0.25		Pass
Web weld strength near the tension bolts	kips	209.0	208.8	-0.09		Pass
Shear weld length lwv	in.	23.00	23.00	+0.00		Pass
Web weld strength for shear	kips	128.0	128.1	+0.06		Pass
Web shear rupture at the weld	kips	225.0	224.2	-0.33		Pass

ILX governing check: (Beam flange to end-plate fillet welds (DG39 Eq. 3-38)), ratio 0.951. ILX result: **OK**; published: **OK**.

DG39-5.2-6: Six-bolt flush four-wide / two-wide unstiffened, thick end plate

Source: AISC Design Guide 39 (2023), Example 5.2-6, pp. 105-111. Connection: End-plate moment.

DG39-5.2-6 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.740	3.742	+0.04		Pass
Yield-line parameter Yp	in.	436.0	435.7	-0.06		Pass
db,reqd (Eq. 5-3)	in.	0.927	0.927	-0.00		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	1.030	1.026	-0.43		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	317.0	317.5	+0.15		Pass
Flange weld demand (Eq. 3-38)	kips	317.0	317.5	+0.15		Pass
Flange fillet length lw	in.	24.90	24.88	-0.10		Pass
Flange weld strength	kips	364.0	363.6	-0.11		Pass
Web tension zone length	in.	11.50	11.50	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	211.0	211.6	+0.30		Pass
Web tension yielding	kips	259.0	258.8	-0.10		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	211.0	211.6	+0.30		Pass
Web weld strength near the tension bolts	kips	240.0	240.1	+0.06		Pass
Shear weld length lwv	in.	23.30	23.25	-0.21		Pass
Web weld strength for shear	kips	194.0	194.2	+0.10		Pass
Web shear rupture at the weld	kips	341.0	340.0	-0.28		Pass

ILX governing check: (Beam web to end-plate welds near the tension bolts (DG39 Eq. 3-41)), ratio 0.881. ILX result: **OK**; published: **OK**.

DG39-5.2-6 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.740	3.742	+0.04		Pass
Yield-line parameter Yp	in.	436.0	435.7	-0.06		Pass
db,reqd (Eq. 5-3)	in.	0.927	0.927	-0.00		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	1.030	1.027	-0.33		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	212.0	211.6	-0.17		Pass
Flange weld demand (Eq. 3-38)	kips	212.0	211.6	-0.17		Pass
Flange fillet length lw	in.	24.90	24.88	-0.10		Pass
Flange weld strength	kips	243.0	242.4	-0.25		Pass
Web tension zone length	in.	11.50	11.50	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	141.0	141.1	+0.07		Pass
Web tension yielding	kips	172.0	172.2	+0.09		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	141.0	141.1	+0.07		Pass
Web weld strength near the tension bolts	kips	160.0	160.1	+0.06		Pass
Shear weld length lwv	in.	23.30	23.25	-0.21		Pass
Web weld strength for shear	kips	130.0	129.5	-0.41		Pass
Web shear rupture at the weld	kips	227.0	226.7	-0.14		Pass

ILX governing check: (Beam web to end-plate welds near the tension bolts (DG39 Eq. 3-41)), ratio 0.881. ILX result: **OK**; published: **OK**.

DG39-5.3-1: Four-bolt extended unstiffened (4E), thick end plate

Source: AISC Design Guide 39 (2023), Example 5.3-1, pp. 123-137. Connection: End-plate moment.

DG39-5.3-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.450	2.449	-0.02		Pass
Yield-line parameter Yp	in.	186.0	185.8	-0.11		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	2,640	2,640	-0.00		Pass
db,reqd (Eq. 5-3)	in.	0.720	0.720	+0.03		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.589	0.589	+0.06		Pass
Shear transfer, compression bolts	kips	71.70	71.57	-0.18		Pass
Extended part shear demand	kips	55.90	55.87	-0.05		Pass
Extended part shear yielding	kips	150.0	150.0	+0.00		Pass
Extended part shear rupture	kips	114.0	114.3	+0.23		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	112.0	111.7	-0.23		Pass
Flange weld demand (Eq. 3-38)	kips	112.0	111.7	-0.23		Pass
Flange fillet length lw	in.	15.80	15.75	-0.32		Pass
Flange weld strength	kips	132.0	131.6	-0.34		Pass
Web tension zone length	in.	7.750	7.750	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	56.00	55.87	-0.23		Pass
Web tension yielding	kips	87.20	87.19	-0.01		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	58.10	58.12	+0.04		Pass
Web weld strength near the tension bolts	kips	96.80	97.10	+0.31		Pass
Shear weld length lwv	in.	11.60	11.62	+0.22		Pass
Web weld strength for shear	kips	96.80	97.10	+0.31		Pass
Web shear rupture at the weld	kips	84.80	85.01	+0.25		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.922. ILX result: **OK**; published: **OK**.

DG39-5.3-1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.450	2.449	-0.02		Pass
Yield-line parameter Yp	in.	186.0	185.8	-0.11		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	1,760	1,756	-0.21		Pass
db,reqd (Eq. 5-3)	in.	0.720	0.719	-0.08		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.590	0.589	-0.12		Pass
Shear transfer, compression bolts	kips	47.80	47.71	-0.18		Pass
Extended part shear demand	kips	37.20	37.17	-0.08		Pass
Extended part shear yielding	kips	100.0	100.0	+0.00		Pass
Extended part shear rupture	kips	76.00	76.17	+0.23		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	74.30	74.34	+0.05		Pass
Flange weld demand (Eq. 3-38)	kips	74.30	74.34	+0.05		Pass
Flange fillet length lw	in.	15.80	15.75	-0.32		Pass
Flange weld strength	kips	88.00	87.70	-0.34		Pass
Web tension zone length	in.	7.750	7.750	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	37.20	37.17	-0.08		Pass
Web tension yielding	kips	58.00	58.01	+0.02		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	38.80	38.75	-0.13		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Web weld strength near the tension bolts	kips	64.50	64.73	+0.36		Pass
Shear weld length lwv	in.	11.60	11.62	+0.22		Pass
Web weld strength for shear	kips	64.50	64.73	+0.36		Pass
Web shear rupture at the weld	kips	56.50	56.67	+0.30		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.920. ILX result: **OK**; published: **OK**.

DG39-5.3-2: Four-bolt extended stiffened (4ES), thick end plate

Source: AISC Design Guide 39 (2023), Example 5.3-2, pp. 137-153. Connection: End-plate moment.

DG39-5.3-2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.600	3.597	-0.09		Pass
Yield-line parameter Yp	in.	233.0	232.9	-0.06		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	7,860	7,858	-0.03		Pass
db,reqd (Eq. 5-3)	in.	1.120	1.116	-0.37		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.908	0.908	+0.03		Pass
Shear transfer, compression bolts	kips	203.0	202.8	-0.11		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	337.0	336.8	-0.05		Pass
Web tension zone length	in.	8.000	8.000	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	169.0	168.4	-0.35		Pass
Web tension yielding	kips	169.0	169.2	+0.12		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	169.0	168.4	-0.35		Pass
Web weld strength near the tension bolts	kips	200.0	200.5	+0.23		Pass
Shear weld length lwv	in.	11.30	11.28	-0.18		Pass
Web weld strength for shear	kips	126.0	125.6	-0.30		Pass
Web shear rupture at the weld	kips	155.0	155.1	+0.05		Pass
Stiffener-to-flange weld demand (per in.)	kips	15.00	15.00	+0.00		Pass
Stiffener-to-flange weld strength (per in.)	kips	16.70	16.71	+0.03		Pass
Stiffener-to-plate weld demand (per in.)	kips	25.00	25.00	+0.00		Pass
Stiffener-to-plate weld strength (per in.)	kips	25.10	25.06	-0.17		Pass
Column flange Yc (Appendix A)	in.	202.0	202.1	+0.06		Pass
Column flange Mcf (Eq. 3-43)	kip-in.	6,140	6,149	+0.14		Pass
Column flange strength φRn (Eq. 3-42)	kips	237.0	237.2	+0.09		Pass
Stiffened column flange Yc	in.	321.0	320.6	-0.13		Pass
Stiffened column flange strength	kips	376.0	376.2	+0.06		Pass
Column web local yielding (Eq. 3-46)	kips	268.0	268.0	-0.01		Pass
Column web crippling (J10-4)	kips	278.0	277.4	-0.23		Pass
Continuity plate required strength (Eq. 3-48)	kips	100.0	99.62	-0.38		Pass
Panel-zone shear demand (Eq. 3-34)	kips	297.0	296.8	-0.06		Pass
Panel-zone shear strength with the doubler	kips	329.0	329.7	+0.22		Pass

ILX governing check: (End-plate stiffener to end-plate welds, per inch (tensile yield of the stiffener)), ratio 0.998. ILX result: **OK**; published: **OK**.

DG39-5.3-2 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.600	3.597	-0.09		Pass
Yield-line parameter Yp	in.	233.0	232.9	-0.06		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	5,240	5,239	-0.03		Pass
db,reqd (Eq. 5-3)	in.	1.120	1.116	-0.37		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.909	0.909	+0.02		Pass
Shear transfer, compression bolts	kips	135.0	135.2	+0.14		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	225.0	224.5	-0.20		Pass
Web tension zone length	in.	8.000	8.000	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	113.0	112.3	-0.64		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Web tension yielding	kips	113.0	112.6	-0.38		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	113.0	112.3	-0.64		Pass
Web weld strength near the tension bolts	kips	134.0	133.6	-0.27		Pass
Shear weld length lwv	in.	11.30	11.28	-0.18		Pass
Web weld strength for shear	kips	84.00	83.75	-0.30		Pass
Web shear rupture at the weld	kips	104.0	103.4	-0.59		Pass
Stiffener-to-flange weld demand (per in.)	kips	10.00	10.00	+0.00		Pass
Stiffener-to-flange weld strength (per in.)	kips	11.20	11.14	-0.56		Pass
Stiffener-to-plate weld demand (per in.)	kips	16.70	16.67	-0.20		Pass
Stiffener-to-plate weld strength (per in.)	kips	16.70	16.71	+0.03		Pass
Column flange Yc (Appendix A)	in.	202.0	202.1	+0.06		Pass
Column flange Mcf (Eq. 3-43)	kip-in.	6,140	6,149	+0.14		Pass
Column flange strength φRn (Eq. 3-42)	kips	157.0	157.8	+0.52		Pass
Stiffened column flange Yc	in.	321.0	320.6	-0.13		Pass
Stiffened column flange strength	kips	250.0	250.3	+0.12		Pass
Column web local yielding (Eq. 3-46)	kips	179.0	178.6	-0.20		Pass
Column web crippling (J10-4)	kips	185.0	184.9	-0.05		Pass
Continuity plate required strength (Eq. 3-48)	kips	68.00	66.73	-1.87		Pass
Panel-zone shear demand (Eq. 3-34)	kips	198.0	197.8	-0.08		Pass
Panel-zone shear strength with the doubler	kips	219.0	219.4	+0.17		Pass

ILX governing check: (End-plate stiffener to end-plate welds, per inch (tensile yield of the stiffener)), ratio 0.998. ILX result: **OK**; published: **OK**.

DG39-5.3-3: Multiple-row extended 1/2 unstiffened, thick end plate

Source: AISC Design Guide 39 (2023), Example 5.3-3, pp. 153-159. Connection: End-plate moment.

DG39-5.3-3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	195.0	194.7	-0.16		Pass
db,reqd (Eq. 5-3)	in.	0.831	0.831	+0.04		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.776	0.776	+0.04		Pass
Extended part shear demand	kips	68.10	68.09	-0.02		Pass
Extended part shear yielding	kips	210.0	210.0	+0.00		Pass
Extended part shear rupture	kips	154.0	153.6	-0.28		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	204.0	204.3	+0.13		Pass
Web tension zone length	in.	10.80	10.75	-0.46		Pass
Web tension demand (Eq. 3-40)	kips	136.0	136.2	+0.13		Pass
Web tension yielding	kips	183.0	181.4	-0.87		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	136.0	136.2	+0.13		Pass
Web weld strength near the tension bolts	kips	181.0	179.6	-0.78		Pass
Shear weld length lwv	in.	11.50	11.50	+0.00		Pass
Web weld strength for shear	kips	96.00	96.06	+0.06		Pass
Web shear rupture at the weld	kips	126.0	126.1	+0.11		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.903. ILX result: **OK**; published: **OK**.

DG39-5.3-3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	195.0	194.7	-0.16		Pass
db,reqd (Eq. 5-3)	in.	0.831	0.831	+0.04		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.776	0.777	+0.14		Pass
Extended part shear demand	kips	45.40	45.39	-0.02		Pass
Extended part shear yielding	kips	140.0	140.0	+0.00		Pass
Extended part shear rupture	kips	103.0	102.4	-0.61		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	136.0	136.2	+0.13		Pass
Web tension zone length	in.	10.80	10.75	-0.46		Pass
Web tension demand (Eq. 3-40)	kips	90.70	90.78	+0.09		Pass
Web tension yielding	kips	122.0	120.7	-1.07		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	90.70	90.78	+0.09		Pass
Web weld strength near the tension bolts	kips	121.0	119.7	-1.06		Pass
Shear weld length lwv	in.	11.50	11.50	+0.00		Pass
Web weld strength for shear	kips	64.00	64.04	+0.06		Pass
Web shear rupture at the weld	kips	84.00	84.09	+0.11		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.903. ILX result: **OK**; published: **OK**.

DG39-5.3-4: Multiple-row extended 1/3 unstiffened, thick end plate

Source: AISC Design Guide 39 (2023), Example 5.3-4, pp. 159-166. Connection: End-plate moment.

DG39-5.3-4 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	333.0	332.6	-0.12		Pass
db,reqd (Eq. 5-3)	in.	0.765	0.765	-0.03		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.766	0.767	+0.10		Pass
Extended part shear demand	kips	56.30	56.34	+0.07		Pass
Extended part shear yielding	kips	210.0	210.0	+0.00		Pass
Extended part shear rupture	kips	154.0	153.6	-0.28		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	225.0	225.4	+0.16		Pass
Web tension zone length	in.	13.80	13.75	-0.36		Pass
Web tension demand (Eq. 3-40)	kips	169.0	169.0	+0.01		Pass
Web tension yielding	kips	233.0	232.0	-0.42		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	169.0	169.0	+0.01		Pass
Web weld strength near the tension bolts	kips	173.0	172.3	-0.42		Pass
Shear weld length lwv	in.	17.50	17.50	+0.00		Pass
Web weld strength for shear	kips	146.0	146.2	+0.12		Pass
Web shear rupture at the weld	kips	192.0	192.0	-0.02		Pass

ILX governing check: (Beam web to end-plate welds near the tension bolts (DG39 Eq. 3-41)), ratio 0.981. ILX result: **OK**; published: **OK**.

DG39-5.3-4 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	333.0	332.6	-0.12		Pass
db,reqd (Eq. 5-3)	in.	0.765	0.765	-0.06		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.767	0.767	+0.04		Pass
Extended part shear demand	kips	37.50	37.54	+0.09		Pass
Extended part shear yielding	kips	140.0	140.0	+0.00		Pass
Extended part shear rupture	kips	103.0	102.4	-0.61		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	150.0	150.1	+0.09		Pass
Web tension zone length	in.	13.80	13.75	-0.36		Pass
Web tension demand (Eq. 3-40)	kips	113.0	112.6	-0.35		Pass
Web tension yielding	kips	155.0	154.4	-0.40		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	113.0	112.6	-0.35		Pass
Web weld strength near the tension bolts	kips	116.0	114.8	-0.99		Pass
Shear weld length lwv	in.	17.50	17.50	+0.00		Pass
Web weld strength for shear	kips	97.50	97.45	-0.05		Pass
Web shear rupture at the weld	kips	128.0	128.0	-0.02		Pass

ILX governing check: (Beam web to end-plate welds near the tension bolts (DG39 Eq. 3-41)), ratio 0.980. ILX result: **OK**; published: **OK**.

DG39-5.3-5: Multiple-row extended 1/3 stiffened, thick end plate

Source: AISC Design Guide 39 (2023), Example 5.3-5, pp. 166-174. Connection: End-plate moment.

DG39-5.3-5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	440.0	439.6	-0.09		Pass
db,reqd (Eq. 5-3)	in.	0.868	0.868	-0.02		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.756	0.757	+0.10		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	290.0	290.1	+0.05		Pass
Web tension zone length	in.	13.80	13.75	-0.36		Pass
Web tension demand (Eq. 3-40)	kips	218.0	217.6	-0.18		Pass
Web tension yielding	kips	233.0	232.0	-0.42		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	218.0	217.6	-0.18		Pass
Web weld strength near the tension bolts	kips	230.0	229.7	-0.13		Pass
Shear weld length lwv	in.	17.50	17.50	+0.00		Pass
Web weld strength for shear	kips	146.0	146.2	+0.12		Pass
Web shear rupture at the weld	kips	192.0	192.0	-0.02		Pass
Stiffener-to-flange weld demand (per in.)	kips	11.30	11.25	-0.44		Pass
Stiffener-to-flange weld strength (per in.)	kips	14.00	13.92	-0.56		Pass
Stiffener-to-plate weld demand (per in.)	kips	18.80	18.75	-0.27		Pass
Stiffener-to-plate weld strength (per in.)	kips	20.90	20.88	-0.09		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.984. ILX result: **OK**; published: **OK**.

DG39-5.3-5 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	440.0	439.6	-0.09		Pass
db,reqd (Eq. 5-3)	in.	0.868	0.868	-0.00		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.757	0.758	+0.10		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	194.0	193.5	-0.25		Pass
Web tension zone length	in.	13.80	13.75	-0.36		Pass
Web tension demand (Eq. 3-40)	kips	146.0	145.1	-0.59		Pass
Web tension yielding	kips	155.0	154.4	-0.40		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	146.0	145.1	-0.59		Pass
Web weld strength near the tension bolts	kips	154.0	153.1	-0.56		Pass
Shear weld length lwv	in.	17.50	17.50	+0.00		Pass
Web weld strength for shear	kips	97.50	97.45	-0.05		Pass
Web shear rupture at the weld	kips	128.0	128.0	-0.02		Pass
Stiffener-to-flange weld demand (per in.)	kips	7.500	7.500	+0.00		Pass
Stiffener-to-flange weld strength (per in.)	kips	9.300	9.281	-0.21		Pass
Stiffener-to-plate weld demand (per in.)	kips	12.50	12.50	+0.00		Pass
Stiffener-to-plate weld strength (per in.)	kips	13.90	13.92	+0.15		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.984. ILX result: **OK**; published: **OK**.

DG39-5.3-6: Eight-bolt extended four-wide unstiffened (8E/4W), thick end plate

Source: AISC Design Guide 39 (2023), Example 5.3-6, pp. 174-180. Connection: End-plate moment.

DG39-5.3-6 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.740	3.742	+0.04		Pass
Yield-line parameter Yp	in.	258.0	258.2	+0.09		Pass
db,reqd (Eq. 5-3)	in.	0.928	0.928	+0.05		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.897	0.897	+0.00		Pass
Extended part shear demand	kips	183.0	182.8	-0.11		Pass
Extended part shear yielding	kips	420.0	420.0	+0.00		Pass
Extended part shear rupture	kips	271.0	270.6	-0.16		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	366.0	365.6	-0.11		Pass
Web tension zone length	in.	8.000	8.000	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	91.50	91.40	-0.11		Pass
Web tension yielding	kips	135.0	135.0	+0.00		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	91.50	91.40	-0.11		Pass
Web weld strength near the tension bolts	kips	101.0	100.2	-0.76		Pass
Shear weld length lwv	in.	11.30	11.25	-0.44		Pass
Web weld strength for shear	kips	94.50	93.97	-0.56		Pass
Web shear rupture at the weld	kips	124.0	123.4	-0.49		Pass

ILX governing check: (Beam web to end-plate welds near the tension bolts (DG39 Eq. 3-41)), ratio 0.912. ILX result: **OK**; published: **OK**.

DG39-5.3-6 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.740	3.742	+0.04		Pass
Yield-line parameter Yp	in.	258.0	258.2	+0.09		Pass
db,reqd (Eq. 5-3)	in.	0.928	0.929	+0.08		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.899	0.898	-0.09		Pass
Extended part shear demand	kips	122.0	121.9	-0.05		Pass
Extended part shear yielding	kips	280.0	280.0	+0.00		Pass
Extended part shear rupture	kips	181.0	180.4	-0.35		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	244.0	243.9	-0.05		Pass
Web tension zone length	in.	8.000	8.000	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	61.00	60.97	-0.05		Pass
Web tension yielding	kips	89.80	89.82	+0.02		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	61.00	60.97	-0.05		Pass
Web weld strength near the tension bolts	kips	67.00	66.82	-0.27		Pass
Shear weld length lwv	in.	11.30	11.25	-0.44		Pass
Web weld strength for shear	kips	63.00	62.65	-0.56		Pass
Web shear rupture at the weld	kips	82.50	82.27	-0.28		Pass

ILX governing check: (Beam web to end-plate welds near the tension bolts (DG39 Eq. 3-41)), ratio 0.912. ILX result: **OK**; published: **OK**.

DG39-5.3-7: Eight-bolt extended stiffened (8ES), thick end plate

Source: AISC Design Guide 39 (2023), Example 5.3-7, pp. 180-188. Connection: End-plate moment.

DG39-5.3-7 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	4.060	4.062	+0.05		Pass
Yield-line parameter Yp	in.	546.0	545.7	-0.05		Pass
db,reqd (Eq. 5-3)	in.	1.250	1.248	-0.15		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	1.020	1.017	-0.27		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	661.0	660.8	-0.04		Pass
Web tension zone length	in.	11.80	11.75	-0.42		Pass
Web tension demand (Eq. 3-40)	kips	331.0	330.4	-0.19		Pass
Web tension yielding	kips	332.0	330.5	-0.46		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	331.0	330.4	-0.19		Pass
Web weld strength near the tension bolts	kips	345.0	343.5	-0.43		Pass
Shear weld length lwv	in.	17.00	17.01	+0.06		Pass
Web weld strength for shear	kips	189.0	189.4	+0.23		Pass
Web shear rupture at the weld	kips	311.0	311.0	-0.01		Pass
Stiffener-to-flange weld demand (per in.)	kips	18.80	18.75	-0.27		Pass
Stiffener-to-flange weld strength (per in.)	kips	19.50	19.49	-0.05		Pass
Stiffener-to-plate weld demand (per in.)	kips	31.30	31.25	-0.16		Pass
Stiffener-to-plate weld strength (per in.)	kips	33.40	33.41	+0.03		Pass

ILX governing check: (Beam web tension yielding near the tension bolts (DG39 Eq. 3-40; J4.1(a))), ratio 1.000. ILX result: **OK**; published: **OK**.

DG39-5.3-7 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	4.060	4.062	+0.05		Pass
Yield-line parameter Yp	in.	546.0	545.7	-0.05		Pass
db,reqd (Eq. 5-3)	in.	1.250	1.248	-0.15		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	1.020	1.018	-0.17		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	441.0	440.5	-0.11		Pass
Web tension zone length	in.	11.80	11.75	-0.42		Pass
Web tension demand (Eq. 3-40)	kips	221.0	220.3	-0.34		Pass
Web tension yielding	kips	221.0	219.9	-0.51		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	221.0	220.3	-0.34		Pass
Web weld strength near the tension bolts	kips	230.0	229.0	-0.43		Pass
Shear weld length lwv	in.	17.00	17.01	+0.06		Pass
Web weld strength for shear	kips	126.0	126.3	+0.23		Pass
Web shear rupture at the weld	kips	207.0	207.3	+0.15		Pass
Stiffener-to-flange weld demand (per in.)	kips	12.50	12.50	+0.00		Pass
Stiffener-to-flange weld strength (per in.)	kips	13.00	12.99	-0.05		Pass
Stiffener-to-plate weld demand (per in.)	kips	20.80	20.83	+0.16		Pass
Stiffener-to-plate weld strength (per in.)	kips	22.30	22.27	-0.12		Pass

ILX governing check: (Beam web tension yielding near the tension bolts (DG39 Eq. 3-40; J4.1(a))), ratio 1.002. ILX result: **NG**; published: **OK**.

DG39-5.3-8: 12-bolt multiple-row extended 1/3 four-wide / two-wide unstiffened, thick end plate

Source: AISC Design Guide 39 (2023), Example 5.3-8, pp. 188-195. Connection: End-plate moment.

DG39-5.3-8 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.870	3.873	+0.08		Pass
Yield-line parameter Yp	in.	461.0	460.9	-0.01		Pass
db,reqd (Eq. 5-3)	in.	0.987	0.987	+0.03		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	1.030	1.032	+0.24		Pass
Extended part shear demand	kips	190.0	190.1	+0.04		Pass
Extended part shear yielding	kips	506.0	506.2	+0.05		Pass
Extended part shear rupture	kips	337.0	337.3	+0.09		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	570.0	570.2	+0.04		Pass
Web tension zone length	in.	16.00	16.00	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	285.0	285.1	+0.04		Pass
Web tension yielding	kips	360.0	360.0	+0.00		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	285.0	285.1	+0.04		Pass
Web weld strength near the tension bolts	kips	334.0	334.1	+0.03		Pass
Shear weld length lwv	in.	17.30	17.25	-0.29		Pass
Web weld strength for shear	kips	193.0	192.1	-0.46		Pass
Web shear rupture at the weld	kips	253.0	252.3	-0.28		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.975. ILX result: **OK**; published: **OK**.

DG39-5.3-8 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.870	3.873	+0.08		Pass
Yield-line parameter Yp	in.	461.0	460.9	-0.01		Pass
db,reqd (Eq. 5-3)	in.	0.987	0.987	+0.03		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	1.030	1.033	+0.34		Pass
Extended part shear demand	kips	127.0	126.7	-0.23		Pass
Extended part shear yielding	kips	337.0	337.5	+0.15		Pass
Extended part shear rupture	kips	225.0	224.9	-0.06		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	380.0	380.1	+0.04		Pass
Web tension zone length	in.	16.00	16.00	+0.00		Pass
Web tension demand (Eq. 3-40)	kips	190.0	190.1	+0.04		Pass
Web tension yielding	kips	240.0	239.5	-0.20		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	190.0	190.1	+0.04		Pass
Web weld strength near the tension bolts	kips	223.0	222.7	-0.12		Pass
Shear weld length lwv	in.	17.30	17.25	-0.29		Pass
Web weld strength for shear	kips	129.0	128.1	-0.72		Pass
Web shear rupture at the weld	kips	169.0	168.2	-0.48		Pass

ILX governing check: (Bolt tension rupture without prying: φMnp ≥ Mr,eq (DG39 Eq. 5-3)), ratio 0.975. ILX result: **OK**; published: **OK**.

DG39-5.3-9: 12-bolt extended stiffened (MRE 2/2), thick end plate

Source: AISC Design Guide 39 (2023), Example 5.3-9, pp. 195-203. Connection: End-plate moment.

DG39-5.3-9 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.870	3.873	+0.08		Pass
Yield-line parameter Yp	in.	584.0	584.1	+0.01		Pass
db,reqd (Eq. 5-3)	in.	0.947	0.947	-0.03		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.917	0.917	+0.02		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	570.0	570.2	+0.04		Pass
Web tension zone length	in.	12.30	12.25	-0.41		Pass
Web tension demand (Eq. 3-40)	kips	190.0	190.1	+0.04		Pass
Web tension yielding	kips	208.0	206.7	-0.62		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	190.0	190.1	+0.04		Pass
Web weld strength near the tension bolts	kips	206.0	204.6	-0.66		Pass
Shear weld length lwv	in.	17.30	17.25	-0.29		Pass
Web weld strength for shear	kips	145.0	144.1	-0.63		Pass
Web shear rupture at the weld	kips	190.0	189.2	-0.42		Pass
Stiffener-to-flange weld demand (per in.)	kips	18.80	18.75	-0.27		Pass
Stiffener-to-flange weld strength (per in.)	kips	19.50	19.49	-0.05		Pass
Stiffener-to-plate weld demand (per in.)	kips	31.30	31.25	-0.16		Pass
Stiffener-to-plate weld strength (per in.)	kips	33.40	33.41	+0.03		Pass

ILX governing check: (End-plate stiffener to beam flange welds, per inch (shear yield of the stiffener)), ratio 0.962. ILX result: **OK**; published: **OK**.

DG39-5.3-9 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.870	3.873	+0.08		Pass
Yield-line parameter Yp	in.	584.0	584.1	+0.01		Pass
db,reqd (Eq. 5-3)	in.	0.947	0.947	-0.03		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.918	0.918	+0.01		Pass
Tr,calc = Mr/(d − tbf) + Tr/2 (Eq. 3-39)	kips	380.0	380.1	+0.04		Pass
Web tension zone length	in.	12.30	12.25	-0.41		Pass
Web tension demand (Eq. 3-40)	kips	127.0	126.7	-0.23		Pass
Web tension yielding	kips	138.0	137.5	-0.34		Pass
Web weld demand near the tension bolts (Eq. 3-41)	kips	127.0	126.7	-0.23		Pass
Web weld strength near the tension bolts	kips	137.0	136.4	-0.42		Pass
Shear weld length lwv	in.	17.30	17.25	-0.29		Pass
Web weld strength for shear	kips	96.50	96.06	-0.46		Pass
Web shear rupture at the weld	kips	127.0	126.1	-0.68		Pass
Stiffener-to-flange weld demand (per in.)	kips	12.50	12.50	+0.00		Pass
Stiffener-to-flange weld strength (per in.)	kips	13.00	12.99	-0.05		Pass
Stiffener-to-plate weld demand (per in.)	kips	20.80	20.83	+0.16		Pass
Stiffener-to-plate weld strength (per in.)	kips	22.30	22.27	-0.12		Pass

ILX governing check: (End-plate stiffener to beam flange welds, per inch (shear yield of the stiffener)), ratio 0.962. ILX result: **OK**; published: **OK**.

DG39-B.2-1: Two-bolt flush unstiffened, thin end plate

Source: AISC Design Guide 39 (2023), Example B.2-1, pp. 277-282. Connection: End-plate moment.

DG39-B.2-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.470	2.475	+0.20		Pass
Yield-line parameter Yp	in.	93.90	93.67	-0.25		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	829.0	828.5	-0.06		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.495	0.496	+0.14		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	1,300	1,296	-0.33		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	975.0	971.8	-0.33		Pass
Shear transfer, compression bolts	kips	48.80	48.71	-0.19		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.983. ILX result: **OK**; published: **OK**.

DG39-B.2-1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.470	2.475	+0.20		Pass
Yield-line parameter Yp	in.	93.90	93.67	-0.25		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	552.0	552.0	+0.00		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.495	0.496	+0.21		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	1,300	1,296	-0.33		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	650.0	647.9	-0.33		Pass
Shear transfer, compression bolts	kips	32.50	32.47	-0.09		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.984. ILX result: **OK**; published: **OK**.

DG39-B.2-2: Four-bolt flush unstiffened, thin end plate

Source: AISC Design Guide 39 (2023), Example B.2-2, pp. 282-287. Connection: End-plate moment.

DG39-B.2-2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.120	2.121	+0.06		Pass
Yield-line parameter Yp	in.	114.0	113.3	-0.57		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.605	0.606	+0.22		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	2,590	2,587	-0.13		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	1,940	1,940	-0.00		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.941. ILX result: **OK**; published: **OK**.

DG39-B.2-2 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.120	2.121	+0.06		Pass
Yield-line parameter Yp	in.	114.0	113.3	-0.57		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.605	0.607	+0.32		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	2,590	2,587	-0.13		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	1,300	1,293	-0.52		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.943. ILX result: **OK**; published: **OK**.

DG39-B.2-3: Four-bolt flush, web stiffeners between the tension rows, thin end plate

Source: AISC Design Guide 39 (2023), Example B.2-3, pp. 287-292. Connection: End-plate moment.

DG39-B.2-3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.290	2.291	+0.06		Pass
Yield-line parameter Yp	in.	181.0	180.8	-0.10		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.619	0.620	+0.11		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	3,810	3,801	-0.25		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	2,860	2,850	-0.34		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.983. ILX result: **OK**; published: **OK**.

DG39-B.2-3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.290	2.291	+0.06		Pass
Yield-line parameter Yp	in.	181.0	180.8	-0.10		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.621	0.621	-0.01		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	3,810	3,801	-0.25		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	1,910	1,900	-0.51		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.987. ILX result: **OK**; published: **OK**.

DG39-B.2-4: Four-bolt flush, web stiffeners below the tension rows, thin end plate

Source: AISC Design Guide 39 (2023), Example B.2-4, pp. 292-297. Connection: End-plate moment.

DG39-B.2-4 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.290	2.291	+0.06		Pass
Yield-line parameter Yp	in.	124.0	123.8	-0.20		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.748	0.749	+0.15		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	3,960	3,954	-0.16		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	2,970	2,965	-0.16		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.998. ILX result: **OK**; published: **OK**.

DG39-B.2-4 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.290	2.291	+0.06		Pass
Yield-line parameter Yp	in.	124.0	123.8	-0.20		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.750	0.751	+0.08		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	3,960	3,954	-0.16		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	1,980	1,977	-0.16		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 1.002. ILX result: **NG**; published: **OK**.

DG39-B.2-5: Six-bolt flush unstiffened (three rows), thin end plate

Source: AISC Design Guide 39 (2023), Example B.2-5, pp. 297-302. Connection: End-plate moment.

DG39-B.2-5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.710	3.708	-0.05		Pass
Yield-line parameter Yp	in.	391.0	391.4	+0.11		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.997	0.997	-0.02		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	21,800	21,835	+0.16		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	16,400	16,376	-0.15		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.994. ILX result: **OK**; published: **OK**.

DG39-B.2-5 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.710	3.708	-0.05		Pass
Yield-line parameter Yp	in.	391.0	391.4	+0.11		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.998	0.998	-0.04		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	21,800	21,835	+0.16		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	10,900	10,917	+0.16		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.995. ILX result: **OK**; published: **OK**.

DG39-B.2-6: Six-bolt flush four-wide / two-wide unstiffened, thin end plate

Source: AISC Design Guide 39 (2023), Example B.2-6, pp. 302-307. Connection: End-plate moment.

DG39-B.2-6 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.740	3.742	+0.04		Pass
Yield-line parameter Yp	in.	436.0	435.7	-0.06		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.978	0.978	-0.01		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	22,000	22,000	-0.00		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	16,500	16,500	-0.00		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.956. ILX result: **OK**; published: **OK**.

DG39-B.2-6 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.740	3.742	+0.04		Pass
Yield-line parameter Yp	in.	436.0	435.7	-0.06		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.979	0.979	-0.02		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	22,000	22,000	-0.00		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	11,000	11,000	-0.00		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.958. ILX result: **OK**; published: **OK**.

DG39-B.3-1: Four-bolt extended unstiffened (4E), thin end plate

Source: AISC Design Guide 39 (2023), Example B.3-1, pp. 307-314. Connection: End-plate moment.

DG39-B.3-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.450	2.449	-0.02		Pass
Yield-line parameter Yp	in.	186.0	185.8	-0.11		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	2,640	2,640	-0.00		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.562	0.562	-0.02		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	3,920	3,924	+0.09		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	2,940	2,943	+0.09		Pass
Shear transfer, compression bolts	kips	97.50	97.41	-0.09		Pass
Extended part shear demand	kips	55.90	55.87	-0.05		Pass
Extended part shear yielding	kips	135.0	135.0	+0.00		Pass
Extended part shear rupture	kips	99.00	98.72	-0.28		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.998. ILX result: **OK**; published: **OK**.

DG39-B.3-1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	2.450	2.449	-0.02		Pass
Yield-line parameter Yp	in.	186.0	185.8	-0.11		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	1,760	1,756	-0.21		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.562	0.562	-0.02		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	3,920	3,924	+0.09		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	1,960	1,962	+0.09		Pass
Shear transfer, compression bolts	kips	65.00	64.94	-0.09		Pass
Extended part shear demand	kips	37.20	37.17	-0.08		Pass
Extended part shear yielding	kips	90.00	90.00	+0.00		Pass
Extended part shear rupture	kips	66.00	65.81	-0.28		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.998. ILX result: **OK**; published: **OK**.

DG39-B.3-2: Four-bolt extended stiffened (4ES), thin end plate

Source: AISC Design Guide 39 (2023), Example B.3-2, pp. 314-321. Connection: End-plate moment.

DG39-B.3-2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.600	3.597	-0.09		Pass
Yield-line parameter Yp	in.	233.0	232.9	-0.06		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	7,860	7,858	-0.03		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.866	0.866	-0.00		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	11,000	10,957	-0.39		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	8,250	8,218	-0.39		Pass
Shear transfer, compression bolts	kips	251.0	250.3	-0.26		Pass

ILX governing check: (End-plate stiffener to end-plate welds, per inch (tensile yield of the stiffener)), ratio 0.998. ILX result: **OK**; published: **OK**.

DG39-B.3-2 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.600	3.597	-0.09		Pass
Yield-line parameter Yp	in.	233.0	232.9	-0.06		Pass
Mr,eq = Mr + (Tr/2)(d − tbf) (Eq. 3-30)	kip-in.	5,240	5,239	-0.03		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.867	0.867	-0.02		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	11,000	10,957	-0.39		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	5,500	5,479	-0.39		Pass
Shear transfer, compression bolts	kips	167.0	166.9	-0.06		Pass

ILX governing check: (End-plate stiffener to end-plate welds, per inch (tensile yield of the stiffener)), ratio 0.998. ILX result: **OK**; published: **OK**.

DG39-B.3-3: Multiple-row extended 1/2 unstiffened, thin end plate

Source: AISC Design Guide 39 (2023), Example B.3-3, pp. 321-328. Connection: End-plate moment.

DG39-B.3-3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	195.0	194.7	-0.16		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.740	0.740	+0.03		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	7,370	7,380	+0.13		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	5,530	5,535	+0.09		Pass
Extended part shear demand	kips	68.10	68.09	-0.02		Pass
Extended part shear yielding	kips	180.0	180.0	+0.00		Pass
Extended part shear rupture	kips	124.0	123.4	-0.49		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.974. ILX result: **OK**; published: **OK**.

DG39-B.3-3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	195.0	194.7	-0.16		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.740	0.741	+0.13		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	7,370	7,380	+0.13		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	3,690	3,690	-0.00		Pass
Extended part shear demand	kips	45.40	45.39	-0.02		Pass
Extended part shear yielding	kips	120.0	120.0	+0.00		Pass
Extended part shear rupture	kips	82.50	82.27	-0.28		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.976. ILX result: **OK**; published: **OK**.

DG39-B.3-4: Multiple-row extended 1/3 unstiffened, thin end plate

Source: AISC Design Guide 39 (2023), Example B.3-4, pp. 328-334. Connection: End-plate moment.

DG39-B.3-4 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	333.0	332.6	-0.12		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.731	0.731	+0.01		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	14,200	14,214	+0.10		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	10,700	10,661	-0.37		Pass
Extended part shear demand	kips	56.30	56.34	+0.07		Pass
Extended part shear yielding	kips	180.0	180.0	+0.00		Pass
Extended part shear rupture	kips	124.0	123.4	-0.49		Pass

ILX governing check: (Beam web to end-plate welds near the tension bolts (DG39 Eq. 3-41)), ratio 0.981. ILX result: **OK**; published: **OK**.

DG39-B.3-4 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	333.0	332.6	-0.12		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.731	0.732	+0.08		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	14,200	14,214	+0.10		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	7,100	7,107	+0.10		Pass
Extended part shear demand	kips	37.50	37.54	+0.09		Pass
Extended part shear yielding	kips	120.0	120.0	+0.00		Pass
Extended part shear rupture	kips	82.50	82.27	-0.28		Pass

ILX governing check: (Beam web to end-plate welds near the tension bolts (DG39 Eq. 3-41)), ratio 0.980. ILX result: **OK**; published: **OK**.

DG39-B.3-5: Multiple-row extended 1/3 stiffened, thin end plate

Source: AISC Design Guide 39 (2023), Example B.3-5, pp. 334-340. Connection: End-plate moment.

DG39-B.3-5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	440.0	439.6	-0.09		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.721	0.722	+0.08		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	14,200	14,214	+0.10		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	10,700	10,661	-0.37		Pass

ILX governing check: (Bolt tension rupture with prying: φMq ≥ Mr,eq (DG39 Eq. 5-6)), ratio 0.966. ILX result: **OK**; published: **OK**.

DG39-B.3-5 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.160	3.162	+0.07		Pass
Yield-line parameter Yp	in.	440.0	439.6	-0.09		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.722	0.722	+0.07		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	14,200	14,214	+0.10		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	7,100	7,107	+0.10		Pass

ILX governing check: (Bolt tension rupture with prying: φMq ≥ Mr,eq (DG39 Eq. 5-6)), ratio 0.967. ILX result: **OK**; published: **OK**.

DG39-B.3-6: Eight-bolt extended four-wide unstiffened (8E/4W), thin end plate

Source: AISC Design Guide 39 (2023), Example B.3-6, pp. 340-347. Connection: End-plate moment.

DG39-B.3-6 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.740	3.742	+0.04		Pass
Yield-line parameter Yp	in.	258.0	258.2	+0.09		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.856	0.855	-0.09		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	11,700	11,649	-0.43		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	8,780	8,737	-0.49		Pass
Extended part shear demand	kips	183.0	182.8	-0.11		Pass
Extended part shear yielding	kips	368.0	367.5	-0.14		Pass
Extended part shear rupture	kips	224.0	223.9	-0.02		Pass

ILX governing check: (Bolt tension rupture with prying: φMq ≥ Mr,eq (DG39 Eq. 5-6)), ratio 0.973. ILX result: **OK**; published: **OK**.

DG39-B.3-6 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.740	3.742	+0.04		Pass
Yield-line parameter Yp	in.	258.0	258.2	+0.09		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.857	0.856	-0.07		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	11,700	11,649	-0.43		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	5,850	5,825	-0.43		Pass
Extended part shear demand	kips	122.0	121.9	-0.05		Pass
Extended part shear yielding	kips	245.0	245.0	+0.00		Pass
Extended part shear rupture	kips	150.0	149.3	-0.47		Pass

ILX governing check: (Bolt tension rupture with prying: φMq ≥ Mr,eq (DG39 Eq. 5-6)), ratio 0.973. ILX result: **OK**; published: **OK**.

DG39-B.3-7: Eight-bolt extended stiffened (8ES), thin end plate

Source: AISC Design Guide 39 (2023), Example B.3-7, pp. 347-357. Connection: End-plate moment.

DG39-B.3-7 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.320	3.317	-0.10		Pass
Yield-line parameter Yp	in.	424.0	423.7	-0.07		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.687	0.687	+0.01		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	16,200	16,138	-0.38		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	12,200	12,103	-0.79		Pass

ILX governing check: (End-plate stiffener to end-plate welds, per inch (tensile yield of the stiffener)), ratio 0.998. ILX result: **OK**; published: **OK**.

DG39-B.3-7 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.320	3.317	-0.10		Pass
Yield-line parameter Yp	in.	424.0	423.7	-0.07		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.687	0.688	+0.11		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	16,200	16,138	-0.38		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	8,100	8,069	-0.38		Pass

ILX governing check: (End-plate stiffener to end-plate welds, per inch (tensile yield of the stiffener)), ratio 0.998. ILX result: **OK**; published: **OK**.

DG39-B.3-8: 12-bolt multiple-row extended 1/3 four-wide / two-wide unstiffened, thin end plate

Source: AISC Design Guide 39 (2023), Example B.3-8, pp. 357-363. Connection: End-plate moment.

DG39-B.3-8 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.870	3.873	+0.08		Pass
Yield-line parameter Yp	in.	461.0	460.9	-0.01		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.984	0.984	+0.04		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	27,400	27,296	-0.38		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	20,600	20,472	-0.62		Pass
Extended part shear demand	kips	190.0	190.1	+0.04		Pass
Extended part shear yielding	kips	450.0	450.0	+0.00		Pass
Extended part shear rupture	kips	271.0	270.6	-0.16		Pass

ILX governing check: (Bolt tension rupture with prying: φMq ≥ Mr,eq (DG39 Eq. 5-6)), ratio 0.982. ILX result: **OK**; published: **OK**.

DG39-B.3-8 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.870	3.873	+0.08		Pass
Yield-line parameter Yp	in.	461.0	460.9	-0.01		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.985	0.985	+0.04		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	27,400	27,296	-0.38		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	13,700	13,648	-0.38		Pass
Extended part shear demand	kips	127.0	126.7	-0.23		Pass
Extended part shear yielding	kips	300.0	300.0	+0.00		Pass
Extended part shear rupture	kips	180.0	180.4	+0.21		Pass

ILX governing check: (Bolt tension rupture with prying: φMq ≥ Mr,eq (DG39 Eq. 5-6)), ratio 0.982. ILX result: **OK**; published: **OK**.

DG39-B.3-9: 12-bolt extended stiffened (MRE 2/2), thin end plate

Source: AISC Design Guide 39 (2023), Example B.3-9, pp. 363-370. Connection: End-plate moment.

DG39-B.3-9 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.870	3.873	+0.08		Pass
Yield-line parameter Yp	in.	584.0	584.1	+0.01		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.875	0.874	-0.06		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	27,500	27,515	+0.06		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	20,600	20,636	+0.18		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 0.999. ILX result: **OK**; published: **OK**.

DG39-B.3-9 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
s = √(bp g)/2	in.	3.870	3.873	+0.08		Pass
Yield-line parameter Yp	in.	584.0	584.1	+0.01		Pass
tp,reqd (Eq. 5-4 / 5-5)	in.	0.875	0.875	+0.04		Pass
Mq = Σ αi Pqi ni hi (Eq. 3-28)	kip-in.	27,500	27,515	+0.06		Pass
φMq / (Mq/Ω) (Eq. 5-6)	kip-in.	13,800	13,758	-0.31		Pass

ILX governing check: (End-plate flexural yielding, thin plate: γr φb Mpl ≥ Mr,eq (DG39 Eq. 5-5)), ratio 1.001. ILX result: **NG**; published: **OK**.

II.A-20: All-bolted single-plate shear splice

Source: AISC Design Examples v16.0, Example II.A-20, pp. IIA-230 to IIA-235. Connection: Beam shear splice.

II.A-20 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	60.00	60.00	+0.00		Pass
Eccentricity per bolt group e = 5/2	in.	2.500	2.500	+0.00		Pass
Bolt shear per bolt (Table 7-1)	kips	24.30	24.35	+0.22		Pass
Plate bearing per bolt 2.4 d t Fu	kips	38.40	38.39	-0.02		Pass
Plate tearout, edge bolt (lc = 1.03)	kips	22.60	22.62	+0.10		Pass
C (Table 7-6, n = 4, ex = 2½)		3.070	3.065	-0.15		Pass
Bolt group C × rn,min (side A) Published as Ru / rn,min = 2.65 < C = 3.07; capacity = 3.07 × 22.6 = 69.4 (15.1 ASD).	kips	69.40	69.35	-0.08		Pass
Bolt group C × rn,min (side B)	kips	69.40	69.35	-0.08		Pass
Plate required moment Mu = Ru e/2	kip-in.	150.0	150.0	+0.00		Pass
Plate flexural yielding φMn = φ Fy Zx	kip-in.	608.0	607.5	-0.08		Pass
Plate flexural rupture φ Fu Znet (Znet = 9.00)	kip-in.	439.0	438.8	-0.06		Pass
Plate shear yielding	kips	135.0	135.0	+0.00		Pass
Plate shear rupture (Anv = 3.00)	kips	87.80	87.75	-0.06		Pass
Plate block shear (leh = lev = 1½, Ubs = 1.0)	kips	95.20	95.06	-0.14		Pass

ILX governing check: `bolts_a` (Side A bolt group: shear, bearing and tearout), ratio 0.865. ILX result: **OK**; published: **OK**.

II.A-20 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	40.00	40.00	+0.00		Pass
Eccentricity per bolt group e = 5/2	in.	2.500	2.500	+0.00		Pass
Bolt shear per bolt (Table 7-1)	kips	16.20	16.24	+0.22		Pass
Plate bearing per bolt 2.4 d t Fu	kips	25.60	25.59	-0.02		Pass
Plate tearout, edge bolt (lc = 1.03)	kips	15.10	15.08	-0.12		Pass
C (Table 7-6, n = 4, ex = 2½)		3.070	3.065	-0.15		Pass
Bolt group C × rn,min (side A) Published as Ru / rn,min = 2.65 < C = 3.07; capacity = 3.07 × 22.6 = 69.4 (15.1 ASD).	kips	46.40	46.23	-0.36		Pass
Bolt group C × rn,min (side B)	kips	46.40	46.23	-0.36		Pass
Plate required moment Mu = Ru e/2	kip-in.	100.0	100.0	+0.00		Pass
Plate flexural yielding φMn = φ Fy Zx	kip-in.	404.0	404.2	+0.05		Pass
Plate flexural rupture φ Fu Znet (Znet = 9.00)	kip-in.	293.0	292.5	-0.17		Pass
Plate shear yielding	kips	90.00	90.00	+0.00		Pass
Plate shear rupture (Anv = 3.00)	kips	58.50	58.50	+0.00		Pass
Plate block shear (leh = lev = 1½, Ubs = 1.0)	kips	63.60	63.38	-0.35		Pass

ILX governing check: `bolts_a` (Side A bolt group: shear, bearing and tearout), ratio 0.865. ILX result: **OK**; published: **OK**.

II.A-21: Bolted/welded single-plate shear splice

Source: AISC Design Examples v16.0, Example II.A-21, pp. IIA-236 to IIA-242. Connection: Beam shear splice.

II.A-21 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	48.00	48.00	+0.00		Pass
Weld eccentricity ex = al (actual kl = 3¼)	in.	5.850	5.929	+1.35		Deviation DS1
DS1 II.A-21 weld length: AISC takes the horizontal welds kl = 3½ in. from the splice centerline (k = 0.292); the welds start at the W16×31 beam end, ¼ in. from the centerline, so ILX uses the actual kl = 3¼ in. (k = 0.271). Shorter, less eccentric-resistant weld group: C and the weld eccentricity differ (ILX conservative). The row below with the AISC idealization reproduces the published value.						
Weld eccentricity ex = al (AISC kl = 3½) Run with the AISC idealization kl = 3½ in. (welds measured from the splice centerline).	in.	5.850	5.855	+0.09		Pass
Weld C (Table 8-8, actual kl = 3¼)		2.150	2.056	-4.39		Deviation DS1
DS1 II.A-21 weld length: AISC takes the horizontal welds kl = 3½ in. from the splice centerline (k = 0.292); the welds start at the W16×31 beam end, ¼ in. from the centerline, so ILX uses the actual kl = 3¼ in. (k = 0.271). Shorter, less eccentric-resistant weld group: C and the weld eccentricity differ (ILX conservative). The row below with the AISC idealization reproduces the published value.						
Weld C (Table 8-8, k = 0.292, a = 0.488) Run with the AISC idealization kl = 3½ in. (welds measured from the splice centerline).		2.150	2.146	-0.20		Pass
Required weld size Dmin (sixteenths) Run with the AISC idealization kl = 3½ in. (welds measured from the splice centerline).		2.480	2.486	+0.23		Pass
Beam W16×31 web tmin = 3.09 D/Fu Run with the AISC idealization kl = 3½ in. (welds measured from the splice centerline).	in.	0.118	0.118	+0.14		Pass
Bolt shear per bolt (Table 7-1)	kips	17.90	17.89	-0.04		Pass
Plate bearing per bolt 2.4 d t Fu	kips	32.90	32.91	+0.02		Pass
Plate tearout, edge bolt (lc = 1.09)	kips	23.90	23.99	+0.39		Pass
Bolt group, shear only (n × φrn = 4 × 17.9) Published as nmin = 2.68 (2.69 ASD) < 4 bolts.	kips	71.60	71.57	-0.04		Pass
Plate required moment Mu = Ru ex (actual kl = 3¼)	kip-in.	281.0	284.6	+1.28		Deviation DS1
DS1 II.A-21 weld length: AISC takes the horizontal welds kl = 3½ in. from the splice centerline (k = 0.292); the welds start at the W16×31 beam end, ¼ in. from the centerline, so ILX uses the actual kl = 3¼ in. (k = 0.271). Shorter, less eccentric-resistant weld group: C and the weld eccentricity differ (ILX conservative). The row below with the AISC idealization reproduces the published value.						
Plate required moment Mu = Ru ex (AISC kl = 3½) Run with the AISC idealization kl = 3½ in. (welds measured from the splice centerline).	kip-in.	281.0	281.1	+0.02		Pass
Plate flexural yielding φMn = φ Fy Zx	kip-in.	608.0	607.5	-0.08		Pass
Plate flexural rupture φ Fu Znet (Znet = 9.56)	kip-in.	466.0	466.2	+0.04		Pass
Plate shear yielding	kips	135.0	135.0	+0.00		Pass
Plate shear rupture (Anv = 3.19)	kips	93.00	93.23	+0.25		Pass
Plate block shear (leh = lev = 1½, Ubs = 1.0)	kips	101.0	101.0	+0.00		Pass

ILX governing check: `weld_b` (Side B weld group (eccentric, instantaneous center)), ratio 0.865. ILX result: **OK**; published: **OK**.

II.A-21 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	32.00	32.00	+0.00		Pass
Weld eccentricity ex = al (actual kl = 3¼)	in.	5.850	5.929	+1.35		Deviation DS1
DS1 II.A-21 weld length: AISC takes the horizontal welds kl = 3½ in. from the splice centerline (k = 0.292); the welds start at the W16×31 beam end, ¼ in. from the centerline, so ILX uses the actual kl = 3¼ in. (k = 0.271). Shorter, less eccentric-resistant weld group: C and the weld eccentricity differ (ILX conservative). The row below with the AISC idealization reproduces the published value.						
Weld eccentricity ex = al (AISC kl = 3½) Run with the AISC idealization kl = 3½ in. (welds measured from the splice centerline).	in.	5.850	5.855	+0.09		Pass
Weld C (Table 8-8, actual kl = 3¼)		2.150	2.056	-4.39		Deviation DS1

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
DS1 II.A-21 weld length: AISC takes the horizontal welds kl = 3½ in. from the splice centerline (k = 0.292); the welds start at the W16×31 beam end, ¼ in. from the centerline, so ILX uses the actual kl = 3¼ in. (k = 0.271). Shorter, less eccentric-resistant weld group: C and the weld eccentricity differ (ILX conservative). The row below with the AISC idealization reproduces the published value.						
Weld C (Table 8-8, k = 0.292, a = 0.488) Run with the AISC idealization kl = 3½ in. (welds measured from the splice centerline).		2.150	2.146	-0.20		Pass
Required weld size Dmin (sixteenths) Run with the AISC idealization kl = 3½ in. (welds measured from the splice centerline).		2.480	2.486	+0.23		Pass
Beam W16×31 web tmin = 3.09 D/Fu Run with the AISC idealization kl = 3½ in. (welds measured from the splice centerline).	in.	0.118	0.118	+0.14		Pass
Bolt shear per bolt (Table 7-1)	kips	11.90	11.93	+0.24		Pass
Plate bearing per bolt 2.4 d t Fu	kips	22.00	21.94	-0.28		Pass
Plate tearout, edge bolt (lc = 1.09)	kips	16.00	16.00	-0.02		Pass
Bolt group, shear only (n × φrn = 4 × 17.9) Published as nmin = 2.68 (2.69 ASD) < 4 bolts.	kips	47.60	47.71	+0.24		Pass
Plate required moment Mu = Ru ex (actual kl = 3¼)	kip-in.	187.0	189.7	+1.46		Deviation DS1
DS1 II.A-21 weld length: AISC takes the horizontal welds kl = 3½ in. from the splice centerline (k = 0.292); the welds start at the W16×31 beam end, ¼ in. from the centerline, so ILX uses the actual kl = 3¼ in. (k = 0.271). Shorter, less eccentric-resistant weld group: C and the weld eccentricity differ (ILX conservative). The row below with the AISC idealization reproduces the published value.						
Plate required moment Mu = Ru ex (AISC kl = 3½) Run with the AISC idealization kl = 3½ in. (welds measured from the splice centerline).	kip-in.	187.0	187.4	+0.20		Pass
Plate flexural yielding φMn = φ Fy Zx	kip-in.	404.0	404.2	+0.05		Pass
Plate flexural rupture φ Fu Znet (Znet = 9.56)	kip-in.	311.0	310.8	-0.07		Pass
Plate shear yielding	kips	90.00	90.00	+0.00		Pass
Plate shear rupture (Anv = 3.19)	kips	62.00	62.16	+0.25		Pass
Plate block shear (leh = lev = 1½, Ubs = 1.0)	kips	67.30	67.34	+0.05		Pass

ILX governing check: `weld_b` (Side B weld group (eccentric, instantaneous center)), ratio 0.865. ILX result: **OK**; published: **OK**.

II.C-3 diagonal: Heavy W compression connection, flanges outside: diagonal W14×61 to gusset plates

Source: AISC Design Examples v16.0, Example II.C-3, pp. IIC-24 to IIC-33. Connection: Compression splice (flange plates).

II.C-3 diagonal · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa (+316 / +226)	kips	316.0	316.4	+0.13		Pass
Slip resistance per bolt φrn = μ Du hf Tb	kips	17.30	17.29	-0.06		Pass
Bolts required n = P / φrn		18.30	18.30	+0.00		Pass
Slip resistance, 2 plates × 2 lines × 5 rows Published as n = 18.3 (19.7) < 20 bolts; 20 × 17.3 = 346 (20 × 11.5 = 230).	kips	346.0	345.8	-0.06		Pass
Whitmore width lw = 5½ + 2 (12) tan 30° Gusset plate (Whitmore width not limited by the plate): run with a 32 in. wide plate.	in.	19.40	19.36	-0.22		Pass
Gusset tensile yielding on the Whitmore section (2 plates) Gusset plate (Whitmore width not limited by the plate): run with a 32 in. wide plate.	kips	657.0	653.3	-0.57		Pass
Gusset block shear (2 plates, inner block)	kips	538.0	537.5	-0.10		Pass
Bolt shear per bolt (Table 7-1)	kips	31.80	31.81	+0.03		Pass
Gusset bearing/tearout, edge bolt (le = 2, Table 7-5)	kips	31.50	31.54	+0.11		Pass
Gusset bearing/tearout, other bolts (s = 3, Table 7-4)	kips	41.30	41.13	-0.40		Pass
Bolt group bearing strength, 2 sides × 2 lines × (1 + 4 bolts)	kips	635.0	635.1	+0.01		Pass

ILX governing check: `bolts_a_slip` (Side A bolts (per flange): slip resistance), ratio 0.915. ILX result: **OK**; published: **OK**.

II.C-3 diagonal · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa (+316 / +226)	kips	226.0	226.0	+0.00		Pass
Slip resistance per bolt φrn = μ Du hf Tb	kips	11.50	11.53	+0.23		Pass
Bolts required n = P / φrn		19.70	19.61	-0.47		Pass
Slip resistance, 2 plates × 2 lines × 5 rows Published as n = 18.3 (19.7) < 20 bolts; 20 × 17.3 = 346 (20 × 11.5 = 230).	kips	230.0	230.5	+0.23		Pass
Whitmore width lw = 5½ + 2 (12) tan 30° Gusset plate (Whitmore width not limited by the plate): run with a 32 in. wide plate.	in.	19.40	19.36	-0.22		Pass
Gusset tensile yielding on the Whitmore section (2 plates) Gusset plate (Whitmore width not limited by the plate): run with a 32 in. wide plate.	kips	437.0	434.6	-0.54		Pass
Gusset block shear (2 plates, inner block)	kips	359.0	358.3	-0.19		Pass
Bolt shear per bolt (Table 7-1)	kips	21.20	21.21	+0.03		Pass
Gusset bearing/tearout, edge bolt (le = 2, Table 7-5)	kips	21.00	21.02	+0.11		Pass
Gusset bearing/tearout, other bolts (s = 3, Table 7-4)	kips	27.40	27.42	+0.08		Pass
Bolt group bearing strength, 2 sides × 2 lines × (1 + 4 bolts)	kips	423.0	423.4	+0.09		Pass

ILX governing check: `bolts_a_slip` (Side A bolts (per flange): slip resistance), ratio 0.980. ILX result: **OK**; published: **OK**.

II.C-3 chord: Heavy W compression connection, flanges outside: W14×109 chord to gusset plates

Source: AISC Design Examples v16.0, Example II.C-3, pp. IIC-24 to IIC-33. Connection: Compression splice (flange plates).

II.C-3 chord · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (chord force difference 966 − 734 / 690 − 524)	kips	232.0	232.4	+0.17		Pass
Bolts required n = P / φrn		13.40	13.44	+0.31		Pass
Slip resistance, 2 plates × 2 lines × 5 rows	kips	346.0	345.8	-0.06		Pass
Maximum bolt spacing 24t (t = 3/8)	in.	9.000	9.000	+0.00		Pass
Gusset shear yielding along the chord (l = 32 in.)	kips	720.0	720.0	+0.00		Pass
Gusset shear rupture along the chord	kips	571.0	571.7	+0.13		Pass

ILX governing check: `bolts_a_slip` (Side A bolts (per flange): slip resistance), ratio 0.672. ILX result: **OK**; published: **OK**.

II.C-3 chord · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (chord force difference 966 − 734 / 690 − 524)	kips	166.0	166.0	+0.00		Pass
Bolts required n = P / φrn		14.40	14.40	+0.02		Pass
Slip resistance, 2 plates × 2 lines × 5 rows	kips	230.0	230.5	+0.23		Pass
Maximum bolt spacing 24t (t = 3/8)	in.	9.000	9.000	+0.00		Pass
Gusset shear yielding along the chord (l = 32 in.)	kips	480.0	480.0	+0.00		Pass
Gusset shear rupture along the chord	kips	381.0	381.2	+0.04		Pass

ILX governing check: `bolts_a_slip` (Side A bolts (per flange): slip resistance), ratio 0.720. ILX result: **OK**; published: **OK**.

II.C-3 vertical: Heavy W compression connection, flanges outside: vertical W14×61 to gusset plates

Source: AISC Design Examples v16.0, Example II.C-3, pp. IIC-24 to IIC-33. Connection: Compression splice (flange plates).

II.C-3 vertical · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa (−286 / −204)	kips	286.0	285.6	-0.14		Pass
Bolts required n = P / φrn		16.50	16.52	+0.12		Pass
Slip resistance, 2 plates × 2 lines × 5 rows	kips	346.0	345.8	-0.06		Pass
Gusset shear yielding along the vertical (l = 31¾ in.)	kips	714.0	714.4	+0.05		Pass
Gusset shear rupture along the vertical Published 515 = 0.75 × 0.60 × 65 × 17.6 (Anv rounded); unrounded Anv = 17.58 in.² gives 514.	kips	515.0	514.2	-0.16		Pass

ILX governing check: `bolts_a_slip` (Side A bolts (per flange): slip resistance), ratio 0.826. ILX result: **OK**; published: **OK**.

II.C-3 vertical · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa (−286 / −204)	kips	204.0	204.0	+0.00		Pass
Bolts required n = P / φrn		17.70	17.70	-0.01		Pass
Slip resistance, 2 plates × 2 lines × 5 rows	kips	230.0	230.5	+0.23		Pass
Gusset shear yielding along the vertical (l = 31¾ in.)	kips	476.0	476.2	+0.05		Pass
Gusset shear rupture along the vertical Published 515 = 0.75 × 0.60 × 65 × 17.6 (Anv rounded); unrounded Anv = 17.58 in.² gives 514.	kips	343.0	342.8	-0.07		Pass

ILX governing check: `bolts_a_slip` (Side A bolts (per flange): slip resistance), ratio 0.885. ILX result: **OK**; published: **OK**.

II.C-1: Truss support connection (gusset, clip angles bolted to the column flange)

Source: AISC Design Examples v16.0, Example II.C-1, pp. IIC-2 to IIC-15. Connection: Truss connection, support Column flange.

II.C-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Diagonal weld: required length per weld (D = 4, four welds)	in.	7.540	7.543	+0.03		Pass
Gusset tmin = 6.19 D/Fu (Eq. 9-7)	in.	0.381	0.381	-0.02		Pass
Brace tensile yielding	kips	241.0	241.2	+0.08		Pass
Shear lag U (Table D3.1 Case 4, l = 8 in.)		0.814	0.814	-0.02		Pass
Brace tensile rupture	kips	212.0	212.6	+0.31		Pass
Bolt shear per bolt (Table 7-1)	kips	24.30	24.35	+0.22		Pass
Rows required for shear only		2.180	2.176	-0.17		Pass
Clip-angle bearing per bolt (2.4 d t Fu)	kips	63.90	63.98	+0.13		Pass
Clip-angle tearout, edge bolt (lc = 1.03 in.)	kips	37.70	37.71	+0.01		Pass
Clip-angle tearout, interior bolt (lc = 2.06 in.)	kips	75.00	75.41	+0.55		Pass
Eccentricity e = d/2	in.	6.100	6.100	+0.00		Pass
n' (bolts above the neutral axis)		4.000	4.000	+0.00		Pass
dm (tension-compression moment arm)	in.	9.000	9.000	+0.00		Pass
Tension per bolt rut = P e / (n' dm) (Eq. 7-14)	kips	18.00	17.96	-0.22		Pass
Shear stress per bolt frv	ksi	17.60	17.63	+0.16		Pass
F'nt (J3-3a / J3-3b)	ksi	77.90	77.83	-0.09		Pass
Available tension per bolt Tc	kips	35.10	35.10	-0.00		Pass
Prying: a (column flange governs)	in.	1.790	1.790	+0.00		Pass
Prying: b	in.	1.690	1.688	-0.15		Pass
Prying: a' (Eq. 9-23)	in.	2.230	2.228	-0.11		Pass
Prying: b' (Eq. 9-24)	in.	1.250	1.250	+0.00		Pass
Prying: ρ (Eq. 9-29)		0.561	0.561	+0.03		Pass
Prying: p = l/n	in.	3.000	3.000	+0.00		Pass
Prying: δ (Eq. 9-28)		0.688	0.688	-0.07		Pass
Prying: tc (Eq. 9-30)	in.	1.000	1.000	-0.00		Pass
Prying: α' (Eq. 9-38)		1.450	1.453	+0.23		Pass
Prying: Q (Eq. 9-39c)		0.659	0.659	+0.03		Pass
Clip angles: tension per bolt with prying Q Tc (Eq. 9-40)	kips	23.10	23.14	+0.16		Pass
Clip angles: shear yielding	kips	564.0	562.5	-0.27		Pass
Clip angles: shear rupture	kips	366.0	365.6	-0.10		Pass
Clip angles: block shear	kips	422.0	420.5	-0.36		Pass
Column flange: tension per bolt with prying	kips	18.70	18.63	-0.35		Pass
Clip weld: average return kl	in.	3.060	3.062	+0.08		Pass
Clip weld: k = kl/l		0.204	0.204	+0.08		Pass
Clip weld: xl	in.	0.443	0.444	+0.22		Pass
Clip weld: a = al/l		0.644	0.644	-0.04		Pass
Clip weld: C (Table 8-8, angle 0°) AISC interpolates Manual Table 8-8; ILX solves the IC method on the same weld group.		1.500	1.496	-0.24		Pass
Clip weld: Dmin (sixteenths)		3.140	3.148	+0.27		Pass
Whitmore width lw = 4 + 2 (8) tan 30°	in.	13.20	13.24	+0.28		Pass
Gusset tensile yielding on the Whitmore section	kips	297.0	297.8	+0.28		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Interface: horizontal shear H	kips	59.00	59.16	+0.26		Pass
Interface: vertical tension V	kips	42.40	42.40	+0.00		Pass
Interface: compression C (WT to column)	kips	72.00	71.84	-0.22		Pass
Interface: moment M about the column face	kip-in.	340.0	340.4	+0.11		Pass

ILX governing check: `column_prying` (Column flange: prying action), ratio 0.964. ILX result: **OK**; published: **OK**.

II.C-1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Diagonal weld: required length per weld (D = 4, four welds)	in.	7.540	7.543	+0.03		Pass
Gusset tmin = 6.19 D/Fu (Eq. 9-7)	in.	0.381	0.381	-0.02		Pass
Brace tensile yielding	kips	160.0	160.5	+0.30		Pass
Shear lag U (Table D3.1 Case 4, l = 8 in.)		0.814	0.814	-0.02		Pass
Brace tensile rupture	kips	142.0	141.8	-0.17		Pass
Bolt shear per bolt (Table 7-1)	kips	16.20	16.24	+0.22		Pass
Rows required for shear only		2.170	2.168	-0.09		Pass
Clip-angle bearing per bolt (2.4 d t Fu)	kips	42.70	42.66	-0.10		Pass
Clip-angle tearout, edge bolt (lc = 1.03 in.)	kips	25.10	25.14	+0.15		Pass
Clip-angle tearout, interior bolt (lc = 2.06 in.)	kips	50.00	50.27	+0.55		Pass
Eccentricity e = d/2	in.	6.100	6.100	+0.00		Pass
n' (bolts above the neutral axis)		4.000	4.000	+0.00		Pass
dm (tension-compression moment arm)	in.	9.000	9.000	+0.00		Pass
Tension per bolt rut = P e / (n' dm) (Eq. 7-14)	kips	11.90	11.93	+0.24		Pass
Shear stress per bolt frv	ksi	11.70	11.71	+0.06		Pass
F'nt (J3-3a / J3-3b)	ksi	78.00	77.97	-0.03		Pass
Available tension per bolt Tc	kips	23.40	23.44	+0.19		Pass
Prying: a (column flange governs)	in.	1.790	1.790	+0.00		Pass
Prying: b	in.	1.690	1.688	-0.15		Pass
Prying: a' (Eq. 9-23)	in.	2.230	2.228	-0.11		Pass
Prying: b' (Eq. 9-24)	in.	1.250	1.250	+0.00		Pass
Prying: ρ (Eq. 9-29)		0.561	0.561	+0.03		Pass
Prying: p = l/n	in.	3.000	3.000	+0.00		Pass
Prying: δ (Eq. 9-28)		0.688	0.688	-0.07		Pass
Prying: tc (Eq. 9-30)	in.	1.000	1.002	+0.19		Pass
Clip angles: tension per bolt with prying Q Tc (Eq. 9-40)	kips	15.40	15.39	-0.04		Pass
Clip angles: shear yielding	kips	376.0	375.0	-0.27		Pass
Clip angles: shear rupture	kips	244.0	243.8	-0.10		Pass
Clip angles: block shear	kips	282.0	280.3	-0.60		Pass
Column flange: tension per bolt with prying	kips	12.40	12.40	-0.02		Pass
Clip weld: average return kl	in.	3.060	3.062	+0.08		Pass
Clip weld: k = kl/l		0.204	0.204	+0.08		Pass
Clip weld: xl	in.	0.443	0.444	+0.22		Pass
Clip weld: a = al/l		0.644	0.644	-0.04		Pass
Clip weld: C (Table 8-8, angle 0°) AISC interpolates Manual Table 8-8; ILX solves the IC method on the same weld group.		1.500	1.496	-0.24		Pass
Clip weld: Dmin (sixteenths)		3.130	3.136	+0.21		Pass
Whitmore width lw = 4 + 2 (8) tan 30°	in.	13.20	13.24	+0.28		Pass
Gusset tensile yielding on the Whitmore section	kips	198.0	198.2	+0.08		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Interface: horizontal shear H	kips	39.60	39.48	-0.29		Pass
Interface: vertical tension V	kips	28.20	28.16	-0.14		Pass
Interface: compression C (WT to column)	kips	47.60	47.72	+0.24		Pass
Interface: moment M about the column face	kip-in.	227.0	227.4	+0.16		Pass

ILX governing check: `column_prying` (Column flange: prying action), ratio 0.962. ILX result: **OK**; published: **OK**.

II.C-2 (L1): Truss panel point L1: diagonal and vertical welded to the bottom chord stem (stem plate)

Source: AISC Design Examples v16.0, Example II.C-2, Solution A, pp. IIC-16 to IIC-21. Connection: Truss connection, support Chord stem (panel point).

II.C-2 (L1) · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Bottom chord stem: required shear at Section A-A	kips	104.0	104.0	+0.00		Pass
Bottom chord stem: shear yielding (0.60 Fy d tw)	kips	106.0	106.0	+0.04		Pass
U1L1 welds: minimum length per weld (D = 3)	in.	6.230	6.226	-0.07		Pass
U1L1 angle tmin = 3.09 D/Fu (Eq. 9-6)	in.	0.143	0.143	-0.27		Pass
Tee stem tmin = 6.19 D/Fu (Eq. 9-7)	in.	0.286	0.286	-0.11		Pass
U0L1 welds: minimum length per weld (D = 3)	in.	9.880	9.877	-0.03		Pass
U0L1 tensile yielding	kips	241.0	241.2	+0.08		Pass
U0L1 shear lag U (l = 10 in.)		0.859	0.859	+0.05		Pass
U0L1 tensile rupture	kips	224.0	224.6	+0.26		Pass
Bottom chord block shear	kips	278.0	277.4	-0.23		Pass

ILX governing check: `m0_weld` (U0L1: fillet welds to the chord stem / stem plate), ratio 0.988. ILX result: **OK**; published: **OK**.

II.C-2 (L1) · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Bottom chord stem: required shear at Section A-A	kips	69.20	69.20	+0.00		Pass
Bottom chord stem: shear yielding (0.60 Fy d tw)	kips	70.70	70.69	-0.01		Pass
U1L1 welds: minimum length per weld (D = 3)	in.	6.210	6.214	+0.06		Pass
U1L1 angle tmin = 3.09 D/Fu (Eq. 9-6)	in.	0.143	0.143	-0.27		Pass
Tee stem tmin = 6.19 D/Fu (Eq. 9-7)	in.	0.286	0.286	-0.11		Pass
U0L1 welds: minimum length per weld (D = 3)	in.	9.880	9.877	-0.03		Pass
U0L1 tensile yielding	kips	160.0	160.5	+0.30		Pass
U0L1 shear lag U (l = 10 in.)		0.859	0.859	+0.05		Pass
U0L1 tensile rupture	kips	150.0	149.7	-0.19		Pass
Bottom chord block shear	kips	185.0	184.9	-0.05		Pass

ILX governing check: `m0_weld` (U0L1: fillet welds to the chord stem / stem plate), ratio 0.988. ILX result: **OK**; published: **OK**.

II.C-2 (U1): Truss panel point U1: vertical and diagonal welded to the top chord stem (unequal welds)

Source: AISC Design Examples v16.0, Example II.C-2, Solution B, pp. IIC-21 to IIC-23. Connection: Truss connection, support Chord stem (panel point).

II.C-2 (U1) · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Top chord stem: required shear at Section B-B (104 − 30)	kips	74.00	74.00	+0.00		Pass
Top chord stem: shear yielding (0.60 Fy d tw)	kips	113.0	112.7	-0.22		Pass
U1L2 welds: minimum length per angle, heel + toe (D = 4)	in.	10.20	10.24	+0.36		Pass
U1L2 welds provided: 7½ + 4	in.	11.50	11.50	+0.00		Pass
U1L2 angle tmin = 3.09 D/Fu (Eq. 9-6)	in.	0.190	0.190	+0.08		Pass
Tee stem tmin = 6.19 D/Fu (Eq. 9-7)	in.	0.381	0.381	-0.02		Pass
U1L2 tensile yielding	kips	161.0	161.1	+0.06		Pass
U1L2 shear lag U (l = 5.75 in.)		0.792	0.792	+0.03		Pass
U1L2 tensile rupture	kips	138.0	138.3	+0.19		Pass

ILX governing check: `m0_weld` (U1L1: fillet welds to the chord stem), ratio 0.958. ILX result: **OK**; published: **OK**.

II.C-2 (U1) · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Top chord stem: required shear at Section B-B (104 − 30)	kips	49.20	49.20	+0.00		Pass
Top chord stem: shear yielding (0.60 Fy d tw)	kips	75.30	75.17	-0.18		Pass
U1L2 welds: minimum length per angle, heel + toe (D = 4)	in.	10.20	10.24	+0.36		Pass
U1L2 welds provided: 7½ + 4	in.	11.50	11.50	+0.00		Pass
U1L2 angle tmin = 3.09 D/Fu (Eq. 9-6)	in.	0.190	0.190	+0.08		Pass
Tee stem tmin = 6.19 D/Fu (Eq. 9-7)	in.	0.381	0.381	-0.02		Pass
U1L2 tensile yielding	kips	107.0	107.2	+0.17		Pass
U1L2 shear lag U (l = 5.75 in.)		0.792	0.792	+0.03		Pass
U1L2 tensile rupture	kips	92.00	92.18	+0.19		Pass

ILX governing check: `m0_weld` (U1L1: fillet welds to the chord stem), ratio 0.956. ILX result: **OK**; published: **OK**.

II.D-1: WT hanger connection (2L3×3×5/16 welded to a WT6×17.5 stem, bolted to a W21×57)

Source: AISC Design Examples v16.0, Example II.D-1, pp. IID-2 to IID-13. Connection: WT hanger.

II.D-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa	kips	60.00	60.00	+0.00		Pass
Minimum weld length lmin (Manual Eq. 8-2)	in.	3.590	3.592	+0.05		Pass
Angle shear rupture along the welds	kips	146.0	146.5	+0.33		Pass
Angle tensile yielding	kips	160.0	160.2	+0.12		Pass
Shear lag U (Table D3.1, Case 4)		0.661	0.661	+0.01		Pass
Angle tensile rupture	kips	115.0	114.7	-0.24		Pass
Tension per bolt rut / rat	kips	15.00	15.00	+0.00		Pass
Available bolt tension (Manual Table 7-2)	kips	29.80	29.82	+0.07		Pass
b = (g − tw)/2	in.	1.600	1.600	+0.00		Pass
Tributary length p (Manual Fig. 9-4)	in.	4.500	4.500	+0.00		Pass
a = (bf − g)/2	in.	1.530	1.530	-0.00		Pass
b' (Manual Eq. 9-24)	in.	1.230	1.225	-0.41		Pass
a' (Manual Eq. 9-23)	in.	1.910	1.905	-0.26		Pass
ρ (Manual Eq. 9-29)		0.644	0.643	-0.15		Pass
β (Manual Eq. 9-35)		1.530	1.537	+0.42		Pass
α' (Manual Eq. 9-36a)		1.000	1.000	+0.00		Pass
δ (Manual Eq. 9-28)		0.819	0.819	+0.05		Pass
tmin of the WT flange (Manual Eq. 9-37)	in.	0.393	0.392	-0.32		Pass
t to eliminate prying (Manual Eq. 9-30 at Tr)	in.	0.529	0.528	-0.11		Pass
WT flange shear yielding	kips	281.0	280.8	-0.07		Pass
WT flange shear rupture	kips	221.0	220.5	-0.21		Pass
Whitmore width lw	in.	7.620	7.619	-0.02		Pass
Stem Whitmore yielding, nominal Rn = Fy Ag	kips	115.0	114.3	-0.62		Pass
Stem Whitmore yielding, available AISC rounds Ag = 2.29 in.² and Rn = 115 kips before applying φ (exact: lw tw = 2.286 in.², Rn = 114.3 kips; φRn = 102.9 kips). The nominal row above matches within 1 %.	kips	104.0	102.9	-1.10		Pass
Stem shear rupture at the welds	kips	70.20	70.20	-0.00		Pass
Stem block shear, U-shaped	kips	98.30	97.88	-0.43		Pass
Stem block shear, L-shaped	kips	115.0	114.8	-0.22		Pass
Beam required flexural strength Mu / Ma	kip-in.	4,460	4,458	-0.04		Pass
Beam Mn with holes in the tension flange (Spec. Eq. F13-1)	kip-in.	5,280	5,290	+0.19		Pass
Beam available flexural strength at the holes	kip-in.	4,750	4,761	+0.24		Pass

ILX governing check: `beam_holes_flexure` (Supporting beam: flexure with bolt holes in the tension flange), ratio 0.936. ILX result: **OK**; published: **OK**.

II.D-1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa	kips	40.00	40.00	+0.00		Pass
Minimum weld length lmin (Manual Eq. 8-2)	in.	3.590	3.592	+0.05		Pass
Angle shear rupture along the welds	kips	97.50	97.66	+0.16		Pass
Angle tensile yielding	kips	107.0	106.6	-0.39		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Shear lag U (Table D3.1, Case 4)		0.661	0.661	+0.01		Pass
Angle tensile rupture	kips	76.50	76.48	-0.02		Pass
Tension per bolt rut / rat	kips	10.00	10.00	+0.00		Pass
Available bolt tension (Manual Table 7-2)	kips	19.90	19.88	-0.10		Pass
b = (g − tw)/2	in.	1.600	1.600	+0.00		Pass
Tributary length p (Manual Fig. 9-4)	in.	4.500	4.500	+0.00		Pass
a = (bf − g)/2	in.	1.530	1.530	-0.00		Pass
b' (Manual Eq. 9-24)	in.	1.230	1.225	-0.41		Pass
a' (Manual Eq. 9-23)	in.	1.910	1.905	-0.26		Pass
ρ (Manual Eq. 9-29)		0.644	0.643	-0.15		Pass
β (Manual Eq. 9-35)		1.540	1.537	-0.23		Pass
α' (Manual Eq. 9-36a)		1.000	1.000	+0.00		Pass
δ (Manual Eq. 9-28)		0.819	0.819	+0.05		Pass
tmin of the WT flange (Manual Eq. 9-37)	in.	0.393	0.392	-0.22		Pass
t to eliminate prying (Manual Eq. 9-30 at Tr)	in.	0.530	0.529	-0.20		Pass
WT flange shear yielding	kips	187.0	187.2	+0.11		Pass
WT flange shear rupture	kips	147.0	147.0	+0.02		Pass
Whitmore width lw	in.	7.620	7.619	-0.02		Pass
Stem Whitmore yielding, nominal Rn = Fy Ag	kips	115.0	114.3	-0.62		Pass
Stem Whitmore yielding, available AISC rounds Ag = 2.29 in.² and Rn = 115 kips before applying φ (exact: lw tw = 2.286 in.², Rn = 114.3 kips; φRn = 102.9 kips). The nominal row above matches within 1 %.	kips	68.90	68.43	-0.68		Pass
Stem shear rupture at the welds	kips	46.80	46.80	+0.00		Pass
Stem block shear, U-shaped	kips	65.50	65.25	-0.38		Pass
Stem block shear, L-shaped	kips	76.50	76.50	+0.00		Pass
Beam required flexural strength Mu / Ma	kip-in.	2,960	2,955	-0.17		Pass
Beam Mn with holes in the tension flange (Spec. Eq. F13-1)	kip-in.	5,280	5,290	+0.19		Pass
Beam available flexural strength at the holes	kip-in.	3,160	3,168	+0.25		Pass

ILX governing check: `beam_holes_flexure` (Supporting beam: flexure with bolt holes in the tension flange), ratio 0.933. ILX result: **OK**; published: **OK**.

II.D-2A: Beam bearing on a concrete wall without a plate (lb = h = 10 in.)

Source: AISC Design Examples v16.0, Example II.D-2 Solution A, pp. IID-14 to IID-17. Connection: Beam bearing plate.

II.D-2A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	90.00	90.00	+0.00		Pass
Web local yielding φR1 / R1/Ω (Table 9-4)	kips	43.10	43.13	+0.08		Pass
Web local yielding φR2 / R2/Ω (kip/in., Table 9-4)		17.80	17.75	-0.28		Pass
lb,min for web local yielding (Manual Eq. 9-60)	in.	2.630	2.640	+0.40		Pass
Web crippling φR5 / R5/Ω (Table 9-4)	kips	52.00	52.02	+0.03		Pass
Web crippling φR6 / R6/Ω (kip/in., Table 9-4)		6.300	6.301	+0.01		Pass
lb,min for web crippling (Manual Eq. 9-63)	in.	6.030	6.028	-0.03		Pass
Concrete bearing Pp = 0.85 f'c A1 (Spec. Eq. J8-1)	kips	191.0	191.2	+0.13		Pass
Available concrete bearing φcPp / Pp/Ωc	kips	124.0	124.3	+0.25		Pass
Flange cantilever n = bf/2 − kdes	in.	2.780	2.778	-0.07		Pass
Required flange thickness tf,min	in.	0.642	0.642	-0.07		Pass

ILX governing check: `flange_thickness` (Beam flange bending without a bearing plate), ratio 1.126. ILX result: **NG**; published: **NG**.

II.D-2A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Ru / Ra	kips	60.00	60.00	+0.00		Pass
Web local yielding φR1 / R1/Ω (Table 9-4)	kips	28.80	28.75	-0.16		Pass
Web local yielding φR2 / R2/Ω (kip/in., Table 9-4)		11.80	11.83	+0.28		Pass
lb,min for web local yielding (Manual Eq. 9-60)	in.	2.640	2.640	+0.02		Pass
Web crippling φR5 / R5/Ω (Table 9-4)	kips	34.70	34.68	-0.06		Pass
Web crippling φR6 / R6/Ω (kip/in., Table 9-4)		4.200	4.201	+0.01		Pass
lb,min for web crippling (Manual Eq. 9-63)	in.	6.020	6.028	+0.14		Pass
Concrete bearing Pp = 0.85 f'c A1 (Spec. Eq. J8-1)	kips	191.0	191.2	+0.13		Pass
Available concrete bearing φcPp / Pp/Ωc	kips	82.70	82.79	+0.11		Pass
Flange cantilever n = bf/2 − kdes	in.	2.780	2.778	-0.07		Pass
Required flange thickness tf,min	in.	0.643	0.642	-0.13		Pass

ILX governing check: `flange_thickness` (Beam flange bending without a bearing plate), ratio 1.127. ILX result: **NG**; published: **NG**.

II.D-2B: Beam bearing plate PL3/4×10×0'-8 on the full wall thickness (lb = 10 in.)

Source: AISC Design Examples v16.0, Example II.D-2 Solution B, pp. IID-17 to IID-18. Connection: Beam bearing plate.

II.D-2B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required bearing area A1,req (in.²)		54.30	54.30	-0.00		Pass
Required plate width B,req	in.	5.430	5.430	-0.00		Pass
Plate cantilever n = B/2 − kdes (Manual Eq. 14-1)	in.	3.030	3.028	-0.07		Pass
Required plate thickness tmin	in.	0.678	0.677	-0.14		Pass

ILX governing check: `plate_thickness` (Bearing plate thickness (cantilever bending)), ratio 0.903. ILX result: **OK**; published: **OK**.

II.D-2B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required bearing area A1,req (in.²)		54.40	54.35	-0.09		Pass
Required plate width B,req	in.	5.440	5.435	-0.09		Pass
Plate cantilever n = B/2 − kdes (Manual Eq. 14-1)	in.	3.030	3.028	-0.07		Pass
Required plate thickness tmin	in.	0.678	0.678	-0.04		Pass

ILX governing check: `plate_thickness` (Bearing plate thickness (cantilever bending)), ratio 0.904. ILX result: **OK**; published: **OK**.

II.D-2C: Beam bearing plate PL7/8×6-1/2×0'-8 centred on the wall (lb = 6-1/2 in.)

Source: AISC Design Examples v16.0, Example II.D-2 Solution C, pp. IID-18 to IID-20. Connection: Beam bearing plate.

II.D-2C · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Bearing area A1 = B lb (in.²)		52.00	52.00	+0.00		Pass
Geometrically similar area A2 (in.²)		115.0	115.0	+0.00		Pass
Concrete bearing Pp (Spec. Eq. J8-2)	kips	197.0	197.2	+0.10		Pass
Available concrete bearing φcPp / Pp/Ωc	kips	128.0	128.2	+0.14		Pass
Plate cantilever n = B/2 − kdes	in.	3.030	3.028	-0.07		Pass
Required plate thickness tmin	in.	0.840	0.840	-0.02		Pass

ILX governing check: `web_crippling` (Beam web local crippling at the bearing), ratio 0.968. ILX result: **OK**; published: **OK**.

II.D-2C · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Bearing area A1 = B lb (in.²)		52.00	52.00	+0.00		Pass
Geometrically similar area A2 (in.²)		115.0	115.0	+0.00		Pass
Concrete bearing Pp (Spec. Eq. J8-2)	kips	197.0	197.2	+0.10		Pass
Available concrete bearing φcPp / Pp/Ωc	kips	85.30	85.36	+0.08		Pass
Plate cantilever n = B/2 − kdes	in.	3.030	3.028	-0.07		Pass
Required plate thickness tmin	in.	0.841	0.841	-0.04		Pass

ILX governing check: `web_crippling` (Beam web local crippling at the bearing), ratio 0.968. ILX result: **OK**; published: **OK**.

K.10: Rectangular HSS strut end plate (HSS4×4×1/4, PL1/2, (4) 3/4 in. Group 120 bolts)

Source: AISC Design Examples v16.0, Example K.10, pp. K-45 to K-48. Connection: HSS strut end plate.

K.10 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa	kips	99.20	99.20	+0.00		Pass
Tension per bolt rut / rat	kips	24.80	24.80	+0.00		Pass
Available bolt tension (Manual Table 7-2)	kips	29.80	29.82	+0.07		Pass
a' (Manual Eq. 9-23)	in.	1.880	1.875	-0.27		Pass
b' (Manual Eq. 9-24)	in.	1.130	1.125	-0.44		Pass
ρ (Manual Eq. 9-29)		0.601	0.600	-0.17		Pass
Tributary length p = plate width / bolts per side	in.	10.00	10.00	+0.00		Pass
δ (Manual Eq. 9-28)		0.919	0.919	-0.03		Pass
β (Manual Eq. 9-35)		0.335	0.337	+0.72		Pass
α' (Manual Eq. 9-36b) AISC carries the rounded b' = 1.13 in., a' = 1.88 in. (ρ = 0.601) and φrn = 29.8 kips into β; unrounded, ρ = 0.600, β = 0.337 and α' = 0.554 (LRFD). tmin agrees within 1 %.		0.548	0.554	+1.14		Pass
Minimum end-plate thickness (Eq. 9-37 with Fy)	in.	0.407	0.405	-0.40		Pass
Weld length l = 4 × 4.00 in.	in.	16.00	16.00	+0.00		Pass
Required weld size D (sixteenths) The ASD line of the example prints (1.50) for kds; the published 4.44 follows from kds = 1.0.		4.450	4.454	+0.08		Pass
Minimum fillet (Table J2.4, t = 1/4 in.)	in.	0.125	0.125	+0.00		Pass

ILX governing check: `weld_hss` (HSS-to-end-plate fillet weld (kds = 1.0, full perimeter)), ratio 0.891. ILX result: **OK**; published: **OK**.

K.10 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa	kips	66.00	66.00	+0.00		Pass
Tension per bolt rut / rat	kips	16.50	16.50	+0.00		Pass
Available bolt tension (Manual Table 7-2)	kips	19.90	19.88	-0.10		Pass
a' (Manual Eq. 9-23)	in.	1.880	1.875	-0.27		Pass
b' (Manual Eq. 9-24)	in.	1.130	1.125	-0.44		Pass
ρ (Manual Eq. 9-29)		0.601	0.600	-0.17		Pass
Tributary length p = plate width / bolts per side	in.	10.00	10.00	+0.00		Pass
δ (Manual Eq. 9-28)		0.919	0.919	-0.03		Pass
β (Manual Eq. 9-35)		0.343	0.341	-0.45		Pass
α' (Manual Eq. 9-36b) AISC carries the rounded b' = 1.13 in., a' = 1.88 in. (ρ = 0.601) and φrn = 29.8 kips into β; unrounded, ρ = 0.600, β = 0.337 and α' = 0.554 (LRFD). tmin agrees within 1 %.		0.568	0.564	-0.64		Pass
Minimum end-plate thickness (Eq. 9-37 with Fy)	in.	0.405	0.404	-0.22		Pass
Weld length l = 4 × 4.00 in.	in.	16.00	16.00	+0.00		Pass
Required weld size D (sixteenths) The ASD line of the example prints (1.50) for kds; the published 4.44 follows from kds = 1.0.		4.440	4.445	+0.11		Pass
Minimum fillet (Table J2.4, t = 1/4 in.)	in.	0.125	0.125	+0.00		Pass

ILX governing check: `weld_hss` (HSS-to-end-plate fillet weld (kds = 1.0, full perimeter)), ratio 0.889. ILX result: **OK**; published: **OK**.

J.6: Column base plate bearing on concrete, W12×96 on a 24 × 24 pier

Source: AISC Design Examples v16.0, Example J.6, pp. J-20 to J-23. Connection: Base plate.

J.6 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Concrete bearing φcPp / Pp/Ωc (J8)	kips	875.0	875.2	+0.02		Pass
Required plate thickness tmin	in.	1.540	1.541	+0.06		Pass
Cantilever m	in.	4.970	4.968	-0.05		Pass
Cantilever n	in.	6.120	6.120	+0.00		Pass
Cantilever n′	in.	3.110	3.112	+0.06		Pass
λn′ (λ = 1)	in.	3.110	3.112	+0.06		Pass

ILX result: **– (surrogate)**; published: **OK**.

J.6 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Concrete bearing φcPp / Pp/Ωc (J8)	kips	583.0	582.9	-0.02		Pass
Required plate thickness tmin	in.	1.540	1.542	+0.13		Pass
λn′ (λ = 1)	in.	3.110	3.112	+0.06		Pass

ILX result: **– (surrogate)**; published: **OK**.

K.9: Rectangular HSS column base plate, HSS6×6×½ on a 7 ft 6 in. footing

Source: AISC Design Examples v16.0, Example K.9, pp. K-42 to K-44. Connection: Base plate.

K.9 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Nominal bearing strength Pp	kips	862.0	861.9	-0.01		Pass
Cantilever m (0.95 × HSS depth)	in.	3.650	3.650	+0.00		Pass
Cantilever n (0.95 × HSS width)	in.	3.650	3.650	+0.00		Pass
Concrete bearing φcPp / Pp/Ωc (J8)	kips	560.0	560.2	+0.04		Pass
Required plate thickness tmin	in.	0.917	0.917	+0.00		Pass

ILX result: **– (surrogate)**; published: **OK**.

K.9 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Concrete bearing φcPp / Pp/Ωc (J8)	kips	373.0	373.1	+0.03		Pass
Required plate thickness tmin	in.	0.918	0.918	+0.00		Pass

ILX result: **– (surrogate)**; published: **OK**.

STI 2024 Ex. 1: Round HSS column base plate, axial load

Source: Steel Tube Institute (2024), HSS column base plate examples (DG1 3rd Ed.). Connection: Base plate.

STI 2024 Ex. 1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Cantilever m	in.	4.200	4.200	-0.00		Pass
Cantilever n	in.	4.200	4.200	-0.00		Pass
Required plate thickness	in.	1.100	1.100	-0.01		Pass

ILX result: **– (surrogate)**; published: **OK**.

STI 2024 Ex. 2: Rectangular HSS16×12×½ column base plate, large moment

Source: Steel Tube Institute (2024), HSS column base plate examples (DG1 3rd Ed.). Connection: Base plate.

STI 2024 Ex. 2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Bearing length Y	in.	9.710	9.713	+0.03		Pass
Total anchor rod tension T	kips	53.30	53.32	+0.03		Pass
Required plate thickness, bearing interface	in.	1.380	1.379	-0.07		Pass
Required plate thickness, tension interface	in.	0.730	0.727	-0.41		Pass

ILX result: **– (surrogate)**; published: **OK**.

DG1-3 4.7-1: Concentric axial compression, no concrete confinement (A2 = A1)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-1, pp. 64 to 67 (PDF 74 to 77). Connection: Base plate.

> Surrogate model: The example sets A2 = A1 (Case I, confinement ignored) although the pedestal is 24 × 24 in.; ILX models a 22 × 20 in. support (A2 = A1) to reproduce that assumption. Rod pattern 16 × 14 in. assumed.

DG1-3 4.7-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Concrete bearing φcPp / Pp/Ωc (Spec. Eq. J8-1)	kips	729.0	729.3	+0.04		Pass
m = (N − 0.95d)/2 (Eq. 4-10)	in.	4.970	4.968	-0.05		Pass
n = (B − 0.8bf)/2 (Eq. 4-11)	in.	5.120	5.120	+0.00		Pass
X (Eq. 4-14)		0.960	0.959	-0.06		Pass
λ = 2√X/(1 + √(1 − X)) ≤ 1 (Eq. 4-13)		1.000	1.000	+0.00		Pass
λn′ = λ√(d bf)/4 (Eq. 4-12)	in.	3.110	3.112	+0.06		Pass
l = max(m, n, λn′)	in.	5.120	5.120	+0.00		Pass
tmin = l √(2Pu/(φb Fy BN)) (Eq. 4-15)	in.	1.360	1.361	+0.07		Pass

ILX governing check: (Concrete bearing (J8)), ratio 0.960. ILX result: **OK**; published: **OK**.

DG1-3 4.7-1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Concrete bearing φcPp / Pp/Ωc (Spec. Eq. J8-1)	kips	486.0	485.7	-0.06		Pass
m = (N − 0.95d)/2 (Eq. 4-10)	in.	4.970	4.968	-0.05		Pass
n = (B − 0.8bf)/2 (Eq. 4-11)	in.	5.120	5.120	+0.00		Pass
X (Eq. 4-14)		0.958	0.959	+0.11		Pass
λ = 2√X/(1 + √(1 − X)) ≤ 1 (Eq. 4-13)		1.000	1.000	+0.00		Pass
λn′ = λ√(d bf)/4 (Eq. 4-12)	in.	3.110	3.112	+0.06		Pass
l = max(m, n, λn′)	in.	5.120	5.120	+0.00		Pass
tmin = l √(2Pu/(φb Fy BN)) (Eq. 4-15)	in.	1.360	1.362	+0.15		Pass

ILX governing check: (Concrete bearing (J8)), ratio 0.959. ILX result: **OK**; published: **OK**.

DG1-3 4.7-2: Concentric axial compression with concrete confinement (Case III)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-2, pp. 67 to 70 (PDF 77 to 80). Connection: Base plate.

> Surrogate model: Rod pattern 16 × 14 in. assumed (the example keeps the 4.7-1 rods).

DG1-3 4.7-2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
A2 on the 24 × 24 in. pier	in.²	528.0	518.4	-1.82		Deviation B4
B4 A2 by equal edge offsets: DG1 takes the pier-limited area as N2 = 24 in. by B2 = B + (24 − N) = 22 in. (A2 = 528 in.², 2 in. all round); ILX uses the AISC 360-22 J8 definition, the largest area geometrically similar to the plate (k = 24/20 = 1.2, A2 = 1.2² × 360 = 518.4 in.²), which DG1 Section 4.2 also states. √(A2/A1) 1.200 vs 1.211: ILX bearing strength 0.9 % lower (conservative).						
Concrete bearing φcPp / Pp/Ωc (Spec. Eq. J8-2) ILX 716 / 477 kips with A2 = 518.4 in.² (B4); within the 1 % band.	kips	723.0	716.0	-0.96		Pass
m (Eq. 4-10)	in.	3.970	3.967	-0.06		Pass
n (Eq. 4-11)	in.	4.120	4.120	+0.00		Pass
X (Eq. 4-14) ILX X = 0.977 with its 0.9 % lower φcPp (B4); within the 1 % band.		0.968	0.977	+0.95		Pass
λ (Eq. 4-13, ≤ 1)		1.000	1.000	+0.00		Pass
λn′ (Eq. 4-12)	in.	3.110	3.112	+0.06		Pass
l = max(m, n, λn′)	in.	4.120	4.120	+0.00		Pass
tmin (Eq. 4-15)	in.	1.210	1.211	+0.08		Pass

ILX governing check: (Concrete bearing (J8)), ratio 0.978. ILX result: **OK**; published: **OK**.

DG1-3 4.7-2 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Concrete bearing φcPp / Pp/Ωc (Spec. Eq. J8-2) ILX 716 / 477 kips with A2 = 518.4 in.² (B4); within the 1 % band.	kips	481.0	476.9	-0.86		Pass
m (Eq. 4-10)	in.	3.970	3.967	-0.06		Pass
n (Eq. 4-11)	in.	4.120	4.120	+0.00		Pass
X (Eq. 4-14) ILX X = 0.977 with its 0.9 % lower φcPp (B4); within the 1 % band.		0.968	0.977	+0.91		Pass
λ (Eq. 4-13, ≤ 1)		1.000	1.000	+0.00		Pass
λn′ (Eq. 4-12)	in.	3.110	3.112	+0.06		Pass
l = max(m, n, λn′)	in.	4.120	4.120	+0.00		Pass
tmin (Eq. 4-15)	in.	1.210	1.212	+0.17		Pass

ILX governing check: (Concrete bearing (J8)), ratio 0.977. ILX result: **OK**; published: **OK**.

DG1-3 4.7-3: Concentric axial tension (uplift), rods inside the column flanges

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-3, pp. 70 to 76 (PDF 80 to 86). Connection: Base plate.

> Surrogate model: Plate plan size not given in the example: 14 × 14 in. used. The web-weld rows use the example's 3/16 in. web fillet (override); the base case keeps 5/16 in., because ILX takes the minimum fillet size of the web weld from the flange thickness (Table J2.4: ¼ in. for tf = 0.62 in.; DG1: 3/16 in. for the 0.350 in. web). The hooked-rod row overrides the headed rod with the 3½ in. hook.

DG1-3 4.7-3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Tension per rod ru / ra	kips	17.50	17.50	+0.00		Pass
Rod tension φRn / Rn/Ω = Fu Ase,N (Eq. 4-22, AISC rod check) Rod tension area: DG1 3rd Ed. (Eq. 4-22, Table 4-1) takes Rn = Fu Ase,N with the threaded tensile stress area (AISC 360-22 Table J3.2 footnote b, as ACI 318-19 Eq. 17.6.1.2); the ILX AISC rod-tension check uses the Specification default Rn = 0.75 Fu Ab. Both are permitted; ILX is 2.4 % lower (conservative, within the 0.5 kip band). The ILX ACI 17.6.1 steel check (next row) uses Ase,N and agrees.	kips	20.10	19.62	-2.40		Pass
Rod tension φNsa = 0.75 Fu Ase,N (ACI 318-19 17.6.1)	kips	20.10	20.09	-0.07		Pass
Plate moment per rod Mu = ru a (a = g − tw/2)	kip-in.	32.00	31.94	-0.20		Pass
Required plate thickness treq (b_eff = 2a = 3.66 in.)	in.	0.882	0.882	+0.00		Pass
Web weld demand ruw = ru/b_eff Fixed (B10): ILX halved this demand before the DG1 3rd Ed. verification.	kip/in.	4.780	4.795	+0.30		Pass
Web weld φRn / Rn/Ω, 3/16 in. fillet, kds = 1.5	kip/in.	6.260	6.264	+0.07		Pass
Column web stress fweb = 2 ruw/tw	ksi	27.30	27.40	+0.36		Pass
Hooked rod (3½ in. hook, eh = 2.63 in.) φNpn = 0.70 × 0.9 f'c eh da	kips	5.800	5.788	-0.20		Pass
Headed rod pullout φNpn (Table 4-2, 8 Abrg f'c)	kips	26.70	26.62	-0.31		Pass
ANc (hef = 15 in., 4 × 4 in. pattern)	in.²	2,400	2,401	+0.04		Pass
ANco = 9 hef²	in.²	2,030	2,025	-0.25		Pass
Nb = 16 λa √f'c hef^5/3 (Eq. 17.6.2.2.3)	kips	92.30	92.32	+0.02		Pass
Ncbg (Eq. 17.6.2.1b)	kips	109.0	109.5	+0.43		Pass
φNcbg (φ = 0.70, Condition B)	kips	76.30	76.62	+0.43		Pass

ILX governing check: (Concrete breakout in tension (ACI 318-19 17.6.2)), ratio 0.914. ILX result: **OK**; published: **OK**.

DG1-3 4.7-3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Tension per rod ru / ra	kips	11.30	11.25	-0.44		Pass
Rod tension φRn / Rn/Ω = Fu Ase,N (Eq. 4-22, AISC rod check) Rod tension area: DG1 3rd Ed. (Eq. 4-22, Table 4-1) takes Rn = Fu Ase,N with the threaded tensile stress area (AISC 360-22 Table J3.2 footnote b, as ACI 318-19 Eq. 17.6.1.2); the ILX AISC rod-tension check uses the Specification default Rn = 0.75 Fu Ab. Both are permitted; ILX is 2.4 % lower (conservative, within the 0.5 kip band). The ILX ACI 17.6.1 steel check (next row) uses Ase,N and agrees.	kips	13.40	13.08	-2.40		Pass
Plate moment per rod Mu = ru a (a = g − tw/2)	kip-in.	20.70	20.53	-0.82		Pass
Required plate thickness treq (b_eff = 2a = 3.66 in.)	in.	0.869	0.867	-0.23		Pass
Web weld demand ruw = ru/b_eff Fixed (B10): ILX halved this demand before the DG1 3rd Ed. verification.	kip/in.	3.090	3.082	-0.25		Pass
Web weld φRn / Rn/Ω, 3/16 in. fillet, kds = 1.5	kip/in.	4.180	4.176	-0.09		Pass
Column web stress fweb = 2 ruw/tw	ksi	17.70	17.61	-0.49		Pass

ILX governing check: (Concrete breakout in tension (ACI 318-19 17.6.2)), ratio 0.940. ILX result: **OK**; published: **OK**.

DG1-3 4.7-4: Concentric shear on the anchor rods, limited by the edge distance

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-4, pp. 76 to 78 (PDF 86 to 88). Connection: Base plate.

> Surrogate model: Column, plate and embedment not given: W10×45, 14 × 14 × 1 in. plate, hef = 12 in.; concrete wall modelled as a 28 × 60 × 48 in. support (ca1 = 12 in., ca2 = 28 in., ha = 48 in.).

DG1-3 4.7-4 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Rod shear φRnv = φ 0.450 Fu Ab (per rod)	kips	8.630	8.648	+0.21		Pass
AVc = 1.5ca1 (1.5ca1 + s + 1.5ca1)	in.²	720.0	720.0	+0.00		Pass
AVco = 4.5 ca1²	in.²	648.0	648.0	+0.00		Pass
Vb = 9 λa √f'c ca1^1.5 (Eq. 17.7.2.2.1b)	kips	23.70	23.66	-0.16		Pass
Vcbg (Eq. 17.7.2.1b)	kips	26.30	26.29	-0.04		Pass
φVcbg (φ = 0.70)	kips	18.40	18.40	+0.02		Pass

ILX governing check: (Anchor steel in shear (ACI 318-19 17.7.1)), ratio 1.429. ILX result: **NG**; published: **OK**.
The example sizes the edge distance for the AISC rod shear strength of two rods (17.3 kips). ILX also checks the ACI 318-19 17.7.1 steel strength in shear with the 0.80 grout-pad factor (φVsa = 6.05 kips per rod) and the 1.25 shear magnifier of a grout pad without welded washers, so it reports the rods NG at 17.3 kips; the overall status is not compared.

DG1-3 4.7-5: Concentric shear by a shear lug (ACI 318-19 17.11)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-5, pp. 80 to 91 (PDF 90 to 101). Connection: Base plate.

> Surrogate model: The wall (30 in. wide, length not given) is a 30 × 120 × 60 in. support. Column web fillet ¼ in. in the base case (ILX minimum size from the flange); the web-weld rows use the example's 3/16 in. (override).

DG1-3 4.7-5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Lug eccentricity e = tgrout + hef,sl/2	in.	3.000	3.000	+0.00		Pass
Moment Mu = V e	kip-in.	75.00	75.00	+0.00		Pass
Available bearing stress φc fp(max) (A2/A1 = 4)	ksi	4.420	4.420	+0.00		Pass
Bearing length Y (Eq. 4-32)	in.	0.097	0.097	-0.03		Pass
Total rod tension T = qmax Y	kips	6.410	6.409	-0.01		Pass
Tension per rod (two rods)	kips	3.210	3.205	-0.17		Pass
Rod tension φRn / Rn/Ω (Table 4-1) ILX 0.75 Fu Ab is 0.6 % lower (see 4.7-3); within the 0.5 kip band.	kips	14.50	14.41	-0.60		Pass
Pullout φNpn (Table 4-2, ¾ in. heavy hex)	kips	20.40	20.41	+0.07		Pass
ψed,N (ca,min = 10.8 in.)		0.880	0.879	-0.09		Pass
ANco = 9 hef²	in.²	1,300	1,296	-0.31		Pass
ANc (two tension rods, one edge)	in.²	1,280	1,279	-0.05		Pass
Nb = 16 λa √f'c hef^5/3	kips	63.60	63.65	+0.08		Pass
Ncbg	kips	55.10	55.24	+0.25		Pass
φNcbg (φ = 0.70)	kips	38.60	38.67	+0.18		Pass
Lug bearing Vbrg,sl = 1.7 f'c Aef,sl ψbrg,sl (Eq. 17.11.2.1)	kips	109.0	108.8	-0.18		Pass
Lug bearing φVbrg,sl (φ = 0.65)	kips	70.90	70.72	-0.25		Pass
Lug breakout AVc (17.11.3.1.1)	in.²	1,210	1,207	-0.24		Pass
Lug breakout AVco = 4.5 ca1²	in.²	946.0	946.1	+0.01		Pass
Lug breakout Vb = 9 λa √f'c ca1^1.5 (ca1 = 14.5 in.)	kips	31.40	31.43	+0.09		Pass
Lug breakout Vcb	kips	40.20	40.10	-0.25		Pass
Lug breakout φVcb (φ = 0.65)	kips	26.10	26.06	-0.14		Pass
Lug shear yielding φRn / Rn/Ω (Eq. J4-3)	kips	240.0	240.0	+0.00		Pass
Lug shear rupture φRn / Rn/Ω (Eq. J4-4)	kips	234.0	234.0	+0.00		Pass
Lug flexural yielding φMn / Mn/Ω	kip-in.	90.00	90.00	+0.00		Pass
Lug flexural rupture φMn / Mn/Ω	kip-in.	97.50	97.50	+0.00		Pass
Lug flexure-shear interaction (Manual Eq. 9-1)		0.833	0.833	+0.05		Pass
Lug weld resultant ru = √(ruv² + rum²) (a = tsl + 2w/3)	kip/in.	7.910	7.914	+0.06		Pass
Lug weld φRn / Rn/Ω (5/16 in., kds = 1.5) ILX takes kds at the resultant angle (θ = 78.6°, kds = 1.49): 0.6 % / 0.8 % lower.	kip/in.	10.40	10.34	-0.59		Pass
Base plate local bending at the lug Mu	kip-in.	47.80	47.76	-0.08		Pass
Base plate flexural strength at the lug φMn / Mn/Ω (Zy = bsl tp²/4)	kip-in.	90.00	90.00	+0.00		Pass
Column web weld demand ru = V/(2T) (3/16 in.) Shear component (ILX also adds the rod tension of the lug moment, B15).	kip/in.	1.250	1.250	+0.00		Pass
Column web weld φRn / Rn/Ω (3/16 in., kds = 1.0)	kip/in.	4.180	4.525	+8.25		Deviation B15
B15 Column web weld with rods between the flanges and a shear lug: ILX adds the rod tension caused by the lug moment (3.21 / 2.05 kips per rod over b_eff = 2a) to the web weld shear and rates the resultant at its angle (kds > 1); DG1 checks the web weld for shear only (kds = 1.0, 4.18 / 2.79 kip/in.). ILX demand and capacity both higher; ratio slightly more conservative.						
Column web shear rupture φRn / Rn/Ω (Eq. J4-4)	kips	129.0	128.7	-0.23		Pass

ILX governing check: (Shear lug concrete breakout (ACI 318-19 17.11.3)), ratio 0.959. ILX result: **NG**; published: **OK**.
Every strength check passes, as in the example. ILX's detailing rule that the plate projects past the column by at least the weld size + ½ in. flags the example's 15 in. plate (¼ in. past the 14.5 in. W14×90 flange), so ILX reports NG on geometry; the overall status is not compared.

DG1-3 4.7-5 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Lug eccentricity e = tgrout + hef,sl/2	in.	3.000	3.000	+0.00		Pass
Moment Mu = V e	kip-in.	48.00	48.00	+0.00		Pass
Available bearing stress φc fp(max) (A2/A1 = 4)	ksi	2.940	2.944	+0.13		Pass
Bearing length Y (Eq. 4-32)	in.	0.093	0.093	-0.13		Pass
Total rod tension T = qmax Y	kips	4.100	4.101	+0.03		Pass
Tension per rod (two rods)	kips	2.050	2.051	+0.03		Pass
Rod tension φRn / Rn/Ω (Table 4-1) ILX 0.75 Fu Ab is 0.6 % lower (see 4.7-3); within the 0.5 kip band.	kips	9.690	9.609	-0.84		Pass
Lug shear yielding φRn / Rn/Ω (Eq. J4-3)	kips	160.0	160.0	+0.00		Pass
Lug shear rupture φRn / Rn/Ω (Eq. J4-4)	kips	156.0	156.0	+0.00		Pass
Lug flexural yielding φMn / Mn/Ω	kip-in.	59.90	59.88	-0.03		Pass
Lug flexural rupture φMn / Mn/Ω	kip-in.	65.00	65.00	+0.00		Pass
Lug flexure-shear interaction (Manual Eq. 9-1)		0.801	0.802	+0.09		Pass
Lug weld resultant ru = √(ruv² + rum²) (a = tsl + 2w/3)	kip/in.	5.060	5.065	+0.10		Pass
Lug weld φRn / Rn/Ω (5/16 in., kds = 1.5) ILX takes kds at the resultant angle (θ = 78.6°, kds = 1.49): 0.6 % / 0.8 % lower.	kip/in.	6.950	6.892	-0.83		Pass
Base plate local bending at the lug Mu	kip-in.	30.60	30.57	-0.10		Pass
Base plate flexural strength at the lug φMn / Mn/Ω (Zy = bsl tp²/4)	kip-in.	59.90	59.88	-0.03		Pass
Column web weld demand ru = V/(2T) (3/16 in.) Shear component (ILX also adds the rod tension of the lug moment, B15).	kip/in.	0.800	0.800	+0.00		Pass
Column web weld φRn / Rn/Ω (3/16 in., kds = 1.0)	kip/in.	2.790	3.016	+8.12		Deviation B15
B15 Column web weld with rods between the flanges and a shear lug: ILX adds the rod tension caused by the lug moment (3.21 / 2.05 kips per rod over b_eff = 2a) to the web weld shear and rates the resultant at its angle (kds > 1); DG1 checks the web weld for shear only (kds = 1.0, 4.18 / 2.79 kip/in.). ILX demand and capacity both higher; ratio slightly more conservative.						
Column web shear rupture φRn / Rn/Ω (Eq. J4-4)	kips	86.00	85.80	-0.23		Pass

ILX governing check: (Shear lug concrete breakout (ACI 318-19 17.11.3)), ratio 0.982. ILX result: **NG**; published: **OK**.
Every strength check passes, as in the example. ILX's detailing rule that the plate projects past the column by at least the weld size + ½ in. flags the example's 15 in. plate (¼ in. past the 14.5 in. W14×90 flange), so ILX reports NG on geometry; the overall status is not compared.

DG1-3 4.7-6: Anchor rods in combined tension, bending and shear (trial 1⅛ in. rods)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-6, pp. 91 to 94 (PDF 101 to 104). Connection: Base plate.

> Surrogate model: Plate plan size and rod pattern not given: 18 × 18 in. plate, 14 × 14 in. pattern; hef = 12 in.

DG1-3 4.7-6 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Shear stress frv = V/(4 Ab)	ksi	9.560	9.557	-0.03		Pass
Lever arm (tp + t_washer/2)/2	in.	0.594	0.594	-0.04		Pass
Rod moment Ml = (V/4) × arm	kip-in.	5.640	5.641	+0.01		Pass
Bending stress fb = Ml/Z, Z = d³/6	ksi	23.80	23.77	-0.13		Pass
Axial stress fa = N/(4 Ab)	ksi	18.40	18.41	+0.05		Pass
Total tensile stress ft	ksi	42.20	42.18	-0.05		Pass
φF′nt / F′nt/Ω (Spec. Eq. J3-3a/b)	ksi	26.50	26.48	-0.06		Pass

ILX governing check: (Tension-shear interaction (ACI 318-19 17.8)), ratio 7.616. ILX result: **NG**; published: **NG**.
Only the AISC steel limit states of the rods are evaluated in the example (the pier is stated to be reinforced for shear breakout); ILX also checks the ACI 318-19 concrete limit states of the 20 in. pier, which fail without anchor reinforcement, and the Table 14-1 washer thickness. The overall status is not compared.

DG1-3 4.7-6 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Shear stress frv = V/(4 Ab)	ksi	5.730	5.734	+0.07		Pass
Lever arm (tp + t_washer/2)/2	in.	0.594	0.594	-0.04		Pass
Rod moment Ml = (V/4) × arm	kip-in.	3.390	3.384	-0.17		Pass
Bending stress fb = Ml/Z, Z = d³/6	ksi	14.30	14.26	-0.27		Pass
Axial stress fa = N/(4 Ab)	ksi	10.70	10.71	+0.13		Pass
Total tensile stress ft	ksi	25.00	24.98	-0.10		Pass
φF′nt / F′nt/Ω (Spec. Eq. J3-3a/b)	ksi	18.70	18.72	+0.10		Pass

ILX governing check: (Tension-shear interaction (ACI 318-19 17.8)), ratio 7.215. ILX result: **NG**; published: **NG**.
Only the AISC steel limit states of the rods are evaluated in the example (the pier is stated to be reinforced for shear breakout); ILX also checks the ACI 318-19 concrete limit states of the 20 in. pier, which fail without anchor reinforcement, and the Table 14-1 washer thickness. The overall status is not compared.

DG1-3 4.7-6b: Anchor rods in combined tension, bending and shear (final 1½ in. rods)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-6, pp. 94 to 96 (PDF 104 to 106). Connection: Base plate.

> Surrogate model: As 4.7-6 with 1½ in. rods; the example's ⅜ in. washer (its Table 4-3, standard hole) is kept, thinner than the Manual Table 14-1 minimum for oversized holes that ILX checks.

DG1-3 4.7-6b · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Shear stress frv	ksi	5.370	5.376	+0.11		Pass
Bending stress fb (Z = 0.563 in.³)	ksi	10.00	10.03	+0.28		Pass
Axial stress fa	ksi	10.30	10.36	+0.54		Pass
Total tensile stress ft	ksi	20.30	20.38	+0.41		Pass
φF′nt / F′nt/Ω (≤ φFnt / Fnt/Ω)	ksi	32.60	32.62	+0.08		Pass
Plate washer bearing φRn / Rn/Ω = 3.0 d t Fu (Eq. J3-6b)	kips	82.50	82.27	-0.28		Pass
Plate washer tearout φRn / Rn/Ω = 1.5 lc t Fu (Eq. J3-6d)	kips	32.60	32.56	-0.11		Pass

ILX governing check: (Tension-shear interaction (ACI 318-19 17.8)), ratio 7.616. ILX result: **NG**; published: **OK**.
Only the AISC steel limit states of the rods are evaluated in the example (the pier is stated to be reinforced for shear breakout); ILX also checks the ACI 318-19 concrete limit states of the 20 in. pier, which fail without anchor reinforcement, and the Table 14-1 washer thickness. The overall status is not compared.

DG1-3 4.7-6b · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Shear stress frv	ksi	3.220	3.226	+0.17		Pass
Bending stress fb (Z = 0.563 in.³)	ksi	6.020	6.017	-0.06		Pass
Axial stress fa	ksi	6.020	6.027	+0.11		Pass
Total tensile stress ft	ksi	12.00	12.04	+0.36		Pass
φF′nt / F′nt/Ω (≤ φFnt / Fnt/Ω)	ksi	21.80	21.75	-0.23		Pass
Plate washer bearing φRn / Rn/Ω = 3.0 d t Fu (Eq. J3-6b)	kips	55.00	54.84	-0.28		Pass
Plate washer tearout φRn / Rn/Ω = 1.5 lc t Fu (Eq. J3-6d)	kips	21.80	21.71	-0.42		Pass

ILX governing check: (Tension-shear interaction (ACI 318-19 17.8)), ratio 7.215. ILX result: **NG**; published: **OK**.
Only the AISC steel limit states of the rods are evaluated in the example (the pier is stated to be reinforced for shear breakout); ILX also checks the ACI 318-19 concrete limit states of the 20 in. pier, which fail without anchor reinforcement, and the Table 14-1 washer thickness. The overall status is not compared.

DG1-3 4.7-7: Base at a brace: combined tension and shear, eight rods with a setting plate

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-7, pp. 96 to 104 (PDF 106 to 114). Connection: Base plate.

> Surrogate model: ILX's rod pattern is two rod lines across the column depth with rods spaced along B; the eight-rod pattern of Fig. 4-29 (two rows along the web) cannot be entered. ILX models the four rods between the flanges (x = ±6, y = ±3¼ in.) with half of the brace force (P = −69 / −45.85, V = 58 / 38.7 kips), which reproduces the per-rod forces and the plate and web-weld checks at a rod. The group strengths (breakout, pryout, interaction) are computed by the ILX anchorage engine (ACI 318-19 Ch. 17) with the exact eight rod positions.

DG1-3 4.7-7 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Tension per rod Nua,i = Nu / 8	kips	17.30	17.25	-0.29		Pass
Shear per rod Vua,i = Vu / 8	kips	14.50	14.50	+0.00		Pass
φNsa (Ase,N = 1.41 in.², futa = 58 ksi) ACI 318 strengths are LRFD (the example gives no ASD values); ILX Ase,N = 1.405 in.².	kips	61.40	61.13	-0.44		Pass
ANc (8 rods, hef = 24 in., no edges)	in.²	7,850	7,850	+0.00		Pass
ANco = 9 hef²	in.²	5,180	5,184	+0.08		Pass
Nb = 16 λa √f'c hef^5/3	kips	226.0	225.9	-0.03		Pass
φNcbg (φ = 0.70)	kips	239.0	239.5	+0.20		Pass
φNpn = 0.70 × 8 Abrg f'c (Abrg = 3.12 in.²)	kips	87.50	87.30	-0.23		Pass
φVsa = 0.65 × 0.80 × 0.6 Ase,V futa (grout pad)	kips	25.50	25.43	-0.28		Pass
φVcpg = 0.70 × 2 Ncbg	kips	479.0	478.9	-0.01		Pass
Interaction Nua/φNn + Vua/φVn (≤ 1.2)		1.150	1.146	-0.31		Pass
Setting plate bearing φRn = 0.75 × 2.4 d t Fu (¼ in. setting plate)	kips	43.90	43.88	-0.06		Pass
Setting plate field welds φRn (8 × ¼ in. × 2 in., kds = 1.5) ILX field-weld strength of the four-rod surrogate (4 × 2 in.) × 2 for the eight rods.	kips	134.0	133.6	-0.27		Pass
Plate moment arm a = (s − tw)/2 ILX uses tw = 0.515 in. (a = 2.99 in.); DG1 rounds tw to ½ in.	in.	3.000	2.993	-0.25		Pass
Plate moment Mr = Nua,i a ILX moment per unit width × b_e = 2a.	kip-in.	51.90	51.62	-0.54		Pass
Plate flexural strength φMn / Mn/Ω on b_e = 2a (1¾ in., Fy = 50 ksi)	kip-in.	207.0	206.2	-0.39		Pass
Web weld for the rod tension: demand per inch Nu / (8 × 6 in.) Published per-inch value = 138 / 48 (91.7 / 48) kips.	kip/in.	2.875	2.882	+0.25		Pass
Web weld strength per inch φRn / 48 in. (¼ in. fillet, kds = 1.5) Published per-inch value = 401 / 48 (268 / 48) kips.	kip/in.	8.354	7.856	-5.97		Deviation B22
B22 Web weld strength for the rod tension: DG1 rates the web fillets for the rod tension alone with the transverse-load increase kds = 1.5 (θ = 90°, Spec. Eq. J2-5); ILX rates the resultant of the web shear and the rod tension at its own angle (θ ≈ 64°, kds = 1.41): 6 % lower capacity per inch (conservative).						

ILX governing check: (Anchor rod combined tension, bending and shear (AISC J3.8; DG1)), ratio 1.293. ILX result: **NG**; published: **OK**.
Not compared: ILX checks the four-rod surrogate with welded plate washers (AISC J3.8 rod bending, which the setting plate of the example precludes) and its own weld minimum and grout-space detailing.

DG1-3 4.7-7 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Tension per rod Nua,i = Nu / 8	kips	11.50	11.46	-0.33		Pass
Shear per rod Vua,i = Vu / 8	kips	9.680	9.675	-0.05		Pass
Setting plate bearing φRn = 0.75 × 2.4 d t Fu (¼ in. setting plate)	kips	29.30	29.25	-0.17		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Setting plate field welds φRn (8 × ¼ in. × 2 in., kds = 1.5) ILX field-weld strength of the four-rod surrogate (4 × 2 in.) × 2 for the eight rods.	kips	89.00	89.09	+0.11		Pass
Plate moment arm a = (s − tw)/2 ILX uses tw = 0.515 in. (a = 2.99 in.); DG1 rounds tw to ½ in.	in.	3.000	2.993	-0.25		Pass
Plate moment Mr = Nua,i a ILX moment per unit width × b_e = 2a.	kip-in.	34.50	34.30	-0.58		Pass
Plate flexural strength φMn / Mn/Ω on b_e = 2a (1¾ in., Fy = 50 ksi)	kip-in.	138.0	137.2	-0.58		Pass
Web weld for the rod tension: demand per inch Nu / (8 × 6 in.) Published per-inch value = 138 / 48 (91.7 / 48) kips.	kip/in.	1.910	1.915	+0.25		Pass
Web weld strength per inch φRn / 48 in. (¼ in. fillet, kds = 1.5) Published per-inch value = 401 / 48 (268 / 48) kips.	kip/in.	5.583	5.235	-6.24		Deviation B22
B22 Web weld strength for the rod tension: DG1 rates the web fillets for the rod tension alone with the transverse-load increase kds = 1.5 (θ = 90°, Spec. Eq. J2-5); ILX rates the resultant of the web shear and the rod tension at its own angle (θ ≈ 64°, kds = 1.41): 6 % lower capacity per inch (conservative).						

ILX governing check: (Anchor rod combined tension, bending and shear (AISC J3.8; DG1)), ratio 1.293. ILX result: **NG**; published: **OK**.
Not compared: ILX checks the four-rod surrogate with welded plate washers (AISC J3.8 rod bending, which the setting plate of the example precludes) and its own weld minimum and grout-space detailing.

DG1-3 4.7-8: Base at a brace: combined compression and shear (friction)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-8, pp. 104 to 109 (PDF 114 to 119). Connection: Base plate.

> Surrogate model: Anchor rods not dimensioned in the example: four ¾ in. rods between the flanges, 6 × 6 in., assumed.

DG1-3 4.7-8 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Pp = 1.7 f'c A1 (A2 ≥ 4 A1)	kips	2,210	2,210	+0.00		Pass
Concrete bearing φcPp / Pp/Ωc	kips	1,440	1,436	-0.24		Pass
m (Eq. 4-10)	in.	1.050	1.052	+0.24		Pass
n (Eq. 4-11)	in.	1.380	1.380	-0.00		Pass
n′ = √(d bf)/4	in.	4.390	4.391	+0.02		Pass
X (Eq. 4-14), Pu = 619 / Pa = 486 kips		0.390	0.390	+0.13		Pass
λ (Eq. 4-13)		0.701	0.702	+0.12		Pass
l = max(m, n, λn′)	in.	3.080	3.082	+0.06		Pass
tmin (Eq. 4-15)	in.	0.896	0.897	+0.11		Pass
Friction φVn (Eq. 4-30; μ = 0.4, Pu = 496 kips) DG1: only LRFD is applicable to friction.	kips	129.0	129.0	-0.03		Pass
Web fillets (2 × 3/16 × 20 in., θ = 0°) φRn / Rn/Ω ILX strength per inch × the DG1 length 2T = 40 in. (ILX itself uses 2(d − 2k) = 42.2 in.).	kips	167.0	167.1	+0.03		Pass
Column web shear rupture at the welds φRn / Rn/Ω	kips	293.0	292.5	-0.17		Pass

ILX governing check: (Shear by friction (DG1 3rd Ed. §4.3.5)), ratio 0.985. ILX result: **NG**; published: **OK**.
Not compared: ILX flags the 0.1 in. plate projection past the flanges (B = 13 in. on bf = 12.8 in.; ILX asks for weld + ½ in. on every side). Friction now follows DG1 Eq. 4-30 (fixed in this verification); DG1 gives friction for LRFD only, ILX rates ASD loads against φVn/α (α = 1.6).

DG1-3 4.7-8 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Pp = 1.7 f'c A1 (A2 ≥ 4 A1)	kips	2,210	2,210	+0.00		Pass
Concrete bearing φcPp / Pp/Ωc	kips	957.0	956.7	-0.03		Pass
m (Eq. 4-10)	in.	1.050	1.052	+0.24		Pass
n (Eq. 4-11)	in.	1.380	1.380	-0.00		Pass
n′ = √(d bf)/4	in.	4.390	4.391	+0.02		Pass
X (Eq. 4-14), Pu = 619 / Pa = 486 kips		0.460	0.460	+0.08		Pass
λ (Eq. 4-13)		0.782	0.782	+0.04		Pass
l = max(m, n, λn′)	in.	3.430	3.435	+0.15		Pass
tmin (Eq. 4-15)	in.	1.080	1.086	+0.56		Pass
Web fillets (2 × 3/16 × 20 in., θ = 0°) φRn / Rn/Ω ILX strength per inch × the DG1 length 2T = 40 in. (ILX itself uses 2(d − 2k) = 42.2 in.).	kips	112.0	111.4	-0.56		Pass
Column web shear rupture at the welds φRn / Rn/Ω	kips	195.0	195.0	+0.00		Pass

ILX governing check: (Shear by friction (DG1 3rd Ed. §4.3.5)), ratio 1.456. ILX result: **NG**; published: **OK**.
Not compared: ILX flags the 0.1 in. plate projection past the flanges (B = 13 in. on bf = 12.8 in.; ILX asks for weld + ½ in. on every side). Friction now follows DG1 Eq. 4-30 (fixed in this verification); DG1 gives friction for LRFD only, ILX rates ASD loads against φVn/α (α = 1.6).

DG1-3 4.7-9: Base connection for bending (no axial load), anchor rods in tension

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-9, pp. 109 to 115 (PDF 119 to 125). Connection: Base plate.

DG1-3 4.7-9 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
fp(max) = φc 1.7 f'c / 1.7 f'c/Ωc	ksi	4.420	4.420	+0.00		Pass
qmax = fp(max) B (Eq. 4-37)	kip/in.	53.00	53.04	+0.08		Pass
Bearing length Y (Eq. 4-32)	in.	0.886	0.885	-0.09		Pass
Anchor rod tension T = qmax Y (Eq. 4-31)	kips	47.00	46.95	-0.10		Pass
Tension per rod (2 rods)	kips	23.50	23.48	-0.10		Pass
φNsa (Ase,N = 0.606 in.²)	kips	26.30	26.35	+0.19		Pass
ANc (2 rods, s = 6 in., hef = 12 in.)	in.²	1,510	1,512	+0.13		Pass
ANco = 9 hef²	in.²	1,300	1,296	-0.31		Pass
Nb = 16 √f'c hef^5/3	kips	63.60	63.65	+0.08		Pass
φNcbg (φ = 0.70)	kips	51.70	51.98	+0.54		Pass
φNpn = 0.70 × 8 Abrg f'c (Abrg = 1.50 in.²)	kips	33.60	33.63	+0.10		Pass
x = f − d/2 + tf/2 (Eq. 4-61)	in.	3.240	3.240	+0.00		Pass
tp(req), tension interface (Eq. 4-62)	in.	1.060	1.062	+0.19		Pass
m (Eq. 4-10)	in.	5.360	5.355	-0.09		Pass
n (Eq. 4-11)	in.	1.600	1.600	-0.00		Pass
tp(req), bearing interface, Y < m (Eq. 4-52)	in.	1.310	1.307	-0.23		Pass
Flange weld force Ru = Mu/d ILX force per inch × bf = 11.0 in. (outside face only).	kips	65.90	68.49	+3.93		Deviation B25
B25 Flange weld force lever: DG1 resolves the moment into a couple over the column depth, Ru = Mu/d = 1,200/18.2 = 65.9 kips; ILX uses the flange centroid distance d − tf (Mu/(d − tf) = 68.5 kips, 3.9 % higher, conservative).						
Flange weld φRn / Rn/Ω (¼ in., 11 in., kds = 1.5) ILX strength per inch × bf = 11.0 in.	kips	92.30	91.88	-0.46		Pass

ILX governing check: (Anchor rod tension (AISC)), ratio 0.916. ILX result: **NG**; published: **OK**.
Not compared: with B = 12 in. on bf = 11.0 in. the plate projects ½ in. past the flanges; ILX asks for weld + ½ in. (¾ in.) on every side and reports NG on that detailing check. The strength checks pass, as in the example.

DG1-3 4.7-9 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
fp(max) = φc 1.7 f'c / 1.7 f'c/Ωc	ksi	2.940	2.944	+0.13		Pass
qmax = fp(max) B (Eq. 4-37)	kip/in.	35.30	35.32	+0.07		Pass
Bearing length Y (Eq. 4-32)	in.	0.905	0.904	-0.09		Pass
Anchor rod tension T = qmax Y (Eq. 4-31)	kips	31.90	31.94	+0.13		Pass
Tension per rod (2 rods)	kips	16.00	15.97	-0.19		Pass
x = f − d/2 + tf/2 (Eq. 4-61)	in.	3.240	3.240	+0.00		Pass
tp(req), tension interface (Eq. 4-62)	in.	1.070	1.073	+0.28		Pass
m (Eq. 4-10)	in.	5.360	5.355	-0.09		Pass
n (Eq. 4-11)	in.	1.600	1.600	-0.00		Pass
tp(req), bearing interface, Y < m (Eq. 4-52)	in.	1.320	1.320	+0.00		Pass
Flange weld force Ru = Mu/d ILX force per inch × bf = 11.0 in. (outside face only).	kips	44.80	46.58	+3.96		Deviation B25
B25 Flange weld force lever: DG1 resolves the moment into a couple over the column depth, Ru = Mu/d = 1,200/18.2 = 65.9 kips; ILX uses the flange centroid distance d − tf (Mu/(d − tf) = 68.5 kips, 3.9 % higher, conservative).						
Flange weld φRn / Rn/Ω (¼ in., 11 in., kds = 1.5) ILX strength per inch × bf = 11.0 in.	kips	61.50	61.25	-0.40		Pass

ILX governing check: (Concrete breakout in tension (ACI 318-19 17.6.2)), ratio 0.983. ILX result: **NG**; published: **OK**.
Not compared: with B = 12 in. on bf = 11.0 in. the plate projects ½ in. past the flanges; ILX asks for weld + ½ in. (¾ in.) on every side and reports NG on that detailing check. The strength checks pass, as in the example.

DG1-3 4.7-10: Base connection for bending without anchor rod tension (low moment)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-10, pp. 115 to 118 (PDF 125 to 128). Connection: Base plate.

> Surrogate model: Rod pattern not dimensioned in the example: 15 × 15 in. with 1½ in. cover to the pier edge assumed (the pier equals the plate, A2 = A1).

DG1-3 4.7-10 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
e = M/P (Eq. 4-39)	in.	2.500	2.500	+0.00		Pass
fp(max) = φc 0.85 f'c (A2 = A1)	ksi	2.210	2.210	+0.00		Pass
qmax = fp(max) B (Eq. 4-37)	kip/in.	42.00	41.99	-0.02		Pass
ecrit = N/2 − P/(2 qmax) (Eq. 4-40)	in.	5.020	5.023	+0.05		Pass
Y = N − 2e (Eq. 4-42)	in.	14.00	14.00	+0.00		Pass
q = P/Y (Eq. 4-43)	kip/in.	26.90	26.86	-0.16		Pass
fp = P/(B Y) (Eq. 4-44)	ksi	1.410	1.414	+0.25		Pass
m (Eq. 4-10)	in.	3.470	3.467	-0.07		Pass
tp(req) with m, Y ≥ m (Eq. 4-51)	in.	0.868	0.869	+0.13		Pass
n (Eq. 4-11)	in.	4.620	4.620	+0.00		Pass
tp(req) with n, governs	in.	1.160	1.158	-0.17		Pass

ILX governing check: (Base plate flexure at the bearing interface), ratio 0.858. ILX result: **OK**; published: **OK**.

DG1-3 4.7-10 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
e = M/P (Eq. 4-39)	in.	2.500	2.500	+0.00		Pass
fp(max) = φc 0.85 f'c (A2 = A1)	ksi	1.470	1.472	+0.13		Pass
qmax = fp(max) B (Eq. 4-37)	kip/in.	27.90	27.97	+0.23		Pass
ecrit = N/2 − P/(2 qmax) (Eq. 4-40)	in.	4.840	4.851	+0.24		Pass
Y = N − 2e (Eq. 4-42)	in.	14.00	14.00	+0.00		Pass
q = P/Y (Eq. 4-43)	kip/in.	18.60	18.57	-0.15		Pass
fp = P/(B Y) (Eq. 4-44)	ksi	0.977	0.977	+0.05		Pass
m (Eq. 4-10)	in.	3.470	3.467	-0.07		Pass
tp(req) with m, Y ≥ m (Eq. 4-51)	in.	0.888	0.886	-0.22		Pass
n (Eq. 4-11)	in.	4.620	4.620	+0.00		Pass
tp(req) with n, governs	in.	1.180	1.181	+0.08		Pass

ILX governing check: (Base plate flexure at the bearing interface), ratio 0.892. ILX result: **OK**; published: **OK**.

DG1-3 4.7-11: Bending with anchor rod tension (large moment), compression

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-11, pp. 118 to 124 (PDF 128 to 134). Connection: Base plate.

> Surrogate model: A2 = A1 is modelled with a 24 × 22 in. support; the breakout rows use a large footing (the example takes ca,min ≥ 1.5 hef). The trial rows override N, B and the rod spacing.

DG1-3 4.7-11 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
fp(max) = φc 0.85 f'c (A2 = A1)	ksi	2.210	2.210	+0.00		Pass
qmax = fp(max) B (Eq. 4-37)	kip/in.	48.60	48.62	+0.04		Pass
e = M/P (Eq. 4-39)	in.	9.570	9.574	+0.05		Pass
ecrit = N/2 − P/(2qmax) (Eq. 4-40)	in.	8.130	8.133	+0.04		Pass
Trial 19 × 19 (f = 8): (f + N/2)² (Eq. 4-59)	in.²	306.0	306.2	+0.08		Pass
Trial 19 × 19: 2P(e + f)/qmax > (f + N/2)², no solution	in.²	315.0	314.7	-0.08		Pass
Trial 24 × 22, f = 10.5: 2P(e + f)/qmax (Eq. 4-59)	in.²	311.0	310.5	-0.16		Pass
Trial f = 10.5: bearing length Y (Eq. 4-58)	in.	8.500	8.509	+0.10		Pass
Trial f = 10.5: rod tension T (Eq. 4-55)	kips	37.10	37.69	+1.58		Deviation B30
B30 Rounded intermediate values in the rod tension: DG1 computes T = qmax Y − P with qmax and Y rounded to three digits (Y itself from the rounded terms of Eq. 4-58, e.g. 21.3 − 12.7 = 8.60 in.); T is the small difference of two large numbers, so the rounding moves it by more than the 1 % band. ILX keeps every digit (Y and the plate thicknesses agree within 1 %). Trial f = 10.5 in. (LRFD): 48.6 × 8.50 − 376 = 37.1 kips; exact 48.62 × 8.509 − 376 = 37.7 kips (+1.6 %, ILX higher).						
(f + N/2)², f = 9.25 in.	in.²	452.0	451.6	-0.10		Pass
2P(e + f)/qmax, f = 9.25 in.	in.²	291.0	291.2	+0.05		Pass
Bearing length Y (Eq. 4-58)	in.	8.600	8.585	-0.18		Pass
Anchor rod tension T (Eq. 4-55)	kips	42.00	41.39	-1.44		Deviation B30
B30 Rounded intermediate values in the rod tension: DG1 computes T = qmax Y − P with qmax and Y rounded to three digits (Y itself from the rounded terms of Eq. 4-58, e.g. 21.3 − 12.7 = 8.60 in.); T is the small difference of two large numbers, so the rounding moves it by more than the 1 % band. ILX keeps every digit (Y and the plate thicknesses agree within 1 %). f = 9.25 in.: 48.6 × 8.60 − 376 = 42.0 kips vs exact 41.4 (LRFD, −1.4 %); ASD 32.3 × 9.10 − 260 = 33.9 vs 33.4 kips (−1.6 %). Published values conservative; the rods stay adequate.						
Tension per rod (two rods per line)	kips	21.00	20.70	-1.44		Pass
Rod steel φNsa, 1 in. F1554 Gr. 36 (Table 4-1, ACI 17.6.1)	kips	26.40	26.35	-0.19		Pass
Pullout φNp, 1 in. heavy hex (Table 4-2, ACI 17.6.3)	kips	33.60	33.63	+0.10		Pass
Breakout ANc (two rods 12 in. apart, hef = 18 in.) Large footing (ca,min ≥ 1.5 hef) as in the example; the bearing rows use A2 = A1.	in.²	3,560	3,564	+0.11		Pass
Breakout ANco = 9 hef²	in.²	2,920	2,916	-0.14		Pass
Basic breakout Nb = 16 λa √f'c hef^5/3 (ACI Eq. 17.6.2.2.3)	kips	125.0	125.1	+0.08		Pass
Breakout φNcbg (φ = 0.70)	kips	106.0	107.0	+0.97		Pass
Cantilever m (Eq. 4-10)	in.	5.970	5.968	-0.04		Pass
Cantilever n (Eq. 4-11)	in.	6.120	6.120	+0.00		Pass
tp,req from m (Eq. 4-51, Y ≥ m)	in.	1.870	1.870	+0.01		Pass
tp,req bearing interface, n governs (Eq. 4-51)	in.	1.920	1.918	-0.10		Pass
x = f − d/2 + tf/2 (Eq. 4-61)	in.	3.350	3.350	+0.00		Pass
tp,req tension interface (Eq. 4-62)	in.	0.755	0.749	-0.79		Pass

ILX governing check: (Concrete breakout in tension (ACI 318-19 17.6.2)), ratio 3.262. ILX result: **NG**; published: **OK**.
The example sizes the plate and rods only (no shear, welds or edge checks): the overall status is not compared.

DG1-3 4.7-11 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
fp(max) = φc 0.85 f'c (A2 = A1)	ksi	1.470	1.472	+0.13		Pass
qmax = fp(max) B (Eq. 4-37)	kip/in.	32.30	32.38	+0.25		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
e = M/P (Eq. 4-39)	in.	9.620	9.615	-0.05		Pass
ecrit = N/2 − P/(2qmax) (Eq. 4-40)	in.	7.980	7.985	+0.07		Pass
Trial 19 × 19 (f = 8): (f + N/2)² (Eq. 4-59)	in.²	306.0	306.2	+0.08		Pass
Trial 19 × 19: 2P(e + f)/qmax > (f + N/2)², no solution	in.²	328.0	327.5	-0.14		Pass
Trial 24 × 22, f = 10.5: 2P(e + f)/qmax (Eq. 4-59)	in.²	324.0	323.0	-0.30		Pass
Trial f = 10.5: bearing length Y (Eq. 4-58)	in.	9.000	8.964	-0.40		Pass
Trial f = 10.5: rod tension T (Eq. 4-55), ASD	kips	30.70	30.27	-1.41		Pass
(f + N/2)², f = 9.25 in.	in.²	452.0	451.6	-0.10		Pass
2P(e + f)/qmax, f = 9.25 in.	in.²	304.0	303.0	-0.34		Pass
Bearing length Y (Eq. 4-58)	in.	9.100	9.060	-0.44		Pass
Anchor rod tension T (Eq. 4-55)	kips	33.90	33.36	-1.60		Deviation B30
B30 Rounded intermediate values in the rod tension: DG1 computes T = qmax Y − P with qmax and Y rounded to three digits (Y itself from the rounded terms of Eq. 4-58, e.g. 21.3 − 12.7 = 8.60 in.); T is the small difference of two large numbers, so the rounding moves it by more than the 1 % band. ILX keeps every digit (Y and the plate thicknesses agree within 1 %). f = 9.25 in.: 48.6 × 8.60 − 376 = 42.0 kips vs exact 41.4 (LRFD, −1.4 %); ASD 32.3 × 9.10 − 260 = 33.9 vs 33.4 kips (−1.6 %). Published values conservative; the rods stay adequate.						
Cantilever m (Eq. 4-10)	in.	5.970	5.968	-0.04		Pass
Cantilever n (Eq. 4-11)	in.	6.120	6.120	+0.00		Pass
tp,req from m (Eq. 4-51, Y ≥ m)	in.	1.870	1.871	+0.06		Pass
tp,req bearing interface, n governs (Eq. 4-51)	in.	1.920	1.919	-0.05		Pass
x = f − d/2 + tf/2 (Eq. 4-61)	in.	3.350	3.350	+0.00		Pass
tp,req tension interface (Eq. 4-62)	in.	0.829	0.824	-0.60		Pass

ILX governing check: (Concrete breakout in tension (ACI 318-19 17.6.2)), ratio 4.206. ILX result: **NG**; published: **OK**.
The example sizes the plate and rods only (no shear, welds or edge checks): the overall status is not compared.

DG1-3 4.7-12: Bending with net uplift and a compression block (large moment)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-12, pp. 125 to 127 (PDF 135 to 137). Connection: Base plate.

> Surrogate model: Rod size and spacing along B are not given: four 1 in. F1554 Gr. 36 rods, 16 × 16 in., assumed.

DG1-3 4.7-12 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
(f + N/2)² (Eq. 4-66)	in.²	306.0	306.2	+0.08		Pass
2P(e − f)/qmax (Eq. 4-66)	in.²	9.520	9.526	+0.06		Pass
Bearing length Y (Eq. 4-65)	in.	0.300	0.274	-8.56		Deviation B31
B31 Rounded subtraction in the bearing length (net uplift with bearing, Eqs. 4-63 to 4-66): DG1 takes Y = 17.5 − 17.2 = 0.300 in. for both LRFD and ASD; the exact values are 0.274 in. (LRFD) and 0.247 in. (ASD), so T = qmax Y + P is 111.5 vs 113 kips (LRFD, −1.3 %) and 66.9 vs 68.4 kips (ASD, −2.2 %). ILX solves the same equations (its uniform-stress solution with P < 0); published values conservative.						
Anchor rod tension T = qmax Y + P (Eq. 4-63)	kips	113.0	111.5	-1.31		Deviation B31
B31 Rounded subtraction in the bearing length (net uplift with bearing, Eqs. 4-63 to 4-66): DG1 takes Y = 17.5 − 17.2 = 0.300 in. for both LRFD and ASD; the exact values are 0.274 in. (LRFD) and 0.247 in. (ASD), so T = qmax Y + P is 111.5 vs 113 kips (LRFD, −1.3 %) and 66.9 vs 68.4 kips (ASD, −2.2 %). ILX solves the same equations (its uniform-stress solution with P < 0); published values conservative.						

ILX governing check: (Side-face blowout (ACI 318-19 17.6.4)), ratio 17.131. ILX result: **NG**; published: **OK**.
The example determines the rod tension and bearing length only: the overall status is not compared.

DG1-3 4.7-12 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
(f + N/2)² (Eq. 4-66)	in.²	306.0	306.2	+0.08		Pass
2P(e − f)/qmax (Eq. 4-66)	in.²	8.600	8.582	-0.21		Pass
Bearing length Y (Eq. 4-65)	in.	0.300	0.247	-17.69		Deviation B31
B31 Rounded subtraction in the bearing length (net uplift with bearing, Eqs. 4-63 to 4-66): DG1 takes Y = 17.5 − 17.2 = 0.300 in. for both LRFD and ASD; the exact values are 0.274 in. (LRFD) and 0.247 in. (ASD), so T = qmax Y + P is 111.5 vs 113 kips (LRFD, −1.3 %) and 66.9 vs 68.4 kips (ASD, −2.2 %). ILX solves the same equations (its uniform-stress solution with P < 0); published values conservative.						
Anchor rod tension T = qmax Y + P (Eq. 4-63)	kips	68.40	66.91	-2.18		Deviation B31
B31 Rounded subtraction in the bearing length (net uplift with bearing, Eqs. 4-63 to 4-66): DG1 takes Y = 17.5 − 17.2 = 0.300 in. for both LRFD and ASD; the exact values are 0.274 in. (LRFD) and 0.247 in. (ASD), so T = qmax Y + P is 111.5 vs 113 kips (LRFD, −1.3 %) and 66.9 vs 68.4 kips (ASD, −2.2 %). ILX solves the same equations (its uniform-stress solution with P < 0); published values conservative.						

ILX governing check: (Side-face blowout (ACI 318-19 17.6.4)), ratio 16.444. ILX result: **NG**; published: **OK**.
The example determines the rod tension and bearing length only: the overall status is not compared.

DG1-3 4.7-13: Bending with net uplift, no compression block (low moment)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-13, pp. 127 to 129 (PDF 137 to 139). Connection: Base plate.

> Surrogate model: Rod size and spacing along B are not given: four 1 in. F1554 Gr. 36 rods, 16 × 16 in., assumed.

DG1-3 4.7-13 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Rod tension, tension side Pu/n + Pu e y/Ix (Eq. 4-67)	kips	28.10	28.12	+0.09		Pass
Rod tension, other side Pu/n − Pu e y/Ix (Eq. 4-67)	kips	21.90	21.88	-0.11		Pass

ILX governing check: (Side-face blowout (ACI 318-19 17.6.4)), ratio 8.641. ILX result: **NG**; published: **OK**.
The example determines the rod tensions only: the overall status is not compared.

DG1-3 4.7-13 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Rod tension, tension side Pu/n + Pu e y/Ix (Eq. 4-67)	kips	16.90	16.88	-0.15		Pass
Rod tension, other side Pu/n − Pu e y/Ix (Eq. 4-67)	kips	13.10	13.12	+0.19		Pass

ILX governing check: (Side-face blowout (ACI 318-19 17.6.4)), ratio 8.295. ILX result: **NG**; published: **OK**.
The example determines the rod tensions only: the overall status is not compared.

DG1-3 4.7-14: Biaxial bending with axial compression

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-14, pp. 130 to 134 (PDF 140 to 144). Connection: Base plate.

> Surrogate model: A2/A1 ≥ 4 (fp(max) at the 1.7 f'c cap) modelled with a 200 × 200 in. footing and hef = 18 in., so that the concrete breakout does not govern the anchor capacity (the example assumes the embedment precludes the concrete limit states); rod pattern 11 × 11 in. (1.5 in. edges).

DG1-3 4.7-14 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
fp(max) = φc 0.85 f'c √(A2/A1), A2/A1 = 4	ksi	4.420	4.420	+0.00		Pass
qmax = fp(max) B (Eq. 4-37)	kip/in.	61.90	61.88	-0.03		Pass
ecrit = N/2 − P/(2qmax) (Eq. 4-53)	in.	6.270	6.273	+0.04		Pass
ex = Mux/Pu	in.	7.780	7.778	-0.03		Pass
ey = Muy/Pu (weak axis)	in.	5.000	5.000	+0.00		Pass
Strong axis: bearing length Y (Eq. 4-58)	in.	1.700	1.654	-2.68		Deviation B32
B32 Rounded subtraction in the bearing length: DG1 takes Y = 12.5 − 10.8 = 1.70 in.; the exact strong-axis value is 1.654 in., so T = qmax Y − P = 12.4 kips vs 15.2 (published 23 % conservative), 6.19 vs 7.60 kips per rod, and the tension-interface tp,req 0.354 vs 0.392 in. ILX keeps every digit.						
Strong axis: rod tension Tu (Eq. 4-55)	kips	15.20	12.37	-18.59		Deviation B32
B32 Rounded subtraction in the bearing length: DG1 takes Y = 12.5 − 10.8 = 1.70 in.; the exact strong-axis value is 1.654 in., so T = qmax Y − P = 12.4 kips vs 15.2 (published 23 % conservative), 6.19 vs 7.60 kips per rod, and the tension-interface tp,req 0.354 vs 0.392 in. ILX keeps every digit.						
Strong axis: tension per rod	kips	7.600	6.187	-18.59		Deviation B32
B32 Rounded subtraction in the bearing length: DG1 takes Y = 12.5 − 10.8 = 1.70 in.; the exact strong-axis value is 1.654 in., so T = qmax Y − P = 12.4 kips vs 15.2 (published 23 % conservative), 6.19 vs 7.60 kips per rod, and the tension-interface tp,req 0.354 vs 0.392 in. ILX keeps every digit.						
Rod steel φNsa, ⅝ in. F1554 Gr. 55 (Table 4-1)	kips	12.70	12.71	+0.10		Pass
Cantilever m (Eq. 4-10)	in.	2.960	2.962	+0.08		Pass
Cantilever n (Eq. 4-11)	in.	3.760	3.756	-0.11		Pass
tp,req bearing interface, n governs (Eq. 4-51a)	in.	1.670	1.665	-0.30		Pass
x = f − d/2 + tf/2 (Eq. 4-61)	in.	1.590	1.593	+0.16		Pass
tp,req tension interface, strong axis (Eq. 4-62a)	in.	0.392	0.354	-9.69		Deviation B32
B32 Rounded subtraction in the bearing length: DG1 takes Y = 12.5 − 10.8 = 1.70 in.; the exact strong-axis value is 1.654 in., so T = qmax Y − P = 12.4 kips vs 15.2 (published 23 % conservative), 6.19 vs 7.60 kips per rod, and the tension-interface tp,req 0.354 vs 0.392 in. ILX keeps every digit.						
Bearing-interface plate moment fp(max) N n²/2 [kip-in.]	kip-in.	437.0	436.5	-0.12		Pass
Yield-line strength φ Fy N tp²/4 [kip-in.]	kip-in.	482.0	482.3	+0.07		Pass
Y at anchor capacity, (2 × 12.7 + 90)/qmax	in.	1.860	1.865	+0.29		Pass
ex at anchor capacity	in.	9.300	9.335	+0.38		Pass
Mx,Pu (anchor yielding) [kip-in.]	kip-in.	837.0	840.2	+0.38		Pass
My,Pu (anchor yielding, square plate and pattern) [kip-in.]	kip-in.	837.0	840.2	+0.38		Pass
Tu for plate yielding at the tension interface (strong axis)	kips	303.0	302.9	-0.04		Pass
Tu for plate yielding at the tension interface (weak axis, y = n − 1.5)	kips	213.0	213.8	+0.38		Pass
Biaxial interaction (Mux/Mx)² + (Muy/My)² (Eq. 4-69) ILX Mx,Pu = My,Pu = 838 kip-in. (Y = 1.865 in. unrounded): 0.986.		0.988	0.981	-0.70		Pass

ILX governing check: (Column flange fillet welds (tension flange)), ratio 1.345. ILX result: **NG**; published: **OK**.
The example sizes the rods, plate and connection strength only. ILX also checks the column-to-plate welds for the 450 kip-in. weak-axis moment (5/16 in. flange fillets are not enough; the example does not size the welds) and the concrete limit states with the elastic rod forces (ACI 318-19 17.2.1), which the example leaves to the engineer; the overall status is not compared.

DG1-3 4.7-15: Anchor reinforcement for concrete breakout in tension

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-15, pp. 134 to 139 (PDF 144 to 149). Connection: Base plate.

> Surrogate model: The example gives the anchorage only: a W10×45 on a 14 × 14 × 1 in. A572 Gr. 50 plate (Example 4.7-3) with the 4 × 4 in. rods inside the flanges is used; the column is the 20 in. square pier.

DG1-3 4.7-15 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
hef' = max(ca,max/1.5, s/3) (ACI 17.6.2.1.2)	in.	5.330	5.333	+0.06		Pass
ANc	in.²	400.0	400.0	+0.00		Pass
ANco = 9 hef'²	in.²	256.0	256.0	+0.00		Pass
Nb = 24 λa √f'c hef'^1.5 (ACI Eq. 17.6.2.2.1)	kips	18.70	18.70	-0.02		Pass
Ncbg (ACI Eq. 17.6.2.1b)	kips	29.20	29.21	+0.04		Pass
φNcbg (φ = 0.70) < 70 kips: n.g.	kips	20.40	20.45	+0.24		Pass
As,req = Nu/(φ fy), φ = 0.75 (ACI 17.5.2.1)	in.²	1.560	1.556	-0.28		Pass
As = 4-#6 (φ As fy = 79.2 kips ≥ 70 kips)	in.²	1.760	1.760	+0.00		Pass
Bar offset g = 2√2 in.	in.	2.830	2.828	-0.06		Pass
Hooked bar development ldh (ACI 25.4.3.1)	in.	9.710	9.710	-0.00		Pass
Required embedment hef = ldh + g/1.5 + cc	in.	13.60	13.60	-0.03		Pass
Straight bar development ld (ACI Eq. 25.4.2.4a)	in.	17.10	17.08	-0.14		Pass
Reduced development le = ld As,req/As,prov (ACI 25.4.10) ILX 15.09 in. with As,req = 1.556 in.² unrounded (DG1 uses 1.56 and ld = 17.1); within the 1 % band.	in.	15.20	15.09	-0.71		Pass
Anchor reinforcement length lreinf	in.	25.30	25.21	-0.37		Pass
Side-face blowout not applicable: hef ≤ 2.5 ca1 (1 = not applicable) hef = 14 in. < 2.5 ca1 = 20 in. (ACI 17.6.4.1).		1.000	1.000	+0.00		Pass

ILX governing check: (Anchor rod tension (AISC)), ratio 0.892. ILX result: **OK**; published: **OK**.
The example designs the anchorage only (the base plate is not given): the overall status is not compared.

DG1-3 6.4-1: Seismic weak-base design with ductile anchor rods (bearing, rods, concrete, plate)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 6.4-1, pp. 156 to 161 (PDF 166 to 171). Connection: Base plate.

> Surrogate model: Square 100 × 100 in. footing, 60 in. deep (all edges beyond 1.5 hef; A2/A1 capped at 4); CJP flange welds as the example; shear and the shear lug in case 6.4-1b.

DG1-3 6.4-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
fp(max) = φc 0.85 f'c √(A2/A1) (Eq. 4-2)	ksi	4.420	4.420	+0.00		Pass
qmax = fp(max) B (Eq. 4-37)	kip/in.	88.40	88.40	+0.00		Pass
e = Mu/Pu	in.	9.570	9.574	+0.05		Pass
ecrit = N/2 − Pu/(2qmax) (Eq. 4-40)	in.	7.870	7.873	+0.04		Pass
Bearing length Y (Eq. 4-58)	in.	4.800	4.790	-0.20		Pass
Rod-group tension Tu = qmax Y − Pu (Eq. 4-55)	kips	48.30	47.46	-1.74		Deviation B43
B43 Rounding in the source: DG1 rounds Y = 4.789 in. to 4.80 in. before Tu = qmax Y − Pu = 88.4 × 4.80 − 376 = 48.3 kips; the exact Y gives 47.4 kips (−1.7 %). Y itself agrees within 0.3 %.						
Required reduced area Areduced ≥ Tu/(n φt Fy)	in.²	0.325	0.320	-1.67		Deviation B43
B43 Rounding in the source: Areduced = Tu/(n φt Fy) uses the rounded Tu = 48.3 kips; the exact Tu = 47.5 kips gives 0.320 in.² (−1.6 %). dreduced,min (0.638 against 0.644 in.) is within 1 %.						
Minimum reduced diameter dreduced ≥ √(4 Areduced/π)	in.	0.644	0.638	-0.95		Pass
Strain-hardened reduced rod Treduced = π d²/4 Fu	kips	33.10	33.13	+0.10		Pass
Threaded 1 in. Gr. 55 rod φNsa (Table 4-1)	kips	34.10	34.07	-0.08		Pass
Threaded section φNsa ≥ Treduced (capacity of the threads)	kips	34.10	34.07	-0.08		Pass
Minimum stretch length Lstretch ≥ f	in.	8.000	8.000	+0.00		Pass
Rt Treduced (Rt = 1.2)	kips	39.70	39.76	+0.15		Pass
Pullout demand Rt Treduced (per rod)	kips	39.70	39.76	+0.15		Pass
Plate-washer bearing area Abrg = 2² − π/4	in.²	3.210	3.215	+0.14		Pass
Pullout 0.75 φ Npn (seismic, 2 in. washers)	kips	53.90	54.01	+0.20		Pass
ANc (three rods, s = 16 in., hef = 24 in.)	in.²	6,340	6,336	-0.06		Pass
ANco = 9 hef²	in.²	5,180	5,184	+0.08		Pass
Nb = 16 λa √f'c hef^5/3	kips	202.0	202.1	+0.03		Pass
Ncbg	kips	247.0	247.0	-0.01		Pass
Breakout 0.75 φ Ncbg (seismic)	kips	130.0	129.7	-0.26		Pass
Breakout demand Nu = 3 Rt Treduced	kips	119.0	119.3	+0.24		Pass
Tension-interface lever x = f − d/2 + tf/2 (Eq. 4-61)	in.	2.100	2.100	+0.00		Pass
tp,req tension side for Nu = 119 kips (Eq. 4-62a)	in.	1.050	1.055	+0.48		Pass

ILX governing check: (Threaded section develops the strain-hardened reduced shank: Treduced ≤ φNsa (DG1 3rd Ed. Ex. 6.4-1)), ratio 0.972.
ILX result: **NG**; published: **OK**.
Weak-base seismic example (ILX seismic design = weak base, reduced shank 0.750 in., stretch length 8 in.). The status is not compared: the example does not size the leveling nut, grout or washer clearances that ILX also checks on the assumed geometry.

DG1-3 6.4-1b: Seismic weak base: shear lug moment and web welds

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 6.4-1, pp. 160 to 161 (PDF 170 to 171). Connection: Base plate.

> Surrogate model: Lug 8 × 1 in. A572 Gr. 50, 3 in. below the plate (2 in. embedded below 1 in. of grout).

DG1-3 6.4-1b · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Lug moment Vu (G + hsl/2) = 50 (1 + 2/2)	kip-in.	100.0	100.0	+0.00		Pass
Total moment Mu + Mshear-lug Total moment with the lug eccentricity Mu + Vu (G + hsl/2) (ACI 318-19 17.11.1.1.2): ILX carries the lug moment into the bearing analysis (e Pu).	kip-in.	3,700	3,700	+0.00		Pass
Web weld length le = 2(d − 2kdes) DG1 le = 9.70 in. per side; ILX reports both sides.	in.	19.40	18.25	-5.93		Deviation B44
B44 Web weld length: this example welds the web over d − 2kdes = 9.70 in. per side; ILX uses the Manual T dimension (d − 2kdet = 9.13 in.), as DG1 Example 4.7-5 does, because the fillet cannot run into the k region. ILX weld length 6 % shorter, Dreq 6 % larger (conservative).						
Web weld Dreq = Vu/(1.392 × 2 le) (sixteenths)		1.850	1.968	+6.39		Deviation B44
B44 Web weld length: this example welds the web over d − 2kdes = 9.70 in. per side; ILX uses the Manual T dimension (d − 2kdet = 9.13 in.), as DG1 Example 4.7-5 does, because the fillet cannot run into the k region. ILX weld length 6 % shorter, Dreq 6 % larger (conservative).						
dreduced ≥ 0.687 in. for the updated moment	in.	0.687	0.687	+0.01		Pass

ILX governing check: (Shear lug flexure-shear interaction (AISC Manual Eq. 9-1)), ratio 1.113. ILX result: **NG**; published: **OK**.
The example gives the lug lever arm only (lug 3 in. below the plate, 1 in. grout); the lug size is an ILX choice (8 × 1 in.), so the overall status is not compared.

DG1-3 B.2-1: Triangular bearing, small moment (no rod tension)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example B.2-1, pp. 179 to 182 (PDF 189 to 192). Connection: Base plate.

> Surrogate model: Support 19 × 19 in. (A2/A1 = 1, as given); four ¾ in. rods on a 16 × 16 in. pattern assumed. Plate 1 in. (LRFD) or 1¼ in. (ASD) as the example selects.

DG1-3 B.2-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
m (Eq. 4-10)	in.	3.470	3.467	-0.07		Pass
n (Eq. 4-11)	in.	4.620	4.620	+0.00		Pass
e = M/P (Eq. B-8)	in.	2.500	2.500	+0.00		Pass
ekern = N/6 (Eq. B-9)	in.	3.170	3.167	-0.11		Pass
fp(ax) = P/(BN) (Eq. B-10)	ksi	1.040	1.042	+0.15		Pass
fp(b) = 6Pe/(BN²) (Eq. B-11)	ksi	0.822	0.822	+0.03		Pass
fp(max) (Eq. B-12)	ksi	1.860	1.864	+0.21		Pass
fp(min) (Eq. B-14)	ksi	0.218	0.219	+0.58		Pass
Available bearing stress φ 0.85 f'c / 0.85 f'c/Ωc (Eq. B-13)	ksi	2.210	2.210	+0.00		Pass
fp(m) = fp(max) − 2 fp(b) m/N (Eq. B-15) From the ILX fp(max), fp(min) and m used in the engine's m-direction moment.	ksi	1.560	1.564	+0.24		Pass
Mpl at m (Eq. B-16)		10.60	10.60	+0.03		Pass
Mpl at n = fp(ax) n²/2 (Eq. B-17)		11.10	11.12	+0.14		Pass
Critical Mpl		11.10	11.12	+0.14		Pass
treq = √(4 Mpl/(φb Fy)) / √(4 Ωb Mpl/Fy)	in.	0.993	0.994	+0.10		Pass

ILX governing check: (Base plate flexure at the bearing interface), ratio 0.988. ILX result: **NG**; published: **OK**.
The example sizes the plate only (no rods, A2 = A1). ILX models A2 = A1 with a support the size of the plate, so its rod edge-distance checks against that support (ACI 17.9.2) fail; the plate, bearing and welds pass. The overall status is not compared.

DG1-3 B.2-1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
m (Eq. 4-10)	in.	3.470	3.467	-0.07		Pass
n (Eq. 4-11)	in.	4.620	4.620	+0.00		Pass
e = M/P (Eq. B-8)	in.	2.500	2.500	+0.00		Pass
ekern = N/6 (Eq. B-9)	in.	3.170	3.167	-0.11		Pass
fp(ax) = P/(BN) (Eq. B-10)	ksi	0.720	0.720	+0.03		Pass
fp(b) = 6Pe/(BN²) (Eq. B-11)	ksi	0.569	0.569	-0.07		Pass
fp(max) (Eq. B-12)	ksi	1.290	1.289	-0.09		Pass
fp(min) (Eq. B-14)	ksi	0.151	0.152	+0.41		Pass
Available bearing stress φ 0.85 f'c / 0.85 f'c/Ωc (Eq. B-13)	ksi	1.470	1.472	+0.13		Pass
fp(m) = fp(max) − 2 fp(b) m/N (Eq. B-15) From the ILX fp(max), fp(min) and m used in the engine's m-direction moment.	ksi	1.080	1.081	+0.12		Pass
Mpl at m (Eq. B-16)		7.340	7.332	-0.11		Pass
Mpl at n = fp(ax) n²/2 (Eq. B-17)		7.680	7.686	+0.08		Pass
Critical Mpl		7.680	7.686	+0.08		Pass
treq = √(4 Mpl/(φb Fy)) / √(4 Ωb Mpl/Fy)	in.	1.010	1.013	+0.30		Pass

ILX governing check: (Concrete bearing with moment (J8; triangular)), ratio 0.876. ILX result: **NG**; published: **OK**.
The example sizes the plate only (no rods, A2 = A1). ILX models A2 = A1 with a support the size of the plate, so its rod edge-distance checks against that support (ACI 17.9.2) fail; the plate, bearing and welds pass. The overall status is not compared.

DG1-3 B.2-2: Triangular bearing, large moment (rods in tension)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example B.2-2, pp. 182 to 185 (PDF 192 to 195). Connection: Base plate.

> Surrogate model: Pier 28 × 28 in. (A2/A1 = 4); four ¾ in. F1554 Gr. 36 rods on an 11 × 11 in. pattern (1.5 in. from the plate edges; rod size not given); ¼ in. column welds; plate 1¼ in. as selected.

DG1-3 B.2-2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
fp(max) = φc 0.85 f'c √(A2/A1) ≤ φc 1.7 f'c	ksi	3.320	3.315	-0.15		Pass
e = M/P (Eq. B-8)	in.	8.000	8.000	+0.00		Pass
ekern = N/6	in.	2.330	2.333	+0.14		Pass
Bearing length A (Eq. B-21)	in.	4.800	4.804	+0.09		Pass
Rod-group tension T = fp A B/2 − P (Eq. B-22)	kips	21.60	21.48	-0.54		Pass
Tension per rod	kips	10.80	10.74	-0.54		Pass
m (Eq. 4-10)	in.	3.200	3.200	+0.00		Pass
fp at m = fp(max)(A − m)/A From the ILX fp(max) and A used in the engine's m-direction moment.	ksi	1.110	1.107	-0.27		Pass
Mpl at m, bearing side		13.20	13.20	+0.03		Pass
Mpl tension side, 45° width 2(m − 1.5) per rod ILX advisory 45° effective-width check (b_eff = 2x per rod, x = f − d/2 + tf/2 = 1.72 in.; DG1 arm m − 1.5 = 1.70 in.); Mpl = Trod/2 either way. ILX's governing tension-interface check spreads T over the full B (2.65 kip-in./in.), which does not govern here.		5.400	5.371	-0.54		Pass
tp required (Eq. B-23)	in.	1.080	1.083	+0.28		Pass

ILX governing check: (Concrete breakout in tension (ACI 318-19 17.6.2)), ratio 1.051. ILX result: **NG**; published: **OK**.
The example designs the plate and the rod forces only; the rods' size and embedment are not given, so ILX's concrete breakout of the assumed ¾ in. rods (hef = 12 in. in the 28 in. pier) is not part of the comparison. The overall status is not compared.

DG1-3 B.2-2 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
fp(max) = φc 0.85 f'c √(A2/A1) ≤ φc 1.7 f'c	ksi	2.210	2.208	-0.10		Pass
e = M/P (Eq. B-8)	in.	8.000	8.000	+0.00		Pass
ekern = N/6	in.	2.330	2.333	+0.14		Pass
Bearing length A (Eq. B-21)	in.	4.800	4.810	+0.21		Pass
Rod-group tension T = fp A B/2 − P (Eq. B-22)	kips	14.30	14.33	+0.24		Pass
Tension per rod	kips	7.150	7.167	+0.24		Pass
m (Eq. 4-10)	in.	3.200	3.200	+0.00		Pass
fp at m = fp(max)(A − m)/A From the ILX fp(max) and A used in the engine's m-direction moment.	ksi	0.737	0.739	+0.26		Pass
Mpl at m, bearing side		8.800	8.797	-0.03		Pass
Mpl tension side, 45° width 2(m − 1.5) per rod ILX advisory 45° effective-width check (b_eff = 2x per rod, x = f − d/2 + tf/2 = 1.72 in.; DG1 arm m − 1.5 = 1.70 in.); Mpl = Trod/2 either way. ILX's governing tension-interface check spreads T over the full B (2.65 kip-in./in.), which does not govern here.		3.580	3.584	+0.10		Pass
tp required (Eq. B-23)	in.	1.080	1.084	+0.37		Pass

ILX governing check: (Concrete breakout in tension (ACI 318-19 17.6.2)), ratio 1.122. ILX result: **NG**; published: **OK**.
The example designs the plate and the rod forces only; the rods' size and embedment are not given, so ILX's concrete breakout of the assumed ¾ in. rods (hef = 12 in. in the 28 in. pier) is not part of the comparison. The overall status is not compared.

DG1-3 B.3-1: Axial compression considering plate flexibility (effective bearing area)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example B.3-1, pp. 186 to 187 (PDF 196 to 197). Connection: Base plate.

> Surrogate model: Large pedestal 40 × 40 in. (fully confined, A2/A1 ≥ 4); four ¾ in. rods on a 14 × 14 in. pattern assumed; App. B.3 option on (plate yielding not checked).

DG1-3 B.3-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
c = 1.5 tp	in.	1.880	1.875	-0.27		Pass
Effective bearing area Aeff ILX 179.1 in.² = 2 (12.2 + 3.75)(0.900 + 3.75) + (12.7 − 1.80 − 3.75)(0.550 + 3.75) with c = 1.875 in.; the example prints 178 (0.6 %, within the 1 % band).	in.²	178.0	179.1	+0.61		Pass
φ Pn = φ 1.7 f′c Aeff (Eq. B-24)	kips	787.0	791.5	+0.58		Pass

ILX governing check: (Concrete bearing on the effective area (plate flexibility, DG1 App. B.3)), ratio 0.884. ILX result: **NG**; published: **OK**.
The example checks bearing on Aeff only; ILX also checks the rods, welds and detailing of its assumed hardware, so the overall status is not compared.

DG1-Ex5.3-1: Embedded base for bending, shear and axial compression (Type I, W14X176)

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 5.3-1, pp. 148-150. Connection: Embedded column base.

DG1-Ex5.3-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
First trial dembed = 1.5 d	in.	22.80	22.80	-0.00		Pass
fb = 1.54 √f'c (bw/bf)^0.66 (Eq. 5-1)	ksi	7.460	7.462	+0.02		Pass
1.7 f'c cap (Eq. 5-1)	ksi	6.800	6.800	+0.00		Pass
fb used	ksi	6.800	6.800	+0.00		Pass
(Ft − Fb − V) dembed/2 term of Eq. 5-6 (magnitude)	kip-in.	1,060	1,056	-0.38		Pass
(Fb − Ft + V)²/(4 bj fb) term of Eq. 5-6	kip-in.	21.60	21.58	-0.09		Pass
β1 bj dembed² fb (2 − β1)/4 term of Eq. 5-6	kip-in.	12,600	12,627	+0.22		Pass
MHB (Eq. 5-6) = 958 kip-ft DG1 rounds MHB to 11,500 kip-in.; ILX 11,550 kip-in.	kip-in.	11,500	11,550	+0.43		Pass
φMHB = 719 kip-ft (φ = 0.75) DG1 prints the factor as (0.7); 719 = 0.75 × 958 kip-ft.	kip-in.	8,628	8,662	+0.40		Pass
Face bearing area A1 = (bf − tw)(d − 2tf)	in.²	187.0	187.1	+0.03		Pass
φPp = φ 1.7 f'c A1 (φ = 0.65)	kips	827.0	826.8	-0.02		Pass
Initial face plate t = 0.75 tw (AISC 341 F3.5b.4)	in.	0.623	0.623	-0.08		Pass
l = λ √(d bf)/4 (Eq. 5-7)	in.	3.860	3.862	+0.05		Pass
tmin = l √(2Pu/(0.9 Fy A1)) (Eq. 5-8)	in.	0.941	0.941	+0.02		Pass

ILX governing check: (Embedment moment strength at the shear (Mu ≤ φMHB)), ratio 0.970. ILX result: **OK**; published: **OK**.

LRFD, φ = 0.75 on MHB (DG1 §5.3 step 4); φ = 0.65 concret

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HK2023-1: Test 1: welded #4 bars (Scenario 2, MVB = 0)

Source: Hassan and Kanvinde (2023), Seismic Performance of Embedded Column Base Connections with Attached Reinforcement, AISC Engineering Journal, Q4 2023, Table 1, pp. 225-244. Connection: Embedded column base (Type II).

HK2023-1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Model strength M = MHB + MVB (Eq. 20) = 1002 / 0.82 kip-ft Published value = M_test,max / ratio of Table 1 (two decimals: ±0.6 %); tolerance 3 % for that rounding and the specimen data not restated in the paper (bar depths from Fig. 6, f'c of Grilli et al.).	kip-in.	14,663	14,313	-2.39		Pass

ILX governing check: (Embedment moment strength, Type II (Mu ≤ φ(MHB + MVB))), ratio 1.366. ILX result: **NG**; published: **NG**.

Nominal model strength (no φ); the specimen was reloaded to failure.

HK2023-2: Test 2: #4 U-bar hairpins (Scenario 2)

Source: Hassan and Kanvinde (2023), Seismic Performance of Embedded Column Base Connections with Attached Reinforcement, AISC Engineering Journal, Q4 2023, Table 1, pp. 225-244. Connection: Embedded column base (Type II).

HK2023-2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Model strength M = MHB + MVB (Eq. 20) = 1055 / 0.88 kip-ft Published value = M_test,max / ratio of Table 1 (two decimals: ±0.6 %); tolerance 3 % for that rounding and the specimen data not restated in the paper (bar depths from Fig. 6, f'c of Grilli et al.).	kip-in.	14,386	14,323	-0.44		Pass

ILX governing check: (Embedment moment strength, Type II (Mu ≤ φ(MHB + MVB))), ratio 1.339. ILX result: **NG**; published: **NG**.

Nominal model strength (no φ); the specimen was reloaded to failure.

HK2023-3: Test 3: bundled #6 U-bar hairpins (Scenario 2)

Source: Hassan and Kanvinde (2023), Seismic Performance of Embedded Column Base Connections with Attached Reinforcement, AISC Engineering Journal, Q4 2023, Table 1, pp. 225-244. Connection: Embedded column base (Type II).

HK2023-3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Model strength M = MHB + MVB (Eq. 20) = 1334 / 1.06 kip-ft Published value = M_test,max / ratio of Table 1 (two decimals: ±0.6 %); tolerance 3 % for that rounding and the specimen data not restated in the paper (bar depths from Fig. 6, f'c of Grilli et al.).	kip-in.	15,102	14,788	-2.08		Pass

ILX governing check: (Embedment moment strength, Type II (Mu ≤ φ(MHB + MVB))), ratio 1.362. ILX result: **NG**; published: **NG**.

Nominal model strength (no φ); the specimen was reloaded to failure.

HK2023-4: Test 4: #4 hairpins with vertical stirrups (Scenario 3)

Source: Hassan and Kanvinde (2023), Seismic Performance of Embedded Column Base Connections with Attached Reinforcement, AISC Engineering Journal, Q4 2023, Table 1, pp. 225-244. Connection: Embedded column base (Type II).

HK2023-4 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Model strength M = MHB + MVB (Eq. 20) = 1196 / 0.90 kip-ft Published value = M_test,max / ratio of Table 1 (two decimals: ±0.6 %); tolerance 3 % for that rounding and the specimen data not restated in the paper (bar depths from Fig. 6, f'c of Grilli et al.).	kip-in.	15,947	14,181	-11.08		Deviation EB1
EB1 Scenario 3 (attached hairpins with vertical stirrups): the paper's MVB from shear friction across the cracked interface (Eqs. 14-19) needs the crack width from the bond-slip strains, which it does not state; ILX takes MVB = 0 (Scenario 2), the conservative bound, and reproduces MHB only.						

ILX governing check: (Embedment moment strength, Type II (Mu ≤ φ(MHB + MVB))), ratio 1.499. ILX result: **NG**; published: **NG**.

Nominal model strength (no φ); the specimens were reloaded to failure.

HK2023-5: Test 5: W18X311, #4 hairpins with stirrups (Scenario 3)

Source: Hassan and Kanvinde (2023), Seismic Performance of Embedded Column Base Connections with Attached Reinforcement, AISC Engineering Journal, Q4 2023, Table 1, pp. 225-244. Connection: Embedded column base (Type II).

HK2023-5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Model strength M = MHB + MVB (Eq. 20) = 1220 / 1.01 kip-ft Published value = M_test,max / ratio of Table 1 (two decimals: ±0.6 %); tolerance 3 % for that rounding and the specimen data not restated in the paper (bar depths from Fig. 6, f'c of Grilli et al.).	kip-in.	14,495	12,149	-16.19		Deviation EB1
EB1 Scenario 3 (attached hairpins with vertical stirrups): the paper's MVB from shear friction across the cracked interface (Eqs. 14-19) needs the crack width from the bond-slip strains, which it does not state; ILX takes MVB = 0 (Scenario 2), the conservative bound, and reproduces MHB only.						

ILX governing check: (Embedment moment strength, Type II (Mu ≤ φ(MHB + MVB))), ratio 1.591. ILX result: **NG**; published: **NG**.

Nominal model strength (no φ); the specimen was reloaded to failure.

HK2023-1G: Grilli et al. 1G: no attached bars (Scenario 1 breakout)

Source: Hassan and Kanvinde (2023), Seismic Performance of Embedded Column Base Connections with Attached Reinforcement, AISC Engineering Journal, Q4 2023, Table 1, pp. 225-244. Connection: Embedded column base (Type II).

HK2023-1G · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Model strength M = MHB + MVB (Eq. 20) = 1927 / 1.22 kip-ft Published value = M_test,max / ratio of Table 1 (two decimals: ±0.6 %); tolerance 3 % for that rounding and the specimen data not restated in the paper (bar depths from Fig. 6, f'c of Grilli et al.).	kip-in.	18,954	18,623	-1.75		Pass

ILX governing check: (Embedment moment strength, Type II (Mu ≤ φ(MHB + MVB))), ratio 1.357. ILX result: **NG**; published: **NG**.

Nominal model strength (no φ); the specimen was reloaded to failure.

HK2023-2G: Grilli et al. 2G: W18X311, no attached bars (Scenario 1)

Source: Hassan and Kanvinde (2023), Seismic Performance of Embedded Column Base Connections with Attached Reinforcement, AISC Engineering Journal, Q4 2023, Table 1, pp. 225-244. Connection: Embedded column base (Type II).

HK2023-2G · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Model strength M = MHB + MVB (Eq. 20) = 1714 / 1.17 kip-ft Published value = M_test,max / ratio of Table 1 (two decimals: ±0.6 %); tolerance 3 % for that rounding and the specimen data not restated in the paper (bar depths from Fig. 6, f'c of Grilli et al.).	kip-in.	17,580	17,258	-1.83		Pass

ILX governing check: (Embedment moment strength, Type II (Mu ≤ φ(MHB + MVB))), ratio 1.358. ILX result: **NG**; published: **NG**.

Nominal model strength (no φ); the specimens were reloaded to failure.

HK2023-3G: Grilli et al. 3G: 30 in. embedment, no axial load (Scenario 1)

Source: Hassan and Kanvinde (2023), Seismic Performance of Embedded Column Base Connections with Attached Reinforcement, AISC Engineering Journal, Q4 2023, Table 1, pp. 225-244. Connection: Embedded column base (Type II).

HK2023-3G · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Model strength M = MHB + MVB (Eq. 20) = 2759 / 0.91 kip-ft Published value = M_test,max / ratio of Table 1 (two decimals: ±0.6 %); tolerance 3 % for that rounding and the specimen data not restated in the paper (bar depths from Fig. 6, f'c of Grilli et al.).	kip-in.	36,382	36,851	+1.29		Pass

ILX governing check: (Embedment moment strength, Type II (Mu ≤ φ(MHB + MVB))), ratio 1.316. ILX result: **NG**; published: **NG**.

Nominal model strength (no φ); the specimen was reloaded to failure.

HK2023-4G: Grilli et al. 4G: 30 in. embedment, 100 kips compression

Source: Hassan and Kanvinde (2023), Seismic Performance of Embedded Column Base Connections with Attached Reinforcement, AISC Engineering Journal, Q4 2023, Table 1, pp. 225-244. Connection: Embedded column base (Type II).

HK2023-4G · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Model strength M = MHB + MVB (Eq. 20) = 3042 / 0.99 kip-ft Published value = M_test,max / ratio of Table 1 (two decimals: ±0.6 %); tolerance 3 % for that rounding and the specimen data not restated in the paper (bar depths from Fig. 6, f'c of Grilli et al.).	kip-in.	36,873	37,417	+1.48		Pass

ILX governing check: (Embedment moment strength, Type II (Mu ≤ φ(MHB + MVB))), ratio 1.314. ILX result: **NG**; published: **NG**.

Nominal model strength (no φ); the specimen was reloaded to failure.

HK2023-5G: Grilli et al. 5G: 30 in. embedment, 150 kips tension

Source: Hassan and Kanvinde (2023), Seismic Performance of Embedded Column Base Connections with Attached Reinforcement, AISC Engineering Journal, Q4 2023, Table 1, pp. 225-244. Connection: Embedded column base (Type II).

HK2023-5G · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Model strength M = MHB + MVB (Eq. 20) = 2803 / 0.95 kip-ft Published value = M_test,max / ratio of Table 1 (two decimals: ±0.6 %); tolerance 3 % for that rounding and the specimen data not restated in the paper (bar depths from Fig. 6, f'c of Grilli et al.).	kip-in.	35,406	36,033	+1.77		Pass

ILX governing check: (Embedment moment strength, Type II (Mu ≤ φ(MHB + MVB))), ratio 1.310. ILX result: **NG**; published: **NG**.

Nominal model strength (no φ); the specimen was reloaded to failure.

DG29 5.12.1: Brace-to-column base plate, strong axis (gusset on the column flange)

Source: AISC Design Guide 29 (2014, errata 2023), Example 5.12.1, pp. 268-283. Connection: Braced-frame column base.

DG29 5.12.1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Brace tensile yielding φRn / Rn/Ω	kips	860.0	859.5	-0.06		Pass
Brace An = Ag − 2 (dh + 1/16) tw	in.²	18.30	18.32	+0.11		Pass
x̄ of the half W12X65 (channel)	in.	2.340	2.343	+0.13		Pass
U = 1 − x̄/l (Table D3.1 Case 2)		0.610	0.609	-0.09		Pass
Ae = An U	in.²	11.20	11.17	-0.31		Pass
Brace tensile rupture φRn / Rn/Ω	kips	546.0	544.3	-0.31		Pass
Bolt bearing / tearout on the brace web (2 outer + 4 inner)	kips	207.0	206.8	-0.12		Pass
Brace web block shear	kips	190.0	190.1	+0.07		Pass
Angles tensile yielding (4 L4X4X1/2)	kips	486.0	486.0	+0.00		Pass
Angle An = Ag − t (dh + 1/16)	in.²	3.250	3.250	+0.00		Pass
Angle U = max(1 − x̄/l, Case 8)		0.803	0.803	+0.04		Pass
Angle Ae	in.²	2.610	2.611	+0.03		Pass
Angles tensile rupture	kips	454.0	454.3	+0.06		Pass
Bolt shear in the angles (6 bolts, double shear)	kips	292.0	292.2	+0.08		Pass
Angles block shear	kips	330.0	330.0	-0.00		Pass
Bolt bearing / tearout on the gusset	kips	262.0	262.1	+0.04		Pass
Whitmore width lw = 5 + 2 (6) tan 30°	in.	11.90	11.93	+0.24		Pass
Whitmore tensile yielding	kips	241.0	241.5	+0.23		Pass
Gusset block shear	kips	261.0	260.6	-0.14		Pass
KL/r = 0.6 (8.32) / (t/√12)		27.70	27.67	-0.11		Pass
φcFcr / Fcr/Ωc (Manual Table 4-22)	ksi	31.10	31.12	+0.06		Pass
Whitmore buckling φcPn / Pn/Ωc	kips	231.0	232.0	+0.44		Pass
β = (36 − 3/4)/2 + 3/4	in.	18.38	18.38	+0.00		Pass
Hub = [H (β − e) − V ec] / β	kips	-9.860	-10.06	+2.00		Pass
Huc = (H e + V ec) / β	kips	119.0	119.0	+0.01		Pass
Gusset shear yielding along the column	kips	477.0	475.9	-0.24		Pass
Gusset tensile yielding along the column	kips	715.0	713.8	-0.17		Pass
Gusset-to-column resultant √(Hc² + V²)	kips	186.0	186.3	+0.14		Pass
Resultant angle θ = atan(Hc / V)	deg	39.8	39.7	-0.22		Pass
Gusset-to-flange weld Dreq (with 1.25)		1.880	1.890	+0.52		Pass
Column web local yielding (J10-3)	kips	994.0	994.0	-0.01		Pass
Column web crippling (J10-4)	kips	829.0	828.0	-0.12		Pass
Gusset shear yielding along the base plate	kips	48.10	48.09	-0.01		Pass
Gusset-to-base-plate weld Dreq		0.994	1.014	+2.01		Deviation B50
B50 Rounded H and V: DG29 Ex. 5.12.1 rounds the brace components to Hu = 109 and Vu = 143 kips before Hub = [H (β − e) − V ec] / β, a small difference of two large terms (1,349 − 1,530 kip-in.); ILX carries H = 108.95 and V = 143.28 kips from the 12 : 9 1/8 bevel, so Hub = −10.06 kips (published −9.86, within the 0.5 kip band) and the base weld Dreq = 1.014 sixteenths against 0.994 (+2 %). Both welds are the J2.4 minimum either way.						
Column web shear yielding (Huc)	kips	331.0	330.6	-0.11		Pass
Column web-to-base-plate weld length l (1/4 in.)	in.	10.70	10.69	-0.13		Pass
Column web tmin = 6.19 D / Fu (D = 4)	in.	0.381	0.381	-0.07		Pass
Tension per flange V/2	kips	71.50	71.64	+0.20		Pass
Flange weld length l (5/16 in., θ = 90°)	in.	3.420	3.431	+0.32		Pass
Column flange tmin = 6.19 D / Fu (D = 5)	in.	0.476	0.476	-0.01		Pass

ILX governing check: (Brace web block shear), ratio 0.947. ILX result: **OK**; published: **OK**.

Notcompared:DG29designsthegussetsidedonly;thetype'sdefaultbaseplateisused.

DG29 5.12.1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Brace tensile yielding φRn / Rn/Ω	kips	572.0	571.9	-0.03		Pass
Brace An = Ag − 2 (dh + 1/16) tw	in.²	18.30	18.32	+0.11		Pass
x̄ of the half W12X65 (channel)	in.	2.340	2.343	+0.13		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
U = 1 − x̄/l (Table D3.1 Case 2)		0.610	0.609	-0.09		Pass
Ae = An U	in.²	11.20	11.17	-0.31		Pass
Brace tensile rupture φRn / Rn/Ω	kips	364.0	362.9	-0.31		Pass
Bolt bearing / tearout on the brace web (2 outer + 4 inner)	kips	138.0	137.8	-0.12		Pass
Brace web block shear	kips	127.0	126.8	-0.20		Pass
Angles tensile yielding (4 L4X4X1/2)	kips	323.0	323.4	+0.11		Pass
Angle An = Ag − t (dh + 1/16)	in.²	3.250	3.250	+0.00		Pass
Angle U = max(1 − x̄/l, Case 8)		0.803	0.803	+0.04		Pass
Angle Ae	in.²	2.610	2.611	+0.03		Pass
Angles tensile rupture	kips	303.0	302.9	-0.05		Pass
Bolt shear in the angles (6 bolts, double shear)	kips	195.0	194.8	-0.09		Pass
Angles block shear	kips	220.0	220.0	-0.00		Pass
Bolt bearing / tearout on the gusset	kips	175.0	174.7	-0.15		Pass
Whitmore width lw = 5 + 2 (6) tan 30°	in.	11.90	11.93	+0.24		Pass
Whitmore tensile yielding	kips	160.0	160.7	+0.44		Pass
Gusset block shear	kips	174.0	173.8	-0.14		Pass
KL/r = 0.6 (8.32) / (t/√12)		27.70	27.67	-0.11		Pass
φcFcr / Fcr/Ωc (Manual Table 4-22)	ksi	20.70	20.71	+0.03		Pass
Whitmore buckling φcPn / Pn/Ωc	kips	154.0	154.4	+0.23		Pass
β = (36 − 3/4)/2 + 3/4	in.	18.38	18.38	+0.00		Pass
Hub = [H (β − e) − V ec] / β	kips	-6.720	-6.705	-0.22		Pass
Huc = (H e + V ec) / β	kips	79.30	79.34	+0.05		Pass
Gusset shear yielding along the column	kips	318.0	317.2	-0.24		Pass
Gusset tensile yielding along the column	kips	476.0	474.9	-0.23		Pass
Gusset-to-column resultant √(Hc² + V²)	kips	124.0	124.2	+0.14		Pass
Resultant angle θ = atan(Hc / V)	deg	39.7	39.7	+0.03		Pass
Gusset-to-flange weld Dreq (with 1.25)		1.880	1.890	+0.52		Pass
Column web local yielding (J10-3)	kips	663.0	662.6	-0.06		Pass
Column web crippling (J10-4)	kips	553.0	552.0	-0.18		Pass
Gusset shear yielding along the base plate	kips	32.10	32.06	-0.12		Pass
Gusset-to-base-plate weld Dreq		1.020	1.014	-0.59		Pass
Column web shear yielding (Huc)	kips	220.0	220.4	+0.19		Pass
Column web-to-base-plate weld length l (1/4 in.)	in.	10.70	10.69	-0.13		Pass
Column web tmin = 6.19 D / Fu (D = 4)	in.	0.381	0.381	-0.07		Pass
Tension per flange V/2	kips	47.80	47.76	-0.08		Pass
Flange weld length l (5/16 in., θ = 90°)	in.	3.430	3.431	+0.02		Pass
Column flange tmin = 6.19 D / Fu (D = 5)	in.	0.476	0.476	-0.01		Pass

ILX governing check: (Brace web block shear), ratio 0.947. ILX result: **OK**; published: **OK**.

Notcompared:DG29

designs the guesses it sideonly; the type's default base plate is used.

DG29 5.12.2: Brace-to-column base plate, weak axis (gusset on the column web)

Source: AISC Design Guide 29 (2014, errata 2023), Example 5.12.2, pp. 284-289. Connection: Braced-frame column base.

DG29 5.12.2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
KL/r = 0.6 (14) / (t/√12)		46.60	46.56	-0.09		Pass
φcFcr / Fcr/Ωc (Manual Table 4-22)	ksi	28.90	28.91	+0.02		Pass
Whitmore buckling φcPn / Pn/Ωc	kips	215.0	215.5	+0.23		Pass
β = (25 − 3/4)/2 + 3/4	in.	12.88	12.88	+0.00		Pass
Hub = H (β − e) / β	kips	61.90	61.98	+0.13		Pass
Huc = H e / β	kips	54.10	54.09	-0.01		Pass
Gusset shear yielding along the column web	kips	328.0	327.4	-0.19		Pass
Gusset tensile yielding along the column web	kips	492.0	491.1	-0.19		Pass
Gusset-to-web resultant √(Hc² + V²)	kips	148.0	147.8	-0.12		Pass
Resultant angle θ	deg	21.4	21.5	+0.30		Pass
Gusset-to-web weld Dreq (no 1.25)		1.970	1.971	+0.06		Pass
Column web yield line φ 4 Fy tw² L / β (Eq. 4-20)	kips	92.70	92.70	-0.00		Pass
Gusset shear yielding along the base plate	kips	77.60	77.62	+0.03		Pass
Gusset-to-base-plate weld Dreq		3.870	3.872	+0.04		Pass
Ductile weld Dmin = ⅝ tg × 16		6.250	6.250	+0.00		Pass
Axial per flange V/2	kips	69.00	68.79	-0.31		Pass
Shear per flange Hc/2	kips	27.10	27.05	-0.20		Pass
Resultant per flange	kips	74.10	73.91	-0.25		Pass
Resultant angle per flange	deg	68.6	68.5	-0.09		Pass
Flange weld length l (5/16 in.)	in.	3.670	3.664	-0.15		Pass
Column flange tmin	in.	0.476	0.476	-0.01		Pass
Column web shear 0.60 Fy tw L (V/2 to each flange)	kips	386.0	386.2	+0.06		Pass

ILX governing check: (Shear along B by friction (the lug bears for shear along N only; DG1 3rd Ed. §4.3.5)), ratio 99.000. ILX result: **NG**; published: **OK**.

Notcompared:DG29designsthegussets

ideonly;thetype'sdefaultbaseplateisused.

DG29 5.12.2 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
KL/r = 0.6 (14) / (t/√12)		46.60	46.56	-0.09		Pass
φcFcr / Fcr/Ωc (Manual Table 4-22)	ksi	19.20	19.23	+0.17		Pass
Whitmore buckling φcPn / Pn/Ωc	kips	143.0	143.4	+0.26		Pass
β = (25 − 3/4)/2 + 3/4	in.	12.88	12.88	+0.00		Pass
Hub = H (β − e) / β	kips	41.30	41.32	+0.05		Pass
Huc = H e / β	kips	36.10	36.06	-0.10		Pass
Gusset shear yielding along the column web	kips	219.0	218.2	-0.34		Pass
Gusset tensile yielding along the column web	kips	327.0	326.7	-0.09		Pass
Gusset-to-web resultant √(Hc² + V²)	kips	98.50	98.55	+0.05		Pass
Resultant angle θ	deg	21.5	21.5	-0.16		Pass
Gusset-to-web weld Dreq (no 1.25)		1.970	1.971	+0.06		Pass
Column web yield line φ 4 Fy tw² L / β (Eq. 4-20)	kips	61.70	61.68	-0.04		Pass
Gusset shear yielding along the base plate	kips	51.80	51.75	-0.10		Pass
Gusset-to-base-plate weld Dreq		3.870	3.872	+0.04		Pass
Ductile weld Dmin = ⅝ tg × 16		6.250	6.250	+0.00		Pass
Axial per flange V/2	kips	45.90	45.86	-0.09		Pass
Shear per flange Hc/2	kips	18.10	18.03	-0.38		Pass
Resultant per flange	kips	49.30	49.28	-0.05		Pass
Resultant angle per flange	deg	68.5	68.5	+0.05		Pass
Flange weld length l (5/16 in.)	in.	3.670	3.664	-0.15		Pass
Column flange tmin	in.	0.476	0.476	-0.01		Pass
Column web shear 0.60 Fy tw L (V/2 to each flange)	kips	258.0	257.5	-0.19		Pass

ILX governing check: (Shear along B by friction (the lug bears for shear along N only; DG1 3rd Ed. §4.3.5)), ratio 99.000. ILX result: **NG**; published: **OK**.

Notcompared:DG29designsthegussetsidedonly;thetype'sdefaultbaseplateisused.

DG1-3 4.7-7 (braced base): Base at a brace, tension + shear: the DG29 Ex. 5.12.2 gusset on the W21X83 web

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-7, pp. 96 to 104 (PDF 106 to 114). Connection: Braced-frame column base.

> Surrogate model: ILX's rod pattern is two rod lines across the column depth with rods spaced along B; the eight-rod pattern of Fig. 4-29 (two rows along the web) cannot be entered. ILX models the four rods between the flanges (x = ±6, y = ±3¼ in.) with half of the brace force (P = −69 / −45.85, V = 58 / 38.7 kips), which reproduces the per-rod forces and the plate and web-weld checks at a rod. The group strengths (breakout, pryout, interaction) are computed by the ILX anchorage engine (ACI 318-19 Ch. 17) with the exact eight rod positions. Through the braced base the four-rod surrogate takes half the brace force (90 / 60 kips at 12 : 10 1/8, weak axis, work point at the plate).

DG1-3 4.7-7 (braced base) · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Tension per rod Nua,i = Nu / 8	kips	17.30	17.20	-0.60		Pass
Shear per rod Vua,i = Vu / 8	kips	14.50	14.51	+0.07		Pass
φNsa (Ase,N = 1.41 in.², futa = 58 ksi) ACI 318 strengths are LRFD (the example gives no ASD values); ILX Ase,N = 1.405 in.².	kips	61.40	61.13	-0.44		Pass
ANc (8 rods, hef = 24 in., no edges)	in.²	7,850	7,850	+0.00		Pass
ANco = 9 hef²	in.²	5,180	5,184	+0.08		Pass
Nb = 16 λa √f'c hef^5/3	kips	226.0	225.9	-0.03		Pass
φNcbg (φ = 0.70)	kips	239.0	239.5	+0.20		Pass
φNpn = 0.70 × 8 Abrg f'c (Abrg = 3.12 in.²)	kips	87.50	87.30	-0.23		Pass
φVsa = 0.65 × 0.80 × 0.6 Ase,V futa (grout pad)	kips	25.50	25.43	-0.28		Pass
φVcpg = 0.70 × 2 Ncbg	kips	479.0	478.9	-0.01		Pass
Interaction Nua/φNn + Vua/φVn (≤ 1.2)		1.150	1.146	-0.31		Pass
Setting plate bearing φRn = 0.75 × 2.4 d t Fu (¼ in. setting plate)	kips	43.90	43.88	-0.06		Pass
Setting plate field welds φRn (8 × ¼ in. × 2 in., kds = 1.5) ILX field-weld strength of the four-rod surrogate (4 × 2 in.) × 2 for the eight rods.	kips	134.0	133.6	-0.27		Pass
Plate moment arm a = (s − tw)/2 ILX uses tw = 0.515 in. (a = 2.99 in.); DG1 rounds tw to ½ in.	in.	3.000	2.993	-0.25		Pass
Plate moment Mr = Nua,i a ILX moment per unit width × b_e = 2a.	kip-in.	51.90	51.46	-0.85		Pass
Plate flexural strength φMn / Mn/Ω on b_e = 2a (1¾ in., Fy = 50 ksi)	kip-in.	207.0	206.2	-0.39		Pass
Web weld for the rod tension: demand per inch Nu / (8 × 6 in.) Published per-inch value = 138 / 48 (91.7 / 48) kips.	kip/in.	2.875	2.873	-0.06		Pass
Web weld strength per inch φRn / 48 in. (¼ in. fillet, kds = 1.5) Published per-inch value = 401 / 48 (268 / 48) kips.	kip/in.	8.354	8.353	-0.02		Pass

ILX governing check: (Anchor rod combined tension, bending and shear (AISC J3.8; DG1)), ratio 1.293. ILX result: **NG**; published: **OK**.

Notcompared:theb

ase-plate suite's surrogate and detailing notes apply.

DG1-3 4.7-7 (braced base) · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Tension per rod Nua,i = Nu / 8	kips	11.50	11.46	-0.31		Pass
Shear per rod Vua,i = Vu / 8	kips	9.680	9.673	-0.07		Pass
Setting plate bearing φRn = 0.75 × 2.4 d t Fu (¼ in. setting plate)	kips	29.30	29.25	-0.17		Pass
Setting plate field welds φRn (8 × ¼ in. × 2 in., kds = 1.5) ILX field-weld strength of the four-rod surrogate (4 × 2 in.) × 2 for the eight rods.	kips	89.00	89.09	+0.11		Pass
Plate moment arm a = (s − tw)/2 ILX uses tw = 0.515 in. (a = 2.99 in.); DG1 rounds tw to ½ in.	in.	3.000	2.993	-0.25		Pass
Plate moment Mr = Nua,i a ILX moment per unit width × b_e = 2a.	kip-in.	34.50	34.31	-0.56		Pass
Plate flexural strength φMn / Mn/Ω on b_e = 2a (1¾ in., Fy = 50 ksi)	kip-in.	138.0	137.2	-0.58		Pass
Web weld for the rod tension: demand per inch Nu / (8 × 6 in.) Published per-inch value = 138 / 48 (91.7 / 48) kips.	kip/in.	1.910	1.916	+0.27		Pass
Web weld strength per inch φRn / 48 in. (¼ in. fillet, kds = 1.5) Published per-inch value = 401 / 48 (268 / 48) kips.	kip/in.	5.583	5.568	-0.27		Pass

ILX governing check: (Anchor rod combined tension, bending and shear (AISC J3.8; DG1)), ratio 1.293. ILX result: **NG**; published: **OK**.

No

t c o m p a r e d : t h e b a s e - p l a t e s u i t e ' s s u r r o g a t e a n d d e t a i l i n g n o t e s a p p l y .

DG1-3 4.7-8 (braced base): Base at a brace, compression + shear: brace at 45° on the W24X104, concentric

Source: AISC Design Guide 1, 3rd Ed. (2024), Example 4.7-8, pp. 104 to 109 (PDF 114 to 119). Connection: Braced-frame column base.

> Surrogate model: The brace (W = 127 kips down and 127 kips shear: 179.6 kips at 45°, compression) is entered as the brace force of each case, the dead load as the column force; the gusset is not part of the example (a 30 × 12 in. gusset with the DG29 Ex. 5.12 brace is assumed).

DG1-3 4.7-8 (braced base) · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Pp = 1.7 f'c A1 (A2 ≥ 4 A1)	kips	2,210	2,210	+0.00		Pass
Concrete bearing φcPp / Pp/Ωc	kips	1,440	1,436	-0.24		Pass
m (Eq. 4-10)	in.	1.050	1.052	+0.24		Pass
n (Eq. 4-11)	in.	1.380	1.380	-0.00		Pass
n′ = √(d bf)/4	in.	4.390	4.391	+0.02		Pass
X (Eq. 4-14), Pu = 619 / Pa = 486 kips		0.390	0.390	+0.13		Pass
λ (Eq. 4-13)		0.701	0.702	+0.12		Pass
l = max(m, n, λn′)	in.	3.080	3.082	+0.06		Pass
tmin (Eq. 4-15)	in.	0.896	0.897	+0.11		Pass
Friction φVn (Eq. 4-30; μ = 0.4, Pu = 496 kips) DG1: only LRFD is applicable to friction.	kips	129.0	129.0	-0.03		Pass
Web fillets (2 × 3/16 × 20 in., θ = 0°) φRn / Rn/Ω ILX strength per inch × the DG1 length 2T = 40 in. (ILX itself uses 2(d − 2k) = 42.2 in.).	kips	167.0	167.1	+0.03		Pass
Column web shear rupture at the welds φRn / Rn/Ω	kips	293.0	292.5	-0.17		Pass

ILX governing check: (Shear by friction (DG1 3rd Ed. §4.3.5)), ratio 0.985. ILX result: **NG**; published: **OK**.

Not compared: the base-plate's surrogate

anddetailingnotesapply.

DG1-3 4.7-8 (braced base) · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Pp = 1.7 f'c A1 (A2 ≥ 4 A1)	kips	2,210	2,210	+0.00		Pass
Concrete bearing φcPp / Pp/Ωc	kips	957.0	956.7	-0.03		Pass
m (Eq. 4-10)	in.	1.050	1.052	+0.24		Pass
n (Eq. 4-11)	in.	1.380	1.380	-0.00		Pass
n′ = √(d bf)/4	in.	4.390	4.391	+0.02		Pass
X (Eq. 4-14), Pu = 619 / Pa = 486 kips		0.460	0.461	+0.12		Pass
λ (Eq. 4-13)		0.782	0.783	+0.07		Pass
l = max(m, n, λn′)	in.	3.430	3.436	+0.17		Pass
tmin (Eq. 4-15)	in.	1.080	1.086	+0.56		Pass
Web fillets (2 × 3/16 × 20 in., θ = 0°) φRn / Rn/Ω ILX strength per inch × the DG1 length 2T = 40 in. (ILX itself uses 2(d − 2k) = 42.2 in.).	kips	112.0	111.4	-0.56		Pass
Column web shear rupture at the welds φRn / Rn/Ω	kips	195.0	195.0	+0.00		Pass

ILX governing check: (Shear by friction (DG1 3rd Ed. §4.3.5)), ratio 1.455. ILX result: **NG**; published: **OK**.

Notcomparedthebase-plateresuite'ssu

rrogateanddetailingnotesapply.

II.A-22: Bolted bracket plate

Source: AISC Design Examples v16.0, Example II.A-22, pp. IIA-243 to IIA-249. Connection: Bracket plate.

II.A-22 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa	kips	36.00	36.00	+0.00		Pass
θ = tan⁻¹(b / a)	deg	37.3	37.3	+0.07		Pass
a' = a / cos θ	in.	25.10	25.15	+0.20		Pass
b' = a sin θ	in.	12.10	12.13	+0.22		Pass
Bolt shear per bolt φrn (Table 7-1)	kips	17.90	17.89	-0.04		Pass
Plate bearing per bolt (Table 7-5)	kips	32.90	32.91	+0.02		Pass
C (Table 7-8, ex = 12 in., n = 6)		4.530	4.529	-0.03		Pass
Cmin = Pu / φrn		2.010	2.012	+0.10		Pass
Mr = P e (Eq. 15-1)	kip-in.	333.0	333.0	+0.00		Pass
Flexural yielding φMn (Eq. 15-2)	kip-in.	1,690	1,688	-0.15		Pass
Znet (Table 15-2)	in.³	21.50	21.52	+0.07		Pass
Flexural rupture φMn (Eq. 15-3)	kip-in.	1,050	1,049	-0.11		Pass
Section B-B Vr = P sin θ	kips	21.80	21.83	+0.13		Pass
Section B-B shear yielding φVn (Eq. 15-7)	kips	136.0	136.4	+0.31		Pass
λ (Eq. 15-18)		1.680	1.686	+0.38		Pass
Q = 1.30 / λ² (Eq. 15-16)		0.461	0.457	-0.85		Pass
Fcr = Q Fy	ksi	23.10	22.85	-1.06		Deviation R1
R1 intermediate rounding: AISC rounds b' = 12.1 in. and λ = 1.68 before Q = 1.30/λ² and Fcr = Q Fy (23.1 ksi, Nc = 94.5 kips); ILX carries b' = 12.127 in., λ = 1.686, Fcr = 22.85 ksi, Nc = 93.5 kips (−1.06 %). The interaction ratio agrees within 0.5 % (0.868 vs 0.864).						
Nr = P cos θ (Eq. 15-9)	kips	28.60	28.63	+0.10		Pass
Mr = P e − Nr b'/2 (Eq. 15-8)	kip-in.	160.0	159.4	-0.36		Pass
Nc	kips	94.50	93.54	-1.02		Deviation R1
R1 intermediate rounding: AISC rounds b' = 12.1 in. and λ = 1.68 before Q = 1.30/λ² and Fcr = Q Fy (23.1 ksi, Nc = 94.5 kips); ILX carries b' = 12.127 in., λ = 1.686, Fcr = 22.85 ksi, Nc = 93.5 kips (−1.06 %). The interaction ratio agrees within 0.5 % (0.868 vs 0.864).						
Mc	kip-in.	285.0	283.6	-0.50		Pass
Interaction Nr/Nc + Mr/Mc (Eq. 15-10)		0.864	0.868	+0.49		Pass
Section A-A shear yielding	kips	225.0	225.0	+0.00		Pass
Section A-A shear rupture	kips	162.0	161.8	-0.13		Pass

ILX governing check: (Section B-B local buckling: normal force and flexure interaction), ratio 0.868. ILX result: **OK**; published: **OK**.

II.A-22 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa	kips	24.00	24.00	+0.00		Pass
θ = tan⁻¹(b / a)	deg	37.3	37.3	+0.07		Pass
a' = a / cos θ	in.	25.10	25.15	+0.20		Pass
b' = a sin θ	in.	12.10	12.13	+0.22		Pass
Bolt shear per bolt φrn (Table 7-1)	kips	11.90	11.93	+0.24		Pass
Plate bearing per bolt (Table 7-5)	kips	21.90	21.94	+0.17		Pass
C (Table 7-8, ex = 12 in., n = 6)		4.530	4.529	-0.03		Pass
Cmin = Pu / φrn		2.020	2.012	-0.39		Pass
Mr = P e (Eq. 15-1)	kip-in.	222.0	222.0	+0.00		Pass
Flexural yielding φMn (Eq. 15-2)	kip-in.	1,130	1,123	-0.64		Pass
Znet (Table 15-2)	in.³	21.50	21.52	+0.07		Pass
Flexural rupture φMn (Eq. 15-3)	kip-in.	700.0	699.3	-0.11		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Section B-B Vr = P sin θ	kips	14.50	14.55	+0.36		Pass
Section B-B shear yielding φVn (Eq. 15-7)	kips	90.70	90.95	+0.28		Pass
λ (Eq. 15-18)		1.680	1.686	+0.38		Pass
Q = 1.30 / λ² (Eq. 15-16)		0.461	0.457	-0.85		Pass
Fcr = Q Fy	ksi	23.10	22.85	-1.06		Deviation R1
R1 intermediate rounding: AISC rounds b' = 12.1 in. and λ = 1.68 before Q = 1.30/λ² and Fcr = Q Fy (23.1 ksi, Nc = 94.5 kips); ILX carries b' = 12.127 in., λ = 1.686, Fcr = 22.85 ksi, Nc = 93.5 kips (−1.06 %). The interaction ratio agrees within 0.5 % (0.868 vs 0.864).						
Nr = P cos θ (Eq. 15-9)	kips	19.10	19.08	-0.08		Pass
Mr = P e − Nr b'/2 (Eq. 15-8)	kip-in.	106.0	106.3	+0.26		Pass
Nc	kips	62.90	62.23	-1.06		Deviation R1
R1 intermediate rounding: AISC rounds b' = 12.1 in. and λ = 1.68 before Q = 1.30/λ² and Fcr = Q Fy (23.1 ksi, Nc = 94.5 kips); ILX carries b' = 12.127 in., λ = 1.686, Fcr = 22.85 ksi, Nc = 93.5 kips (−1.06 %). The interaction ratio agrees within 0.5 % (0.868 vs 0.864).						
Mc	kip-in.	190.0	188.7	-0.70		Pass
Interaction Nr/Nc + Mr/Mc (Eq. 15-10)		0.862	0.870	+0.92		Pass
Section A-A shear yielding	kips	150.0	150.0	+0.00		Pass
Section A-A shear rupture	kips	108.0	107.9	-0.13		Pass

ILX governing check: (Section B-B local buckling: normal force and flexure interaction), ratio 0.870. ILX result: **OK**; published: **OK**.

II.A-23: Welded bracket plate

Source: AISC Design Examples v16.0, Example II.A-23, pp. IIA-250 to IIA-255. Connection: Bracket plate.

II.A-23 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa (both plates)	kips	54.00	54.00	+0.00		Pass
θ	deg	32.6	32.6	-0.08		Pass
a'	in.	21.40	21.36	-0.19		Pass
b'	in.	9.700	9.691	-0.09		Pass
Section A-A shear yielding (2 plates)	kips	405.0	405.0	+0.00		Pass
Mr = P e	kip-in.	446.0	445.5	-0.11		Pass
Flexural yielding φMn (2 plates)	kip-in.	2,740	2,734	-0.23		Pass
C (Table 8-8, k = 0.167, a = 0.606)		1.460	1.460	+0.02		Pass
Dmin (Eq. 8-30), sixteenths		1.370	1.370	-0.03		Pass
Maximum fillet (J2.2b(b))	in.	0.312	0.312	+0.00		Pass
Minimum fillet (Table J2.4)	in.	0.188	0.188	+0.00		Pass
Section B-B Vr	kips	29.10	29.07	-0.09		Pass
Section B-B shear yielding φVn (2 plates)	kips	218.0	218.0	+0.02		Pass
Nr	kips	45.50	45.51	+0.01		Pass
Mr (Eq. 15-8)	kip-in.	225.0	225.0	+0.00		Pass
λ (Eq. 15-18)		1.380	1.376	-0.30		Pass
Q = 1.34 − 0.486 λ (Eq. 15-15)		0.669	0.671	+0.34		Pass
Fcr	ksi	33.50	33.57	+0.20		Pass
Nc (2 plates)	kips	220.0	219.6	-0.20		Pass
Mc (2 plates)	kip-in.	532.0	532.0	-0.01		Pass
Interaction (Eq. 15-10)		0.630	0.630	+0.04		Pass

ILX governing check: (Section B-B local buckling: normal force and flexure interaction), ratio 0.630. ILX result: **OK**; published: **OK**.

II.A-23 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength Pu / Pa (both plates)	kips	36.00	36.00	+0.00		Pass
θ	deg	32.6	32.6	-0.08		Pass
a'	in.	21.40	21.36	-0.19		Pass
b'	in.	9.700	9.691	-0.09		Pass
Section A-A shear yielding (2 plates)	kips	270.0	270.0	+0.00		Pass
Mr = P e	kip-in.	297.0	297.0	+0.00		Pass
Flexural yielding φMn (2 plates)	kip-in.	1,820	1,819	-0.06		Pass
C (Table 8-8, k = 0.167, a = 0.606)		1.460	1.460	+0.02		Pass
Dmin (Eq. 8-30), sixteenths		1.370	1.370	-0.03		Pass
Maximum fillet (J2.2b(b))	in.	0.312	0.312	+0.00		Pass
Minimum fillet (Table J2.4)	in.	0.188	0.188	+0.00		Pass
Section B-B Vr	kips	19.40	19.38	-0.09		Pass
Section B-B shear yielding φVn (2 plates)	kips	145.0	145.4	+0.25		Pass
Nr	kips	30.30	30.34	+0.12		Pass
Mr (Eq. 15-8)	kip-in.	150.0	150.0	+0.00		Pass
λ (Eq. 15-18)		1.380	1.376	-0.30		Pass
Q = 1.34 − 0.486 λ (Eq. 15-15)		0.669	0.671	+0.34		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Fcr	ksi	33.50	33.57	+0.20		Pass
Nc (2 plates)	kips	146.0	146.1	+0.06		Pass
Mc (2 plates)	kip-in.	354.0	353.9	-0.02		Pass
Interaction (Eq. 15-10)		0.631	0.631	+0.08		Pass

ILX governing check: (Section B-B local buckling: normal force and flexure interaction), ratio 0.631. ILX result: **OK**; published: **OK**.

II.A-24A: Eccentric bolt group, IC method, vertical load

Source: AISC Design Examples v16.0, Example II.A-24, pp. IIA-256 to IIA-257. Connection: Bolt group.

II.A-24A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Bolt shear per bolt φrn (Table 7-1)	kips	24.30	24.35	+0.22		Pass
C (Table 7-8, ex = 16, n = 6, 0°)		3.550	3.554	+0.10		Pass
C, Manual table grid (interpolated)		3.550	3.554	+0.10		Pass
Available strength φRn = C φrn	kips	86.30	86.54	+0.28		Pass

ILX governing check: (Bolt group, IC method (φRn = C φrn)), ratio 0.578. ILX result: **OK**; published: **OK**.

II.A-24A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Bolt shear per bolt φrn (Table 7-1)	kips	16.20	16.24	+0.22		Pass
C (Table 7-8, ex = 16, n = 6, 0°)		3.550	3.554	+0.10		Pass
C, Manual table grid (interpolated)		3.550	3.554	+0.10		Pass
Available strength φRn = C φrn	kips	57.50	57.69	+0.34		Pass

ILX governing check: (Bolt group, IC method (φRn = C φrn)), ratio 0.867. ILX result: **OK**; published: **OK**.

II.A-24B: Eccentric bolt group, IC method, load at 15°

Source: AISC Design Examples v16.0, Example II.A-24, p. IIA-257. Connection: Bolt group.

II.A-24B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
ex at the centroid = 16 − 7.5 tan 15° Manual table convention	in.	14.00	13.99	-0.07		Pass
C (Table 7-8, ex = 14, 15°)		4.050	4.048	-0.04		Pass
C, Manual table grid		4.050	4.049	-0.04		Pass
Available strength φRn = C φrn	kips	98.40	98.59	+0.19		Pass

ILX governing check: (Bolt group, IC method (φRn = C φrn)), ratio 0.507. ILX result: **OK**; published: **OK**.

II.A-24B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
ex at the centroid = 16 − 7.5 tan 15° Manual table convention	in.	14.00	13.99	-0.07		Pass
C (Table 7-8, ex = 14, 15°)		4.050	4.048	-0.04		Pass
C, Manual table grid		4.050	4.049	-0.04		Pass
Available strength φRn = C φrn	kips	65.60	65.73	+0.19		Pass

ILX governing check: (Bolt group, IC method (φRn = C φrn)), ratio 0.761. ILX result: **OK**; published: **OK**.

II.A-25: Eccentric bolt group, elastic method

Source: AISC Design Examples v16.0, Example II.A-25, pp. IIA-258 to IIA-259. Connection: Bolt group.

II.A-25 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ix = Σ y²		315.0	315.0	+0.00		Pass
Iy = Σ x²		90.80	90.75	-0.06		Pass
Ip		406.0	405.8	-0.06		Pass
Critical bolt resultant per unit load r / P		0.352	0.352	+0.14		Pass
Available strength P ≤ φrn / 0.352	kips	69.00	69.09	+0.13		Pass

ILX governing check: (Bolt group, elastic method (φRn = C φrn)), ratio 0.579. ILX result: **OK**; published: **OK**.

II.A-25 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ix = Σ y²		315.0	315.0	+0.00		Pass
Iy = Σ x²		90.80	90.75	-0.06		Pass
Ip		406.0	405.8	-0.06		Pass
Critical bolt resultant per unit load r / P		0.352	0.352	+0.14		Pass
Available strength P ≤ φrn / 0.352	kips	46.00	46.06	+0.13		Pass

ILX governing check: (Bolt group, elastic method (φRn = C φrn)), ratio 0.868. ILX result: **OK**; published: **OK**.

II.A-26A: Eccentric weld group, IC method, vertical load

Source: AISC Design Examples v16.0, Example II.A-26, pp. IIA-260 to IIA-261. Connection: Weld group.

II.A-26A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
x̄ l	in.	1.250	1.250	+0.00		Pass
a l = 0.875 × 10	in.	8.750	8.750	+0.00		Pass
C (Table 8-8, k = 0.5, a = 0.875, 0°)		1.880	1.874	-0.30		Pass
C, Manual table grid		1.880	1.877	-0.14		Pass
Rn = C C1 D l	kips	113.0	112.5	-0.48		Pass
Available strength	kips	84.80	84.34	-0.54		Pass

ILX governing check: (Weld group, IC method (φRn = φ C C1 D l)), ratio 0.593. ILX result: **OK**; published: **OK**.

II.A-26A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
x̄ l	in.	1.250	1.250	+0.00		Pass
a l = 0.875 × 10	in.	8.750	8.750	+0.00		Pass
C (Table 8-8, k = 0.5, a = 0.875, 0°)		1.880	1.874	-0.30		Pass
C, Manual table grid		1.880	1.877	-0.14		Pass
Rn = C C1 D l	kips	113.0	112.5	-0.48		Pass
Available strength	kips	56.50	56.23	-0.48		Pass

ILX governing check: (Weld group, IC method (φRn = φ C C1 D l)), ratio 0.889. ILX result: **OK**; published: **OK**.

II.A-26B: Eccentric weld group, IC method, load at 75°

Source: AISC Design Examples v16.0, Example II.A-26, p. IIA-262. Connection: Weld group.

II.A-26B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
C (Table 8-8, 75°)		3.450	3.458	+0.24		Pass
Rn = C C1 D l	kips	207.0	207.5	+0.24		Pass
Available strength	kips	155.0	155.6	+0.40		Pass

ILX governing check: (Weld group, IC method (φRn = φ C C1 D l)), ratio 0.321. ILX result: **OK**; published: **OK**.

II.A-26B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
C (Table 8-8, 75°)		3.450	3.458	+0.24		Pass
Rn = C C1 D l	kips	207.0	207.5	+0.24		Pass
Available strength	kips	104.0	103.7	-0.24		Pass

ILX governing check: (Weld group, IC method (φRn = φ C C1 D l)), ratio 0.482. ILX result: **OK**; published: **OK**.

II.A-27: Eccentric weld group, elastic method

Source: AISC Design Examples v16.0, Example II.A-27, pp. IIA-263 to IIA-265. Connection: Weld group.

II.A-27 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ix		333.0	333.3	+0.10		Pass
Iy		52.10	52.08	-0.03		Pass
Ip		385.0	385.4	+0.11		Pass
Resultant per unit load r (1/in.)		0.177	0.176	-0.29		Pass
Available strength	kips	47.20	47.33	+0.27		Pass

ILX governing check: (Weld group, elastic method), ratio 0.634. ILX result: **OK**; published: **OK**.

II.A-27 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ix		333.0	333.3	+0.10		Pass
Iy		52.10	52.08	-0.03		Pass
Ip		385.0	385.4	+0.11		Pass
Resultant per unit load r (1/in.)		0.177	0.176	-0.29		Pass
Available strength	kips	31.50	31.55	+0.16		Pass

ILX governing check: (Weld group, elastic method), ratio 0.951. ILX result: **OK**; published: **OK**.

J.3: Combined tension and shear, bearing-type

Source: AISC Design Examples v16.0, Example J.3, pp. J-11 to J-12. Connection: Bolted joint.

J.3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required tension	kips	23.40	23.40	+0.00		Pass
Required shear	kips	8.000	7.996	-0.05		Pass
frv = V / Ab	ksi	18.10	18.10	-0.00		Pass
F'nt (Eqs. J3-3a / J3-3b)	ksi	76.80	76.78	-0.03		Pass
Available tension with shear (Eq. J3-2)	kips	25.50	25.44	-0.23		Pass

ILX governing check: (Combined tension and shear, bearing-type (J3.8)), ratio 0.920. ILX result: **OK**; published: **OK**.

J.3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required tension	kips	15.50	15.50	+0.00		Pass
Required shear	kips	5.330	5.330	+0.00		Pass
frv = V / Ab	ksi	12.10	12.06	-0.29		Pass
F'nt (Eqs. J3-3a / J3-3b)	ksi	76.70	76.78	+0.11		Pass
Available tension with shear (Eq. J3-2)	kips	17.00	16.96	-0.23		Pass

ILX governing check: (Combined tension and shear, bearing-type (J3.8)), ratio 0.914. ILX result: **OK**; published: **OK**.

J.4A: Slip-critical connection with short-slotted holes

Source: AISC Design Examples v16.0, Example J.4A, pp. J-13 to J-14. Connection: Bolted joint.

J.4A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	102.0	102.0	+0.00		Pass
rn = μ Du hf Tb ns	kips	19.00	18.98	-0.08		Pass
Available slip per bolt	kips	19.00	18.98	-0.08		Pass
Bolts required		5.370	5.373	+0.05		Pass

ILX governing check: (Slip resistance), ratio 0.895. ILX result: **OK**; published: **OK**.

J.4A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	68.00	68.00	+0.00		Pass
rn = μ Du hf Tb ns	kips	19.00	18.98	-0.08		Pass
Available slip per bolt	kips	12.70	12.66	-0.35		Pass
Bolts required		5.350	5.373	+0.43		Pass

ILX governing check: (Slip resistance), ratio 0.895. ILX result: **OK**; published: **OK**.

J.4B: Slip-critical connection with long-slotted holes

Source: AISC Design Examples v16.0, Example J.4B, pp. J-15 to J-16. Connection: Bolted joint.

J.4B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Available slip per bolt (φ = 0.70)	kips	13.30	13.29	-0.08		Pass
Bolts required		7.670	7.676	+0.07		Pass
Slip resistance, 8 bolts 8 × 13.3 / 8.88 kips (the example's 'use 8 bolts')	kips	106.0	106.3	+0.29		Pass

ILX governing check: (Slip resistance), ratio 0.959. ILX result: **OK**; published: **OK**.

J.4B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Available slip per bolt (φ = 0.70)	kips	8.880	8.871	-0.10		Pass
Bolts required		7.660	7.665	+0.07		Pass
Slip resistance, 8 bolts 8 × 13.3 / 8.88 kips (the example's 'use 8 bolts')	kips	71.00	70.97	-0.04		Pass

ILX governing check: (Slip resistance), ratio 0.958. ILX result: **OK**; published: **OK**.

J.5: Combined tension and shear in a slip-critical connection

Source: AISC Design Examples v16.0, Example J.5, pp. J-17 to J-19. Connection: Bolted joint.

J.5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Tension Tu / Ta	kips	72.00	72.00	+0.00		Pass
Shear Vu / Va	kips	54.00	54.00	+0.00		Pass
Tension per bolt	kips	9.000	9.000	+0.00		Pass
Available tension per bolt	kips	29.90	29.82	-0.27		Pass
Slip resistance per bolt (T = 0)	kips	9.490	9.492	+0.02		Pass
ksc (Eqs. J3-5a / J3-5b)		0.716	0.716	-0.06		Pass
Available slip resistance	kips	54.40	54.34	-0.12		Pass

ILX governing check: (Slip resistance with tension (J3.10)), ratio 0.994. ILX result: **OK**; published: **OK**.

J.5 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Tension Tu / Ta	kips	48.00	48.00	+0.00		Pass
Shear Vu / Va	kips	36.00	36.00	+0.00		Pass
Tension per bolt	kips	6.000	6.000	+0.00		Pass
Available tension per bolt	kips	19.90	19.88	-0.10		Pass
Slip resistance per bolt (T = 0)	kips	6.330	6.328	-0.03		Pass
ksc (Eqs. J3-5a / J3-5b)		0.716	0.716	-0.06		Pass
Available slip resistance	kips	36.30	36.22	-0.21		Pass

ILX governing check: (Slip resistance with tension (J3.10)), ratio 0.994. ILX result: **OK**; published: **OK**.

II.D-3: Slip-critical connection with oversized holes

Source: AISC Design Examples v16.0, Example II.D-3, pp. IID-21 to IID-28. Connection: Bolted joint.

II.D-3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Slip resistance per bolt, OVS, double shear (Table 7-3)	kips	16.10	16.14	+0.23		Pass
Bolts required for slip		5.590	5.577	-0.22		Pass
Bolt shear per bolt, double shear (Table 7-1)	kips	35.80	35.78	-0.04		Pass
Angles, edge bolt (le = 1¼, Table 7-5)	kips	30.90	30.90	-0.00		Pass
Plate (OVS), edge bolt (le = 1¼)	kips	22.90	22.85	-0.21		Pass
Bolt group Σ rn,i	kips	197.0	196.9	-0.06		Pass
Angles tension yielding	kips	160.0	160.2	+0.12		Pass
U = 1 − x̄ / l		0.943	0.943	-0.04		Pass
Ae		2.840	2.840	-0.02		Pass
Angles tension rupture	kips	139.0	138.4	-0.41		Pass
Angles block shear (lev = 1½) AISC uses le = 1¼ for bearing and 1½ for block shear	kips	238.0	238.8	+0.34		Pass
Plate tension yielding (Whitmore = full width)	kips	135.0	135.0	+0.00		Pass
Plate tension rupture	kips	122.0	121.9	-0.10		Pass
Plate block shear (lev = 1½)	kips	222.0	221.8	-0.08		Pass

ILX governing check: (Slip resistance), ratio 0.930. ILX result: **OK**; published: **OK**.

II.D-3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Slip resistance per bolt, OVS, double shear (Table 7-3)	kips	10.80	10.79	-0.13		Pass
Bolts required for slip		5.560	5.563	+0.05		Pass
Bolt shear per bolt, double shear (Table 7-1)	kips	23.90	23.86	-0.18		Pass
Angles, edge bolt (le = 1¼, Table 7-5)	kips	20.60	20.60	-0.00		Pass
Plate (OVS), edge bolt (le = 1¼)	kips	15.30	15.23	-0.43		Pass
Bolt group Σ rn,i	kips	132.0	131.3	-0.56		Pass
Angles tension yielding	kips	107.0	106.6	-0.39		Pass
U = 1 − x̄ / l		0.943	0.943	-0.04		Pass
Ae		2.840	2.840	-0.02		Pass
Angles tension rupture	kips	92.50	92.29	-0.23		Pass
Angles block shear (lev = 1½) AISC uses le = 1¼ for bearing and 1½ for block shear	kips	159.0	159.2	+0.13		Pass
Plate tension yielding (Whitmore = full width)	kips	89.80	89.82	+0.02		Pass
Plate tension rupture	kips	81.50	81.25	-0.31		Pass
Plate block shear (lev = 1½)	kips	148.0	147.9	-0.08		Pass

ILX governing check: (Slip resistance), ratio 0.927. ILX result: **OK**; published: **OK**.

J.1: Fillet weld in longitudinal shear

Source: AISC Design Examples v16.0, Example J.1, pp. J-2 to J-4. Connection: Welded joint.

J.1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (1.2D + 1.6L = 199.6, printed 200)	kips	200.0	199.6	-0.20		Pass
kds (θ = 0)		1.000	1.000	+0.00		Pass
rn per inch, 3/16 fillet	kip/in.	5.570	5.568	-0.03		Pass
β (Eq. J2-1, l/w = 144)		0.912	0.912	-0.00		Pass
Rn = β rn × 2 × 27	kips	274.0	274.2	+0.09		Pass
Available weld strength	kips	206.0	205.7	-0.16		Pass
Base metal (Eq. J2-2)	kips	395.0	394.9	-0.03		Pass
Maximum fillet (J2.2b(b))	in.	0.188	0.188	+0.00		Pass
Minimum fillet (Table J2.4)	in.	0.125	0.125	+0.00		Pass

ILX governing check: (Fillet weld strength), ratio 0.970. ILX result: **OK**; published: **OK**.

J.1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (1.2D + 1.6L = 199.6, printed 200)	kips	133.0	133.0	+0.00		Pass
kds (θ = 0)		1.000	1.000	+0.00		Pass
rn per inch, 3/16 fillet	kip/in.	5.570	5.568	-0.03		Pass
β (Eq. J2-1, l/w = 144)		0.912	0.912	-0.00		Pass
Rn = β rn × 2 × 27	kips	274.0	274.2	+0.09		Pass
Available weld strength	kips	137.0	137.1	+0.09		Pass
Base metal (Eq. J2-2)	kips	264.0	263.2	-0.28		Pass
Maximum fillet (J2.2b(b))	in.	0.188	0.188	+0.00		Pass
Minimum fillet (Table J2.4)	in.	0.125	0.125	+0.00		Pass

ILX governing check: (Fillet weld strength), ratio 0.970. ILX result: **OK**; published: **OK**.

J.2A: Fillet weld loaded at an angle

Source: AISC Design Examples v16.0, Example J.2A, pp. J-5 to J-6. Connection: Welded joint.

J.2A · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
kds (60°)		1.400	1.403	+0.21		Pass
rn per inch, 5/16 fillet	kip/in.	13.00	13.02	+0.16		Pass
Available per inch, both sides	kip/in.	19.50	19.53	+0.16		Pass
Required length	in.	15.40	15.36	-0.26		Pass
Minimum fillet (Table J2.4, ¾ in.)	in.	0.250	0.250	+0.00		Pass

ILX governing check: (Fillet weld strength), ratio 0.960. ILX result: **OK**; published: **OK**.

J.2A · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
kds (60°)		1.400	1.403	+0.21		Pass
rn per inch, 5/16 fillet	kip/in.	13.00	13.02	+0.16		Pass
Available per inch, both sides	kip/in.	13.00	13.02	+0.16		Pass
Required length	in.	15.40	15.36	-0.26		Pass
Minimum fillet (Table J2.4, ¾ in.)	in.	0.250	0.250	+0.00		Pass

ILX governing check: (Fillet weld strength), ratio 0.960. ILX result: **OK**; published: **OK**.

J.2B: PJP groove weld loaded at an angle

Source: AISC Design Examples v16.0, Example J.2B, pp. J-7 to J-10. Connection: Welded joint.

J.2B · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
φrnv per inch (shear)	kip/in.	15.80	15.75	-0.32		Pass
φrnt per inch (tension)	kip/in.	16.80	16.80	+0.00		Pass
Required length	in.	18.10	18.16	+0.34		Pass
Pr = P sin θ	kips	260.0	259.8	-0.07		Pass
Vr = P cos θ	kips	150.0	150.0	+0.00		Pass
Pc, base metal (l = 18¼)	kips	445.0	444.8	-0.04		Pass
Vc, base metal	kips	266.0	266.9	+0.34		Pass
Base metal interaction (Manual Eq. 9-1)		0.442	0.441	-0.26		Pass
Minimum effective throat (Table J2.3)	in.	0.250	0.250	+0.00		Pass

ILX governing check: (PJP groove weld strength (required length)), ratio 0.995. ILX result: **OK**; published: **OK**.

J.2B · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
φrnv per inch (shear)	kip/in.	10.50	10.50	+0.00		Pass
φrnt per inch (tension)	kip/in.	11.20	11.17	-0.27		Pass
Required length	in.	18.20	18.20	-0.02		Pass
Pr = P sin θ	kips	173.0	173.2	+0.12		Pass
Vr = P cos θ	kips	100.0	100.0	+0.00		Pass
Pc, base metal (l = 18¼)	kips	297.0	296.6	-0.15		Pass
Vc, base metal	kips	178.0	177.9	-0.04		Pass
Base metal interaction (Manual Eq. 9-1)		0.439	0.441	+0.42		Pass
Minimum effective throat (Table J2.3)	in.	0.250	0.250	+0.00		Pass

ILX governing check: (PJP groove weld strength (required length)), ratio 0.997. ILX result: **OK**; published: **OK**.

II.D-3 weld: II.D-3 plate-to-beam-flange fillet welds

Source: AISC Design Examples v16.0, Example II.D-3, pp. IID-27 to IID-28. Connection: Welded joint.

II.D-3 weld · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
kds (90°)		1.500	1.500	+0.00		Pass
Required size D (sixteenths, Eq. 8-2)		3.590	3.592	+0.05		Pass
Beam flange tmin = 3.09 D / Fu (Eq. 9-6)	in.	0.171	0.171	-0.15		Pass
Minimum fillet (Table J2.4)	in.	0.188	0.188	+0.00		Pass

ILX governing check: (Fillet weld strength), ratio 0.898. ILX result: **OK**; published: **OK**.

II.D-3 weld · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
kds (90°)		1.500	1.500	+0.00		Pass
Required size D (sixteenths, Eq. 8-2)		3.590	3.592	+0.05		Pass
Beam flange tmin = 3.09 D / Fu (Eq. 9-6)	in.	0.171	0.171	-0.15		Pass
Minimum fillet (Table J2.4)	in.	0.188	0.188	+0.00		Pass

ILX governing check: (Fillet weld strength), ratio 0.898. ILX result: **OK**; published: **OK**.

D.7: Pin-connected tension member

Source: AISC Design Examples v16.0, Example D.7, pp. D-20 to D-23. Connection: Pin-connected member / eyebar.

D.7 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (1.2D + 1.6L / D + L)	kips	24.00	24.00	+0.00		Pass
b = (w − dh) / 2	in.	1.610	1.609	-0.04		Pass
be = 2t + 0.63 ≤ b	in.	1.610	1.609	-0.04		Pass
D5.2(d): 1.33 be	in.	2.140	2.140	+0.02		Pass
D5.2(c): 2 be + d	in.	4.220	4.219	-0.03		Pass
Tensile rupture Pn = Fu (2 t be) (Eq. D5-1)	kips	105.0	104.6	-0.37		Pass
Available tensile rupture	kips	78.80	78.46	-0.44		Pass
Asf = 2t (a + d/2)	in.²	2.750	2.750	+0.00		Pass
Cr (dh − d ≤ 1/32 in.)		1.000	1.000	+0.00		Pass
Shear rupture Pn = 0.6 Cr Fu Asf (Eq. D5-2)	kips	107.0	107.2	+0.23		Pass
Available shear rupture	kips	80.30	80.44	+0.17		Pass
Apb = t d	in.²	0.500	0.500	+0.00		Pass
Bearing Rn = 1.8 Fy Apb (Eq. J7-1)	kips	45.00	45.00	+0.00		Pass
Available bearing (governs)	kips	33.80	33.75	-0.15		Pass
Ag = w t	in.²	2.130	2.125	-0.23		Pass
Tensile yielding Pn = Fy Ag (Eq. D2-1) AISC rounds Ag to 2.13 in.² (Pn = 106.5, printed 107); ILX carries 2.125 in.² (106.25 kips).	kips	107.0	106.2	-0.70		Pass
Available tensile yielding	kips	96.30	95.62	-0.70		Pass

ILX governing check: (Bearing on the projected area of the pin (J7)), ratio 0.711. ILX result: **OK**; published: **OK**.

D.7 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (1.2D + 1.6L / D + L)	kips	16.00	16.00	+0.00		Pass
b = (w − dh) / 2	in.	1.610	1.609	-0.04		Pass
be = 2t + 0.63 ≤ b	in.	1.610	1.609	-0.04		Pass
D5.2(d): 1.33 be	in.	2.140	2.140	+0.02		Pass
D5.2(c): 2 be + d	in.	4.220	4.219	-0.03		Pass
Tensile rupture Pn = Fu (2 t be) (Eq. D5-1)	kips	105.0	104.6	-0.37		Pass
Available tensile rupture	kips	52.50	52.30	-0.37		Pass
Asf = 2t (a + d/2)	in.²	2.750	2.750	+0.00		Pass
Cr (dh − d ≤ 1/32 in.)		1.000	1.000	+0.00		Pass
Shear rupture Pn = 0.6 Cr Fu Asf (Eq. D5-2)	kips	107.0	107.2	+0.23		Pass
Available shear rupture	kips	53.50	53.62	+0.23		Pass
Apb = t d	in.²	0.500	0.500	+0.00		Pass
Bearing Rn = 1.8 Fy Apb (Eq. J7-1)	kips	45.00	45.00	+0.00		Pass
Available bearing (governs)	kips	22.50	22.50	+0.00		Pass
Ag = w t	in.²	2.130	2.125	-0.23		Pass
Tensile yielding Pn = Fy Ag (Eq. D2-1) AISC rounds Ag to 2.13 in.² (Pn = 106.5, printed 107); ILX carries 2.125 in.² (106.25 kips).	kips	107.0	106.2	-0.70		Pass
Available tensile yielding	kips	64.10	63.62	-0.74		Pass

ILX governing check: (Bearing on the projected area of the pin (J7)), ratio 0.711. ILX result: **OK**; published: **OK**.

D.8: Eyebar tension member

Source: AISC Design Examples v16.0, Example D.8, pp. D-24 to D-26. Connection: Pin-connected member / eyebar.

D.8 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (1.2D + 1.6L / D + L)	kips	54.00	54.00	+0.00		Pass
D6.1: 8 t	in.	5.000	5.000	+0.00		Pass
D6.2: 7/8 w	in.	2.630	2.625	-0.19		Pass
D6.2: d + 1/32	in.	3.030	3.031	+0.04		Pass
D6.2: R ≥ dhead	in.	7.500	7.500	+0.00		Pass
b = (dhead − dh) / 2	in.	2.230	2.234	+0.20		Pass
D6.2: 2/3 w	in.	2.000	2.000	+0.00		Pass
Ag = w t (body)	in.²	1.880	1.875	-0.27		Pass
Tensile yielding Pn = Fy Ag (Eq. D2-1)	kips	94.00	93.75	-0.27		Pass
Available tensile yielding (governs)	kips	84.60	84.38	-0.27		Pass

ILX governing check: (Tensile yielding on the gross area of the body), ratio 0.640. ILX result: **OK**; published: **OK**.

D.8 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (1.2D + 1.6L / D + L)	kips	40.00	40.00	+0.00		Pass
D6.1: 8 t	in.	5.000	5.000	+0.00		Pass
D6.2: 7/8 w	in.	2.630	2.625	-0.19		Pass
D6.2: d + 1/32	in.	3.030	3.031	+0.04		Pass
D6.2: R ≥ dhead	in.	7.500	7.500	+0.00		Pass
b = (dhead − dh) / 2	in.	2.230	2.234	+0.20		Pass
D6.2: 2/3 w	in.	2.000	2.000	+0.00		Pass
Ag = w t (body)	in.²	1.880	1.875	-0.27		Pass
Tensile yielding Pn = Fy Ag (Eq. D2-1)	kips	94.00	93.75	-0.27		Pass
Available tensile yielding (governs)	kips	56.30	56.14	-0.29		Pass

ILX governing check: (Tensile yielding on the gross area of the body), ratio 0.713. ILX result: **OK**; published: **OK**.

D.1: W-shape tension member

Source: AISC Design Examples v16.0, Example D.1, pp. D-2 to D-4. Connection: Tension member end connection.

D.1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (1.2D + 1.6L | D + L)	kips	180.0	180.0	+0.00		Pass
Tensile yielding (Manual Table 5-1)	kips	277.0	277.2	+0.07		Pass
U ≥ 2 bf tf / Ag		0.684	0.684	+0.06		Pass
Case 2: U = 1 − x̄/l (x̄ = ȳ of WT4×10.5, l = 9 in.)		0.908	0.908	-0.04		Pass
Case 7: U (bf < 2d/3)		0.850	0.850	+0.00		Pass
U (larger)		0.908	0.908	-0.04		Pass
An = Ag − 4 (dh + 1/16) tf	in.²	4.760	4.760	+0.00		Pass
Ae = An U	in.²	4.320	4.320	+0.01		Pass
Pn = Fu Ae	kips	281.0	280.8	-0.06		Pass
Tensile rupture	kips	211.0	210.6	-0.18		Pass
L/r (ry)		238.000	238.095	+0.04		Pass

ILX governing check: (Member tensile rupture (W8X21)), ratio 0.855. ILX result: **OK**; published: **OK**.

Member limit states (the example assumes the connection does n

otgovern);fullIconnectionstatus:OK.

D.1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (1.2D + 1.6L | D + L)	kips	120.0	120.0	+0.00		Pass
Tensile yielding (Manual Table 5-1)	kips	184.0	184.4	+0.23		Pass
U ≥ 2 bf tf / Ag		0.684	0.684	+0.06		Pass
Case 2: U = 1 − x̄/l (x̄ = ȳ of WT4×10.5, l = 9 in.)		0.908	0.908	-0.04		Pass
Case 7: U (bf < 2d/3)		0.850	0.850	+0.00		Pass
U (larger)		0.908	0.908	-0.04		Pass
An = Ag − 4 (dh + 1/16) tf	in.²	4.760	4.760	+0.00		Pass
Ae = An U	in.²	4.320	4.320	+0.01		Pass
Pn = Fu Ae	kips	281.0	280.8	-0.06		Pass
Tensile rupture	kips	141.0	140.4	-0.41		Pass
L/r (ry)		238.000	238.095	+0.04		Pass

ILX governing check: (Member tensile rupture (W8X21)), ratio 0.855. ILX result: **OK**; published: **OK**.

Memberlimitstates(theexam

please summes the connection does not govern); full connections status: OK.

D.2: Single-angle tension member

Source: AISC Design Examples v16.0, Example D.2, pp. D-5 to D-7. Connection: Tension member end connection.

D.2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	120.0	120.0	+0.00		Pass
Pn = Fy Ag	kips	188.0	187.5	-0.27		Pass
Tensile yielding	kips	169.0	168.8	-0.15		Pass
U ≥ connected half of the angle		0.500	0.500	+0.00		Pass
Case 2: U = 1 − x̄/l (l = 9 in.)		0.869	0.869	-0.01		Pass
Case 8: U (4 bolts per line)		0.800	0.800	+0.00		Pass
An = Ag − (dh + 1/16) t	in.²	3.310	3.312	+0.08		Pass
Ae = An U	in.²	2.880	2.878	-0.06		Pass
Pn = Fu Ae	kips	187.0	187.1	+0.04		Pass
Tensile rupture	kips	140.0	140.3	+0.22		Pass
Lmax = 300 rz any member length gives Lmax; L = 1 in. is entered to run the D1 check	ft	19.40	19.40	+0.00		Pass

ILX governing check: (Bolt shear, bearing and tearout (bolt group)), ratio 1.677. ILX result: **OK**; published: **OK**.

Member limit states (the example assumes the connection does)

snotgovern);fullconnectionstatus:NG.

D.2 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	80.00	80.00	+0.00		Pass
Pn = Fy Ag	kips	188.0	187.5	-0.27		Pass
Tensile yielding	kips	113.0	112.3	-0.64		Pass
U ≥ connected half of the angle		0.500	0.500	+0.00		Pass
Case 2: U = 1 − x̄/l (l = 9 in.)		0.869	0.869	-0.01		Pass
Case 8: U (4 bolts per line)		0.800	0.800	+0.00		Pass
An = Ag − (dh + 1/16) t	in.²	3.310	3.312	+0.08		Pass
Ae = An U	in.²	2.880	2.878	-0.06		Pass
Pn = Fu Ae	kips	187.0	187.1	+0.04		Pass
Tensile rupture	kips	93.50	93.54	+0.04		Pass
Lmax = 300 rz any member length gives Lmax; L = 1 in. is entered to run the D1 check	ft	19.40	19.40	+0.00		Pass

ILX governing check: (Bolt shear, bearing and tearout (bolt group)), ratio 1.677. ILX result: **OK**; published: **OK**.

Memberlimitstates(the

example assumes the connection does not govern); full connection status: NG.

D.3: WT-shape tension member

Source: AISC Design Examples v16.0, Example D.3, pp. D-8 to D-10. Connection: Tension member end connection.

D.3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	240.0	240.0	+0.00		Pass
Tensile yielding (Manual Table 5-3)	kips	263.0	262.8	-0.08		Pass
U ≥ bf tf / Ag		0.706	0.706	+0.05		Pass
Case 4: U = [3l²/(3l² + w²)](1 − x̄/l)		0.860	0.860	+0.00		Pass
An = Ag (no holes)	in.²	5.840	5.840	+0.00		Pass
Ae = An U	in.²	5.020	5.023	+0.05		Pass
Pn = Fu Ae	kips	326.0	326.5	+0.14		Pass
Tensile rupture	kips	245.0	244.8	-0.06		Pass
L/rx		229.000	229.299	+0.13		Pass

ILX governing check: (Member tensile rupture (WT6X20)), ratio 0.980. ILX result: **OK**; published: **OK**.

Member limit states (the example assumes the connection does not g

overn); full connection status: OK.

D.3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	160.0	160.0	+0.00		Pass
Tensile yielding (Manual Table 5-3)	kips	175.0	174.9	-0.09		Pass
U ≥ bf tf / Ag		0.706	0.706	+0.05		Pass
Case 4: U = [3l²/(3l² + w²)](1 − x̄/l)		0.860	0.860	+0.00		Pass
An = Ag (no holes)	in.²	5.840	5.840	+0.00		Pass
Ae = An U	in.²	5.020	5.023	+0.05		Pass
Pn = Fu Ae	kips	326.0	326.5	+0.14		Pass
Tensile rupture	kips	163.0	163.2	+0.14		Pass
L/rx		229.000	229.299	+0.13		Pass

ILX governing check: (Member tensile rupture (WT6X20)), ratio 0.980. ILX result: **OK**; published: **OK**.

Member limit states (the example ass

umesthecondoesnotgovern);fullconnectionstatus:OK.

D.4: Rectangular HSS tension member

Source: AISC Design Examples v16.0, Example D.4, pp. D-11 to D-13. Connection: Tension member end connection.

D.4 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	224.0	224.0	+0.00		Pass
Tensile yielding (Manual Table 5-4)	kips	278.0	278.1	+0.04		Pass
x̄ (half section beside the gusset)	in.	1.300	1.297	-0.23		Pass
U = 1 − x̄/l		0.919	0.919	-0.01		Pass
An = Ag − 2 (tp + 1/16) t	in.²	5.790	5.787	-0.05		Pass
Ae = An U	in.²	5.320	5.318	-0.03		Pass
Pn = Fu Ae	kips	330.0	329.7	-0.08		Pass
Tensile rupture	kips	248.0	247.3	-0.28		Pass
L/r		232.000	232.258	+0.11		Pass

ILX governing check: (Member tensile rupture (HSS6X4X3/8)), ratio 0.906. ILX result: **OK**; published: **OK**.

Member limit states (the example assumes the connection does not g

overn); full connection status: OK.

D.4 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	150.0	150.0	+0.00		Pass
Tensile yielding (Manual Table 5-4)	kips	185.0	185.0	+0.02		Pass
x̄ (half section beside the gusset)	in.	1.300	1.297	-0.23		Pass
U = 1 − x̄/l		0.919	0.919	-0.01		Pass
An = Ag − 2 (tp + 1/16) t	in.²	5.790	5.787	-0.05		Pass
Ae = An U	in.²	5.320	5.318	-0.03		Pass
Pn = Fu Ae	kips	330.0	329.7	-0.08		Pass
Tensile rupture	kips	165.0	164.9	-0.08		Pass
L/r		232.000	232.258	+0.11		Pass

ILX governing check: (Member tensile rupture (HSS6X4X3/8)), ratio 0.910. ILX result: **OK**; published: **OK**.

Member limit states (the example ass

umesthecondondoesnotgovern);fullconnectionstatus:OK.

D.5: Round HSS tension member

Source: AISC Design Examples v16.0, Example D.5, pp. D-14 to D-16. Connection: Tension member end connection.

D.5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	240.0	240.0	+0.00		Pass
Tensile yielding (Manual Table 5-6)	kips	364.0	364.1	+0.01		Pass
θ = π/2 − sin⁻¹(tp/D) (rad)		1.490	1.487	-0.18		Pass
x̄ = R sinθ/θ − tp/2	in.	1.760	1.760	-0.00		Pass
U = [1 + (x̄/l)^3.2]^−10		0.991	0.991	+0.05		Pass
An = Ag − 2 (tp + 1/16) t	in.²	7.570	7.567	-0.04		Pass
Ae = An U	in.²	7.500	7.502	+0.03		Pass
Pn = Fu Ae	kips	465.0	465.1	+0.03		Pass
Tensile rupture	kips	349.0	348.9	-0.04		Pass
L/r		184.000	183.673	-0.18		Pass

ILX governing check: (Member tensile rupture (HSS6.000X0.500)), ratio 0.688. ILX result: **OK**; published: **OK**.

Member limit states (the example assumes the connection does not

governing: full connection status: OK.

D.5 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	160.0	160.0	+0.00		Pass
Tensile yielding (Manual Table 5-6)	kips	242.0	242.2	+0.09		Pass
θ = π/2 − sin⁻¹(tp/D) (rad)		1.490	1.487	-0.18		Pass
x̄ = R sinθ/θ − tp/2	in.	1.760	1.760	-0.00		Pass
U = [1 + (x̄/l)^3.2]^−10		0.991	0.991	+0.05		Pass
An = Ag − 2 (tp + 1/16) t	in.²	7.570	7.567	-0.04		Pass
Ae = An U	in.²	7.500	7.502	+0.03		Pass
Pn = Fu Ae	kips	465.0	465.1	+0.03		Pass
Tensile rupture	kips	233.0	232.6	-0.18		Pass
L/r		184.000	183.673	-0.18		Pass

ILX governing check: (Member tensile rupture (HSS6.000X0.500)), ratio 0.688. ILX result: **OK**; published: **OK**.

Member limit states (the example a

s s u m e s t h e c o n n e c t i o n d o e s n o t g o v e r n) ; f u l l c o n n e c t i o n s t a t u s : O K .

D.6: Double-angle tension member

Source: AISC Design Examples v16.0, Example D.6, pp. D-17 to D-19. Connection: Tension member end connection.

D.6 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	240.0	240.0	+0.00		Pass
Tensile yielding (Manual Table 5-8)	kips	338.0	337.5	-0.15		Pass
U ≥ connected half		0.500	0.500	+0.00		Pass
Case 2: U = 1 − x̄/l (l = 21 in.)		0.944	0.944	-0.02		Pass
Case 8: U (8 bolts per line)		0.800	0.800	+0.00		Pass
An = Ag − 2 (dh + 1/16) t	in.²	6.630	6.625	-0.08		Pass
Ae = An U	in.²	6.260	6.253	-0.12		Pass
Pn = Fu Ae	kips	407.0	406.4	-0.14		Pass
Tensile rupture	kips	305.0	304.8	-0.06		Pass
L/rx		248.000	247.934	-0.03		Pass

ILX governing check: (Bolt shear, bearing and tearout (bolt group)), ratio 0.944. ILX result: **OK**; published: **OK**.

Member limit states (the example assumes the connection does not

governing); full connection status: OK.

D.6 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength	kips	160.0	160.0	+0.00		Pass
Tensile yielding (Manual Table 5-8)	kips	225.0	224.6	-0.20		Pass
U ≥ connected half		0.500	0.500	+0.00		Pass
Case 2: U = 1 − x̄/l (l = 21 in.)		0.944	0.944	-0.02		Pass
Case 8: U (8 bolts per line)		0.800	0.800	+0.00		Pass
An = Ag − 2 (dh + 1/16) t	in.²	6.630	6.625	-0.08		Pass
Ae = An U	in.²	6.260	6.253	-0.12		Pass
Pn = Fu Ae	kips	407.0	406.4	-0.14		Pass
Tensile rupture	kips	204.0	203.2	-0.39		Pass
L/rx		248.000	247.934	-0.03		Pass

ILX governing check: (Bolt shear, bearing and tearout (bolt group)), ratio 0.944. ILX result: **OK**; published: **OK**.

Member limit states (the example a

s s u m e s t h e c o n n e c t i o n d o e s n o t g o v e r n) ; f u l l c o n n e c t i o n s t a t u s : O K .

D.9: Plate with staggered bolts

Source: AISC Design Examples v16.0, Example D.9, pp. D-27 to D-28. Connection: Tension member end connection.

D.9 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Line A-B-E-F (lines 1-4)	in.	12.30	12.25	-0.41		Pass
Line A-B-C-D-E-F (lines 1-2-3-4)	in.	11.50	11.54	+0.36		Pass
Line A-B-C-D-G (lines 1-2-3)	in.	11.90	11.90	-0.04		Pass
Line A-B-D-E-F (lines 1-3-4)	in.	12.10	12.12	+0.16		Pass
Controlling net width AISC rounds w to 11.5 in.; ILX carries 11.54 in.	in.	11.50	11.54	+0.36		Pass
An = w t	in.²	5.750	5.771	+0.36		Pass
U (Case 1)		1.000	1.000	+0.00		Pass
Ae = An U	in.²	5.750	5.771	+0.36		Pass

ILX governing check: (Bolt shear, bearing and tearout (bolt group)), ratio 0.699. ILX result: **OK**; published: **OK**.

Member limit states (the example assumes the connection does not go

vern);fullconnectionstatus:OK.

D.9 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Line A-B-E-F (lines 1-4)	in.	12.30	12.25	-0.41		Pass
Line A-B-C-D-E-F (lines 1-2-3-4)	in.	11.50	11.54	+0.36		Pass
Line A-B-C-D-G (lines 1-2-3)	in.	11.90	11.90	-0.04		Pass
Line A-B-D-E-F (lines 1-3-4)	in.	12.10	12.12	+0.16		Pass
Controlling net width AISC rounds w to 11.5 in.; ILX carries 11.54 in.	in.	11.50	11.54	+0.36		Pass
An = w t	in.²	5.750	5.771	+0.36		Pass
U (Case 1)		1.000	1.000	+0.00		Pass
Ae = An U	in.²	5.750	5.771	+0.36		Pass

ILX governing check: (Bolt shear, bearing and tearout (bolt group)), ratio 1.048. ILX result: **OK**; published: **OK**.

Memberlimitstates(theexamplesassum

esthecondoesnotgovern);fullconnectionstatus:NG.

J.7 (girder web): Concentrated forces for beam bearing on girder

Source: AISC Design Examples v16.0, Example J.7, pp. J-24 to J-27. Connection: Column bearing on beam.

J.7 (girder web) · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (1.2D + 1.6L / D + L)	kips	66.00	66.00	+0.00		Pass
Length of bearing lb	in.	7.500	7.500	+0.00		Pass
Web local yielding Rn (Eq. J10-2)	kips	248.0	247.9	-0.06		Pass
Available web local yielding	kips	248.0	247.9	-0.06		Pass
Web local crippling Rn (Eq. J10-4)	kips	282.0	282.0	+0.01		Pass
Available web local crippling	kips	212.0	211.5	-0.22		Pass
Web sidesway buckling Rn (Eq. J10-6, Cr = 960,000 ksi) The Example rounds (h/tw)/(Lb/bf) to 1.59; ILX carries 1.595 (54.6 / (240 / 7.01)), +0.9 % on Rn (168.5 vs 167 kips).	kips	167.0	168.5	+0.87		Pass
Available web sidesway buckling The Example rounds (h/tw)/(Lb/bf) to 1.59; ILX carries 1.595 (54.6 / (240 / 7.01)), +0.9 % on Rn (168.5 vs 167 kips).	kips	142.0	143.2	+0.83		Pass

ILX governing check: (Beam web sidesway buckling (J10.4(a))), ratio 0.461. ILX result: **OK**; published: **OK**.

J.7 (girder web) · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Required strength (1.2D + 1.6L / D + L)	kips	45.00	45.00	+0.00		Pass
Length of bearing lb	in.	7.500	7.500	+0.00		Pass
Web local yielding Rn (Eq. J10-2)	kips	248.0	247.9	-0.06		Pass
Available web local yielding	kips	165.0	165.2	+0.15		Pass
Web local crippling Rn (Eq. J10-4)	kips	282.0	282.0	+0.01		Pass
Available web local crippling	kips	141.0	141.0	+0.01		Pass
Web sidesway buckling Rn (Eq. J10-6, Cr = 960,000 ksi) The Example rounds (h/tw)/(Lb/bf) to 1.59; ILX carries 1.595 (54.6 / (240 / 7.01)), +0.9 % on Rn (168.5 vs 167 kips).	kips	167.0	168.5	+0.87		Pass
Available web sidesway buckling The Example rounds (h/tw)/(Lb/bf) to 1.59; ILX carries 1.595 (54.6 / (240 / 7.01)), +0.9 % on Rn (168.5 vs 167 kips).	kips	94.90	95.71	+0.85		Pass

ILX governing check: (Beam web sidesway buckling (J10.4(a))), ratio 0.470. ILX result: **OK**; published: **OK**.

II.D-3 (V14.1): Hanger plate on a beam bottom flange: web local yielding

Source: AISC Design Examples V14.1, Example II.D-3, p. IID-22. Connection: Column bearing on beam.

II.D-3 (V14.1) · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Length of bearing lb = plate length	in.	6.000	6.000	+0.00		Pass
Web local yielding Rn (Eq. J10-2)	kips	122.0	121.7	-0.26		Pass
Available web local yielding	kips	122.0	121.7	-0.26		Pass

ILX governing check: (Beam flange local bending under uplift (J10.1)), ratio 2.689. ILX result: **NG**; published: **NG**.

II.D-3 (V14.1) · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Length of bearing lb = plate length	in.	6.000	6.000	+0.00		Pass
Web local yielding Rn (Eq. J10-2)	kips	122.0	121.7	-0.26		Pass
Available web local yielding	kips	81.30	81.12	-0.22		Pass

ILX governing check: (Beam flange local bending under uplift (J10.1)), ratio 2.694. ILX result: **NG**; published: **NG**.

F.14: Plate girder flange-to-web fillet welds (continuous)

Source: AISC Design Examples v16.0, Example F.14, pp. F-65 to F-74. Connection: Built-up member connectors.

F.14 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ix = Σ bh³/12 + Ad²	in.⁴	67,300	67,293	-0.01		Pass
Q = bf tf (h/2 + tf/2)	in.³	896.0	896.0	+0.00		Pass
Required shear flow V Q / Ix	kip/in.	3.740	3.741	+0.04		Pass
Minimum fillet, 1/2 in. web (Table J2.4)	in.	0.188	0.188	+0.00		Pass
Dreq = q / (1.392 or 0.928 × 2 sides), sixteenths		1.340	1.344	+0.29		Pass
Web shear rupture 0.60 Fu tw (Eq. J2-2)	kip/in.	14.60	14.62	+0.17		Pass

ILX governing check: (Fillet welds, top flange to web), ratio 0.448. ILX result: **OK**; published: **OK**.

Connector design of the built-up member (the member strength itself is th

esubjectoftherestoftheexample).

F.14 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ix = Σ bh³/12 + Ad²	in.⁴	67,300	67,293	-0.01		Pass
Q = bf tf (h/2 + tf/2)	in.³	896.0	896.0	+0.00		Pass
Required shear flow V Q / Ix	kip/in.	2.760	2.756	-0.14		Pass
Minimum fillet, 1/2 in. web (Table J2.4)	in.	0.188	0.188	+0.00		Pass
Dreq = q / (1.392 or 0.928 × 2 sides), sixteenths		1.490	1.485	-0.34		Pass
Web shear rupture 0.60 Fu tw (Eq. J2-2)	kip/in.	9.750	9.750	+0.00		Pass

ILX governing check: (Fillet welds, top flange to web), ratio 0.495. ILX result: **OK**; published: **OK**.

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F.14-int: Plate girder flange-to-web fillet welds (intermittent, 12 in. pitch)

Source: AISC Design Examples v16.0, Example F.14, pp. F-73 to F-74. Connection: Built-up member connectors.

F.14-int · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
lreq = q s / (1.392 or 0.928 D × 2 sides) at s = 12 in.	in.	5.370	5.375	+0.10		Pass
Segment ≥ 4 w (J2.2b(e))	in.	0.750	0.750	+0.00		Pass
Segment ≥ 1-1/2 in. (J2.2b(e))	in.	1.500	1.500	+0.00		Pass

ILX governing check: (Fillet welds, top flange to web), ratio 0.896. ILX result: **OK**; published: **OK**.

Connector design of the built-up member (the member strength itself is the subj

ectoftheresistoftheexample).

F.14-int · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
lreq = q s / (1.392 or 0.928 D × 2 sides) at s = 12 in.	in.	5.950	5.940	-0.17		Pass
Segment ≥ 4 w (J2.2b(e))	in.	0.750	0.750	+0.00		Pass
Segment ≥ 1-1/2 in. (J2.2b(e))	in.	1.500	1.500	+0.00		Pass

ILX governing check: (Fillet welds, top flange to web), ratio 0.990. ILX result: **OK**; published: **OK**.

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E.5: Double-angle strut: intermediate connectors

Source: AISC Design Examples v16.0, Example E.5, pp. E-36 to E-41. Connection: Built-up member connectors.

E.5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Lcx / rx		76.800	76.800	+0.00		Pass
ry of 2L4×3-1/2×3/8 LLBB (3/4 in. separation)	in.	1.690	1.689	-0.07		Pass
Lcy / ry		56.800	56.844	+0.08		Pass
a max = 3 rz (Lc/r)max / 4	in.	41.40	41.41	+0.03		Pass
a = L / 3 (two connectors)	in.	32.00	32.00	+0.00		Pass
a / ri		44.500	44.506	+0.01		Pass
(Lc/r)m, Eq. E6-2b, Ki = 0.50		61.000	61.045	+0.07		Pass

ILX governing check: (), ratio 0.000. ILX result: **OK**; published: **OK**.

Connector design of the built-up member (the member strength itself is

the subject of the rest of the example).

E.5 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Lcx / rx		76.800	76.800	+0.00		Pass
ry of 2L4×3-1/2×3/8 LLBB (3/4 in. separation)	in.	1.690	1.689	-0.07		Pass
Lcy / ry		56.800	56.844	+0.08		Pass
a max = 3 rz (Lc/r)max / 4	in.	41.40	41.41	+0.03		Pass
a = L / 3 (two connectors)	in.	32.00	32.00	+0.00		Pass
a / ri		44.500	44.506	+0.01		Pass
(Lc/r)m, Eq. E6-2b, Ki = 0.50		61.000	61.045	+0.07		Pass

ILX governing check: (), ratio 0.000. ILX result: **OK**; published: **OK**.

Connector design of the built-up member

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E.6: Double-angle strut with slender elements: intermediate connectors

Source: AISC Design Examples v16.0, Example E.6, pp. E-42 to E-48. Connection: Built-up member connectors.

E.6 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Lcx / rx		59.300	59.259	-0.07		Pass
ry of 2L5×3×1/4 LLBB (3/4 in. separation)	in.	1.330	1.332	+0.13		Pass
Lcy / ry		72.200	72.090	-0.15		Pass
a max = 3 rz (Lc/r)max / 4	in.	35.30	35.25	-0.14		Pass
a / ri		49.100	49.080	-0.04		Pass
(Lc/r)m, Eq. E6-2b, Ki = 0.50		76.300	76.152	-0.19		Pass

ILX governing check: (), ratio 0.000. ILX result: **OK**; published: **OK**.

Connector design of the built-up member (the member strength itself is th

esubjectofthereistoftheexample).

E.6 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Lcx / rx		59.300	59.259	-0.07		Pass
ry of 2L5×3×1/4 LLBB (3/4 in. separation)	in.	1.330	1.332	+0.13		Pass
Lcy / ry		72.200	72.090	-0.15		Pass
a max = 3 rz (Lc/r)max / 4	in.	35.30	35.25	-0.14		Pass
a / ri		49.100	49.080	-0.04		Pass
(Lc/r)m, Eq. E6-2b, Ki = 0.50		76.300	76.152	-0.19		Pass

ILX governing check: (), ratio 0.000. ILX result: **OK**; published: **OK**.

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E.13: Double-WT strut: intermediate connectors

Source: AISC Design Examples v16.0, Example E.13, pp. E-76 to E-80. Connection: Built-up member connectors.

E.13 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ix = 2 [Ix + A (ȳ + s/2)²]	in.⁴	165.0	165.5	+0.29		Pass
rx of the double WT	in.	3.740	3.751	+0.30		Pass
a max = 3/4 ry (Lcy/ry)	in.	81.00	81.00	+0.00		Pass
a (one connector at mid-length)	in.	54.00	54.00	+0.00		Pass
a / ri		42.500	42.520	+0.05		Pass
(Lc/r)o = Lcx / rx AISC divides by the rounded rx = 3.74 in. (Ix = 165 in.⁴, A = 11.8 in.²); ILX carries rx = 3.751 in.		28.900	28.792	-0.37		Pass
Ki a / ri, Ki = 0.86		36.600	36.567	-0.09		Pass
(Lc/r)m, Eq. E6-2b		46.600	46.541	-0.13		Pass

ILX governing check: (), ratio 0.000. ILX result: **OK**; published: **OK**.

Connector design of the built-up member (the member strength this is se

I f i s t h e s u b j e c t o f t h e r e s t o f t h e e x a m p l e) .

E.13 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Ix = 2 [Ix + A (ȳ + s/2)²]	in.⁴	165.0	165.5	+0.29		Pass
rx of the double WT	in.	3.740	3.751	+0.30		Pass
a max = 3/4 ry (Lcy/ry)	in.	81.00	81.00	+0.00		Pass
a (one connector at mid-length)	in.	54.00	54.00	+0.00		Pass
a / ri		42.500	42.520	+0.05		Pass
(Lc/r)o = Lcx / rx AISC divides by the rounded rx = 3.74 in. (Ix = 165 in.⁴, A = 11.8 in.²); ILX carries rx = 3.751 in.		28.900	28.792	-0.37		Pass
Ki a / ri, Ki = 0.86		36.600	36.567	-0.09		Pass
(Lc/r)m, Eq. E6-2b		46.600	46.541	-0.13		Pass

ILX governing check: (), ratio 0.000. ILX result: **OK**; published: **OK**.

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II.C-3a (V14.1): UFM general case, gusset to column web (α ≠ ᾱ)

Source: AISC Design Examples V14.1, Example II.C-3, Solution A, pp. IIC-43 to IIC-45. Connection: Vertical bracing gusset (UFM).

II.C-3a (V14.1) · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
eb = d / 2	in.	11.80	11.80	+0.00		Pass
ᾱ = 15¾ in. (given)	in.	15.75	15.75	+0.00		Pass
β = β̄ = 3 in. (given)	in.	3.000	3.000	+0.00		Pass
α = eb tan θ − ec + β tan θ (Eq. 13-1) Mub is not compared: AISC rounds α to 16.1 in. before Mub = Vub (α − ᾱ) = 105 (16.1 − 15.75) / 12 = 3.06 kip-ft (2.04 ASD); ILX carries α = 16.05 in. (α − ᾱ = 0.30 in.), Mb = 32.0 kip-in. (2.67 kip-ft), a small difference of two rounded lengths. The example calls the moment negligible.	in.	16.10	16.05	-0.28		Pass
r (Eq. 13-6)	in.	21.90	21.84	-0.30		Pass
Vc = β P / r (Eq. 13-2)	kips	26.70	26.79	+0.34		Pass
Hc = ec P / r (Eq. 13-3)	kips	0.000	0.000	+0.00		Pass
Vb = eb P / r (Eq. 13-4)	kips	105.0	105.4	+0.36		Pass
Hb = α P / r (Eq. 13-5)	kips	143.0	143.4	+0.26		Pass
Beam-to-column shear R + Vb	kips	149.0	149.4	+0.26		Pass
Beam-to-column axial A + Hc	kips	26.00	26.00	+0.00		Pass

ILX governing check: (Brace end: Member tensile rupture (HSS6X6X3/8)), ratio 0.709. ILX result: **OK**; published: **OK**.
The example publishes the UFM interface forces only; the overall status of the surrogate design is not compared.

II.C-3a (V14.1) · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
eb = d / 2	in.	11.80	11.80	+0.00		Pass
ᾱ = 15¾ in. (given)	in.	15.75	15.75	+0.00		Pass
β = β̄ = 3 in. (given)	in.	3.000	3.000	+0.00		Pass
α = eb tan θ − ec + β tan θ (Eq. 13-1) Mub is not compared: AISC rounds α to 16.1 in. before Mub = Vub (α − ᾱ) = 105 (16.1 − 15.75) / 12 = 3.06 kip-ft (2.04 ASD); ILX carries α = 16.05 in. (α − ᾱ = 0.30 in.), Mb = 32.0 kip-in. (2.67 kip-ft), a small difference of two rounded lengths. The example calls the moment negligible.	in.	16.10	16.05	-0.28		Pass
r (Eq. 13-6)	in.	21.90	21.84	-0.30		Pass
Vc = β P / r (Eq. 13-2)	kips	17.80	17.86	+0.34		Pass
Hc = ec P / r (Eq. 13-3)	kips	0.000	0.000	+0.00		Pass
Vb = eb P / r (Eq. 13-4)	kips	70.00	70.25	+0.36		Pass
Hb = α P / r (Eq. 13-5)	kips	95.60	95.58	-0.02		Pass
Beam-to-column shear R + Vb	kips	99.00	99.25	+0.26		Pass
Beam-to-column axial A + Hc	kips	17.00	17.00	+0.00		Pass

ILX governing check: (Brace end: Member tensile rupture (HSS6X6X3/8)), ratio 0.709. ILX result: **OK**; published: **OK**.
The example publishes the UFM interface forces only; the overall status of the surrogate design is not compared.

II.C-3b (V14.1): UFM special case 1 (w.p. at the gusset corner)

Source: AISC Design Examples V14.1, Example II.C-3, Solution B, pp. IIC-45 to IIC-46. Connection: Vertical bracing gusset (UFM).

II.C-3b (V14.1) · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
θ = tan⁻¹(12 / 10 1/8)	deg	49.8	49.8	+0.09		Pass
Hb = P sin θ (Eq. 13-9)	kips	149.0	149.0	+0.02		Pass
Vc = P cos θ (Eq. 13-7)	kips	126.0	125.7	-0.20		Pass
Hc = 0 (Eq. 13-10)	kips	0.000	0.000	+0.00		Pass
Vb = 0 (Eq. 13-8)	kips	0.000	0.000	+0.00		Pass
Beam moment Mb = Hb eb (Eq. 13-11) [kip-ft × 12]	kip-in.	1,764	1,759	-0.30		Pass
Beam-to-column shear R	kips	44.00	44.00	+0.00		Pass
Beam-to-column axial A	kips	26.00	26.00	+0.00		Pass

ILX governing check: (Brace end: Member tensile rupture (HSS6X6X3/8)), ratio 0.709. ILX result: **OK**; published: **OK**.
The example publishes the UFM interface forces only; the overall status of the surrogate design is not compared.

II.C-3b (V14.1) · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
θ = tan⁻¹(12 / 10 1/8)	deg	49.8	49.8	+0.09		Pass
Hb = P sin θ (Eq. 13-9)	kips	99.30	99.36	+0.06		Pass
Vc = P cos θ (Eq. 13-7)	kips	83.90	83.83	-0.08		Pass
Hc = 0 (Eq. 13-10)	kips	0.000	0.000	+0.00		Pass
Vb = 0 (Eq. 13-8)	kips	0.000	0.000	+0.00		Pass
Beam moment Mb = Hb eb (Eq. 13-11) [kip-ft × 12]	kip-in.	1,171	1,172	+0.10		Pass
Beam-to-column shear R	kips	29.00	29.00	+0.00		Pass
Beam-to-column axial A	kips	17.00	17.00	+0.00		Pass

ILX governing check: (Brace end: Member tensile rupture (HSS6X6X3/8)), ratio 0.709. ILX result: **OK**; published: **OK**.
The example publishes the UFM interface forces only; the overall status of the surrogate design is not compared.

II.C-3c (V14.1): UFM special case 2 (ΔVb = Vb to the column)

Source: AISC Design Examples V14.1, Example II.C-3, Solution C, pp. IIC-46 to IIC-48. Connection: Vertical bracing gusset (UFM).

II.C-3c (V14.1) · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
β = $\bar{\beta}$ (given)	in.	10.50	10.50	+0.00		Pass
α (Eq. 13-1)	in.	24.20	24.19	-0.04		Pass
r (Eq. 13-6)	in.	32.90	32.90	+0.00		Pass
ΔVb = Vb (general case, Eq. 13-4)	kips	69.90	69.94	+0.05		Pass
Vc + ΔVb	kips	132.0	132.2	+0.13		Pass
Hc	kips	0.000	0.000	+0.00		Pass
Hb (Eq. 13-5, unchanged)	kips	143.0	143.4	+0.26		Pass
Vb − ΔVb	kips	0.000	0.000	+0.00		Pass
Mb = ΔVb α (Eq. 13-13) [kip-ft × 12]	kip-in.	1,692	1,692	-0.01		Pass
Beam-to-column shear R + Vb − ΔVb	kips	44.00	44.00	+0.00		Pass
Beam-to-column axial A + Hc	kips	26.00	26.00	+0.00		Pass

ILX governing check: (Brace end: Member tensile rupture (HSS6X6X3/8)), ratio 0.709. ILX result: **OK**; published: **OK**.
The example publishes the UFM interface forces only; the overall status of the surrogate design is not compared.

II.C-3c (V14.1) · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
β = $\bar{\beta}$ (given)	in.	10.50	10.50	+0.00		Pass
α (Eq. 13-1)	in.	24.20	24.19	-0.04		Pass
r (Eq. 13-6)	in.	32.90	32.90	+0.00		Pass
ΔVb = Vb (general case, Eq. 13-4)	kips	46.60	46.63	+0.05		Pass
Vc + ΔVb	kips	88.10	88.11	+0.02		Pass
Hc	kips	0.000	0.000	+0.00		Pass
Hb (Eq. 13-5, unchanged)	kips	95.60	95.58	-0.02		Pass
Vb − ΔVb	kips	0.000	0.000	+0.00		Pass
Mb = ΔVb α (Eq. 13-13) [kip-ft × 12]	kip-in.	1,128	1,128	-0.01		Pass
Beam-to-column shear R + Vb − ΔVb	kips	29.00	29.00	+0.00		Pass
Beam-to-column axial A + Hc	kips	17.00	17.00	+0.00		Pass

ILX governing check: (Brace end: Member tensile rupture (HSS6X6X3/8)), ratio 0.709. ILX result: **OK**; published: **OK**.
The example publishes the UFM interface forces only; the overall status of the surrogate design is not compared.

II.C-3d (V14.1): UFM special case 3 (no gusset-to-column connection)

Source: AISC Design Examples V14.1, Example II.C-3, Solution D, pp. IIC-48 to IIC-49. Connection: Vertical bracing gusset (UFM).

II.C-3d (V14.1) · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
α = eb tan θ (β = 0)	in.	12.80	12.80	+0.00		Pass
r = √(α² + eb²)	in.	17.40	17.41	+0.05		Pass
Hb = α P / r (Eq. 13-5)	kips	143.0	143.4	+0.26		Pass
Vb = eb P / r (Eq. 13-4)	kips	132.0	132.2	+0.13		Pass
Mb = Vb (α − $\bar{\alpha}$) (Eq. 13-14) [kip-ft × 12] α − $\bar{\alpha}$ = −0.70 in. is a small difference of two rounded lengths: 2 % tolerance.	kip-in.	-92.40	-92.52	+0.13		Pass
Beam-to-column shear R + Vb	kips	176.0	176.2	+0.10		Pass
Beam-to-column axial A + Hc	kips	26.00	26.00	+0.00		Pass

ILX governing check: (Brace end: Member tensile rupture (HSS6X6X3/8)), ratio 0.709. ILX result: **OK**; published: **OK**.
The example publishes the UFM interface forces only; the overall status of the surrogate design is not compared.

II.C-3d (V14.1) · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
α = eb tan θ (β = 0)	in.	12.80	12.80	+0.00		Pass
r = √(α² + eb²)	in.	17.40	17.41	+0.05		Pass
Hb = α P / r (Eq. 13-5)	kips	95.60	95.58	-0.02		Pass
Vb = eb P / r (Eq. 13-4)	kips	88.20	88.11	-0.10		Pass
Mb = Vb (α − $\bar{\alpha}$) (Eq. 13-14) [kip-ft × 12] α − $\bar{\alpha}$ = −0.70 in. is a small difference of two rounded lengths: 2 % tolerance.	kip-in.	-61.80	-61.68	-0.19		Pass
Beam-to-column shear R + Vb	kips	117.0	117.1	+0.10		Pass
Beam-to-column axial A + Hc	kips	17.00	17.00	+0.00		Pass

ILX governing check: (Brace end: Member tensile rupture (HSS6X6X3/8)), ratio 0.709. ILX result: **OK**; published: **OK**.
The example publishes the UFM interface forces only; the overall status of the surrogate design is not compared.

II.C-2 (V14.1): Bracing connection: UFM forces, gusset-to-beam weld, beam web

Source: AISC Design Examples V14.1, Example II.C-2, pp. IIC-25 to IIC-40. Connection: Vertical bracing gusset (UFM).

II.C-2 (V14.1) · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
eb = d_beam / 2	in.	9.350	9.350	+0.00		Pass
ec = d_column / 2 The example rounds ec = 20.9 / 2 to 10.5 in. and tan θ = 12 / 9 9/16 = 1.255 to 1.25; ILX carries 10.45 in. and 1.255 (α 21.99 in., Hb +0.8 %).	in.	10.50	10.45	-0.48		Pass
$\bar{\alpha}$ = 42 / 2 + ½ setback	in.	21.50	21.50	+0.00		Pass
$\bar{\beta}$ = 33 / 2	in.	16.50	16.50	+0.00		Pass
α (Eq. 13-1) The example rounds ec = 20.9 / 2 to 10.5 in. and tan θ = 12 / 9 9/16 = 1.255 to 1.25; ILX carries 10.45 in. and 1.255 (α 21.99 in., Hb +0.8 %).	in.	21.80	21.99	+0.87		Pass
r (Eq. 13-6)	in.	41.40	41.48	+0.19		Pass
Hc = ec P / r	kips	171.0	170.1	-0.55		Pass
Vc = β P / r	kips	269.0	268.5	-0.18		Pass
Hb = α P / r The example rounds ec = 20.9 / 2 to 10.5 in. and tan θ = 12 / 9 9/16 = 1.255 to 1.25; ILX carries 10.45 in. and 1.255 (α 21.99 in., Hb +0.8 %).	kips	355.0	357.8	+0.80		Pass
Vb = eb P / r	kips	152.0	152.2	+0.10		Pass
Gusset normal stress at the beam Vb / (t l)	ksi	4.830	4.830	+0.01		Pass
Gusset shear stress at the beam Hb / (t l) The example rounds ec = 20.9 / 2 to 10.5 in. and tan θ = 12 / 9 9/16 = 1.255 to 1.25; ILX carries 10.45 in. and 1.255 (α 21.99 in., Hb +0.8 %).	ksi	11.30	11.36	+0.53		Pass
Weld load angle θ = tan⁻¹(Vb / Hb) The example takes θ from the rounded forces (152 / 355, ASD 102 / 237 kips): 1.5 % tolerance on the angle; the resulting μ = 1.12 agrees.	deg	23.2	23.0	-0.71		Pass
μ = 1.0 + 0.50 sin^1.5 θ		1.120	1.122	+0.21		Pass
Peak weld force per inch	kip/in.	4.610	4.629	+0.41		Pass
Design weld force max(peak, 1.25 average)	kip/in.	5.760	5.786	+0.46		Pass
Required fillet Dreq (sixteenths)		3.690	3.703	+0.36		Pass
Beam web local yielding φRn (Table 9-4, lb = 42 in.)	kips	1,340	1,338	-0.16		Pass
Beam web crippling φRn (Table 9-4, lb = 42 in.)	kips	853.0	1,381	+61.91		Deviation BG1
BG1 AISC sources disagree on beam web crippling at a web-connected beam end: V14.1 II.C-2 (p. IIC-35) uses the end equation J10-5b (x < d/2 from the beam end), φRn = 853 kips (ASD 570). ILX uses J10-4 because the beam web is connected to the column: AISC 360-22 Commentary J10.3 (p. 16.1-514) states that J10-5a/b are intended for beam ends whose web is not supported and that J10-4 should be used where the beam end connection is a web connection, and AISC Design Guide 29 does the same in Ex. 5.1, 5.4, 6.1a and 6.1b. ILX J10-4: 1,381 kips (ASD 921), +62 %. The V14.1 value is reproduced with beam_end = 'unsupported' (companion row).						
Beam web crippling φRn, unsupported beam end option (J10-5b, as V14.1) The V14.1 practice reproduced with beam_end = "unsupported" (Eq. J10-5b); see BG1.	kips	853.0	852.0	-0.11		Pass
Beam-to-column shear R + Vb	kips	167.0	167.2	+0.09		Pass
Beam-to-column axial A + (H − Hb) = A + Hc	kips	171.0	170.1	-0.55		Pass
Whitmore buckling KL/r (K = 0.5, l1 = 17 in.)		39.30	39.26	-0.10		Pass
Whitmore buckling Fcr (E3-2)	ksi	33.20	33.19	-0.02		Pass
Whitmore buckling φcPn (Aw = 26.4 in.²)	kips	788.0	788.7	+0.09		Pass

ILX governing check: (Gusset tensile yielding on the Whitmore section), ratio 0.965. ILX result: **OK**; published: **OK**.

II.C-2 (V14.1) · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
eb = d_beam / 2	in.	9.350	9.350	+0.00		Pass
ec = d_column / 2 The example rounds ec = 20.9 / 2 to 10.5 in. and tan θ = 12 / 9 9/16 = 1.255 to 1.25; ILX carries 10.45 in. and 1.255 (α 21.99 in., Hb +0.8 %).	in.	10.50	10.45	-0.48		Pass
$\bar{\alpha}$ = 42 / 2 + ½ setback	in.	21.50	21.50	+0.00		Pass
$\bar{\beta}$ = 33 / 2	in.	16.50	16.50	+0.00		Pass
α (Eq. 13-1) The example rounds ec = 20.9 / 2 to 10.5 in. and tan θ = 12 / 9 9/16 = 1.255 to 1.25; ILX carries 10.45 in. and 1.255 (α 21.99 in., Hb +0.8 %).	in.	21.80	21.99	+0.87		Pass
r (Eq. 13-6)	in.	41.40	41.48	+0.19		Pass
Hc = ec P / r	kips	114.0	113.4	-0.55		Pass
Vc = β P / r	kips	179.0	179.0	+0.00		Pass
Hb = α P / r The example rounds ec = 20.9 / 2 to 10.5 in. and tan θ = 12 / 9 9/16 = 1.255 to 1.25; ILX carries 10.45 in. and 1.255 (α 21.99 in., Hb +0.8 %).	kips	237.0	238.6	+0.66		Pass
Vb = eb P / r	kips	102.0	101.4	-0.55		Pass
Gusset normal stress at the beam Vb / (t l)	ksi	3.240	3.220	-0.61		Pass
Gusset shear stress at the beam Hb / (t l) The example rounds ec = 20.9 / 2 to 10.5 in. and tan θ = 12 / 9 9/16 = 1.255 to 1.25; ILX carries 10.45 in. and 1.255 (α 21.99 in., Hb +0.8 %).	ksi	7.520	7.573	+0.71		Pass
Weld load angle θ = tan⁻¹(Vb / Hb) The example takes θ from the rounded forces (152 / 355, ASD 102 / 237 kips): 1.5 % tolerance on the angle; the resulting μ = 1.12 agrees.	deg	23.3	23.0	-1.13		Pass
μ = 1.0 + 0.50 sin^1.5 θ		1.120	1.122	+0.21		Pass
Peak weld force per inch	kip/in.	3.070	3.086	+0.52		Pass
Design weld force max(peak, 1.25 average)	kip/in.	3.840	3.858	+0.46		Pass
Required fillet Dreq (sixteenths)		3.690	3.703	+0.36		Pass
Beam web local yielding φRn (Table 9-4, lb = 42 in.)	kips	893.0	891.9	-0.13		Pass
Beam web crippling φRn (Table 9-4, lb = 42 in.)	kips	570.0	920.7	+61.53		Deviation BG1
BG1 AISC sources disagree on beam web crippling at a web-connected beam end: V14.1 II.C-2 (p. IIC-35) uses the end equation J10-5b (x < d/2 from the beam end), φRn = 853 kips (ASD 570). ILX uses J10-4 because the beam web is connected to the column: AISC 360-22 Commentary J10.3 (p. 16.1-514) states that J10-5a/b are intended for beam ends whose web is not supported and that J10-4 should be used where the beam end connection is a web connection, and AISC Design Guide 29 does the same in Ex. 5.1, 5.4, 6.1a and 6.1b. ILX J10-4: 1,381 kips (ASD 921), +62 %. The V14.1 value is reproduced with beam_end = 'unsupported' (companion row).						
Beam web crippling φRn, unsupported beam end option (J10-5b, as V14.1) The V14.1 practice reproduced with beam_end = "unsupported" (Eq. J10-5b); see BG1.	kips	570.0	568.0	-0.35		Pass
Beam-to-column shear R + Vb	kips	112.0	111.4	-0.50		Pass
Beam-to-column axial A + (H − Hb) = A + Hc	kips	114.0	113.4	-0.55		Pass
Whitmore buckling KL/r (K = 0.5, l1 = 17 in.)		39.30	39.26	-0.10		Pass
Whitmore buckling Fcr (E3-2)	ksi	33.20	33.19	-0.02		Pass
Whitmore buckling φcPn (Aw = 26.4 in.²)	kips	525.0	524.7	-0.05		Pass

ILX governing check: (Gusset tensile yielding on the Whitmore section), ratio 0.967. ILX result: **OK**; published: **OK**.

DG29 5.1: Corner gusset to a column flange, UFM general case (2L8X6X1 bolted, W21X83 / W14X90)

Source: AISC Design Guide 29 (2014, errata 2023), Example 5.1, pp. 43 to 78. Connection: Vertical bracing gusset (UFM).

> Surrogate model: The end plate (7 rows of 2 ⅞ in. A325-X at 3 in., g = 5½ in., PL ⅝ × 10) is centred on 22.5 in. of the gusset edge ($\bar{\beta}$ = 12.0 in., as the example's bolt group); its edge distance is 2¼ in. (DG29 1¾ in. after the optional cut) and the 1 in. trial end plate thickness is kept as the setback.

DG29 5.1 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
eb = d_beam / 2	in.	10.70	10.70	+0.00		Pass
ec = d_col / 2	in.	7.000	7.000	+0.00		Pass
β = $\bar{\beta}$	in.	12.00	12.00	+0.00		Pass
α = (eb + β) tan θ − ec (Eq. 13-1)	in.	17.50	17.49	-0.08		Pass
r (Eq. 13-6)	in.	33.40	33.39	-0.03		Pass
Vc = β P / r	kips	302.0	301.9	-0.03		Pass
Hc = ec P / r	kips	176.0	176.1	+0.06		Pass
Vb = eb P / r	kips	269.0	269.2	+0.07		Pass
Hb = α P / r	kips	440.0	439.9	-0.02		Pass
Brace tensile yielding (D2-1)	kips	849.0	848.9	-0.01		Pass
Brace tensile rupture (D2-2, U = 0.908)	kips	879.0	877.2	-0.21		Pass
Brace block shear	kips	938.0	936.3	-0.18		Pass
Gusset block shear	kips	855.0	858.0	+0.35		Pass
Bolt group, 14 × ⅞ in. A325-X double shear (bearing / tearout per bolt)	kips	856.0	856.7	+0.08		Pass
Whitmore yielding (23.8 in., 4.70 in. into the beam web)	kips	968.0	880.6	-9.03		Deviation BG2
BG2 Whitmore section geometry: ILX places the brace end by the `gap` clearance and welds the gusset directly to the column with the given setback; DG29 places the brace by its own detailing (Ex. 5.1: end plate, 6.1a: 2t clearance and pull-off). The Whitmore width is the same (lw = w + 2 l tan 30°) but the part that falls outside the gusset or into the beam web differs: Ex. 5.1 counts 19.1 in. of gusset and 4.70 in. of beam web (Aw = 21.5 in.², φRn = 968 kips); ILX's brace end sits so that 4.47 in. enters the beam web and 2.05 in. falls in the column setback, Aw = 19.6 in.², φRn = 881 kips (−9 %, conservative).						
Whitmore buckling (K = 0.5, lb = 9.76 in., KL/r = 16.9 < 25: Fy Ag)	kips	941.0	880.6	-6.42		Deviation BG2
BG2 Whitmore section geometry: ILX places the brace end by the `gap` clearance and welds the gusset directly to the column with the given setback; DG29 places the brace by its own detailing (Ex. 5.1: end plate, 6.1a: 2t clearance and pull-off). The Whitmore width is the same (lw = w + 2 l tan 30°) but the part that falls outside the gusset or into the beam web differs: with KL/r < 25 both give Pn = Fy Aw; DG29 uses Ag = 20.9 in.² here (21.5 for yielding) and ILX Aw = 19.6 in.²: 881 kips (−6 %, conservative).						
Neal interaction at the gusset-to-beam edge		0.083	0.083	+0.57		Pass
Gusset-to-beam weld Dreq (sixteenths, max(f_peak, 1.25 f_avg))		6.200	6.181	-0.30		Pass
Beam web local yielding (J10-3)	kips	897.0	897.4	+0.04		Pass
Beam web crippling (J10-4, web-connected beam)	kips	766.0	765.9	-0.01		Pass
Beam-to-column shear R + Vb	kips	319.0	319.2	+0.06		Pass
Beam-to-column axial (Hc − HD + A)	kips	220.0	276.1	+25.50		Deviation BG3
BG3 beam-to-column axial force: ILX designs for |A| + Hc in every case (conservative); DG29 Ex. 5.1 adds the frame-action (distortional) force, Hc − HD + A = 176 − 55.9 + 100 = 220 kips (Tamboli 2010, DG29 Eqs. 4-12 to 4-16, research/44 G17/G18). ILX: 276 kips (+25 %).						
Beam-to-column end plate: bolts in tension + shear (A490-X, frv = V / 12), φrnt = φF′nt Ab BG10 resolved: the shear end-plate engine with V = R + Vb and the axial force; F′nt depends on the shear only (ILX V = 319 kips as DG29).	kips	30.40	30.47	+0.22		Pass
Beam-to-column end plate (¾ in.): available tension per bolt with prying, B Q The engine reports the group (12 bolts × B Q).	kips	20.40	20.27	-0.66		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-to-column: column flange prying, available tension per bolt (p = 3 in., ⅞ in. A490-X) DG29 (p. 76) checks the beam-to-column bolts with the gusset-to-column flange values: 18.0 < 18.3 kips, n.g. by the cut-column model; the demand differs (BG3).	kips	18.00	17.84	-0.91		Pass
Gusset-to-column end plate: bolt tension with shear, φrnt = φF′nt Ab (A325-X)	kips	24.20	24.23	+0.10		Pass
Gusset-to-column end plate: prying, available T (t = ⅝ in.)	kips	16.00	15.96	-0.27		Pass
Column flange prying at the end-plate bolts (cut-column model)	kips	18.00	17.84	-0.91		Pass

ILX governing check: (Beam-to-column end plate: beam web shear rupture along the weld length), ratio 1.309. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.1 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
eb = d_beam / 2	in.	10.70	10.70	+0.00		Pass
ec = d_col / 2	in.	7.000	7.000	+0.00		Pass
β = β̄	in.	12.00	12.00	+0.00		Pass
α = (eb + β) tan θ − ec (Eq. 13-1)	in.	17.50	17.49	-0.08		Pass
r (Eq. 13-6)	in.	33.40	33.39	-0.03		Pass
Vc = β P / r	kips	201.0	201.3	+0.13		Pass
Hc = ec P / r	kips	117.0	117.4	+0.35		Pass
Vb = eb P / r	kips	179.0	179.5	+0.26		Pass
Hb = α P / r	kips	293.0	293.3	+0.09		Pass
Brace tensile yielding (D2-1)	kips	565.0	564.8	-0.04		Pass
Brace tensile rupture (D2-2, U = 0.908)	kips	586.0	584.8	-0.21		Pass
Brace block shear	kips	625.0	624.2	-0.13		Pass
Gusset block shear	kips	570.0	572.0	+0.35		Pass
Bolt group, 14 × ⅞ in. A325-X double shear (bearing / tearout per bolt)	kips	571.0	571.1	+0.02		Pass
Whitmore yielding (23.8 in., 4.70 in. into the beam web)	kips	644.0	585.9	-9.02		Deviation BG2
BG2 Whitmore section geometry: ILX places the brace end by the `gap` clearance and welds the gusset directly to the column with the given setback; DG29 places the brace by its own detailing (Ex. 5.1: end plate, 6.1a: 2t clearance and pull-off). The Whitmore width is the same (lw = w + 2 l tan 30°) but the part that falls outside the gusset or into the beam web differs: Ex. 5.1 counts 19.1 in. of gusset and 4.70 in. of beam web (Aw = 21.5 in.², φRn = 968 kips); ILX's brace end sits so that 4.47 in. enters the beam web and 2.05 in. falls in the column setback, Aw = 19.6 in.², φRn = 881 kips (−9 %, conservative).						
Whitmore buckling (K = 0.5, lb = 9.76 in., KL/r = 16.9 < 25: Fy Ag)	kips	626.0	585.9	-6.41		Deviation BG2
BG2 Whitmore section geometry: ILX places the brace end by the `gap` clearance and welds the gusset directly to the column with the given setback; DG29 places the brace by its own detailing (Ex. 5.1: end plate, 6.1a: 2t clearance and pull-off). The Whitmore width is the same (lw = w + 2 l tan 30°) but the part that falls outside the gusset or into the beam web differs: with KL/r < 25 both give Pn = Fy Aw; DG29 uses Ag = 20.9 in.² here (21.5 for yielding) and ILX Aw = 19.6 in.²: 881 kips (−6 %, conservative).						
Neal interaction at the gusset-to-beam edge		0.083	0.084	+0.86		Pass
Gusset-to-beam weld Dreq (sixteenths, max(f_peak, 1.25 f_avg))		6.170	6.181	+0.19		Pass
Beam web local yielding (J10-3)	kips	598.0	598.3	+0.04		Pass
Beam web crippling (J10-4, web-connected beam)	kips	511.0	510.6	-0.08		Pass
Beam-to-column shear R + Vb	kips	212.0	212.8	+0.36		Pass
Beam-to-column axial (Hc − HD + A)	kips	146.0	184.1	+26.10		Deviation BG3
BG3 beam-to-column axial force: ILX designs for |A| + Hc in every case (conservative); DG29 Ex. 5.1 adds the frame-action (distortional) force, Hc − HD + A = 176 − 55.9 + 100 = 220 kips (Tamboli 2010, DG29 Eqs. 4-12 to 4-16, research/44 G17/G18). ILX: 276 kips (+25 %).						
Beam-to-column end plate: bolts in tension + shear (A490-X, frv = V / 12), φrnt = φF′nt Ab BG10 resolved: the shear end-plate engine with V = R + Vb and the axial force; F′nt depends on the shear only (ILX V = 319 kips as DG29).	kips	20.30	20.32	+0.08		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-to-column end plate (¾ in.): available tension per bolt with prying, B Q The engine reports the group (12 bolts × B Q).	kips	13.60	13.48	-0.85		Pass
Beam-to-column: column flange prying, available tension per bolt (p = 3 in., ⅞ in. A490-X) DG29 (p. 76) checks the beam-to-column bolts with the gusset-to-column flange values: 18.0 < 18.3 kips, n.g. by the cut-column model; the demand differs (BG3).	kips	12.00	11.87	-1.11		Pass
Gusset-to-column end plate: bolt tension with shear, φrnt = φF′nt Ab (A325-X)	kips	16.10	16.15	+0.31		Pass
Gusset-to-column end plate: prying, available T (t = ⅝ in.)	kips	10.60	10.62	+0.16		Pass
Column flange prying at the end-plate bolts (cut-column model)	kips	12.00	11.87	-1.11		Pass

ILX governing check: (Beam-to-column end plate: beam web shear rupture along the weld length), ratio 1.309. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.2: Example 5.1 with the work point at the gusset corner: Manual special case 1

Source: AISC Design Guide 29 (2014, errata 2023), Example 5.2, pp. 78 to 84. Connection: Vertical bracing gusset (UFM).

DG29 5.2 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Hb = P sin θ (Manual Eq. 13-9)	kips	616.0	616.0	+0.00		Pass
Vc = P cos θ (Manual Eq. 13-7)	kips	571.0	571.1	+0.02		Pass
Beam moment Mub = Hb eb (Manual special case 1)	kip-in.	6,590	6,591	+0.02		Pass
DG29 special case 1: e = eb sin θ − ec cos θ	in.	3.090	3.088	-0.08		Pass
DG29 special case 1: η = Zb / (Zb + 2 Zc) (Eq. 4-8)		0.384	0.384	+0.08		Pass
DG29 special case 1: M = P e (Eq. 4-7)	kip-in.	2,600	2,594	-0.24		Pass
DG29 special case 1: H′ = (1 − η) M / (β + eb) (Eq. 4-5)	kips	70.60	70.35	-0.36		Pass
DG29 special case 1: V′ = (M − H′ β) / α (Eq. 4-6)	kips	100.0	100.1	+0.05		Pass
DG29 special case 1: beam couple η M	kip-in.	998.0	996.8	-0.12		Pass
DG29 special case 1: column couple (1 − η) M / 2, above and below	kip-in.	801.0	798.4	-0.32		Pass
DG29 special case 1: gusset-to-column Hc + H′ (Fig. 5-5c/d)	kips	247.0	246.5	-0.22		Pass
DG29 special case 1: gusset-to-column Vc + V′	kips	402.0	401.9	-0.01		Pass
DG29 special case 1: gusset-to-beam Hb − H′	kips	369.0	369.6	+0.15		Pass
DG29 special case 1: gusset-to-beam Vb − V′	kips	169.0	169.1	+0.08		Pass
DG29 special case 1: beam-to-column shear R + Vb − V′	kips	219.0	219.1	+0.06		Pass

ILX governing check: (Geometry not feasible), ratio 0.000. ILX result: **NOT FEASIBLE**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.2 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Hb = P sin θ (Manual Eq. 13-9)	kips	410.0	410.7	+0.16		Pass
Vc = P cos θ (Manual Eq. 13-7)	kips	380.0	380.7	+0.19		Pass
Beam moment Mub = Hb eb (Manual special case 1)	kip-in.	4,390	4,394	+0.09		Pass
DG29 special case 1: e = eb sin θ − ec cos θ	in.	3.090	3.088	-0.08		Pass
DG29 special case 1: η = Zb / (Zb + 2 Zc) (Eq. 4-8)		0.384	0.384	+0.08		Pass
DG29 special case 1: M = P e (Eq. 4-7)	kip-in.	1,730	1,729	-0.05		Pass
DG29 special case 1: H′ = (1 − η) M / (β + eb) (Eq. 4-5)	kips	46.90	46.90	-0.01		Pass
DG29 special case 1: V′ = (M − H′ β) / α (Eq. 4-6)	kips	66.70	66.70	+0.00		Pass
DG29 special case 1: beam couple η M	kip-in.	668.0	664.5	-0.52		Pass
DG29 special case 1: column couple (1 − η) M / 2, above and below	kip-in.	534.0	532.3	-0.32		Pass
DG29 special case 1: gusset-to-column Hc + H′ (Fig. 5-5c/d)	kips	164.0	164.3	+0.18		Pass
DG29 special case 1: gusset-to-column Vc + V′	kips	268.0	268.0	-0.01		Pass
DG29 special case 1: gusset-to-beam Hb − H′	kips	246.0	246.4	+0.15		Pass
DG29 special case 1: gusset-to-beam Vb − V′	kips	112.0	112.8	+0.68		Pass
DG29 special case 1: beam-to-column shear R + Vb − V′	kips	145.0	146.1	+0.73		Pass

ILX governing check: (Geometry not feasible), ratio 0.000. ILX result: **NOT FEASIBLE**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.3: Example 5.1 with a W21X44 beam, UFM special case 2 (partial ΔVb)

Source: AISC Design Guide 29 (2014, errata 2023), Example 5.3, pp. 84 to 98. Connection: Vertical bracing gusset (UFM).

> Surrogate model: As Example 5.1, with the final ¾ in. end plate, A490-X bolts and the 7/16 in. fillets.

DG29 5.3 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Gusset-to-column shear Vc + ΔVb DG29 keeps the Ex. 5.1 UFM forces (eb = 10.7 in.) for the W21X44 (eb = 10.35 in.), p. 86; ILX uses the W21X44: 3 % tolerance on the UFM rows.	kips	404.0	408.6	+1.14		Pass
Gusset-to-beam normal Vb − ΔVb Vb − ΔVb is a difference (Vb 269 against ILX 263 with eb = 10.35 in.): 5 % tolerance.	kips	167.0	162.5	-2.72		Pass
Gusset-to-beam moment Mb = Vb (α − $\bar{\alpha}$) + ΔVb $\bar{\alpha}$ (Eq. 4-10; α = $\bar{\alpha}$)	kip-in.	1,790	1,785	-0.28		Pass
Equivalent normal force Ne = N + 4M/L (App. B)	kips	394.0	389.1	-1.24		Pass
Beam web local yielding (J10-3)	kips	593.0	592.8	-0.03		Pass
Beam web crippling (J10-4, web-connected beam)	kips	415.0	414.6	-0.09		Pass
Beam-to-column shear R + Vb − ΔVb (= beam φVn)	kips	217.0	212.5	-2.09		Pass
Gusset-to-column end plate: F′nt bolts (A490-X), φrnt frv from Vc + ΔVb: ILX 409 (W21X44, eb = 10.35 in.) against DG29 404 kips: 2 %.	kips	27.30	26.99	-1.15		Pass
Gusset-to-column end plate: prying, available T (t = ¾ in.) B from the row above (2 %); DG29 ASD uses B = 18.5 where it computed 18.3 (+1 %): 2.5 %.	kips	21.80	21.60	-0.91		Pass

ILX governing check: (Beam-to-column end plate: column flange bending with prying action (bolt tension)), ratio 1.563. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.3 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Gusset-to-column shear Vc + ΔVb DG29 keeps the Ex. 5.1 UFM forces (eb = 10.7 in.) for the W21X44 (eb = 10.35 in.), p. 86; ILX uses the W21X44: 3 % tolerance on the UFM rows.	kips	269.0	272.4	+1.27		Pass
Gusset-to-beam normal Vb − ΔVb Vb − ΔVb is a difference (Vb 269 against ILX 263 with eb = 10.35 in.): 5 % tolerance.	kips	111.0	108.3	-2.42		Pass
Gusset-to-beam moment Mb = Vb (α − $\bar{\alpha}$) + ΔVb $\bar{\alpha}$ (Eq. 4-10; α = $\bar{\alpha}$)	kip-in.	1,190	1,190	+0.00		Pass
Equivalent normal force Ne = N + 4M/L (App. B)	kips	262.0	259.4	-0.98		Pass
Beam web local yielding (J10-3)	kips	395.0	395.2	+0.05		Pass
Beam web crippling (J10-4, web-connected beam)	kips	276.0	276.4	+0.15		Pass
Beam-to-column shear R + Vb − ΔVb (= beam φVn)	kips	144.0	141.6	-1.66		Pass
Gusset-to-column end plate: F′nt bolts (A490-X), φrnt frv from Vc + ΔVb: ILX 409 (W21X44, eb = 10.35 in.) against DG29 404 kips: 2 %.	kips	18.30	17.99	-1.69		Pass
Gusset-to-column end plate: prying, available T (t = ¾ in.) B from the row above (2 %); DG29 ASD uses B = 18.5 where it computed 18.3 (+1 %): 2.5 %.	kips	14.70	14.39	-2.08		Pass

ILX governing check: (Beam-to-column end plate: column flange bending with prying action (bolt tension)), ratio 1.567. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.4: Gusset to the beam only at a column flange, UFM special case 3 (2L4X4X3/8, W18X35 / W12X58)

Source: AISC Design Guide 29 (2014, errata 2023), Example 5.4, pp. 98 to 118. Connection: Vertical bracing gusset (UFM).

DG29 5.4 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
α = eb tan θ − ec (β = 0)	in.	9.070	9.071	+0.02		Pass
$\bar{\alpha}$ = 22.0 / 2 + ½ in.	in.	11.50	11.50	+0.00		Pass
Hub = P sin θ Special case 3 at a column flange: before the DG29 fix ILX kept Hc = ec P / r and Hb = α P / r (51.6 kips, −40 %, unconservative); now Hb = P sin θ, Hc = 0 and Mbc = Vb ec (DG29 §4.2.4).	kips	86.30	86.38	+0.09		Pass
Vub = P cos θ	kips	50.50	50.39	-0.22		Pass
Hc = 0 (no gusset-to-column connection)	kips	0.000	0.000	+0.00		Pass
Mub = Vub ($\bar{\alpha}$ − α)	kip-in.	123.0	122.4	-0.51		Pass
Beam-to-column moment Mbc = Vub ec	kip-in.	308.0	307.4	-0.21		Pass
Beam-to-column shear Vub + R	kips	80.50	80.39	-0.14		Pass
Brace tensile yielding	kips	185.0	185.3	+0.18		Pass
Brace tensile rupture (U = 0.812)	kips	176.0	175.5	-0.30		Pass
Bolt group (both plies, ½ in. gusset trial)	kips	116.0	113.0	-2.62		Deviation BG16
BG16 DG29 Ex. 5.4 bolt group (p. 102, ½ in. gusset trial): DG29 adds the gusset end-bolt tearout 26.9, the inner bolt 48.7 (bolt shear, after comparing it with 1.2 lc t Fu = 53.8 only) and the brace end-bolt tearout 40.3 = 116 kips (ASD 77.3). The inner bolt's bearing on the ½ in. gusset is capped by 2.4 d t Fu = 0.75 × 60.9 = 45.7 kips < 48.7, which DG29 itself prints for the end bolt; ILX takes it: 26.9 + 45.7 + 40.3 = 113 kips (−2.6 %). The bolts are adequate either way (100 kips).						
Brace block shear DG29 rounds Rn = 166 kips (0.6 Fy Agv + Fu Ant = 122 + 43.5): 1.5 % tolerance.	kips	125.0	123.8	-1.00		Pass
Gusset block shear (single bolt line, ½ in. trial) BG17 resolved: one bolt line tears out down the line and across to the free edge (Ant = (5.00 − 0.5 × 1.0) × ½ = 2.25 in.²). The example's shaped gusset puts that edge 5.00 in. from the bolt line (Fig. 5-9); run with fe_brace = 5 in. (free edge parallel to the brace).	kips	159.0	158.6	-0.24		Pass
Whitmore yielding (6.93 in., ½ in. trial)	kips	112.0	112.2	+0.21		Pass
Whitmore buckling, t = 1/2 in. trial (K = 1.2, L = 6½ in.)	kips	96.50	90.03	-6.71		Deviation BG4
BG4 special case 3 buckling length: ILX uses DG29's K = 1.2 with the centre line l1 from the Whitmore section to the edge of its rectangular gusset; DG29 Ex. 5.4 (Fig. 5-10) shapes the gusset's free edge toward the brace and scales l1 = 6½ in. to that edge, with the first bolt 24 in. from the w.p. (ILX places the brace by `gap`). Ex. 5.4 L = 6½ in. (K = 1.2): 96.5 kips (n.g.); ILX l1 = 7.78 in.: 90.0 kips (−6.7 %, conservative; also n.g.).						
Whitmore buckling, t = 5/8 in. final (K = 1.2, L = 6½ in.)	kips	127.0	121.8	-4.07		Deviation BG4
BG4 special case 3 buckling length: ILX uses DG29's K = 1.2 with the centre line l1 from the Whitmore section to the edge of its rectangular gusset; DG29 Ex. 5.4 (Fig. 5-10) shapes the gusset's free edge toward the brace and scales l1 = 6½ in. to that edge, with the first bolt 24 in. from the w.p. (ILX places the brace by `gap`). Ex. 5.4 ⅝ in.: 127 kips; ILX 121.8 kips (−4.1 %, conservative).						
Gusset-to-beam weld Dreq (sixteenths)		1.650	1.648	-0.15		Pass
Equivalent normal force Ne = Vub + 4 Mub / L	kips	72.90	72.64	-0.36		Pass
Beam web local yielding (J10-3)	kips	361.0	361.0	+0.00		Pass
Beam web crippling (J10-4, web-connected beam)	kips	249.0	248.5	-0.18		Pass
Beam-to-column: equivalent axial N = 4 Mbc / L (L = 14½ in.)	kips	85.00	84.79	-0.25		Pass
Beam-to-column angles: available bolt tension with prying T = B Q (F′nt 87.2 ksi) BG10 resolved: double_angle engine (Welds A / bolted OSL) with V = 80.5 and P = N = 85.0 kips.	kips	13.30	13.40	+0.74		Pass
Beam-to-column: column flange prying, T = B Q	kips	14.30	14.22	-0.55		Pass
Beam-to-column angles: C-shaped weld Dreq (sixteenths) ILX's IC method takes kl = 4 − ½ setback − ¼ underrun = 3.25 in. at the actual load angle 46.6°; DG29 reads Manual Table 8-8 at 45° with kl = 3.5 in.: 1.85 against 1.81 (+2.0 %, conservative).		1.810	1.847	+2.03		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-to-column angles: shear yielding (2 × 14½ × ⅝)	kips	392.0	391.5	-0.13		Pass
Beam-to-column angles: shear rupture through the bolts	kips	310.0	309.9	-0.02		Pass

ILX governing check: (Gusset compression buckling on the Whitmore section), ratio 0.821. ILX result: **OK**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.4 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
α = eb tan θ − ec (β = 0)	in.	9.070	9.071	+0.02		Pass
$\bar{\alpha}$ = 22.0 / 2 + ½ in.	in.	11.50	11.50	+0.00		Pass
Hub = P sin θ Special case 3 at a column flange: before the DG29 fix ILX kept Hc = ec P / r and Hb = α P / r (51.6 kips, −40 %, unconservative); now Hb = P sin θ, Hc = 0 and Mbc = Vb ec (DG29 §4.2.4).	kips	57.60	57.61	+0.02		Pass
Vub = P cos θ	kips	33.70	33.61	-0.27		Pass
Hc = 0 (no gusset-to-column connection)	kips	0.000	0.000	+0.00		Pass
Mub = Vub ($\bar{\alpha}$ − α)	kip-in.	81.90	81.62	-0.34		Pass
Beam-to-column moment Mbc = Vub ec	kip-in.	206.0	205.0	-0.48		Pass
Beam-to-column shear Vub + R	kips	53.70	53.61	-0.17		Pass
Brace tensile yielding	kips	123.0	123.3	+0.25		Pass
Brace tensile rupture (U = 0.812)	kips	117.0	117.0	-0.01		Pass
Bolt group (both plies, ½ in. gusset trial)	kips	77.30	75.31	-2.58		Deviation BG16
BG16 DG29 Ex. 5.4 bolt group (p. 102, ½ in. gusset trial): DG29 adds the gusset end-bolt tearout 26.9, the inner bolt 48.7 (bolt shear, after comparing it with 1.2 lc t Fu = 53.8 only) and the brace end-bolt tearout 40.3 = 116 kips (ASD 77.3). The inner bolt's bearing on the ½ in. gusset is capped by 2.4 d t Fu = 0.75 × 60.9 = 45.7 kips < 48.7, which DG29 itself prints for the end bolt; ILX takes it: 26.9 + 45.7 + 40.3 = 113 kips (−2.6 %). The bolts are adequate either way (100 kips).						
Brace block shear DG29 rounds Rn = 166 kips (0.6 Fy Agv + Fu Ant = 122 + 43.5): 1.5 % tolerance.	kips	83.00	82.50	-0.60		Pass
Gusset block shear (single bolt line, ½ in. trial) BG17 resolved: one bolt line tears out down the line and across to the free edge (Ant = (5.00 − 0.5 × 1.0) × ½ = 2.25 in.²). The example's shaped gusset puts that edge 5.00 in. from the bolt line (Fig. 5-9); run with fe_brace = 5 in. (free edge parallel to the brace).	kips	106.0	105.8	-0.24		Pass
Whitmore yielding (6.93 in., ½ in. trial)	kips	74.80	74.68	-0.17		Pass
Whitmore buckling, t = 1/2 in. trial (K = 1.2, L = 6½ in.)	kips	64.20	59.90	-6.70		Deviation BG4
BG4 special case 3 buckling length: ILX uses DG29's K = 1.2 with the centre line l1 from the Whitmore section to the edge of its rectangular gusset; DG29 Ex. 5.4 (Fig. 5-10) shapes the gusset's free edge toward the brace and scales l1 = 6½ in. to that edge, with the first bolt 24 in. from the w.p. (ILX places the brace by `gap`). Ex. 5.4 L = 6½ in. (K = 1.2): 96.5 kips (n.g.); ILX l1 = 7.78 in.: 90.0 kips (−6.7 %, conservative; also n.g.).						
Whitmore buckling, t = 5/8 in. final (K = 1.2, L = 6½ in.)	kips	84.90	81.06	-4.53		Deviation BG4
BG4 special case 3 buckling length: ILX uses DG29's K = 1.2 with the centre line l1 from the Whitmore section to the edge of its rectangular gusset; DG29 Ex. 5.4 (Fig. 5-10) shapes the gusset's free edge toward the brace and scales l1 = 6½ in. to that edge, with the first bolt 24 in. from the w.p. (ILX places the brace by `gap`). Ex. 5.4 ⅝ in.: 127 kips; ILX 121.8 kips (−4.1 %, conservative).						
Gusset-to-beam weld Dreq (sixteenths)		1.650	1.648	-0.10		Pass
Equivalent normal force Ne = Vub + 4 Mub / L	kips	48.60	48.45	-0.31		Pass
Beam web local yielding (J10-3)	kips	241.0	240.7	-0.13		Pass
Beam web crippling (J10-4, web-connected beam)	kips	166.0	165.7	-0.18		Pass
Beam-to-column: equivalent axial N = 4 Mbc / L (L = 14½ in.)	kips	56.80	56.55	-0.43		Pass
Beam-to-column angles: available bolt tension with prying T = B Q (F′nt 87.2 ksi) BG10 resolved: double_angle engine (Welds A / bolted OSL) with V = 80.5 and P = N = 85.0 kips.	kips	8.880	8.915	+0.39		Pass
Beam-to-column: column flange prying, T = B Q	kips	9.510	9.462	-0.51		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Beam-to-column angles: C-shaped weld Dreq (sixteenths) ILX's IC method takes kl = 4 − ½ setback − ¼ underrun = 3.25 in. at the actual load angle 46.6°; DG29 reads Manual Table 8-8 at 45° with kl = 3.5 in.: 1.85 against 1.81 (+2.0 %, conservative).		1.810	1.847	+2.07		Pass
Beam-to-column angles: shear yielding (2 × 14½ × ⅝)	kips	261.0	261.0	-0.00		Pass
Beam-to-column angles: shear rupture through the bolts	kips	207.0	206.6	-0.18		Pass

ILX governing check: (Gusset compression buckling on the Whitmore section), ratio 0.823. ILX result: **OK**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.5: Corner gusset to a column web, UFM general case (W18X97 / W14X233 web)

Source: AISC Design Guide 29 (2014, errata 2023), Example 5.5, pp. 118 to 147. Connection: Vertical bracing gusset (UFM).

> Surrogate model: The W12X58 brace and its WT5X16.5 web splices are modelled (BG12 resolved); the brace end sits ½ in. clear of the beam and column (gap). The gusset is welded to the column web over 5.72 in. so that $\bar{\beta} = \beta = 2.86$ in. (DG29 takes $\alpha = \bar{\alpha}$ and β from Eq. 13-1; at a column web Hc = 0, so the location of the gusset-to-column connection does not change the forces).

DG29 5.5 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
ec = 0 (column web)	in.	0.000	0.000	+0.00		Pass
$\alpha = \bar{\alpha}$ = 31½ / 2 + ½	in.	16.20	16.21	+0.08		Pass
β (Eq. 13-1)	in.	2.860	2.860	-0.00		Pass
r (Eq. 13-6)	in.	20.30	20.27	-0.16		Pass
Hub = α P / r	kips	215.0	216.0	+0.47		Pass
Vub = eb P / r	kips	124.0	123.9	-0.08		Pass
Vuc = β P / r	kips	38.00	38.10	+0.27		Pass
Gusset-to-beam weld Dreq (sixteenths, 1.25 R)		3.000	3.019	+0.64		Pass
Beam web local yielding (J10-3)	kips	928.0	927.6	-0.05		Pass
Beam web crippling (J10-4, web-connected beam)	kips	910.0	909.8	-0.02		Pass
Beam-to-column shear Vub + R	kips	184.0	183.9	-0.06		Pass
Beam-to-column axial (transfer force)	kips	37.50	37.50	+0.00		Pass
Brace tensile yielding (W12X58)	kips	765.0	765.0	+0.00		Pass
Brace tensile rupture (web connected, U = 1 − 1.93/4.5 = 0.893) An = 17.0 − 2 (0.360)(1⅛ + 1/16) = 16.1 in.² with the 360-22 hole (DG29 16.2): −0.6 %.	kips	707.0	702.5	-0.63		Pass
Brace web block shear (two lines, 4½ in. pitch)	kips	373.0	365.0	-2.13		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = 14.0 − 9 (1⅛ + 1/16) (0.360) = 10.2 in.² (DG29 10.4), Ant 1.37 (1.40): 365 kips, −2.2 %.						
Brace-side bolts: bearing / tearout on the web (2 × 20.4 + 8 × 42.1) End-bolt lc = 1½ − 9/16 = 0.938 in. (DG29 0.969): 376 kips, −0.4 %.	kips	378.0	376.4	-0.41		Pass
WT splices: tensile yielding (2 × 4.85 in.²)	kips	437.0	436.5	-0.11		Pass
WT splices: tensile rupture (U = 1 − 0.869/12 = 0.928)	kips	350.0	345.2	-1.37		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: An = 9.70 − 4 (0.435)(1⅛ + 1/16) = 7.63 in.² (DG29 7.74): 345 kips, −1.4 %.						
WT splice block shear (errata 2023: Ubs = 1, Ant = 0.80 in.², 2 × 0.75 × 337)	kips	506.0	490.3	-3.11		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: per tee Anv = 11.7 − 9 (1⅛ + 1/16)(0.435) = 7.10 in.² (DG29 7.30), Ant = 2 (1.48 − ½ × 1 3/16)(0.435) = 0.77 in.² (0.80): 2 × 0.75 × 327 = 490 kips, −3.2 % (BG12 resolved: computed now).						
Gusset-side bolts: bearing / tearout on the ½ in. gusset (2 × 25.3 + 8 × 50.6)	kips	455.0	440.4	-3.20		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: lc = 0.938 / 1.875 in. (DG29 0.969 / 1.94): 2 × 24.5 + 8 × 48.9 = 440 kips, −3.3 %.						
Gusset block shear (two lines, 3 in. pitch)	kips	304.0	295.8	-2.70		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = 13.5 − 9 (1⅛ + 1/16) (½) = 8.16 in.² (DG29 8.44), Ant 1.91 (1.94): 296 kips, −2.6 %.						
Whitmore yielding (18.9 in., the whole width at tg and the gusset's Fy) BG12 resolved. DG29 (p. 123): the section enters the beam web, tw = 0.535 > tg, and 'for simplicity' takes the whole 18.9 in. at ½ in. and 36 ksi; run with whitmore_full. ILX's default counts the 3.6 in. in the beam web at the web's 50 ksi (as DG29 does in Ex. 6.1b): 328 kips.	kips	306.0	305.5	-0.17		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Gusset-to-column angles: bolt group (6 × 1 in. A325-N, tearout at the top bolts) ILX's 1⅛ in. hole (360-22) gives lc = 0.688 in. at the top bolts (DG29 0.719): 149.7 (−0.9 %).	kips	151.0	149.7	-0.86		Pass
Gusset-to-column angles: shear yielding (2L4X4X5/16 × 12½)	kips	169.0	169.0	+0.01		Pass
Gusset-to-column angles: shear rupture	kips	149.0	146.0	-2.00		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = [12½ − 3 (1⅛ + 1/16)] × 5/16 × 2 = 5.59 in.² (DG29 5.70): 146 kips (ASD 97.4), −2 %.						
Gusset-to-column angles: block shear (short slots, out to the toe)	kips	137.0	136.2	-0.57		Pass
Column web yield line ('oil can', Tamboli) under the beam angles BG10 resolved: bracing_beam_column.oil_can (h = 11.4, g = 5½, l = 12 in., φ 0.90).	kips	307.0	306.1	-0.30		Pass

ILX governing check: (Gusset compression buckling on the Whitmore section), ratio 0.918. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.5 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
ec = 0 (column web)	in.	0.000	0.000	+0.00		Pass
α = $\bar{\alpha}$ = 31½ / 2 + ½	in.	16.20	16.21	+0.08		Pass
β (Eq. 13-1)	in.	2.860	2.860	-0.00		Pass
r (Eq. 13-6)	in.	20.30	20.27	-0.16		Pass
Hub = α P / r	kips	144.0	144.0	+0.00		Pass
Vub = eb P / r	kips	82.50	82.60	+0.12		Pass
Vuc = β P / r	kips	25.40	25.40	+0.01		Pass
Gusset-to-beam weld Dreq (sixteenths, 1.25 R)		3.020	3.019	-0.02		Pass
Beam web local yielding (J10-3)	kips	618.0	618.4	+0.06		Pass
Beam web crippling (J10-4, web-connected beam)	kips	607.0	606.5	-0.08		Pass
Beam-to-column shear Vub + R	kips	123.0	122.6	-0.33		Pass
Beam-to-column axial (transfer force)	kips	25.00	25.00	+0.00		Pass
Brace tensile yielding (W12X58)	kips	509.0	509.0	-0.00		Pass
Brace tensile rupture (web connected, U = 1 − 1.93/4.5 = 0.893) An = 17.0 − 2 (0.360)(1⅛ + 1/16) = 16.1 in.² with the 360-22 hole (DG29 16.2): −0.6 %.	kips	471.0	468.3	-0.56		Pass
Brace web block shear (two lines, 4½ in. pitch)	kips	249.0	243.4	-2.27		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = 14.0 − 9 (1⅛ + 1/16) (0.360) = 10.2 in.² (DG29 10.4), Ant 1.37 (1.40): 365 kips, −2.2 %.						
Brace-side bolts: bearing / tearout on the web (2 × 20.4 + 8 × 42.1) End-bolt lc = 1½ − 9/16 = 0.938 in. (DG29 0.969): 376 kips, −0.4 %.	kips	252.0	251.0	-0.41		Pass
WT splices: tensile yielding (2 × 4.85 in.²)	kips	290.0	290.4	+0.14		Pass
WT splices: tensile rupture (U = 1 − 0.869/12 = 0.928)	kips	233.0	230.1	-1.23		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: An = 9.70 − 4 (0.435)(1⅛ + 1/16) = 7.63 in.² (DG29 7.74): 345 kips, −1.4 %.						
WT splice block shear (errata 2023: Ubs = 1, Ant = 0.80 in.², 2 × 0.75 × 337)	kips	337.0	326.9	-3.01		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: per tee Anv = 11.7 − 9 (1⅛ + 1/16)(0.435) = 7.10 in.² (DG29 7.30), Ant = 2 (1.48 − ½ × 1 3/16)(0.435) = 0.77 in.² (0.80): 2 × 0.75 × 327 = 490 kips, −3.2 % (BG12 resolved: computed now).						
Gusset-side bolts: bearing / tearout on the ½ in. gusset (2 × 25.3 + 8 × 50.6)	kips	304.0	293.6	-3.41		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: lc = 0.938 / 1.875 in. (DG29 0.969 / 1.94): 2 × 24.5 + 8 × 48.9 = 440 kips, −3.3 %.						
Gusset block shear (two lines, 3 in. pitch)	kips	203.0	197.2	-2.86		Deviation BG5

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = 13.5 − 9 (1⅛ + ¹⁄₁₆) (½) = 8.16 in.² (DG29 8.44), Ant 1.91 (1.94): 296 kips, −2.6 %.						
Whitmore yielding (18.9 in., the whole width at tg and the gusset's Fy) BG12 resolved. DG29 (p. 123): the section enters the beam web, tw = 0.535 > tg, and 'for simplicity' takes the whole 18.9 in. at ½ in. and 36 ksi; run with whitmore_full. ILX's default counts the 3.6 in. in the beam web at the web's 50 ksi (as DG29 does in Ex. 6.1b): 328 kips.	kips	204.0	203.2	-0.37		Pass
Gusset-to-column angles: bolt group (6 × 1 in. A325-N, tearout at the top bolts) ILX's 1⅛ in. hole (360-22) gives lc = 0.688 in. at the top bolts (DG29 0.719): 149.7 (−0.9 %).	kips	100.0	99.80	-0.20		Pass
Gusset-to-column angles: shear yielding (2L4X4X5/16 × 12½)	kips	113.0	112.7	-0.28		Pass
Gusset-to-column angles: shear rupture	kips	99.20	97.35	-1.86		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = [12½ − 3 (1⅛ + 1/16)] × 5/16 × 2 = 5.59 in.² (DG29 5.70): 146 kips (ASD 97.4), −2 %.						
Gusset-to-column angles: block shear (short slots, out to the toe)	kips	91.00	90.81	-0.21		Pass
Column web yield line ('oil can', Tamboli) under the beam angles BG10 resolved: bracing_beam_column.oil_can (h = 11.4, g = 5½, l = 12 in., φ 0.90).	kips	204.0	203.6	-0.17		Pass

ILX governing check: (Gusset compression buckling on the Whitmore section), ratio 0.920. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.7: Example 5.5 with a W18X35 beam, UFM special case 2 (ΔVb = 48 kips)

Source: AISC Design Guide 29 (2014, errata 2023), Example 5.7, pp. 163 to 178. Connection: Vertical bracing gusset (UFM).

> Surrogate model: The W12X58 brace and its WT5X16.5 web splices are modelled (BG12 resolved); the brace end sits ½ in. clear of the beam and column (gap). The gusset is welded to the column web over 6.82 in. so that $\bar{\beta}$ = β = 3.41 in. (DG29 takes α = $\bar{\alpha}$ and β from Eq. 13-1; at a column web Hc = 0, so the location of the gusset-to-column connection does not change the forces).

DG29 5.7 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
β (Eq. 13-1; errata 2023: 3.41 in.)	in.	3.410	3.410	+0.00		Pass
α = $\bar{\alpha}$	in.	16.30	16.35	+0.29		Pass
r (Eq. 13-6)	in.	20.40	20.43	+0.16		Pass
Hub = α P / r	kips	215.0	216.0	+0.47		Pass
ΔVb = Vub + R − φVn(beam)	kips	48.00	48.00	+0.00		Pass
Gusset-to-beam normal Vub − ΔVb	kips	69.00	68.94	-0.09		Pass
Gusset-to-column shear Vuc + ΔVb	kips	93.00	93.06	+0.06		Pass
Mb = Vb (α − $\bar{\alpha}$) + ΔVb $\bar{\alpha}$ (DG29 Eq. 4-10)	kip-in.	782.0	780.0	-0.26		Pass
Equivalent normal force Ne = V + 4M/L	kips	168.0	168.0	-0.01		Pass
Gusset-to-beam weld Dreq (Hewitt-Thornton, App. B)		2.810	2.945	+4.80		Deviation BG18
BG18 interface weld with a moment: ILX (gusset_core.interface_weld) takes the moment stress on the weld as the elastic fb = 6M / (n L²) under max(f_peak, 1.25 f_avg); DG29 App. B (Hewitt-Thornton) uses the equivalent normal N ± 4M/L: Ex. 5.7 Dreq = 2.81 (ASD 2.83). ILX 2.94 (+4.8 %, conservative; DG29's own alternatives give 3.13 and 3.18).						
Beam web local yielding (J10-3)	kips	504.0	503.5	-0.10		Pass
Beam web crippling (J10-4, web-connected beam)	kips	322.0	322.5	+0.14		Pass
Beam-to-column shear R + Vub − ΔVb	kips	159.0	158.9	-0.04		Pass
Gusset-to-column angles: bolt group As Ex. 5.5 (the same angles): 149.7 (−0.9 %, 1⅛ in. hole).	kips	151.0	149.7	-0.86		Pass

ILX governing check: (Gusset at the column: moment, normal and shear combined (Neal)), ratio 2.548. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.7 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
β (Eq. 13-1; errata 2023: 3.41 in.)	in.	3.410	3.410	+0.00		Pass
α = $\bar{\alpha}$	in.	16.30	16.35	+0.29		Pass
r (Eq. 13-6)	in.	20.40	20.43	+0.16		Pass
Hub = α P / r	kips	144.0	144.0	+0.00		Pass
ΔVb = Vub + R − φVn(beam)	kips	32.10	32.10	+0.00		Pass
Gusset-to-beam normal Vub − ΔVb	kips	46.00	45.86	-0.30		Pass
Gusset-to-column shear Vuc + ΔVb	kips	62.20	62.14	-0.10		Pass
Mb = Vb (α − $\bar{\alpha}$) + ΔVb $\bar{\alpha}$ (DG29 Eq. 4-10)	kip-in.	523.0	521.6	-0.26		Pass
Equivalent normal force Ne = V + 4M/L	kips	112.0	112.1	+0.09		Pass
Gusset-to-beam weld Dreq (Hewitt-Thornton, App. B)		2.830	2.947	+4.12		Deviation BG18
BG18 interface weld with a moment: ILX (gusset_core.interface_weld) takes the moment stress on the weld as the elastic fb = 6M / (n L²) under max(f_peak, 1.25 f_avg); DG29 App. B (Hewitt-Thornton) uses the equivalent normal N ± 4M/L: Ex. 5.7 Dreq = 2.81 (ASD 2.83). ILX 2.94 (+4.8 %, conservative; DG29's own alternatives give 3.13 and 3.18).						
Beam web local yielding (J10-3)	kips	336.0	335.7	-0.10		Pass
Beam web crippling (J10-4, web-connected beam)	kips	215.0	215.0	-0.01		Pass
Beam-to-column shear R + Vub − ΔVb	kips	106.0	105.9	-0.13		Pass
Gusset-to-column angles: bolt group As Ex. 5.5 (the same angles): 149.7 (−0.9 %, 1⅛ in. hole).	kips	100.0	99.80	-0.20		Pass

ILX governing check: (Gusset at the column: moment, normal and shear combined (Neal)), ratio 2.564. ILX result: **NG**; published: **OK**.

The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.8: Gusset to the beam only at a column web, UFM special case 3 (flat-bar gusset)

Source: AISC Design Guide 29 (2014, errata 2023), Example 5.8, pp. 178 to 189. Connection: Vertical bracing gusset (UFM).

DG29 5.8 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
α = eb tan θ = ᾱ(β = 0, ec = 0)	in.	15.20	15.17	-0.19		Pass
Hub = P sin θ	kips	86.30	86.38	+0.09		Pass
Vub = P cos θ	kips	50.50	50.39	-0.22		Pass
Beam-to-column shear Vub + R	kips	80.50	80.39	-0.14		Pass
Whitmore yielding (6.93 in. × ⅝ in.)	kips	140.0	140.3	+0.21		Pass
Gusset shear yielding along the flange (lg = 15.9 in.)	kips	215.0	214.3	-0.31		Pass
Gusset tensile yielding along the flange	kips	322.0	321.5	-0.15		Pass
Gusset-to-beam weld Dreq (Table 8-4, no 1.25 factor)		1.920	2.334	+21.57		Deviation BG6
BG6 interface weld: ILX applies the Manual Part 13 1.25 ductility factor to every gusset interface weld; DG29 omits it for a uniform, statically determinate force (Ex. 5.8, p. 183) and checks that weld with Manual Table 8-4 (C = 4.37 at 30°). ILX Dreq is 25 % larger (conservative).						
Beam web local yielding (J10-3)	kips	270.0	269.2	-0.31		Pass
Beam web crippling (J10-4, web-connected beam)	kips	201.0	200.9	-0.04		Pass
Flat bar block shear (single bolt line, 4.00 in. to the bar edge)	kips	171.0	171.1	+0.05		Pass
Beam-to-column angles: bolt group (angle tearout, column web bearing)	kips	104.0	128.0	+23.08		Deviation BG19
BG19 column web bearing at the beam-to-column angles: DG29 Ex. 5.8 (p. 186) halves the column web (2.4 d (tw / 2) Fu = 18.4 kips per bolt), assuming the same connection and load on the other side of the web: 2 (15.3) + 4 (18.4) = 104 kips. ILX takes the full web for a one-sided connection (36.9 > bolt shear 24.3 kips): 2 (15.3) + 4 (24.3) = 128 kips (+23 %); with back-to-back connections (web_both = shared) ILX checks the web per bolt under both reactions (Design Example II.A-8).						
Beam-to-column angles: shear yielding (2 × 8½ × ⅜)	kips	138.0	137.7	-0.22		Pass
Beam-to-column angles: shear rupture	kips	108.0	107.7	-0.31		Pass

ILX governing check: (Gusset compression buckling on the Whitmore section), ratio 0.821. ILX result: **OK**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.8 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
α = eb tan θ = ᾱ(β = 0, ec = 0)	in.	15.20	15.17	-0.19		Pass
Hub = P sin θ	kips	57.60	57.61	+0.02		Pass
Vub = P cos θ	kips	33.70	33.61	-0.27		Pass
Beam-to-column shear Vub + R	kips	53.70	53.61	-0.17		Pass
Whitmore yielding (6.93 in. × ⅝ in.)	kips	93.30	93.34	+0.05		Pass
Gusset shear yielding along the flange (lg = 15.9 in.)	kips	143.0	142.9	-0.07		Pass
Gusset tensile yielding along the flange	kips	214.0	213.9	-0.04		Pass
Gusset-to-beam weld Dreq (Table 8-4, no 1.25 factor)		1.920	2.335	+21.63		Deviation BG6
BG6 interface weld: ILX applies the Manual Part 13 1.25 ductility factor to every gusset interface weld; DG29 omits it for a uniform, statically determinate force (Ex. 5.8, p. 183) and checks that weld with Manual Table 8-4 (C = 4.37 at 30°). ILX Dreq is 25 % larger (conservative).						
Beam web local yielding (J10-3)	kips	180.0	179.4	-0.31		Pass
Beam web crippling (J10-4, web-connected beam)	kips	134.0	133.9	-0.04		Pass
Flat bar block shear (single bolt line, 4.00 in. to the bar edge)	kips	114.0	114.1	+0.05		Pass
Beam-to-column angles: bolt group (angle tearout, column web bearing)	kips	69.60	85.33	+22.61		Deviation BG19
BG19 column web bearing at the beam-to-column angles: DG29 Ex. 5.8 (p. 186) halves the column web (2.4 d (tw / 2) Fu = 18.4 kips per bolt), assuming the same connection and load on the other side of the web: 2 (15.3) + 4 (18.4) = 104 kips. ILX takes the full web for a one-sided connection (36.9 > bolt shear 24.3 kips): 2 (15.3) + 4 (24.3) = 128 kips (+23 %); with back-to-back connections (web_both = shared) ILX checks the web per bolt under both reactions (Design Example II.A-8).						
Beam-to-column angles: shear yielding (2 × 8½ × ⅜)	kips	91.90	91.80	-0.11		Pass
Beam-to-column angles: shear rupture	kips	71.90	71.78	-0.17		Pass

ILX governing check: (Gusset compression buckling on the Whitmore section), ratio 0.823. ILX result: **OK**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.11: Truss connection by the UFM (W36X135 chord as the beam, W14X257 vertical as the column)

Source: AISC Design Guide 29 (2014, errata 2023), Example 5.11, pp. 237 to 267. Connection: Vertical bracing gusset (UFM).

> Surrogate model: The W14X99 diagonal and its flange splice plates are modelled (BG12 resolved). The gusset is welded to the chord over 33 in. starting 2⅛ in. from the vertical (the example bolts it to a tab plate) and to the vertical over 38¾ in. starting 2⅛ in. above the chord ($\bar{\beta}$ = 21.5 in.); $\alpha - \bar{\alpha}$ = 0.6 in. is neglected as in the example. The Tab Plate B rows run with the example's tab plate (gb_conn = tab_plate: PL 1 × 33 A572-50, 2 × 11 1 in. A490-SC, ex = 3½ in.).

DG29 5.11 · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
β = $\bar{\beta}$	in.	21.50	21.50	-0.00		Pass
α = (β + eb) tan θ − ec DG29 uses eb = 17.8 in. (35.6 / 2) and rounds tan θ = 0.698: 2 % tolerance.	in.	19.20	19.23	+0.15		Pass
r (Eq. 13-6)	in.	47.90	47.92	+0.05		Pass
Hub = α P / r	kips	442.0	441.3	-0.15		Pass
Huc = ec P / r	kips	189.0	188.2	-0.42		Pass
Vub = eb P / r	kips	409.0	408.6	-0.11		Pass
Vuc = β P / r	kips	495.0	493.5	-0.31		Pass
Gusset-to-vertical weld Dreq (Table 8-4 with the 1.25 factor)		5.760	5.531	-3.98		Deviation BG8
BG8 weld directional strength: DG29 Ex. 5.11 reads Manual Table 8-4 at the next lower tabulated angle (15° for θ = 20.9°, C = 3.96), which it notes is conservative: Dreq = 5.76 (ASD 5.70). ILX evaluates 1 + 0.50 sin^1.5 θ at the actual angle (J2.4(a)(1)) with the same 1.25 factor: 5.53 (ASD 5.51), −4 %.						
Gusset shear yielding along the vertical	kips	1,160	1,162	+0.22		Pass
Gusset tensile yielding along the vertical	kips	1,740	1,744	+0.22		Pass
Chord web local yielding (J10-3, lb = 33 in.)	kips	1,110	1,106	-0.41		Pass
Brace tensile yielding (W14X99)	kips	1,310	1,310	-0.04		Pass
Brace tensile rupture (U = 1 − 1.14/24 = 0.953) An = 29.1 − 4 (0.780)(1⅛ + 1/16) = 25.4 in.² with the 360-22 hole (DG29 25.6): −0.9 %.	kips	1,190	1,179	-0.91		Pass
Brace flange bolts: 36 × slip (Class B, oversized holes in the plates)	kips	1,110	1,106	-0.32		Pass
Brace flange block shear (both lines out to the flange edges)	kips	2,060	2,008	-2.54		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = 79.6 − 34 (1⅛ + 1/16)(0.780) = 48.1 in.² (DG29 49.8): 2,010 kips, −2.5 %.						
Plates A: tensile rupture at the gusset slot (An = 14 − 1⅛)	kips	1,260	1,255	-0.37		Pass
Plates A: tensile yielding	kips	1,260	1,260	+0.00		Pass
Plates A: tensile rupture at the bolts (1¼ in. oversized holes)	kips	1,110	1,109	-0.08		Pass
Plates A to gusset: weld Dreq (Table 8-4, k = 0, a = 3.22/25: C = 3.69) ILX's IC method: C = 2 × 1.852 = 3.70 (DG29 3.69).		3.970	3.960	-0.26		Pass
Whitmore yielding (45.1 in., into the vertical) BG12 resolved: w = 14.2 + 2 (1.00), l = 25 in. DG29 (p. 245) places the plates so that the section enters the vertical only (tw = 1.18 > tg); ILX places the brace by its clearance: with gap = 7 in. the section clears the chord (at the default 1 in., 12.4 in. of it falls in the chord web at 0.600 in.: 1,804 kips).	kips	2,030	2,028	-0.10		Pass
Tab plate B: bolt group, 2 × 11 1 in. A490-SC Class B, oversized holes (Table 7-7: C = 19.6, ex = 3½ in.) BG11 resolved (bracing_tab.py): ILX's IC method at the actual load angle 42.8° gives C = 19.5 (DG29 reads Table 7-7 at 30°: 19.6); slip governs per bolt (30.7 / 20.5 kips).	kips	602.0	599.4	-0.43		Pass
Tab plate B: shear yielding (33 × 1)	kips	990.0	990.0	+0.00		Pass
Tab plate B: tensile yielding	kips	1,490	1,485	-0.34		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Tab plate B: shear rupture (1¼ in. oversized holes, Anv = 18.6 in.²)	kips	544.0	543.0	-0.19		Pass
Tab plate B: tensile rupture (U = 1)	kips	907.0	904.9	-0.23		Pass
Tab plate B: flexural yielding φ Fy Zg (Zg = 272 in.³)	kip-in.	12,200	12,251	+0.42		Pass
Tab plate B: flexural rupture φ Fu Zn (Zn = 154 in.³, Manual Eq. 15-4)	kip-in.	7,510	7,493	-0.23		Pass
Tab plate B: moment at the bolt line Mu = Hub × 3½ in.	kip-in.	1,550	1,545	-0.34		Pass
Tab plate B Neal interaction (yielding)		0.242	0.241	-0.30		Pass
Tab plate B Neal interaction (rupture) The shear term is to the 4th power: DG29 rounds Anv to 18.6 in.² (ILX 18.56) and Hab to 292 kips (ILX 292.9), so ASD 0.836 (+1.6 %): 2 % tolerance.		0.845	0.847	+0.18		Pass
Tab-to-chord weld Dreq (sixteenths, no ductility factor)		5.570	5.114	-8.19		Deviation BG8
BG8 weld directional strength: DG29 Ex. 5.11 (p. 251) reads Manual Table 8-4 at 30° for the tab-to-chord weld (θ = 42.8°, C = 4.37, no ductility factor): Dreq = 5.57 (ASD 5.52). ILX evaluates 1 + 0.50 sin^1.5 θ at the actual angle: 5.11 (ASD 5.09), −8 %.						

ILX governing check: (Gusset-to-beam fillet welds, both sides (peak / 1.25 average stress)), ratio 1.065. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 5.11 · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
β = β̄	in.	21.50	21.50	-0.00		Pass
α = (β + eb) tan θ − ec DG29 uses eb = 17.8 in. (35.6 / 2) and rounds tan θ = 0.698: 2 % tolerance.	in.	19.20	19.23	+0.15		Pass
r (Eq. 13-6)	in.	47.90	47.92	+0.05		Pass
Hub = α P / r	kips	292.0	292.9	+0.30		Pass
Huc = ec P / r	kips	125.0	124.9	-0.08		Pass
Vub = eb P / r	kips	271.0	271.1	+0.05		Pass
Vuc = β P / r	kips	327.0	327.5	+0.15		Pass
Gusset-to-vertical weld Dreq (Table 8-4 with the 1.25 factor)		5.700	5.506	-3.41		Deviation BG8
BG8 weld directional strength: DG29 Ex. 5.11 reads Manual Table 8-4 at the next lower tabulated angle (15° for θ = 20.9°, C = 3.96), which it notes is conservative: Dreq = 5.76 (ASD 5.70). ILX evaluates 1 + 0.50 sin^1.5 θ at the actual angle (J2.4(a)(1)) with the same 1.25 factor: 5.53 (ASD 5.51), −4 %.						
Gusset shear yielding along the vertical	kips	775.0	775.0	+0.00		Pass
Gusset tensile yielding along the vertical	kips	1,160	1,160	+0.02		Pass
Chord web local yielding (J10-3, lb = 33 in.)	kips	737.0	737.0	+0.00		Pass
Brace tensile yielding (W14X99)	kips	871.0	871.3	+0.03		Pass
Brace tensile rupture (U = 1 − 1.14/24 = 0.953) An = 29.1 − 4 (0.780)(1⅛ + 1/16) = 25.4 in.² with the 360-22 hole (DG29 25.6): −0.9 %.	kips	793.0	786.1	-0.87		Pass
Brace flange bolts: 36 × slip (Class B, oversized holes in the plates)	kips	738.0	739.6	+0.22		Pass
Brace flange block shear (both lines out to the flange edges)	kips	1,380	1,338	-3.01		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = 79.6 − 34 (1⅛ + 1/16)(0.780) = 48.1 in.² (DG29 49.8): 2,010 kips, −2.5 %.						
Plates A: tensile rupture at the gusset slot (An = 14 − 1⅛)	kips	839.0	836.9	-0.25		Pass
Plates A: tensile yielding	kips	838.0	838.3	+0.04		Pass
Plates A: tensile rupture at the bolts (1¼ in. oversized holes)	kips	741.0	739.4	-0.22		Pass
Plates A to gusset: weld Dreq (Table 8-4, k = 0, a = 3.22/25: C = 3.69) ILX's IC method: C = 2 × 1.852 = 3.70 (DG29 3.69).		3.970	3.942	-0.72		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Whitmore yielding (45.1 in., into the vertical) BG12 resolved: w = 14.2 + 2 (1.00), l = 25 in. DG29 (p. 245) places the plates so that the section enters the vertical only (tw = 1.18 > tg); ILX places the brace by its clearance: with gap = 7 in. the section clears the chord (at the default 1 in., 12.4 in. of it falls in the chord web at 0.600 in.: 1,804 kips).	kips	1,350	1,349	-0.05		Pass
Tab plate B: bolt group, 2 × 11 1 in. A490-SC Class B, oversized holes (Table 7-7: C = 19.6, ex = 3½ in.) BG11 resolved (bracing_tab.py): ILX's IC method at the actual load angle 42.8° gives C = 19.5 (DG29 reads Table 7-7 at 30°: 19.6); slip governs per bolt (30.7 / 20.5 kips).	kips	402.0	400.7	-0.33		Pass
Tab plate B: shear yielding (33 × 1)	kips	660.0	660.0	+0.00		Pass
Tab plate B: tensile yielding	kips	988.0	988.0	+0.00		Pass
Tab plate B: shear rupture (1¼ in. oversized holes, Anv = 18.6 in.²)	kips	363.0	362.0	-0.28		Pass
Tab plate B: tensile rupture (U = 1)	kips	605.0	603.3	-0.28		Pass
Tab plate B: flexural yielding φ Fy Zg (Zg = 272 in.³)	kip-in.	8,140	8,151	+0.14		Pass
Tab plate B: flexural rupture φ Fu Zn (Zn = 154 in.³, Manual Eq. 15-4)	kip-in.	5,010	4,995	-0.30		Pass
Tab plate B: moment at the bolt line Mu = Hub × 3½ in.	kip-in.	1,020	1,025	+0.50		Pass
Tab plate B Neal interaction (yielding)		0.239	0.240	+0.35		Pass
Tab plate B Neal interaction (rupture) The shear term is to the 4th power: DG29 rounds Anv to 18.6 in.² (ILX 18.56) and Hab to 292 kips (ILX 292.9), so ASD 0.836 (+1.6 %): 2 % tolerance.		0.823	0.836	+1.56		Pass
Tab-to-chord weld Dreq (sixteenths, no ductility factor)		5.520	5.091	-7.78		Deviation BG8
BG8 weld directional strength: DG29 Ex. 5.11 (p. 251) reads Manual Table 8-4 at 30° for the tab-to-chord weld (θ = 42.8°, C = 4.37, no ductility factor): Dreq = 5.57 (ASD 5.52). ILX evaluates 1 + 0.50 sin^1.5 θ at the actual angle: 5.11 (ASD 5.09), −8 %.						

ILX governing check: (Gusset-to-beam fillet welds, both sides (peak / 1.25 average stress)), ratio 1.061. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 6.1a: SCBF bracing connection (R = 6): slotted HSS8X8X⅝, 1 in. gusset, UFM forces for RyFyAg

Source: AISC Design Guide 29 (2014, errata 2023), Example 6.1a, pp. 292 to 321. Connection: Vertical bracing gusset (UFM).

> Surrogate model: The connection is run in tension only at the example's required connection force RyFyAg = 1,060 kips (ASD 704) for the gusset and interface rows (the brace rupture check fails there without the reinforcement, as in the example before the plates are added). The seismic rows run the SCBF mode (seismic = scbf: Ry Fy Ag and 1.14 Fcre Ag, the 1¼ × 4 reinforcing plates, the moment-release splice) with the brace placed by the 1 in. clearance, not at the example's 43 in. pull-off.

DG29 6.1a · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
β = $\bar{\beta}$	in.	14.50	14.50	+0.00		Pass
α (Eq. 13-1)	in.	26.10	26.15	+0.19		Pass
$\bar{\alpha}$ = (35¼ − 1) / 2 + 1	in.	18.10	18.12	+0.14		Pass
r (Eq. 13-6)	in.	41.40	41.46	+0.15		Pass
Vuc = β P / r	kips	371.0	370.7	-0.09		Pass
Vub = eb P / r	kips	218.0	217.3	-0.32		Pass
Huc = ec P / r	kips	214.0	213.5	-0.25		Pass
Hub = α P / r	kips	668.0	668.5	+0.08		Pass
Mub = Vub (α − $\bar{\alpha}$) (text; Fig. 6-8a prints 1,770)	kip-in.	1,740	1,744	+0.22		Pass
Gusset block shear (t = 1 in.)	kips	1,250	1,245	-0.40		Pass
Whitmore yielding (29.9 in.)	kips	1,350	1,166	-13.60		Deviation BG2
BG2 Whitmore section geometry: ILX places the brace end by the `gap` clearance and welds the gusset directly to the column with the given setback; DG29 places the brace by its own detailing (Ex. 5.1: end plate, 6.1a: 2t clearance and pull-off). The Whitmore width is the same (lw = w + 2 l tan 30°) but the part that falls outside the gusset or into the beam web differs: Ex. 6.1a counts the full 29.9 in. at the gusset thickness (φRn = 1,350 kips); at ILX's brace end 9.7 in. of it runs into the beam web, counted at tw = 0.585 in. as DG29 does in Ex. 5.1 and 6.1b: 1,166 kips (−14 %, conservative; adequate for 1,060).						
Neal interaction at the gusset-to-beam edge		0.328	0.331	+0.98		Pass
AFMM column edge (App. C.4): fa = Hc / (b t), reversible brace, b = 28.0 in. DG29 App. C.4 (p. 380) checks this example's edges with the brace force reversible; run with reversible = true. DG29's a = 16.0 in. is scaled to the bend line; ILX takes the gusset's top edge, so only fa is compared (λ, Q = 1 ≈ φFcr 45 ksi).	ksi	7.640	7.624	-0.21		Pass
Gusset-to-beam weld Dreq (sixteenths)		8.000	8.038	+0.48		Pass
Equivalent normal force Ne = Vub + 2M/(l/2)	kips	421.0	421.0	-0.01		Pass
Beam web local yielding (J10-2, $\bar{\alpha}$ = 18.1 in. > d)	kips	1,210	1,103	-8.81		Deviation BG7
BG7 web local yielding equation: ILX uses J10-3 (force within d of the beam end) with the distance from the beam end to the start of the gusset edge; DG29 Ex. 6.1a measures it to the edge centroid $\bar{\alpha}$ = 18.1 in. > d = 17.0 in. and uses J10-2 (5k): 1,210 kips. ILX J10-3: 1,103 kips (−9 %, conservative).						
Beam web crippling (J10-4, web-connected beam)	kips	1,210	1,208	-0.13		Pass
Gusset-to-column weld Dreq (sixteenths)		6.050	6.047	-0.05		Pass
Beam-to-column shear Vub + R	kips	288.0	287.3	-0.24		Pass
SCBF required tension Pt = Ry Fy Ag (ASD / 1.5; Ry = 1.4)	kips	1,060	1,056	-0.36		Pass
Expected buckling stress Fcre (KL/r = 67.6, Ry Fy in E3-2)	ksi	41.90	41.90	-0.00		Pass
SCBF required compression Pc = 1.14 Fcre Ag (ASD / 1.5)	kips	783.0	783.5	+0.07		Pass
Point A: distance L from the w.p. along the brace (2t hinge zone, Fig. 6-2) ILX checks that the brace end lies 2 tp past Point A (sz_hinge). Its rectangular gusset cannot take the brace 43 in. out as DG29's shaped gusset does, so that check fails in this run.	in.	41.00	40.99	-0.02		Pass
Brace net area with the reinforcing plates An = 15.1 + 2 (5.00)	in.²	25.10	25.09	-0.03		Pass
Brace net section with reinforcing plates, Ae	in.²	20.70	20.99	+1.41		Deviation BG9

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
BG9 slotted rectangular HSS shear lag, edition: DG29 (360-10) uses Table D3.1 Case 6 $\bar{x}$ = (B² + 2BH) / 4(B + H) = 3.00 in., U = 0.75, Ae = 9.68 in.², φRn = 421 kips (ASD 281); 360-22 Table D3.1 takes $\bar{x}$ of the half section beside the gusset (ILX tension_member, as for Design Example D.4): $\bar{x}$ = 2.67 in., U = 0.777, Ae = 10.09 in.², 439 kips (ASD 293), +4.2 %. With the two 1¼ × 4 plates DG29 extends its Case 6 formula: $\bar{x}$ = 3.35 in. from the brace centre, U = 0.824, Ae = 20.7 in.²; ILX takes the 360-22 half section from the gusset face ($\bar{x}$ 2.47 in., the plates at 4.13 in.): $\bar{x}$ = 3.11 in., U = 0.837, Ae = 21.0 in.² (+1.4 %). Both exceed Ag = 16.4 in.² (AISC 341-16 F2.5b(c)).						
Reinforcing plate welds Dreq for Ry Fy Ar (J2-10b, a = 12 in.), sixteenths		7.480	7.483	+0.03		Pass
Moment-release splice bolt group C (IC, ex = 42¾ in.)		1.040	1.035	-0.44		Pass
Moment-release splice: bolt group with every bolt at the beam-web lc = s − dh (C rn)	kips	69.10	66.44	-3.85		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: lc = 3.00 − 1⅛ = 1.875 in. (DG29 1.94): 1.035 × 64.2 = 66.4 kips (ASD 44.3), −3.9 %. Both are below 70.0 kips; DG29 then takes each bolt's own direction and edge distance (71.1 kips), which ILX does not, so its check reports n.g.						
Moment-release splice: Mu = R (ex − g) = 70.0 × 39.75	kip-in.	2,780	2,782	+0.09		Pass
Moment-release splice plates: flexure (2 × ⅞ in.)	kip-in.	2,840	2,835	-0.18		Pass
Moment-release splice: Manual Eq. 10-3 tmax (C′ = 44.7 in.)	in.	2.730	2.732	+0.06		Pass

ILX governing check: (Beam-to-column single plate: plate flexural rupture + shear interaction at first beam bolt column), ratio 6.793. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 6.1a · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
β = $\bar{\beta}$	in.	14.50	14.50	+0.00		Pass
α (Eq. 13-1)	in.	26.10	26.15	+0.19		Pass
$\bar{\alpha}$ = (35¼ − 1) / 2 + 1	in.	18.10	18.12	+0.14		Pass
r (Eq. 13-6)	in.	41.40	41.46	+0.15		Pass
Vuc = β P / r	kips	247.0	246.2	-0.33		Pass
Vub = eb P / r	kips	145.0	144.3	-0.47		Pass
Huc = ec P / r	kips	142.0	141.8	-0.16		Pass
Hub = α P / r	kips	444.0	444.0	-0.00		Pass
Mub = Vub (α − $\bar{\alpha}$) (text; Fig. 6-8a prints 1,770)	kip-in.	1,160	1,158	-0.16		Pass
Gusset block shear (t = 1 in.)	kips	830.0	830.0	+0.00		Pass
Whitmore yielding (29.9 in.)	kips	895.0	776.0	-13.29		Deviation BG2
BG2 Whitmore section geometry: ILX places the brace end by the `gap` clearance and welds the gusset directly to the column with the given setback; DG29 places the brace by its own detailing (Ex. 5.1: end plate, 6.1a: 2t clearance and pull-off). The Whitmore width is the same (lw = w + 2 l tan 30°) but the part that falls outside the gusset or into the beam web differs: Ex. 6.1a counts the full 29.9 in. at the gusset thickness (φRn = 1,350 kips); at ILX's brace end 9.7 in. of it runs into the beam web, counted at tw = 0.585 in. as DG29 does in Ex. 5.1 and 6.1b: 1,166 kips (−14 %, conservative; adequate for 1,060).						
Neal interaction at the gusset-to-beam edge		0.327	0.328	+0.37		Pass
AFMM column edge (App. C.4): fa = Hc / (b t), reversible brace, b = 28.0 in. DG29 App. C.4 (p. 380) checks this example's edges with the brace force reversible; run with reversible = true. DG29's a = 16.0 in. is scaled to the bend line; ILX takes the gusset's top edge, so only fa is compared (λ, Q = 1 ≈ φFcr 45 ksi).	ksi	5.070	5.063	-0.13		Pass
Gusset-to-beam weld Dreq (sixteenths)		7.980	8.008	+0.35		Pass
Equivalent normal force Ne = Vub + 2M/(l/2)	kips	280.0	279.6	-0.15		Pass
Beam web local yielding (J10-2, $\bar{\alpha}$ = 18.1 in. > d)	kips	803.0	735.6	-8.39		Deviation BG7
BG7 web local yielding equation: ILX uses J10-3 (force within d of the beam end) with the distance from the beam end to the start of the gusset edge; DG29 Ex. 6.1a measures it to the edge centroid $\bar{\alpha}$ = 18.1 in. > d = 17.0 in. and uses J10-2 (5k): 1,210 kips. ILX J10-3: 1,103 kips (−9 %, conservative).						
Beam web crippling (J10-4, web-connected beam)	kips	806.0	805.6	-0.05		Pass
Gusset-to-column weld Dreq (sixteenths)		6.040	6.024	-0.26		Pass
Beam-to-column shear Vub + R	kips	192.0	191.0	-0.51		Pass
SCBF required tension Pt = Ry Fy Ag (ASD / 1.5; Ry = 1.4)	kips	704.0	704.1	+0.02		Pass
Expected buckling stress Fcre (KL/r = 67.6, Ry Fy in E3-2)	ksi	41.90	41.90	-0.00		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
SCBF required compression Pc = 1.14 Fcre Ag (ASD / 1.5)	kips	522.0	522.4	+0.07		Pass
Point A: distance L from the w.p. along the brace (2t hinge zone, Fig. 6-2) ILX checks that the brace end lies 2 tp past Point A (sz_hinge). Its rectangular gusset cannot take the brace 43 in. out as DG29's shaped gusset does, so that check fails in this run.	in.	41.00	40.99	-0.02		Pass
Brace net area with the reinforcing plates An = 15.1 + 2 (5.00)	in.²	25.10	25.09	-0.03		Pass
Brace net section with reinforcing plates, Ae	in.²	20.70	20.99	+1.41		Deviation BG9
BG9 slotted rectangular HSS shear lag, edition: DG29 (360-10) uses Table D3.1 Case 6 $\bar{x}$ = (B² + 2BH) / 4(B + H) = 3.00 in., U = 0.75, Ae = 9.68 in.², φRn = 421 kips (ASD 281); 360-22 Table D3.1 takes $\bar{x}$ of the half section beside the gusset (ILX tension_member, as for Design Example D.4): $\bar{x}$ = 2.67 in., U = 0.777, Ae = 10.09 in.², 439 kips (ASD 293), +4.2 %. With the two 1¼ × 4 plates DG29 extends its Case 6 formula: $\bar{x}$ = 3.35 in. from the brace centre, U = 0.824, Ae = 20.7 in.²; ILX takes the 360-22 half section from the gusset face ($\bar{x}$ 2.47 in., the plates at 4.13 in.): $\bar{x}$ = 3.11 in., U = 0.837, Ae = 21.0 in.² (+1.4 %). Both exceed Ag = 16.4 in.² (AISC 341-16 F2.5b(c)).						
Reinforcing plate welds Dreq for Ry Fy Ar (J2-10b, a = 12 in.), sixteenths		7.470	7.483	+0.17		Pass
Moment-release splice bolt group C (IC, ex = 42¾ in.)		1.040	1.035	-0.44		Pass
Moment-release splice: bolt group with every bolt at the beam-web lc = s − dh (C rn)	kips	46.10	44.29	-3.92		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: lc = 3.00 − 1⅛ = 1.875 in. (DG29 1.94): 1.035 × 64.2 = 66.4 kips (ASD 44.3), −3.9 %. Both are below 70.0 kips; DG29 then takes each bolt's own direction and edge distance (71.1 kips), which ILX does not, so its check reports n.g.						
Moment-release splice: Mu = R (ex − g) = 70.0 × 39.75	kip-in.	1,860	1,856	-0.20		Pass
Moment-release splice plates: flexure (2 × ⅞ in.)	kip-in.	1,890	1,886	-0.20		Pass
Moment-release splice: Manual Eq. 10-3 tmax (C′ = 44.7 in.)	in.	2.730	2.732	+0.06		Pass

ILX governing check: (Beam-to-column single plate: plate flexural rupture + shear interaction at first beam bolt column), ratio 6.753. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 6.1b: R = 3 bracing connection: slotted HSS8X8X½, gusset to the beam and a column flange

Source: AISC Design Guide 29 (2014, errata 2023), Example 6.1b, pp. 321 to 345. Connection: Vertical bracing gusset (UFM).

> Surrogate model: The gusset-to-column single plate (bolt group centroid $\bar{\beta}$ = 9.75 in.) is replaced by a fillet weld to the column flange over 19.5 in. (the gusset 19.5 in. tall); the ¾ in. setback is kept. The brace end sits 2 in. clear of the beam (gap), which puts 4.5 in. of the Whitmore width in the beam web (DG29: 4.06 in.).

DG29 6.1b · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
β = $\bar{\beta}$ (single-plate bolt group)	in.	9.750	9.750	+0.00		Pass
α (Eq. 13-1)	in.	19.00	19.02	+0.13		Pass
$\bar{\alpha}$ = 25.0 / 2 + ¾	in.	13.30	13.25	-0.38		Pass
r (Eq. 13-6)	in.	32.90	32.90	+0.00		Pass
Vuc = β P / r	kips	88.90	88.90	+0.00		Pass
Vub = eb P / r	kips	77.50	77.51	+0.01		Pass
Huc = ec P / r	kips	76.20	76.14	-0.08		Pass
Hub = α P / r	kips	173.0	173.5	+0.28		Pass
Mub = Vub (α − $\bar{\alpha}$) DG29 rounds α = 19.0 and $\bar{\alpha}$ = 13.3 (α − $\bar{\alpha}$ = 5.7 in.); ILX 19.03 − 13.25 = 5.78 in.: 1.5 %.	kip-in.	442.0	447.6	+1.27		Pass
Brace tensile yielding (A500 Gr. B)	kips	559.0	558.9	-0.02		Pass
Brace net-section rupture (U = 0.75, Ae = 9.68 in.²)	kips	421.0	438.8	+4.23		Deviation BG9
BG9 slotted rectangular HSS shear lag, edition: DG29 (360-10) uses Table D3.1 Case 6 $\bar{x}$ = (B² + 2BH) / 4(B + H) = 3.00 in., U = 0.75, Ae = 9.68 in.², φRn = 421 kips (ASD 281); 360-22 Table D3.1 takes $\bar{x}$ of the half section beside the gusset (ILX tension_member, as for Design Example D.4): $\bar{x}$ = 2.67 in., U = 0.777, Ae = 10.09 in.², 439 kips (ASD 293), +4.2 %.						
Gusset block shear	kips	368.0	368.4	+0.11		Pass
Whitmore yielding (21.9 in., 4.06 in. into the beam web at Fy = 50)	kips	380.0	382.3	+0.60		Pass
Whitmore buckling (compact, still checked with K = 0.5, L = 10⅜ in.) BG4 resolved: the DG29 App. C corner check (Manual K = 0.5 with the centre line l1, measured from the Whitmore section to the beam / column lines, DG29 Fig. C-3), completed even though tβ = 0.05 in. ≤ ½ in. (compact) as DG29 does. ILX l1 = 9.68 in. (DG29 scales 10⅜): KL/r 33.5, 334 kips (+0.5 %); before: the Thornton average 4.3 in. gave 354 kips (+6.6 %, unconservative).	kips	332.0	333.7	+0.52		Pass
Gusset-to-beam weld Dreq (sixteenths) Mub 448 against 442 kip-in. (α rounding) and ILX's elastic fb under the 1.25 f_avg rule: 3.5 %.		2.860	2.941	+2.85		Pass
Equivalent normal force Ne = Vub + 2M/(l/2)	kips	148.0	149.1	+0.76		Pass
Beam web local yielding (J10-3)	kips	833.0	832.9	-0.01		Pass
Beam web crippling (J10-4, web-connected beam)	kips	969.0	968.7	-0.03		Pass
Beam-to-column shear Vub + R	kips	148.0	147.5	-0.33		Pass
Gusset-to-column single plate: shear yielding (PL ¾ × 12½, A36)	kips	203.0	202.5	-0.25		Pass
Gusset-to-column single plate: shear rupture	kips	157.0	151.7	-3.37		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = [12.5 − 4 (1⅛ + 1/16)] × ¾ = 5.81 in.² (DG29 6.01): 152 kips (ASD 101), −3.4 %.						
Beam-to-column single plate: block shear (¾ in.)	kips	206.0	181.6	-11.86		Deviation BG20
BG20 single-plate block shear path: DG29 Ex. 6.1b (p. 340) takes the shear plane over the full plate length 9.00 + 3½ = 12.5 in. (3.5 holes, 1-1/16 in. holes, Ubs = 0.5): Rn = 183 kips, ¾ in. by ratio 206 kips (ASD 137). The block from the top edge to the bottom bolt row is 9.00 + 1¾ = 10.75 in.; ILX (single_plate engine, 1-1/8 in. holes, the two bolt lines) gives 177 kips (ASD 118), −14 %, conservative.						
Beam-to-column single plate: shear yielding (¾ × 12½)	kips	203.0	202.5	-0.25		Pass
Beam-to-column single plate: shear rupture (4 holes)	kips	157.0	151.7	-3.37		Deviation BG5

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = 9.38 − 4 (1⅛ + 1⁄16) (¾) = 5.81 in.², 152 kips (ASD 101), −3.4 %.						
Beam-to-column single plate: tension yielding	kips	304.0	303.8	-0.08		Pass
Beam-to-column single plate: tension rupture (Ae = An)	kips	261.0	252.8	-3.12		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: An = (12.5 − 4 (1⅛ + 1⁄16)) (¾) = 5.81 in.², 253 kips (ASD 169), −3.1 %.						

ILX governing check: (Beam-to-column single plate: plate flexural rupture + shear interaction at first beam bolt column), ratio 1.565. ILX result: **NG**; published: **OK**.
The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG29 6.1b · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
β = β̄ (single-plate bolt group)	in.	9.750	9.750	+0.00		Pass
α (Eq. 13-1)	in.	19.00	19.02	+0.13		Pass
ᾱ = 25.0 / 2 + ¾	in.	13.30	13.25	-0.38		Pass
r (Eq. 13-6)	in.	32.90	32.90	+0.00		Pass
Vuc = β P / r	kips	59.30	59.27	-0.05		Pass
Vub = eb P / r	kips	51.70	51.67	-0.06		Pass
Huc = ec P / r	kips	50.80	50.76	-0.08		Pass
Hub = α P / r	kips	116.0	115.7	-0.30		Pass
Mub = Vub (α − ᾱ) DG29 rounds α = 19.0 and ᾱ = 13.3 (α − ᾱ = 5.7 in.); ILX 19.03 − 13.25 = 5.78 in.: 1.5 %.	kip-in.	295.0	298.4	+1.15		Pass
Brace tensile yielding (A500 Gr. B)	kips	372.0	371.9	-0.04		Pass
Brace net-section rupture (U = 0.75, Ae = 9.68 in.²)	kips	281.0	292.5	+4.10		Deviation BG9
BG9 slotted rectangular HSS shear lag, edition: DG29 (360-10) uses Table D3.1 Case 6 x̄ = (B² + 2BH) / 4(B + H) = 3.00 in., U = 0.75, Ae = 9.68 in.², φRn = 421 kips (ASD 281); 360-22 Table D3.1 takes x̄ of the half section beside the gusset (ILX tension_member, as for Design Example D.4): x̄ = 2.67 in., U = 0.777, Ae = 10.09 in.², 439 kips (ASD 293), +4.2 %.						
Gusset block shear	kips	246.0	245.6	-0.16		Pass
Whitmore yielding (21.9 in., 4.06 in. into the beam web at Fy = 50)	kips	253.0	254.3	+0.53		Pass
Whitmore buckling (compact, still checked with K = 0.5, L = 10⅜ in.) BG4 resolved: the DG29 App. C corner check (Manual K = 0.5 with the centre line l1, measured from the Whitmore section to the beam / column lines, DG29 Fig. C-3), completed even though tβ = 0.05 in. ≤ ½ in. (compact) as DG29 does. ILX l1 = 9.68 in. (DG29 scales 10⅜): KL/r 33.5, 334 kips (+0.5 %); before: the Thornton average 4.3 in. gave 354 kips (+6.6 %, unconservative).	kips	220.0	222.0	+0.93		Pass
Gusset-to-beam weld Dreq (sixteenths) Mub 448 against 442 kip-in. (α rounding) and ILX's elastic fb under the 1.25 f_avg rule: 3.5 %.		2.850	2.941	+3.21		Pass
Equivalent normal force Ne = Vub + 2M/(l/2)	kips	98.90	99.41	+0.52		Pass
Beam web local yielding (J10-3)	kips	555.0	555.3	+0.05		Pass
Beam web crippling (J10-4, web-connected beam)	kips	646.0	645.8	-0.03		Pass
Beam-to-column shear Vub + R	kips	98.40	98.37	-0.03		Pass
Gusset-to-column single plate: shear yielding (PL ¾ × 12½, A36)	kips	135.0	135.0	-0.00		Pass
Gusset-to-column single plate: shear rupture	kips	105.0	101.1	-3.68		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = [12.5 − 4 (1⅛ + 1/16)] × ¾ = 5.81 in.² (DG29 6.01): 152 kips (ASD 101), −3.4 %.						
Beam-to-column single plate: block shear (¾ in.)	kips	137.0	121.1	-11.64		Deviation BG20
BG20 single-plate block shear path: DG29 Ex. 6.1b (p. 340) takes the shear plane over the full plate length 9.00 + 3½ = 12.5 in. (3.5 holes, 1-1/16 in. holes, Ubs = 0.5): Rn = 183 kips, ¾ in. by ratio 206 kips (ASD 137). The block from the top edge to the bottom bolt row is 9.00 + 1¾ = 10.75 in.; ILX (single_plate engine, 1-1/8 in. holes, the two bolt lines) gives 177 kips (ASD 118), −14 %, conservative.						
Beam-to-column single plate: shear yielding (¾ × 12½)	kips	135.0	135.0	-0.00		Pass
Beam-to-column single plate: shear rupture (4 holes)	kips	104.0	101.1	-2.75		Deviation BG5

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = 9.38 − 4 (1⅛ + 1/16) (¾) = 5.81 in.², 152 kips (ASD 101), −3.4 %.						
Beam-to-column single plate: tension yielding	kips	202.0	202.1	+0.05		Pass
Beam-to-column single plate: tension rupture (Ae = An)	kips	174.0	168.6	-3.12		Deviation BG5
BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: An = (12.5 − 4 (1⅛ + 1/16)) (¾) = 5.81 in.², 253 kips (ASD 169), −3.1 %.						

ILX governing check: (Beam-to-column single plate: plate flexural rupture + shear interaction at first beam bolt column), ratio 1.566. ILX result: **NG**; published: **OK**.

The overall status is not compared: the example designs parts ILX does not model (see the not-checked rows), so ILX's overall result covers less.

DG2-Ex1-6ft: Unreinforced opening, W24X55, 6 ft from the support (Tables 4.6, 4.7)

Source: AISC Design Guide 2 (1990, rev. 3/1/03), Examples 1 and 1A, pp. 22-25. Connection: Beam web opening.

DG2-Ex1-6ft · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Vu / φVm (Table 4.6); ASD 1.7 Va / Vm (Table 4.7)		0.444	0.442	-0.40		Pass
Mu / φMm (Table 4.6); ASD 1.7 Ma / Mm (Table 4.7)		0.576	0.576	+0.00		Pass
R = [(Mu/φMm)³ + (Vu/φVm)³]^(1/3) (Fig. A.1) DG2 reads R from the interaction chart to two decimals.		0.650	0.652	+0.36		Pass

ILX governing check: (Moment–shear interaction (DG2 cubic, R ≤ 1)), ratio 0.652. ILX result: **OK**; published: **OK**.

LRFD, φ = 0.90 (DG2 §3.2).

DG2-Ex1-6ft · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Vu / φVm (Table 4.6); ASD 1.7 Va / Vm (Table 4.7)		0.476	0.474	-0.42		Pass
Mu / φMm (Table 4.6); ASD 1.7 Ma / Mm (Table 4.7)		0.617	0.617	+0.06		Pass
R = [(Mu/φMm)³ + (Vu/φVm)³]^(1/3) (Fig. A.1) DG2 reads R from the interaction chart to two decimals.		0.700	0.699	-0.11		Pass

ILX governing check: (Moment–shear interaction (DG2 cubic, R ≤ 1)), ratio 0.699. ILX result: **OK**; published: **OK**.

ASD per DG2 §3.8: φ = 1.0 with all load fact

orof1.7(ILX:Ω=1.70ontheASDloadsD+L).

DG2-Ex1-12ft: Unreinforced opening, W24X55, 12 ft from the support (Tables 4.6, 4.7)

Source: AISC Design Guide 2 (1990, rev. 3/1/03), Examples 1 and 1A, pp. 22-25. Connection: Beam web opening.

DG2-Ex1-12ft · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Mp = Fy Z	kip-in.	4,824	4,824	+0.00		Pass
φMm (Eq. 3-6); ASD Mm with φ = 1.0 (§3.8)	kip-in.	3,766	3,766	-0.01		Pass
νb = a0 / sb		4.180	4.167	-0.32		Pass
νt = a0 / st		2.280	2.273	-0.32		Pass
p0 = a0/h0 + 6 h0/d (Eq. 3-24)		4.520	4.542	+0.49		Pass
(2/3) V̄p (§3.7a2)	kips	129.0	129.2	+0.13		Pass
sb / d ≥ 0.15		0.200	0.203	+1.69		Pass
Corner radius 2 tw (§3.7b2)	in.	0.790	0.790	+0.00		Pass
Vpb = Fy tw sb / √3	kips	39.28	39.41	+0.32		Pass
αv bottom tee (Eq. 3-13, μ = 0)		0.415	0.415	+0.06		Pass
Vmb = αv Vpb	kips	16.27	16.36	+0.58		Pass
Vpt = Fy tw st / √3	kips	72.13	72.25	+0.16		Pass
αv top tee (Eq. 3-13, μ = 0)		0.610	0.612	+0.27		Pass
Vmt = αv Vpt	kips	44.04	44.19	+0.34		Pass
Vm = Vmb + Vmt (Eq. 3-12)	kips	60.31	60.55	+0.40		Pass
φVm; ASD Vm with φ = 1.0 (§3.8)	kips	54.28	54.50	+0.40		Pass
Vu / φVm (Table 4.6); ASD 1.7 Va / Vm (Table 4.7)		0.223	0.221	-0.85		Pass
Mu / φMm (Table 4.6); ASD 1.7 Ma / Mm (Table 4.7)		0.921	0.922	+0.07		Pass
R = [(Mu/φMm)³ + (Vu/φVm)³]^(1/3) (Fig. A.1) DG2 reads R from the interaction chart to two decimals.		0.930	0.926	-0.45		Pass

ILX governing check: (Moment–shear interaction (DG2 cubic, R ≤ 1)), ratio 0.926. ILX result: **OK**; published: **OK**.

LRFD, φ = 0.90 (DG2 §3.2).

DG2-Ex1-12ft · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Mp = Fy Z	kip-in.	4,824	4,824	+0.00		Pass
φMm (Eq. 3-6); ASD Mm with φ = 1.0 (§3.8)	kip-in.	4,184	4,184	+0.00		Pass
νb = a0 / sb		4.180	4.167	-0.32		Pass
νt = a0 / st		2.280	2.273	-0.32		Pass
p0 = a0/h0 + 6 h0/d (Eq. 3-24)		4.520	4.542	+0.49		Pass
(2/3) V̄p (§3.7a2)	kips	129.0	129.2	+0.13		Pass
sb / d ≥ 0.15		0.200	0.203	+1.69		Pass

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Corner radius 2 tw (§3.7b2)	in.	0.790	0.790	+0.00		Pass
Vpb = Fy tw sb / √3	kips	39.28	39.41	+0.32		Pass
αv bottom tee (Eq. 3-13, μ = 0)		0.415	0.415	+0.06		Pass
Vmb = αv Vpb	kips	16.27	16.36	+0.58		Pass
Vpt = Fy tw st / √3	kips	72.13	72.25	+0.16		Pass
αv top tee (Eq. 3-13, μ = 0)		0.610	0.612	+0.27		Pass
Vmt = αv Vpt	kips	44.04	44.19	+0.34		Pass
Vm = Vmb + Vmt (Eq. 3-12)	kips	60.31	60.55	+0.40		Pass
φVm; ASD Vm with φ = 1.0 (§3.8)	kips	60.31	60.55	+0.40		Pass
Vu / φVm (Table 4.6); ASD 1.7 Va / Vm (Table 4.7)		0.239	0.237	-0.84		Pass
Mu / φMm (Table 4.6); ASD 1.7 Ma / Mm (Table 4.7)		0.987	0.988	+0.08		Pass
R = [(Mu/φMm)³ + (Vu/φVm)³]^(1/3) (Fig. A.1) DG2 reads R from the interaction chart to two decimals.		1.000	0.992	-0.76		Pass

ILX governing check: (Moment–shear interaction (DG2 cubic, R ≤ 1)), ratio 0.992. ILX result: **OK**; published: **OK**.

ASDperDG2§3.8:φ=1.0withaloadfactorof1.7(ILX:Ω=1.70onthe ASDlo

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DG2-Ex1-15ft: Unreinforced opening, W24X55, 15 ft from the support (Tables 4.6, 4.7)

Source: AISC Design Guide 2 (1990, rev. 3/1/03), Examples 1 and 1A, pp. 22-25. Connection: Beam web opening.

DG2-Ex1-15ft · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Vu / φVm (Table 4.6); ASD 1.7 Va / Vm (Table 4.7)		0.111	0.111	-0.40		Pass
Mu / φMm (Table 4.6); ASD 1.7 Ma / Mm (Table 4.7)		1.008	1.008	+0.00		Pass
R = [(Mu/φMm)³ + (Vu/φVm)³]^(1/3) (Fig. A.1) DG2 reads R from the interaction chart to two decimals.		1.010	1.008	-0.15		Pass

ILX governing check: (Moment–shear interaction (DG2 cubic, R ≤ 1)), ratio 1.008. ILX result: **NG**; published: **NG**.

LRFD, φ = 0.90 (DG2 §3.2).

DG2-Ex1-15ft · ASD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Vu / φVm (Table 4.6); ASD 1.7 Va / Vm (Table 4.7)		0.118	0.119	+0.42		Pass
Mu / φMm (Table 4.6); ASD 1.7 Ma / Mm (Table 4.7)		1.079	1.080	+0.13		Pass
R = [(Mu/φMm)³ + (Vu/φVm)³]^(1/3) (Fig. A.1) DG2 reads R from the interaction chart to two decimals.		1.080	1.081	+0.09		Pass

ILX governing check: (Moment–shear interaction (DG2 cubic, R ≤ 1)), ratio 1.081. ILX result: **NG**; published: **NG**.

ASD per DG2 §3.8: φ = 1.0 with all load fact

orof1.7(ILX:Ω=1.70ontheASDloadsD+L).

DG2-Ex2-unreinforced: Concentric opening in a W18X55, unreinforced (NG)

Source: AISC Design Guide 2 (1990, rev. 3/1/03), Example 2, pp. 25-27. Connection: Beam web opening.

DG2-Ex2-unreinforced · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Compression flange b/t limit 65/√Fy (Eq. 3-22)		9.200	9.192	-0.08		Pass
bf / 2tf		6.000	5.976	-0.40		Pass
(2/3) V̄p (§3.7a2)	kips	135.9	135.9	-0.04		Pass
p0 = a0/h0 + 6 h0/d (Eq. 3-24)		5.480	5.465	-0.28		Pass
s / d ≥ 0.15		0.196	0.196	+0.07		Pass
ν = a0 / s		5.630	5.634	+0.07		Pass
Mp = Fy Z	kip-in.	5,600	5,600	+0.00		Pass
φMm (Eq. 3-6)	kip-in.	4,509	4,509	+0.00		Pass
Vp of each tee	kips	40.00	39.97	-0.08		Pass
αv (Eq. 3-13, μ = 0)		0.333	0.333	-0.14		Pass
Vmt = Vmb = αv Vp	kips	13.32	13.29	-0.22		Pass
φVm = φ (Vmb + Vmt)	kips	23.98	23.92	-0.24		Pass
Vu / φVm		1.251	1.254	+0.24		Pass
Mu / φMm		0.798	0.798	+0.05		Pass

ILX governing check: (Moment–shear interaction (DG2 cubic, R ≤ 1)), ratio 1.354. ILX result: **NG**; published: **NG**.

LRFD, φ = 0.90 (DG2 §3.2).

DG2-Ex2-trial: Reinforced with the trial Ar = 0.65 in.² on one side of the web

Source: AISC Design Guide 2 (1990, rev. 3/1/03), Example 2, pp. 25-27. Connection: Beam web opening.

DG2-Ex2-trial · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
φMm (Eq. 3-7, tw e < Ar)	kip-in.	4,831	4,831	-0.00		Pass
s̄ = s − Ar / (2 bf)	in.	3.510	3.507	-0.09		Pass
ν = a0 / s̄		5.700	5.703	+0.06		Pass
dr = s − 3/16 in.	in.	3.368	3.362	-0.16		Pass
Pr = Fy Ar	kips	32.50	32.50	+0.00		Pass
Fy tw a0 / (2√3) (limit on Pr)	kips	113.0	112.6	-0.37		Pass
μ = 2 Pr dr / (Vp s) (Eq. 3-14)		1.540	1.540	+0.03		Pass
αv (Eq. 3-13)		0.537	0.537	-0.07		Pass
Vmt = Vmb	kips	21.50	21.45	-0.24		Pass
Vm = Vmb + Vmt	kips	43.00	42.89	-0.24		Pass
φVm	kips	38.70	38.61	-0.24		Pass
Vu / φVm		0.775	0.777	+0.27		Pass
Mu / φMm		0.745	0.745	+0.03		Pass
R (Fig. 4.6) DG2 reads R from the interaction chart.		0.960	0.959	-0.06		Pass
Af / 3 (Eq. 3-33)	in.²	1.580	1.581	+0.08		Pass
s / tw (Eq. 3-35)		9.100	9.103	+0.03		Pass
140 / √Fy (Eq. 3-35)		19.800	19.799	-0.01		Pass
Mu / (Vu d) (Eq. 3-36)		6.620	6.630	+0.15		Pass

ILX governing check: (Moment–shear interaction (DG2 cubic, R ≤ 1)), ratio 0.959. ILX result: **OK**; published: **OK**.

LRFD, φ = 0.90 (DG2 §3.2).

DG2-Ex2-bar: Selected bar 3/8 × 1-3/4 in., one side of the web: welds and extension

Source: AISC Design Guide 2 (1990, rev. 3/1/03), Example 2, pp. 25-27. Connection: Beam web opening.

DG2-Ex2-bar · LRFD

Limit state	Unit	Published	ILX	Δ %	Δ vs tol.	Status
Bar b / t		4.670	4.667	-0.07		Pass
Ar = 3/8 × 1-3/4	in.²	0.656	0.656	+0.04		Pass
Pr = Fy Ar	kips	32.80	32.81	+0.04		Pass
Rwr = φ 2 Pr within the opening (Eq. 3-31)	kips	59.00	59.06	+0.11		Pass
φ Fw a0 0.707 / 16, one fillet per sixteenth	kips	27.80	27.84	+0.15		Pass
Required fillet within the opening, sixteenths		2.120	2.121	+0.06		Pass
Rwr = φ Fy Ar per extension (Eq. 3-32)	kips	29.50	29.53	+0.11		Pass
ℓ1 ≥ a0 / 4	in.	5.000	5.000	+0.00		Pass
ℓ1 ≥ √3 Ar / (2 tw)	in.	1.460	1.457	-0.19		Pass
Total bar length a0 + 2 ℓ1	in.	30.00	30.00	+0.00		Pass
Minimum fillet (Table J2.4)	in.	0.188	0.188	+0.00		Pass
Bar shear rupture force φ 2Pr (b − w) / b	kips	52.70	52.73	+0.07		Pass
Corner radius 2 tw	in.	0.780	0.780	+0.00		Pass

ILX governing check: (Moment–shear interaction (DG2 cubic, R ≤ 1)), ratio 0.957. ILX result: **OK**; published: **OK**.

LRFD, φ = 0.90 (DG2 §3.2).

Component benchmarks

Benchmark	Source	Published	ILX	Δ %	Status
IC bolts, Table 7-6: n = 4, ex = 1.50 in., 0°	II.A-17A (C/n = 0.885)	3.54	3.556	+0.46	Pass
IC bolts, Table 7-6: n = 4, ex = 2.50 in., 0°	II.A-28A (Table 10-11 Case I)	3.07	3.065	-0.15	Pass
IC bolts, Table 7-6: n = 4, ex = 3.00 in., 0°	Manual 16th Ed. Table 7-6, p. 7-31	2.81	2.814	+0.14	Pass
IC bolts, Table 7-6: n = 5, ex = 2.50 in., 30°	II.A-17B	4.07	4.062	-0.20	Pass
IC bolts, Table 7-6: n = 6, ex = 3.00 in., 0°	Muir & Thornton 2011	4.98	4.984	+0.08	Pass
IC bolts, Table 7-6: n = 6, ex = 6.00 in., 0°	Manual 16th Ed. Table 7-6, p. 7-31	3.55	3.545	-0.13	Pass
IC bolts, Table 7-7: 2 × 4, g = 3, ex = 10.5 in., 0°	II.A-19A	2.33	2.318	-0.53	Pass
IC bolts, Table 7-7: 2 × 5, g = 3, ex = 11.25 in., 30°	II.A-19B	3.53	3.517	-0.36	Pass
IC bolts, Table 7-7: 3 × 4, g = 4, ex = 13.5 in., 0°	Muir & Hewitt 2009	3.44	3.436	-0.11	Pass
IC bolts, Table 7-7: C', 2 × 4, g = 3 (moment only)	II.A-19A	26	26.032	+0.12	Pass
IC bolts, Table 7-7: C', 2 × 5, g = 3 (moment only)	II.A-19B	38.7	38.669	-0.08	Pass
IC bolts, Table 7-7: C', 3 × 4, g = 4 (moment only)	Muir & Hewitt 2009	50.7	50.674	-0.05	Pass
IC welds: Table 8-4: two lines, l = 23.5, ex = 4 in. (a = 0.170)	II.A-2A	3.61	3.613	+0.10	Pass
IC welds: Table 8-8: C-shape l = 14.5, kl = 2.75, 30°, load 3.5 in. from the vertical weld	II.A-2B	2.69	2.688	-0.08	Pass
IC welds: Table 8-10: L-shape l = 11.5, kl = 4.0, load kl + tw/2 (a = 0.319)	II.A-29	2.19	2.194	+0.19	Pass
Bearing / tearout: lc along the resultant, edge Le = 1¼ in. (θ = 38.7°)	II.A-1B	1.13	1.132	+0.18	Pass
Bearing / tearout: lc along the resultant, other edge (β = 51.3°)	II.A-1B	1.53	1.532	+0.15	Pass
Bearing / tearout: Table 7-5: φrn/t, ¾ in. STD, le = 1¼ in. (kips/in.)	II.A-17A	49.4	49.359	-0.08	Pass
Bearing / tearout: Table 7-5: φrn/t, ¾ in. STD, le = 1½ in. (kips/in.)	II.A-18	64	63.984	-0.02	Pass
Bearing / tearout: Table 7-4: φrn/t, ¾ in. STD, s = 3 in. (bearing governs, kips/in.)	II.A-17A	87.8	87.750	-0.06	Pass
Slip-critical: rn per slip plane, ¾ in. Group 120, Class A (kips)	J.4A	9.49	9.492	+0.02	Pass
Slip-critical: φ, STD holes	360-22 J3.9	1	1.000	+0.00	Pass
Slip-critical: φ, oversized holes	360-22 J3.9	0.85	0.850	+0.00	Pass
Slip-critical: φ, long-slotted holes	360-22 J3.9	0.7	0.700	+0.00	Pass
Double angle: Manual Part 10 tables: Table 10-1a angle strength, 2L5X3-1/2X5/16, n = 8 (LRFD)	AISC Manual Table 10-1a	302	302.123	+0.04	Pass
Double angle: Manual Part 10 tables: Table 10-1a angle strength, 2L4X3-1/2X3/8, n = 8 (LRFD)	AISC Manual Table 10-1a	362	361.969	-0.01	Pass
Double angle: Manual Part 10 tables: Table 10-1a angle strength, 2L5X3-1/2X1/4, n = 3 (LRFD)	AISC Manual Table 10-1a	85.9	85.922	+0.03	Pass
Double angle: Manual Part 10 tables: Table 10-1a angle strength, 2L5X3-1/2X1/4, n = 2 (LRFD)	AISC Manual Table 10-1a	54.8	54.844	+0.08	Pass
Double angle: Manual Part 10 tables: Table 10-1a angle strength, 2L5X3-1/2X1/4, n = 5 (LRFD)	AISC Manual Table 10-1a	148	148.078	+0.05	Pass
Double angle: Manual Part 10 tables: Table 10-1a angle strength, 2L5X3-1/2X5/16, n = 8 (ASD)	AISC Manual Table 10-1a	201	201.416	+0.21	Pass
Double angle: Manual Part 10 tables: Table 10-1a angle strength, 2L4X3-1/2X3/8, n = 8 (ASD)	AISC Manual Table 10-1a	241	241.312	+0.13	Pass
Double angle: Manual Part 10 tables: Table 10-1a angle strength, 2L5X3-1/2X1/4, n = 3 (ASD)	AISC Manual Table 10-1a	57.3	57.281	-0.03	Pass
Double angle: Manual Part 10 tables: Table 10-1a angle strength, 2L5X3-1/2X1/4, n = 2 (ASD)	AISC Manual Table 10-1a	36.6	36.562	-0.10	Pass
Double angle: Manual Part 10 tables: Table 10-1a angle strength, 2L5X3-1/2X1/4, n = 5 (ASD)	AISC Manual Table 10-1a	98.7	98.719	+0.02	Pass

Benchmark	Source	Published	ILX	Δ %	Status
Double angle: Manual Part 10 tables: Table 10-1b ¾-in. Group 120-N bolt shear (LRFD)	AISC Manual Table 10-1b	17.9	17.892	-0.04	Pass
Double angle: Manual Part 10 tables: Table 10-1b bolt shear (ASD)	AISC Manual Table 10-1b	11.9	11.928	+0.24	Pass
Double angle: Manual Part 10 tables: Table 10-1b edge bolt, lev = 1¼ in., kip/in. (LRFD)	AISC Manual Table 10-1b	49.4	49.359	-0.08	Pass
Double angle: Manual Part 10 tables: Table 10-1b edge bolt, kip/in. (ASD)	AISC Manual Table 10-1b	32.9	32.906	+0.02	Pass
Double angle: Manual Part 10 tables: Table 10-1b interior bolt, s = 3 in., kip/in. (LRFD)	AISC Manual Table 10-1b	87.8	87.750	-0.06	Pass
Double angle: Manual Part 10 tables: Table 10-1b interior bolt, kip/in. (ASD)	AISC Manual Table 10-1b	58.5	58.500	-0.00	Pass
Double angle: Manual Part 10 tables: Table 10-2 Welds B, 5/16 in., l = 23½ in. (LRFD)	AISC Manual Table 10-2	318	318.638	+0.20	Pass
Double angle: Manual Part 10 tables: Table 10-2 minimum support thickness for Welds B (LRFD)	AISC Manual Table 10-2	0.238	0.238	-0.01	Pass
Double angle: Manual Part 10 tables: Table 10-2 Welds B, 5/16 in., l = 23½ in. (ASD)	AISC Manual Table 10-2	212	212.425	+0.20	Pass
Double angle: Manual Part 10 tables: Table 10-2 minimum support thickness for Welds B (ASD)	AISC Manual Table 10-2	0.238	0.238	-0.01	Pass
Double angle: Manual Part 10 tables: Table 10-2 Welds A, 3/16 in., l = 8½ in. (LRFD)	AISC Manual Table 10-2	110	110.033	+0.03	Pass
Double angle: Manual Part 10 tables: Table 10-2 Welds A (ASD)	AISC Manual Table 10-2	73.5	73.355	-0.20	Pass
Double angle: Manual Part 10 tables: Table 10-2 minimum beam web thickness for Welds A	AISC Manual Table 10-2	0.286	0.286	-0.15	Pass
Double angle: Manual Part 10 tables: Table 10-3 Welds A 3/16 in.: minimum web thickness	AISC Manual Table 10-3	0.286	0.286	-0.15	Pass
Double angle: Manual Part 10 tables: Table 10-3 Welds B ¼ in.: minimum support thickness	AISC Manual Table 10-3	0.19	0.190	+0.20	Pass
Double angle: Manual Part 10 tables: Table 8-4 weld coefficient C (0°, k = 0, a = 0.170), II.A-2A	AISC Manual Table 8-4	3.61	3.616	+0.16	Pass
Double angle: Manual Part 10 tables: Table 8-8 weld coefficient C (30°, k = 0.190, a = 0.214), II.A-2B	AISC Manual Table 8-8	2.69	2.689	-0.03	Pass
Shear end plate: Manual Table 10-4: Table 10-4a end plate, n = 3, ¾-in. bolts, ¼-in. plate (basis)	AISC Design Examples v16.0, Example II.A-11A	85.9	85.922	+0.03	Pass
Shear end plate: Manual Table 10-4: Table 10-4c weld, 3/16-in., L = 8½ in. (φRn)	AISC Design Examples v16.0, Example II.A-11A	67.9	67.865	-0.05	Pass
Shear end plate: Manual Table 10-4: Table 10-4c minimum beam web thickness	AISC Design Examples v16.0, Example II.A-11A	0.286	0.286	-0.15	Pass
Shear end plate: Manual Table 10-4: 15th Ed. Table 10-4 girder-web bearing, 3 rows of ¾-in. bolts (kip/in.)	AISC Design Examples v15.1, Example II.A-11A	527	526.500	-0.09	Pass
Seated: Manual Part 10 tables: Table 10-6 weld, L8×4 seat, 5/16 in. (LRFD)	AISC Manual Table 10-6	66.7	66.737	+0.06	Pass
Seated: Manual Part 10 tables: Table 10-6 weld, L8×4 seat, 5/16 in. (ASD)	AISC Manual Table 10-6	44.5	44.492	-0.02	Pass
Seated: Manual Part 10 tables: Table 10-6 weld, L7×4 seat, 5/16 in. (LRFD)	AISC Manual Table 10-6	53.4	53.392	-0.01	Pass
Seated: Manual Part 10 tables: Table 10-6 weld, L7×4 seat, 5/16 in. (ASD)	AISC Manual Table 10-6	35.6	35.595	-0.01	Pass
Seated: Manual Part 10 tables: Table 10-8 weld, W = 7, l = 15, 5/16 in. (LRFD)	AISC Manual Table 10-8	139	139.425	+0.31	Pass
Seated: Manual Part 10 tables: Table 10-8 weld, W = 7, l = 15, 5/16 in. (ASD)	AISC Manual Table 10-8	93	92.950	-0.05	Pass
Seated: Manual Part 10 tables: Table 10-8 weld, W = 7, l = 24, 5/16 in. (LRFD)	AISC Manual Table 10-8	293	293.099	+0.03	Pass
Seated: Manual Part 10 tables: Table 10-8 weld, W = 7, l = 24, 5/16 in. (ASD)	AISC Manual Table 10-8	195	195.399	+0.20	Pass

Benchmark	Source	Published	ILX	Δ %	Status
Seated: Manual Part 10 tables: Table 10-5/10-6 outstanding leg, L6X4X5/8, L = 8 in. (LRFD)	AISC Manual Tables 10-5 and 10-6	113	112.500	-0.44	Pass
Seated: Manual Part 10 tables: Table 10-5/10-6 outstanding leg, L6X4X5/8, L = 8 in. (ASD)	AISC Manual Tables 10-5 and 10-6	74.9	74.850	-0.07	Pass
Seated: Manual Part 10 tables: Table 10-5/10-6 outstanding leg, L7X4X5/8, L = 6 in. (LRFD)	AISC Manual Tables 10-5 and 10-6	113	112.500	-0.44	Pass
Seated: Manual Part 10 tables: Table 10-5/10-6 outstanding leg, L7X4X5/8, L = 6 in. (ASD)	AISC Manual Tables 10-5 and 10-6	75	75.000	+0.00	Pass
Round HSS end plate (DG24 §5.4): f3 (DG24 Eq. 5-8)	Packer (2023), STI: round HSS bolted end plate, Pu = 150 kips, HSS6.625×0.375, 7/8 in. A325-N, a = b = 1.5	5.23	5.233	+0.05	Pass
Round HSS end plate (DG24 §5.4): tp,req with φ Fyp (DG24 Eq. 5-5)	Packer (2023), STI: round HSS bolted end plate, Pu = 150 kips, HSS6.625×0.375, 7/8 in. A325-N, a = b = 1.5; DG24 1st Ed. form (φ = 0.90, Fyp = 50 ksi)	0.637	0.637	-0.03	Pass
Round HSS end plate (DG24 §5.4): Bolt available tension Bc	Packer (2023), STI: round HSS bolted end plate, Pu = 150 kips, HSS6.625×0.375, 7/8 in. A325-N, a = b = 1.5	40.6	40.589	-0.03	Pass
Round HSS end plate (DG24 §5.4): Bolts required n (DG24 Eq. 5-6)	Packer (2023), STI: round HSS bolted end plate, Pu = 150 kips, HSS6.625×0.375, 7/8 in. A325-N, a = b = 1.5	5.59	5.594	+0.06	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Reduced embedment hef′ (17.6.2.1.2)	SkyCiv worked example (4 × ¾-in. rods in a 22 × 22 pedestal)	5.667	5.667	-0.01	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Breakout φNcbg, three edges	SkyCiv worked example (4 × ¾-in. rods in a 22 × 22 pedestal)	23.58	23.580	+0.00	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Basic breakout Nb = 16 hef^5/3	Hilti PROFIS report (4 × 1-in. anchors, hef = 12 in.)	63.648	63.648	+0.00	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Pryout Vcpg	Hilti PROFIS report (4 × 1-in. anchors, hef = 12 in.)	181.5	181.515	+0.01	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Shear breakout Vcbg, narrow member (ca1 limited to 16 in.)	Hilti PROFIS report (shear breakout)	35.49	35.492	+0.01	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Side-face blowout Nsbg, ca1 = 2.5 in.	Hilti PROFIS report (side-face blowout)	39.643	39.643	-0.00	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Side-face blowout Nsbg, ca1 = 1.5 in.	Hilti PROFIS report (side-face blowout)	21.689	21.623	-0.31	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Shear lug bearing Vbrg,sl (17.11), compression	Hilti PROFIS report (shear lug)	182.844	182.844	+0.00	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Shear lug concrete breakout (17.11), compression	Hilti PROFIS report (shear lug)	33.12	33.120	+0.00	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Shear lug bearing Vbrg,sl under uplift	Hilti PROFIS report (shear lug)	20.483	20.483	-0.00	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Shear lug breakout φVcb under uplift	Hilti PROFIS report (shear lug)	2.367	2.367	+0.00	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Steel strength φNsa, 1-in. F1554 Gr. 36	CivilBay Anchor worked example	26.36	26.350	-0.04	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Steel shear 4 φVsa, 1¼-in. F1554 Gr. 55 with grout pad	CivilBay Anchor-06	90.7	90.709	+0.01	Pass
Base plate: ACI 318-19 Ch. 17 anchorage: Tension-shear interaction (17.8)	CivilBay Anchor worked example	0.89	0.887	-0.38	Pass

Manual Table 10-9 (conventional configuration)

Holes	n	e	tmax
SSLT	2–5	a/2	no limit
SSLT	6–12	a/2	d/2 + 1/16

Holes	n	e	tmax
STD	2–5	a/2	d/2 + 1/16
STD	6–12	a	d/2 − 1/16

Documented deviations

A documented deviation is a limit state where ILX differs from the published number by more than the tolerance for a known reason: a calculation method that AISC permits, or an error or code-edition difference in the source. Each is a strict expected failure in the test suite, so it turns red the moment the behaviour changes.

Code	Explanation
D9	**Bolt tearout distance measured along the actual load direction** (Method difference). II.A-17B, II.A-19B; 6 rows. When a bolt is pushed at an angle (shear plus axial load), the steel in front of it can tear out. AISC's hand calculation uses the shortest edge distance, less a 1/4 in. allowance, as a quick worst case, and notes that a computer program may calculate the true distance. ILX calculates the true distance along the direction the bolt actually bears, so its per-bolt tearout value is higher. **Effect:** None on the result. In both examples the bolt group strength is controlled by bolt shear, not tearout, and ILX reaches the published bolt-group strength. Test record: D9 tearout lc: ILX ray-casts along the resultant (app/connections/single_plate.py, _clear_distance); AISC II.A-17B/19B conservatively uses the smaller edge distance less a ¼ in. underrun (method difference, AISC permits the exact lc).
D10	**Bolt group solved at the true load angle** (Method difference). II.A-19B; 4 rows. AISC reads the bolt-group coefficient from Manual Table 7-7 at 30 degrees, the nearest tabulated angle below the real one, which is conservative. ILX solves the instantaneous-center method directly at the real angle of 38.7 degrees. At 30 degrees ILX reproduces the table value (component benchmark), so the difference is only the angle. **Effect:** ILX's bolt group strength is about 7 % higher than the published, more conservative value. It does not govern. Test record: D10 AISC interpolates Manual Table 7-6/7-7 at 30° (conservative, as AISC notes); ILX solves the IC at the true resultant angle 38.7° (method difference).
D13	**Older code edition in the source paper** (Code edition). M&H 2009; 1 row. Muir and Hewitt (2009) was written to the 2005 Specification, when the bolt shear stress for this bolt grade was 60 ksi. The current 2022 Specification gives 68 ksi. ILX uses the current value. **Effect:** Bolt shear about 13 % higher, and the derived moment and thickness limits about 1 % higher. ILX is correct for AISC 360-22. Test record: D13 code edition: Muir & Hewitt (2009) used 360-05 A490-N Fnv = 60 ksi (φrv = 35.3 kips); 360-22 Group 150-N Fnv = 68 ksi (φrv = 40.1 kips). ILX is correct for 360-22.
D14	**AISC table tolerance in block shear** (Source inconsistency). II.A-18; 2 rows. The example text states a 2-1/4 in. edge distance, but the value AISC takes from Table 10-10c corresponds to 2.0 in. (the table carries a further 1/4 in. length tolerance). With 2.0 in., ILX reproduces the published value; the next row of the comparison shows it. **Effect:** None. Documented for traceability. Test record: D14 AISC Table 10-10c beam-web block shear: the tabulated bottom-edge value (76.2 kips/in.) back-calculates to leh = 2.0 in. although the text says leh = 2¼ in. (the table carries a further ¼ in. length tolerance). ILX at leh = 2.0 reproduces 88.2 kips (see the following row).
D15	**Tearout between bolt holes omitted in the 2009 paper** (Error in the source). M&H 2009; 1 row. The 2009 paper used the bearing value for every bolt. Under the current Specification (J3.11a), the steel between two holes can tear out at a lower load, and that governs here. ILX checks it, so its bolt group strength is lower than the paper's. **Effect:** Bolt group 94.2 kips vs the paper's 100.8 kips, so ILX reports NG where the paper reports OK. ILX follows the current Specification; the paper also predates the flexural-rupture interaction of the 15th and 16th Edition Manuals. Test record: D15 Muir & Hewitt (2009) took 2.4 d t Fu for every bolt; per 360-22 J3.11a the tearout between holes, 1.2 lc t Fu with lc = s − dh = 1.875 in. (36.6 < 39.0 kips nominal), governs. ILX is correct.

Code	Explanation
D16	**Hole size for net area in the 2009 paper** (Error in the source). M&H 2009; 2 rows. For net-area calculations the Specification (B4.3b) adds 1/16 in. to the hole diameter. The 2009 paper did not; ILX does. **Effect:** Shear rupture and block shear about 3 % lower than the paper. ILX is correct. Test record: D16 Muir & Hewitt (2009) net areas use dh = 1⅛ in.; 360-22 B4.3b adds 1/16 in. (dh + 1/16 = 1 3/16 in.). ILX is correct.
D18	**Doubler plate force from rounded intermediate strengths** (Rounding (ILX conservative)). II.A-6; 4 rows. In Example II.A-6 Solution C the force the doubler plate must receive is the plate's yield strength times the ratio of the unreinforced to the reinforced coped-section strengths. AISC uses the rounded values 116 and 165 kips (ratio 0.703). ILX uses its unrounded values, 116.8 and 164.0 kips (ratio 0.712). The doubler force is 1.4 percent higher (52.1 vs 51.4 kips LRFD) and the required longitudinal weld length 1.60 vs 1.50 in. **Effect:** None on the result. The doubler welds (8 in. each side beyond the cope plus the 6 1/2 in. end weld) are far stronger than needed. Every other Solution C and D value matches within tolerance. Test record: D18 II.A-6 C computes the doubler force from rounded intermediate strengths, F = φFy tp dp × (116 / 165) = 51.4 kips; ILX carries the unrounded 116.8 / 164.0 kips (ratio 0.712 vs 0.703), so F is 1.4 % higher and the required weld length 1.60 vs 1.50 in. (conservative, rounding only).
D11	**Single-angle eccentricity** (Method difference (open decision)). II.A-28A; 6 rows. For an all-bolted single angle, AISC ignores eccentricity on the beam leg (Manual Fig. 10-15) and uses a tabulated coefficient on the support leg. ILX applies the actual eccentricity to each leg. The two methods split the eccentricity between the legs differently. **Effect:** The governing strength agrees within 0.3 % (54.8 vs 55.0 kips), but ILX finds it on the other leg. Whether ILX should adopt the Fig. 10-15 simplification is an open engineering decision. Test record: D11 single angle: AISC uses Table 10-11 C = 3.07 (tabulated at e = 2½ in.) for the support leg and neglects eccentricity on the 4-in. beam leg (Manual Fig. 10-15); ILX solves e = g + tw/2 = 1.90 in. on the support leg and applies e = a on the beam leg (method difference).
D12	**Beam-web top-bolt edge distance** (Conservative assumption in the source). II.A-28A; 2 rows. AISC conservatively uses a 1-1/4 in. edge distance for the top bolt in the beam web; the drawn distance is 1-1/2 in., and ILX uses the drawn value. **Effect:** ILX's per-bolt value is higher (19.2 vs 14.8 kips). It does not govern. Test record: D12 AISC conservatively uses le = 1¼ in. for the beam-web top bolt; the actual lev is 1½ in.
D17	**Length of the weld return on a welded single angle** (Method difference). II.A-29; 6 rows. Example II.A-29 welds the 3 in. leg of an L4x3x3/8 to the column with an L-shaped fillet: a vertical weld along the toe and a return across the top of the leg. AISC enters Manual Table 8-10 with a return of kl = 4 in. (k = 0.348), the width of the other leg. ILX runs the return across the welded leg itself, kl = 3 in. (k = 0.261, a = 0.250), which is the weld that can physically be made on that leg. The weld coefficient barely changes (C = 2.20 in ILX, 2.19 in the example), so the weld strength matches the published 56.7 / 37.8 kips within tolerance. **Effect:** The three intermediate weld-geometry rows (kl, k, a) differ; the weld coefficient, the weld strength, the governing limit state and the conclusion all match the example. Test record: D17 AISC II.A-29 takes the weld return kl = 4 in. (k = 0.348) although the 3-in. leg of the L4×3×3/8 is welded to the column; ILX returns the weld across the welded leg's width, kl = 3 in. (k = 0.261, a = 0.250). The weld group coefficient is nearly insensitive to this (C = 2.20 vs. 2.19, both rows below pass).
A1	**Double-angle Welds A evaluated at the true load angle** (Method difference). II.A-2B; 1 row. In II.A-2B the welds joining the angles to the beam web carry shear and axial tension together, so the load acts at 38.7 degrees. AISC reads the weld coefficient from Manual Table 8-8 at 30 degrees, the nearest tabulated angle below, which it notes is conservative, and prints 175.5 kips for the 3/16 in. welds. ILX solves the weld group by the instantaneous-center method at the real angle and gets 180.2 kips. At 30 degrees ILX reproduces the table coefficient (C = 2.69, component benchmark), so the difference is only the angle. **Effect:** ILX's weld strength is 2.7 % higher than the published, more conservative value. The welds are adequate either way, and a companion test confirms ILX stays within 4 % of the published value. Test record: Documented deviation: II.A-2B evaluates Welds A at 30° (Table 8-8 row) instead of the actual 38.7° load angle; the engine uses the actual angle (+2.7 %).

Code	Explanation
A2	**Double-angle block shear interaction uses the smaller axial block** (Conservative method in ILX). II.A-1B; 1 row. Under shear plus axial tension, block shear of the angles is checked by combining the shear block with the axial block. II.A-1B works out two axial tearing patterns, an L-shape (559 kips) and a U-shape (542 kips), but combines the shear block with the larger L-shape value and gets 0.0531. ILX combines it with the smaller U-shape value, the pattern that governs, and gets 0.0543. **Effect:** ILX's interaction ratio is 2.3 % higher (more conservative). The ratio is about 0.05, far below 1.0, so the conclusion is unchanged. Test record: Documented deviation: II.A-1B combines the shear block (368) with the L-shape axial block (559) although the U-shape (542) is smaller; the engine uses the smaller axial block (0.0543 vs 0.0531, +2.3 %).
E1	**End-plate weld evaluated at the true load angle** (Method difference). II.A-11B; 2 rows. In II.A-11B the fillet welds joining the end plate to the beam web carry shear and axial tension, so the resultant acts at 38.7 degrees. AISC reads Manual Table 8-4 at 30 degrees, which it says leads to a conservative result, and finds a required weld size of 2.08 sixteenths of an inch. ILX applies the directional strength increase at the real angle and needs 1.96 sixteenths. **Effect:** ILX's required weld size is about 6 % smaller, because its weld strength at the real angle is higher. The 3/16 in. weld is adequate either way and the conclusion is unchanged. Test record: E1 weld: AISC II.A-11B reads Manual Table 8-4 at 30° ("which will lead to a conservative result"); ILX applies the directional increase at the true resultant angle 38.7° (method difference, ILX is exact).
S1	**Seat bolt shear quoted from the six-bolt column of Table 10-5** (Error in the source). II.A-12A; 2 rows. II.A-12A quotes a bolt shear strength of 107 kips (LRFD) and 71.6 kips (ASD) from Manual Table 10-5 for 'Connection Type B (four bolts)'. Four 3/4 in. Group 120 bolts give 4 x 17.9 = 71.6 kips (LRFD) and 4 x 11.9 = 47.7 kips (ASD); the quoted figures are the six-bolt values in the next column of the table. ILX calculates the four bolts directly, and the next row of the comparison shows that ILX matches 71.6 / 47.7 kips. **Effect:** ILX's seat bolt strength is one third lower than the printed value, and correct for four bolts. The bolts still carry the 54.8 / 36.5 kip reaction, so the published conclusion (o.k.) is unchanged. Test record: D-S1 II.A-12A quotes Table 10-5 bolt shear 107 / 71.6 kips for 'Connection Type B (four bolts)'. Four 3/4 in. Group 120-N bolts give 4 × 17.9 = 71.6 kips (LRFD) and 4 × 11.9 = 47.7 kips (ASD); 107 / 71.6 are six-bolt values (the next Table 10-5 column). ILX is correct; the conclusion (o.k.) is unchanged.
D40	**Block shear of a plate with horizontal short slots** (Conservative (ILX)). II.A-10; 2 rows. The bent plates in II.A-10 have short-slotted holes with the long dimension horizontal. In the block shear check the tension plane runs horizontally through half a hole. AISC's hand calculation deducts the slot width (15/16 in. plus 1/16 in.) there, which is the hole size seen across a vertical plane. ILX deducts the slot length (1 1/8 in. plus 1/16 in.), which is what the horizontal tension plane actually crosses (AISC 360-22 B4.3b). The net tension area is 12 percent smaller and the block shear strength 2.9 percent lower. **Effect:** None on the result. Block shear still passes (53.4 kips available against 50.0 kips required, LRFD); plate shear rupture governs, as published. Test record: D40 block shear Ant: AISC II.A-10 deducts the slot width (15/16 + 1/16 in.) across the horizontal tension plane; the plates have short slots with the long dimension horizontal (SSLT, 1 1/8 in.), so ILX deducts the slot length per AISC 360-22 B4.3b (app/connections/skewed_bent_plate.py). ILX is conservative by 2.9 %.
DS1	**Weld length measured from the beam end, not the splice centerline** (Idealization difference). II.A-21; 6 rows. In the bolted/welded shear splice, AISC measures the top and bottom welds from the splice centerline (3 1/2 in.), although they can only start at the end of the welded beam, 1/4 in. away. ILX uses the weld that can actually be made (3 1/4 in.), so its weld group is slightly shorter and its centroid slightly farther from the bolts. **Effect:** Conservative: the weld coefficient is about 4% lower and the plate moment about 1% higher. With AISC's idealized 3 1/2 in. welds ILX reproduces every published value (separate rows). Test record: DS1 II.A-21 weld length: AISC takes the horizontal welds kl = 3½ in. from the splice centerline (k = 0.292); the welds start at the W16×31 beam end, ¼ in. from the centerline, so ILX uses the actual kl = 3¼ in. (k = 0.271). Shorter, less eccentric-resistant weld group: C and the weld eccentricity differ (ILX conservative). The row below with the AISC idealization reproduces the published value.

Code	Explanation
B4	**Confined concrete area A2: equal edge offsets in DG1, geometrically similar in ILX** (Method difference). DG1-3 4.7-2; 1 row. For the plate on a 24 in. square pier in Design Guide 1 Example 4.7-2, the guide takes the confined area A2 as 24 in. by 22 in. (the plate grown by 2 in. on every side, 528 square inches). ILX uses the AISC Specification J8 definition, which the guide also states in Section 4.2: the largest area of the support that has the same shape (aspect ratio) as the plate and is centred on it, 24 in. by 21.6 in. (518 square inches). **Effect:** The bearing strength square-root factor is 1.200 in ILX against 1.211 in the guide, so ILX's bearing strength is 0.9 % lower (conservative). The bearing strength, X and the plate thickness still agree within the 1 % band; only the A2 row differs. Test record: B4 A2 by equal edge offsets: DG1 takes the pier-limited area as N2 = 24 in. by B2 = B + (24 − N) = 22 in. (A2 = 528 in.², 2 in. all round); ILX uses the AISC 360-22 J8 definition, the largest area geometrically similar to the plate (k = 24/20 = 1.2, A2 = 1.2² × 360 = 518.4 in.²), which DG1 Section 4.2 also states. √(A2/A1) 1.200 vs 1.211: ILX bearing strength 0.9 % lower (conservative).
B15	**Column web weld with a shear lug: ILX adds the rod tension from the lug moment** (Method difference). DG1-3 4.7-5; 2 rows. In Design Guide 1 Example 4.7-5 the shear lug's bearing moment puts the anchor rods, which sit between the column flanges, into tension (3.2 kips per rod). The guide checks the column web weld for the shear only. ILX also sends the rod tension into the web weld next to each rod, as it does for uplift, and rates the combined force at its actual angle, which raises the weld strength per inch. **Effect:** ILX's web weld strength per inch is 8 % higher than the guide's shear-only value because the load is partly transverse; its demand is higher too. The ILX check is slightly more conservative overall. Test record: B15 Column web weld with rods between the flanges and a shear lug: ILX adds the rod tension caused by the lug moment (3.21 / 2.05 kips per rod over b_eff = 2a) to the web weld shear and rates the resultant at its angle (kds > 1); DG1 checks the web weld for shear only (kds = 1.0, 4.18 / 2.79 kip/in.). ILX demand and capacity both higher; ratio slightly more conservative.
B22	**Web weld strength for rod tension: transverse-load increase** (Method difference). DG1-3 4.7-7; 2 rows. Design Guide 1 Example 4.7-7 rates the web fillet welds for the anchor rod tension alone, as transversely loaded (the 1.5 strength increase of AISC Equation J2-5). ILX rates the welds for the combined shear and rod tension, at the actual angle of that combined force, so it applies a smaller increase (1.41). **Effect:** ILX's web weld strength per inch is 6 % lower than the guide's (conservative). Test record: B22 Web weld strength for the rod tension: DG1 rates the web fillets for the rod tension alone with the transverse-load increase kds = 1.5 (θ = 90°, Spec. Eq. J2-5); ILX rates the resultant of the web shear and the rod tension at its own angle (θ ≈ 64°, kds = 1.41): 6 % lower capacity per inch (conservative).
B25	**Flange weld force lever arm** (Method difference). DG1-3 4.7-9; 2 rows. Design Guide 1 turns the column moment into a flange force by dividing by the column depth d. ILX divides by the distance between the flange centres, d minus the flange thickness, which is the usual assumption for a wide-flange couple. **Effect:** ILX's flange weld force is about 4 % higher (conservative); the weld strength agrees. Test record: B25 Flange weld force lever: DG1 resolves the moment into a couple over the column depth, Ru = Mu/d = 1,200/18.2 = 65.9 kips; ILX uses the flange centroid distance d − tf (Mu/(d − tf) = 68.5 kips, 3.9 % higher, conservative).
B30	**Rod tension from rounded intermediate values (DG1 3rd Ed. Example 4.7-11)** (Rounding in the source). DG1-3 4.7-11; 3 rows. The rod tension of a base plate with a large moment is T = qmax Y - P: the bearing force minus the column load, a small difference of two large numbers. Design Guide 1 rounds qmax and the bearing length Y to three digits before subtracting (for example 48.6 x 8.60 - 376 = 42.0 kips). ILX keeps every digit and gets 41.4 kips; for the trial with f = 10.5 in. the guide prints 37.1 kips and ILX 37.7 kips. The bearing length, the plate thicknesses and the per-rod force agree within 1 %. **Effect:** Rod tension 1.4 to 1.6 % from the printed value, in both directions depending on the rounding. The rods chosen in the example remain adequate. Test record: B30 Rounded intermediate values in the rod tension: DG1 computes T = qmax Y − P with qmax and Y rounded to three digits (Y itself from the rounded terms of Eq. 4-58, e.g. 21.3 − 12.7 = 8.60 in.); T is the small difference of two large numbers, so the rounding moves it by more than the 1 % band. ILX keeps every digit (Y and the plate thicknesses agree within 1 %). Trial f = 10.5 in. (LRFD): 48.6 × 8.50 − 376 = 37.1 kips; exact 48.62 × 8.509 − 376 = 37.7 kips (+1.6 %, ILX higher).

Code	Explanation
B31	**Bearing length under net uplift rounded in the source (DG1 3rd Ed. Example 4.7-12)** (Rounding in the source). DG1-3 4.7-12; 4 rows. Under net uplift with a large moment a small compression block forms under the plate. Design Guide 1 computes its length as 17.5 - 17.2 = 0.300 in., the difference of two rounded numbers, and uses the same 0.300 in. for LRFD and ASD. The exact lengths are 0.274 in. (LRFD) and 0.247 in. (ASD). ILX solves the same equations (4-63 to 4-66) without rounding, so its rod tension is 111.5 kips against 113 (LRFD) and 66.9 against 68.4 kips (ASD). **Effect:** ILX rod tension 1.3 % (LRFD) and 2.2 % (ASD) lower than printed; the printed values are slightly conservative. Same method. Test record: B31 Rounded subtraction in the bearing length (net uplift with bearing, Eqs. 4-63 to 4-66): DG1 takes Y = 17.5 − 17.2 = 0.300 in. for both LRFD and ASD; the exact values are 0.274 in. (LRFD) and 0.247 in. (ASD), so T = qmax Y + P is 111.5 vs 113 kips (LRFD, −1.3 %) and 66.9 vs 68.4 kips (ASD, −2.2 %). ILX solves the same equations (its uniform-stress solution with P < 0); published values conservative.
B32	**Strong-axis bearing length rounded in the source (DG1 3rd Ed. Example 4.7-14)** (Rounding in the source). DG1-3 4.7-14; 4 rows. In step 3 of the biaxial example (strong-axis moment alone), Design Guide 1 takes the bearing length as 12.5 - 10.8 = 1.70 in. The exact value is 1.654 in. Because the rod tension T = qmax Y - P is a small difference, that rounding raises the printed tension from 12.4 to 15.2 kips (7.60 instead of 6.19 kips per rod) and the tension-side plate thickness from 0.354 to 0.392 in. ILX keeps every digit. **Effect:** Printed rod tension 23 % higher than the exact value: conservative. The example's anchor and plate selections are unaffected (bearing-side plate thickness agrees). Test record: B32 Rounded subtraction in the bearing length: DG1 takes Y = 12.5 − 10.8 = 1.70 in.; the exact strong-axis value is 1.654 in., so T = qmax Y − P = 12.4 kips vs 15.2 (published 23 % conservative), 6.19 vs 7.60 kips per rod, and the tension-interface tp,req 0.354 vs 0.392 in. ILX keeps every digit.
B43	**Rod tension from a rounded bearing length (DG1 Example 6.4-1)** (Rounding in the source). DG1-3 6.4-1; 2 rows. The guide rounds the bearing length to Y = 4.80 in. (the exact value is 4.789 in.) and then calculates the rod tension as qmax x Y - Pu = 88.4 x 4.80 - 376 = 48.3 kips. ILX keeps the exact length and gets 47.4 kips. The bearing length itself agrees within 0.3 %. The required reduced rod area that follows from it (Tu divided by n x 0.9 x Fy) is 0.320 sq in. against the printed 0.325 sq in. for the same reason. **Effect:** ILX's rod-group tension is 1.7 % (0.9 kip) and the required reduced rod area 1.6 % lower than printed, only because of the rounding. The example's design (0.750 in. reduced diameter) is unaffected. Test record: B43 Rounding in the source: DG1 rounds Y = 4.789 in. to 4.80 in. before Tu = qmax Y − Pu = 88.4 × 4.80 − 376 = 48.3 kips; the exact Y gives 47.4 kips (−1.7 %). Y itself agrees within 0.3 %.
B44	**Column web weld length: k-region excluded** (Method difference). DG1-3 6.4-1b; 2 rows. Design Guide 1 Example 6.4-1 welds the column web over the depth less twice the design k distance (9.70 in. a side). ILX uses the Manual T dimension, the flat part of the web between the detailing k distances (9.13 in. a side), because a fillet cannot run into the fillet region; Design Guide 1 Example 4.7-5 does the same. **Effect:** ILX's web weld length is 6 % shorter and the required weld size 6 % larger (conservative). Test record: B44 Web weld length: this example welds the web over d − 2kdes = 9.70 in. per side; ILX uses the Manual T dimension (d − 2kdet = 9.13 in.), as DG1 Example 4.7-5 does, because the fillet cannot run into the k region. ILX weld length 6 % shorter, Dreq 6 % larger (conservative).
EB1	**Type II Scenario 3 (stirrups) not modeled** (Method difference). HK2023-4, HK2023-5; 2 rows. Tests 4 and 5 of Hassan and Kanvinde (2023) have U-bar hairpins and extra vertical stirrups in the footing. The paper adds a vertical-bearing moment from shear friction across the cracked concrete (its Eqs. 14 to 19), which needs a crack width computed from steel and concrete strains the paper does not state. ILX does not model this Scenario 3 and takes the vertical-bearing moment as zero, as for bars without stirrups (Scenario 2). The horizontal-bearing part, MHB, is the same model as the other rows. **Effect:** ILX's strength is 11 % (Test 4) and 16 % (Test 5) below the paper's model strength: conservative. Test record: EB1 Scenario 3 (attached hairpins with vertical stirrups): the paper's MVB from shear friction across the cracked interface (Eqs. 14-19) needs the crack width from the bond-slip strains, which it does not state; ILX takes MVB = 0 (Scenario 2), the conservative bound, and reproduces MHB only.

Code	Explanation
B50	**Brace force components rounded before the base-plate share** (Rounding). DG29 5.12.1; 1 row. Design Guide 29 Example 5.12.1 rounds the brace components to 109 and 143 kips before computing the force the gusset delivers to the base plate, Hub = [H (β − e) − V ec] / β. That force is the small difference of two large terms, so the rounding moves it from −10.06 kips (ILX, from the 12 : 9⅛ bevel) to the published −9.86 kips. The required size of the gusset-to-base-plate weld follows: 1.014 sixteenths in ILX against 0.994. **Effect:** ILX's required weld size is 2 % larger (conservative). The weld is the AISC minimum size (¼ in.) either way. Test record: B50 Rounded H and V: DG29 Ex. 5.12.1 rounds the brace components to Hu = 109 and Vu = 143 kips before Hub = [H (β − e) − V ec] / β, a small difference of two large terms (1,349 − 1,530 kip-in.); ILX carries H = 108.95 and V = 143.28 kips from the 12 : 9 1/8 bevel, so Hub = −10.06 kips (published −9.86, within the 0.5 kip band) and the base weld Dreq = 1.014 sixteenths against 0.994 (+2 %). Both welds are the J2.4 minimum either way.
R1	**Bracket plate free-edge buckling: rounded intermediate values** (Rounding). II.A-22; 4 rows. For the bolted bracket plate, AISC rounds the width of Section B-B to 12.1 in. and the slenderness to 1.68 before it calculates the buckling stress. ILX keeps every digit (12.127 in., 1.686), so its buckling stress and normal-force strength come out about 1 % lower, just outside the 1 % band. **Effect:** None on the result. The interaction check that uses these values agrees within 0.5 % (0.868 against 0.864), and the plate is adequate in both. Test record: R1 intermediate rounding: AISC rounds b' = 12.1 in. and λ = 1.68 before Q = 1.30/λ² and Fcr = Q Fy (23.1 ksi, Nc = 94.5 kips); ILX carries b' = 12.127 in., λ = 1.686, Fcr = 22.85 ksi, Nc = 93.5 kips (−1.06 %). The interaction ratio agrees within 0.5 % (0.868 vs 0.864).
BG1	**Beam web crippling at a web-connected beam end: J10-4, not the end equation J10-5** (Source disagreement). II.C-2 (V14.1); 2 rows. Design Example II.C-2 (V14.1) checks web crippling of the beam under the gusset with the beam-end equation J10-5b, because the force starts less than d/2 from the beam end, and prints 853 kips. The AISC 360-22 Commentary to J10.3 (p. 16.1-514) says J10-5a/b are meant for beam ends whose web is not supported, and that J10-4 should be used where the beam end has a web connection. Design Guide 29 does the same in Examples 5.1, 5.4, 6.1a and 6.1b. In a bracing joint the beam web is always connected to the column, so ILX now uses J10-4 and gets 1,381 kips. **Effect:** ILX's crippling strength is 62 % higher than II.C-2 and matches Design Guide 29 (766, 249, 1,210, 969 kips). The option 'Beam end at the column: web unsupported' keeps J10-5 and reproduces the 853 kips of II.C-2 (companion row). Test record: BG1 AISC sources disagree on beam web crippling at a web-connected beam end: V14.1 II.C-2 (p. IIC-35) uses the end equation J10-5b (x < d/2 from the beam end), φRn = 853 kips (ASD 570). ILX uses J10-4 because the beam web is connected to the column: AISC 360-22 Commentary J10.3 (p. 16.1-514) states that J10-5a/b are intended for beam ends whose web is not supported and that J10-4 should be used where the beam end connection is a web connection, and AISC Design Guide 29 does the same in Ex. 5.1, 5.4, 6.1a and 6.1b. ILX J10-4: 1,381 kips (ASD 921), +62 %. The V14.1 value is reproduced with beam_end = 'unsupported' (companion row).
BG2	**Whitmore section: position of the brace end** (Geometry difference). DG29 5.1, DG29 6.1a; 6 rows. The Whitmore width (lw = w + 2 l tan 30°) is the same in ILX and Design Guide 29, but which part of it lies in the gusset, in the beam web or outside depends on where the brace end sits. ILX places it by the 'brace clearance' input; the guide places it by its own detailing (an end plate in 5.1, the 2t clearance in 6.1a). Like the guide, ILX counts the part that enters the beam web at the web thickness and the web's Fy. **Effect:** ILX's Whitmore strength is 9 % (5.1) and 14 % (6.1a) lower than published (conservative); the 5.1 buckling row, where KL/r < 25 gives Fy times the same area, is 6 % lower. The section sits at the bolt row or weld end nearest the work point in both (fixed at the source in the shared gusset routines). Example 6.1b, where the brace position matches, agrees within 1 %. Test record: BG2 Whitmore section geometry: ILX places the brace end by the `gap` clearance and welds the gusset directly to the column with the given setback; DG29 places the brace by its own detailing (Ex. 5.1: end plate, 6.1a: 2t clearance and pull-off). The Whitmore width is the same (lw = w + 2 l tan 30°) but the part that falls outside the gusset or into the beam web differs: Ex. 5.1 counts 19.1 in. of gusset and 4.70 in. of beam web (Aw = 21.5 in.², φRn = 968 kips); ILX's brace end sits so that 4.47 in. enters the beam web and 2.05 in. falls in the column setback, Aw = 19.6 in.², φRn = 881 kips (−9 %, conservative).
BG3	**Beam-to-column axial force without frame action** (Conservative method in ILX). DG29 5.1; 2 rows. Example 5.1 reduces the beam-to-column axial force by the distortional (frame-action) force HD = 55.9 kips: Hc − HD + A = 220 kips. ILX has no bay and story inputs and designs for |A| + Hc = 276 kips. **Effect:** ILX's required axial force is 25 % higher (conservative). Test record: BG3 beam-to-column axial force: ILX designs for |A| + Hc in every case (conservative); DG29 Ex. 5.1 adds the frame-action (distortional) force, Hc − HD + A = 176 − 55.9 + 100 = 220 kips (Tamboli 2010, DG29 Eqs. 4-12 to 4-16, research/44 G17/G18). ILX: 276 kips (+25 %).

Code	Explanation
BG4	**Whitmore buckling length, gusset connected to the beam only** (Geometry difference). DG29 5.4; 4 rows. For a gusset connected to the beam only (special case 3) ILX and Design Guide 29 both use K = 1.2 with the centre-line length from the Whitmore section to the gusset edge. The guide shapes the gusset's free edge toward the brace and scales 6½ in. from its drawing (5.4); ILX measures to the edge of its rectangular gusset with the brace placed by the clearance input, which gives a longer line (7.78 in.). Corner gussets now follow the guide exactly (K = 0.5 with the centre line, measured to the beam and column lines, plus Dowswell's check when the gusset is not compact); 6.1b agrees within 1 %. **Effect:** In 5.4 ILX is 4 to 7 % lower (conservative). Before the Design Guide 29 update ILX averaged three lines and was 6.6 % high in 6.1b; that is fixed. Test record: BG4 special case 3 buckling length: ILX uses DG29's K = 1.2 with the centre line l1 from the Whitmore section to the edge of its rectangular gusset; DG29 Ex. 5.4 (Fig. 5-10) shapes the gusset's free edge toward the brace and scales l1 = 6½ in. to that edge, with the first bolt 24 in. from the w.p. (ILX places the brace by `gap`). Ex. 5.4 L = 6½ in. (K = 1.2): 96.5 kips (n.g.); ILX l1 = 7.78 in.: 90.0 kips (−6.7 %, conservative; also n.g.).
BG5	**Standard hole for a 1 in. bolt: 1-1/16 in. (360-10) vs 1-1/8 in. (360-22)** (Edition difference). DG29 5.11, DG29 5.5, DG29 6.1a, DG29 6.1b; 22 rows. Design Guide 29 uses the 360-10 standard hole of 1-1/16 in. for 1 in. bolts. AISC 360-16 and 360-22 Table J3.3 use 1-1/8 in., which reduces net areas, tearout and block shear. ILX uses the current hole. **Effect:** The clip-angle shear rupture of Example 5.5 is 2 % lower, and the single-plate shear rupture of Example 6.1b (gusset-to-column and beam-to-column plates) and the beam-to-column plate tension rupture about 3 % lower. The W-brace rows of Examples 5.5 and 5.11 are now computed: the WT splice block shear is 3.2 % lower (490 against 506 kips), the WT rupture, the brace and gusset block shear and the gusset-side bolts 1.4 to 3.3 % lower, and the moment-release splice bolt group of Example 6.1a 3.9 % lower (66.4 against 69.1 kips). All conservative, per the current Specification. Test record: BG5 1 in. bolts: DG29 (360-10) uses the 1-1/16 in. standard hole; 360-22 Table J3.3 gives 1-1/8 in., so the net shear area is smaller: Anv = 14.0 − 9 (1⅛ + 1⁄16)(0.360) = 10.2 in.² (DG29 10.4), Ant 1.37 (1.40): 365 kips, −2.2 %.
BG6	**1.25 ductility factor on every interface weld** (Conservative method in ILX). DG29 5.8; 2 rows. ILX applies the Manual Part 13 weld ductility factor of 1.25 to every gusset interface weld. In Example 5.8 the force on the flat bar's weld is uniform and statically determinate, so Design Guide 29 leaves the factor out and reads Manual Table 8-4. **Effect:** ILX's required weld size is 25 % larger (conservative). Test record: BG6 interface weld: ILX applies the Manual Part 13 1.25 ductility factor to every gusset interface weld; DG29 omits it for a uniform, statically determinate force (Ex. 5.8, p. 183) and checks that weld with Manual Table 8-4 (C = 4.37 at 30°). ILX Dreq is 25 % larger (conservative).
BG7	**Web local yielding: J10-3 instead of J10-2 when the edge centroid is beyond d** (Conservative method in ILX). DG29 6.1a; 2 rows. Example 6.1a measures the distance from the beam end to the centroid of the gusset edge (18.1 in., more than the beam depth of 17.0 in.) and uses J10-2 with 5k. ILX measures it to the start of the gusset edge and uses J10-3 with 2.5k. **Effect:** ILX's web yielding strength is 9 % lower (conservative). Test record: BG7 web local yielding equation: ILX uses J10-3 (force within d of the beam end) with the distance from the beam end to the start of the gusset edge; DG29 Ex. 6.1a measures it to the edge centroid $\bar{a}$ = 18.1 in. > d = 17.0 in. and uses J10-2 (5k): 1,210 kips. ILX J10-3: 1,103 kips (−9 %, conservative).
BG8	**Weld strength at the actual load angle (no table rounding)** (Method difference). DG29 5.11; 4 rows. Example 5.11 reads Manual Table 8-4 at the tabulated angle below the actual one, which the guide notes is conservative: 15° for the gusset-to-vertical weld (actual 20.9°) and 30° for the tab-to-chord weld (actual 42.8°). ILX computes the directional strength increase at the actual angle (AISC 360-22 J2.4(a)(1)), with the same 1.25 factor on the gusset weld and none on the tab weld, as the guide. **Effect:** ILX's required weld size is 4 % (gusset to vertical) and 8 % (tab to chord) smaller than published; it is the exact value of the same method. The tab bolt group, also read from a table at 30°, agrees within 0.5 % (C = 19.5 at 42.8° against 19.6). Test record: BG8 weld directional strength: DG29 Ex. 5.11 reads Manual Table 8-4 at the next lower tabulated angle (15° for θ = 20.9°, C = 3.96), which it notes is conservative: Dreq = 5.76 (ASD 5.70). ILX evaluates 1 + 0.50 sin^1.5 θ at the actual angle (J2.4(a)(1)) with the same 1.25 factor: 5.53 (ASD 5.51), −4 %.

Code	Explanation
BG9	**Slotted rectangular HSS shear lag: $\bar{x}$ of the half section (360-22)** (Edition difference). DG29 6.1a, DG29 6.1b; 4 rows. Example 6.1b (360-10) takes $\bar{x}$ = (B² + 2BH) / 4(B + H) = 3.00 in. for the slotted HSS8X8X½, U = 0.75. AISC 360-22 Table D3.1 uses the centroid of the half section beside the gusset, 2.67 in., U = 0.777, as ILX does for Design Example D.4. **Effect:** ILX's brace rupture strength is 4.2 % higher (439 vs 421 kips), per the current Specification. In the seismic Example 6.1a the guide extends its formula to the net-section reinforcing plates ($\bar{x}$ = 3.35 in., Ae = 20.7 in.²); ILX adds the plates to the 360-22 half section ($\bar{x}$ = 3.11 in. from the gusset face) and gets Ae = 21.0 in.² (+1.4 %). Both are well above Ag = 16.4 in.². Test record: BG9 slotted rectangular HSS shear lag, edition: DG29 (360-10) uses Table D3.1 Case 6 $\bar{x}$ = (B² + 2BH) / 4(B + H) = 3.00 in., U = 0.75, Ae = 9.68 in.², φRn = 421 kips (ASD 281); 360-22 Table D3.1 takes $\bar{x}$ of the half section beside the gusset (ILX tension_member, as for Design Example D.4): $\bar{x}$ = 2.67 in., U = 0.777, Ae = 10.09 in.², 439 kips (ASD 293), +4.2 %. With the two 1¼ × 4 plates DG29 extends its Case 6 formula: $\bar{x}$ = 3.35 in. from the brace centre, U = 0.824, Ae = 20.7 in.²; ILX takes the 360-22 half section from the gusset face ($\bar{x}$ 2.47 in., the plates at 4.13 in.): $\bar{x}$ = 3.11 in., U = 0.837, Ae = 21.0 in.² (+1.4 %). Both exceed Ag = 16.4 in.² (AISC 341-16 F2.5b(c)).
BG16	**Design Guide 29 Example 5.4 bolt group: inner bolt bearing** (Error in the published example). DG29 5.4; 2 rows. With the ½ in. trial gusset, the guide takes the inner bolt at its shear strength of 48.7 kips after comparing it only with 1.2 lc t Fu = 53.8 kips. The bearing limit 2.4 d t Fu on the ½ in. gusset is 45.7 kips, a value the guide prints for the end bolt. ILX takes it, which gives 113 kips instead of 116. **Effect:** ILX's bolt group strength is 2.6 % lower. The bolts are adequate either way. Test record: BG16 DG29 Ex. 5.4 bolt group (p. 102, ½ in. gusset trial): DG29 adds the gusset end-bolt tearout 26.9, the inner bolt 48.7 (bolt shear, after comparing it with 1.2 lc t Fu = 53.8 only) and the brace end-bolt tearout 40.3 = 116 kips (ASD 77.3). The inner bolt's bearing on the ½ in. gusset is capped by 2.4 d t Fu = 0.75 × 60.9 = 45.7 kips < 48.7, which DG29 itself prints for the end bolt; ILX takes it: 26.9 + 45.7 + 40.3 = 113 kips (−2.6 %). The bolts are adequate either way (100 kips).
BG18	**Interface weld with a moment: elastic moment stress** (Conservative method in ILX). DG29 5.7; 2 rows. With a moment on the gusset-to-beam weld, ILX takes the moment stress as the elastic 6M / (n L²) before applying max(peak, 1.25 average). Design Guide 29 Appendix B (Hewitt-Thornton) uses N ± 4M/L. **Effect:** ILX's required weld size is 4.8 % larger in Example 5.7 (conservative). The guide's own alternative methods give 11 to 13 % more than its Appendix B value. Test record: BG18 interface weld with a moment: ILX (gusset_core.interface_weld) takes the moment stress on the weld as the elastic fb = 6M / (n L²) under max(f_peak, 1.25 f_avg); DG29 App. B (Hewitt-Thornton) uses the equivalent normal N ± 4M/L: Ex. 5.7 Dreq = 2.81 (ASD 2.83). ILX 2.94 (+4.8 %, conservative; DG29's own alternatives give 3.13 and 3.18).
BG19	**Column web bearing at a one-sided beam-to-column connection** (Conservative method in the published example). DG29 5.8; 2 rows. Example 5.8 checks the bolts of the beam-to-column angles on a column web with half the web thickness, assuming the same connection and load on the other side of the web. ILX's double-angle engine uses the full web for a one-sided connection, and for back-to-back connections checks each shared bolt for both reactions (Design Example II.A-8). **Effect:** ILX's bolt group strength is 128 kips against the guide's 104 (+23 %); both exceed the 80.5 kips required. Use the double-angle type with back-to-back connections when there is a beam on the other side. Test record: BG19 column web bearing at the beam-to-column angles: DG29 Ex. 5.8 (p. 186) halves the column web (2.4 d (tw / 2) Fu = 18.4 kips per bolt), assuming the same connection and load on the other side of the web: 2 (15.3) + 4 (18.4) = 104 kips. ILX takes the full web for a one-sided connection (36.9 > bolt shear 24.3 kips): 2 (15.3) + 4 (24.3) = 128 kips (+23 %); with back-to-back connections (web_both = shared) ILX checks the web per bolt under both reactions (Design Example II.A-8).
BG20	**Single-plate block shear path (Example 6.1b)** (Error in the published example). DG29 6.1b; 2 rows. Example 6.1b takes the shear plane of the beam-to-column single plate over the full 12½ in. plate length (9.00 + 3½ in.), with the 1-1/16 in. hole of AISC 360-10. The block from the top edge of the plate to the bottom bolt row is 9.00 + 1¾ = 10.75 in. ILX's single-plate engine uses that length and the 1-1/8 in. hole of AISC 360-22. **Effect:** ILX's block shear strength is 177 kips against the guide's 206 (−14 %, conservative); the plate is adequate either way (148 kips required). Test record: BG20 single-plate block shear path: DG29 Ex. 6.1b (p. 340) takes the shear plane over the full plate length 9.00 + 3½ = 12.5 in. (3.5 holes, 1-1/16 in. holes, Ubs = 0.5): Rn = 183 kips, ¾ in. by ratio 206 kips (ASD 137). The block from the top edge to the bottom bolt row is 9.00 + 1¾ = 10.75 in.; ILX (single_plate engine, 1-1/8 in. holes, the two bolt lines) gives 177 kips (ASD 118), −14 %, conservative.

Method notes

From docs/VERIFICATION_MANUAL.md. Sections 4 to 6 of the manual are the tables above, regenerated from the tests.

1. Purpose and scope

This manual shows how ILX's single-plate and single-angle calculations compare with complete published design examples, limit state by limit state, for LRFD and ASD. Its model is the per-example comparison pages SDS2 publishes. Every number in §4 to §6 is generated by the test code, not typed.

What is verified

The limit states the published examples compute, so far as ILX implements them:

- **Bolts:** bolt shear; bearing and tearout per ply; eccentric bolt groups (IC; C and C′).
- **Plate and angle:** shear yielding, shear rupture, block shear (shear direction, axial U and L shapes, and their interaction), tension yielding and rupture, flexural yielding and rupture (conventional and extended), the Manual Eq. 10-8 / 12-2 / 12-3 interactions, tmax, buckling λ, and compression (Lc = K a).
- **Beam:** web shear (uncoped and coped), coped-web shear rupture and block shear, coped-beam flexure (Dowswell 2018), tension yielding and rupture under axial load (shear lag U).
- **Support and welds:** weld sizing (5/8 tp), support tmin (3.09 D/Fu), support shear rupture along the weld, and the column-web yield line (Manual Eq. 9-45).
- **Geometry:** Table 10-9 eccentricity and thickness rules, the governing limit state, and the overall OK/NG result.

What is not verified, and why

Item	Reason
Double-coped beams (Dowswell & Whyte 2014)	No complete published example has been reproduced yet.
Prying of angle support legs under tension	No published single-angle-with-tension example found.
Slip-critical design at connection level	Only the per-plane value (Ex. J.4A) is verified.
HSS supports	Now verified (§6.HSS): K.6 covers a weld/bolt plate on a rectangular face, K.7 a through plate, and K.8 a round HSS (weld/weld, local HSS strength only). There is no published HSS example with axial load on a rectangular wall, and bolted angles are not allowed on HSS.
Structural integrity (B3.9), rotation capacity	No published numeric example.
Limit states ILX does not check	Listed as coverage gaps in §9 (single plate / single angle; the other types' gaps are in §6C).

Intended use

ILX is a design aid. The engineer of record remains responsible for the design and for judging whether these comparisons are adequate (NCEES responsible charge).

2. Method

1. **Benchmark comparison.** Each published example is mapped field by field onto `SinglePlateInput`. The mapping is in the `Case` definitions of `test_verification_examples.py`; the published inputs are in research/09.
   - The **main model uses the drawn geometry**. Where AISC deliberately applies a ¼ in. beam-length underrun to one limit state, only that row is run with the reduced `Leh_beam`, and the row says so.
   - Each published quantity is read from the ILX check capacity, its demand, or a named calculation step (for example, the nominal per-bolt bearing step, multiplied by φ = 0.75 or divided by Ω = 2.00).
2. **Component benchmarks.** IC coefficients (Tables 7-6, 7-7, 8-4, 8-8, 8-10), bearing and tearout per inch (Tables 7-4 and 7-5), lc along the resultant (II.A-1B), slip (J.4A, J3.9) and the Table 10-9 rows (`test_verification_components.py`).
3. **Consistency.** Every example is also run in SI units, and every check must match its US value (§7).
4. **Robustness.** Property-based fuzzing with Hypothesis (§8).

Acceptance criteria

Quantity	Tolerance	Rationale
Force	±1 % or ±0.5 kip, whichever is larger	Published values are printed to 3 significant figures (rounding ≤ 0.5 %).
Moment	±1 %	Same.

Quantity	Tolerance	Rationale
Length or thickness	±1 % or ±0.005 in.	Same.
Coefficient (C, C′, Snet, k, λ)	±1 %	The IC solution is compared with interpolated Manual tables; the audit (research/08 §6) allowed 3 %, and all components meet 1 %.
Interaction ratio	±2 % or ±0.005	Ratios are built from rounded intermediate values.
Angle	±0.1°	
Exceptions	Documented in the row	Muir & Hewitt Mmax and tmax: ±1.2 % (code-edition note D13).

Status codes

Status	Meaning
PASS	Within tolerance.
DEVIATION (Dn)	Outside tolerance. The cause is analysed in §9. The test is a strict expected failure, so it turns red when the behaviour changes.
NOT CHECKED (gap)	ILX does not compute this limit state (coverage gap, §9). Also a strict expected failure, so it turns red once implemented.

Each example also has three result-level tests:

- `test_governing_limit_state`: ILX's highest-ratio strength check is the published governing limit state, or is tied with it within the 1 % force tolerance (§9).
- `test_connection_capacity`: ILX's strength for that limit state matches the published value.
- `test_overall_result`: ILX's OK/NG matches the published conclusion, and when the published result is NG, it is NG for the published reason.

7. SI / US consistency

For every example and method (`test_si_matches_us`, 22 cases), the inputs are converted to SI (mm, kN) and run again. Every check's capacity and demand must match the US run to within 10^{-6} relative, and every pass/fail must agree. **Result: all 22 pass.**

The existing property test `test_si_and_us_give_the_same_result` in `test_backend_fuzz.py` makes the same comparison over 60 random geometries.

8. Fuzz robustness summary

`tests/test_backend_fuzz.py` drives `/api/design` with Hypothesis-generated inputs:

- **"Never 500" properties:** random inputs and plausible inputs never produce a server error.
- **Result properties:** strength ratios are non-negative for every plate configuration, and SI equals US.
- **Edge cases:** single bolt; a beyond the angle leg; two support columns; SI defaults.

Property test	Examples	Result
`test_random_inputs_never_500` (any field, any value)	150	pass; no HTTP 500
`test_plausible_inputs_never_500` (engineering ranges, all configurations)	150	pass
`test_plate_configurations_strength_ratios_nonnegative`	150	pass
`test_si_and_us_give_the_same_result`	60	pass
Deterministic edge cases (single bolt, a beyond the leg, two support columns, SI defaults, SI round trip)	5	pass

Run time: 114 s (`pytest tests/test_backend_fuzz.py --hypothesis-show-statistics`); 9 tests, 0 failures.

9. Known deviations and coverage gaps

Issue 0.4-B (2026-10-24) resolved D1 to D8 and the coverage gaps G1 to G3 in `backend/app/connections/single_plate.py`. Their rows now pass, and their strict expected failures have been removed. Every remaining deviation is a method difference that AISC permits, or an error or edition difference in the source.

Resolved in issue 0.4-B

#	Deviation	Source text (Design Examples v16.0 unless noted)	Change	Before → after (LRFD)
D1	Default bolt-group method	II.A-17A, p. IIA-172: "The available shear transfer strength at bolt holes is the sum of the effective strength of individual bolts per the User Note in AISC *Specification* Section J3.7, which is the least of (1) … bolt shear …, (2) … bearing or tearout strength of the plate …, and (3) … of the beam web." p. IIA-174: "the available shear transfer strength is multiplied by the factor C/n".	`bolt_group_method` now defaults to `"sum"`: Rn = (C/n) Σ rn,i. `"min"` (Muir & Thornton 2011, conservative) and `"split"` stay as options. The M&T 2011 and M&H 2009 cases run with `"min"`, which is the papers' own method.	II.A-17A bolt group 43.9 → 58.7 kips (AISC 58.5); overall NG → **OK**.
D2	Support tmin	II.A-17A, p. IIA-175 (one plate, welds on both faces): "tmin = 3.09D/Fu (*Manual* Eq. 9-6) = 0.143 in." The same applies in II.A-18 and II.A-19A (0.238 in.). II.A-17B/19B: support shear rupture Anv = (2 shear planes) l t.	tmin = nf × rw / (0.6 Fu): nf = 1 (3.09 D/Fu, each weld line has its own shear plane); nf = 2 (6.19 D/Fu) only when connections frame into both faces of a web.	II.A-19A 0.476 → 0.238 in.
D3	Conventional plate under axial load	II.A-17B, pp. IIA-185 to 188: "Mu = Vu e = (75 kips)(2½ in.) = 188 kip-in.", then Manual Eq. 12-2 [Nu/(2φRnp) + Mux/φMnx]² + (Vu/φRnv)² for the yield check and, "Because Nu/φRnp > 0.2, use AISC *Manual* Eq. 12-3", for the rupture check.	Mr = Vr e (bolt-group eccentricity) enters both interactions, through the shared Part 12 function `_interaction_12`.	Yield 0.153 → 0.182 (AISC 0.181); rupture 0.359 → 0.502 (0.500).
D4	Extended plate interaction	II.A-19B, pp. IIA-221 and 223: "Because Pr/Pc < 0.2, use AISC *Manual* Equation 12-2" for both yield (0.246) and rupture (0.592).	Eq. 12-2 when Pr/Pc < 0.2 and Eq. 12-3 otherwise. Without axial load this reduces to Eq. 10-8 (II.A-19A, 0.200).	0.303 → 0.247; 0.721 → 0.591.
D5	Plate compression length	II.A-19B, p. IIA-229: "Lc/r = KL/r = 1.2(9¾ in.)/(¾ in./√12) = 54.0".	Lc = K a, with a measured from the support to the first beam-side connection line.	381 → 410 kips (AISC 410).
D6	Column-web yield line (was unconservative)	II.A-19B, p. IIA-227/228: "w = d − 2kdes = 11.4 in.; a = d/2 − kdes + tw/2 = 5.90; b = d/2 − kdes − tw/2 − tp = 4.73; c = tp; Rn = (tw² Fy/4)[4√(2wab(a+b)) + l(a+b)]/(ab) (*Manual* Eq. 9-45) = 42.4 kips; φ = 1.00 … 42.4 kips < 60 kips **n.g.**"	Column webs use Manual Eq. 9-45 with φ = 1.00 and Ω = 1.50. The plate (or angle leg) starts tw,beam/2 off the column centreline; for an angle, c is the bolt-line spread and l = (n − 1) s in tension. Girder webs keep the longitudinal-plate mechanism, which is flagged as approximate because the Manual gives no equation for an element perpendicular to the flanges. HSS walls are unchanged.	φRn 70.0 → 42.3 kips (AISC 42.4). II.A-19B is now **NG because of the column web** (ratio 1.418), the published reason.
D7	Leh ≥ 2d in the extended configuration	II.A-17A, p. IIA-175 (conventional): "The horizontal bolt edge distance on the plate and beam web must be greater than or equal to 2d." II.A-19A, p. IIA-205 (extended, leh = 1¼ in. < 2d): "Note: All dimensional limitations are satisfied."	`leh_2d_p` and `leh_2d_b` apply to the conventional configuration only. In the extended configuration, Leh ≥ 2d enters only the Muir & Hewitt tmax exemption.	II.A-19A geometry NG → OK.
D8	Fy Z ≤ Fu Znet ductility rule	II.A-19A, pp. IIA-207 and 211/212: ductility is "the maximum plate thickness, tmax, that will result in the plate yielding before the bolts shear" (Manual Eqs. 10-6/10-7). Flexural yielding (810) and flexural rupture (624 kip-in.) are checked as separate strength limit states, with Fy Z = 900 > Fu Znet = 832 kip-in., and the connection "is found to be adequate".	`plate_yield_rupture` is now a recommendation, shown but not counted in the result.	II.A-19A and II.A-28A overall NG → **OK**.
G1	Support shear rupture along the weld	II.A-17B, p. IIA-183: "Anv = (2 shear planes) l tf = 20.6 in.²; Rn = 0.60 Fu Anv = 803 kips". II.A-19B, p. IIA-227: "Anv = 2 l tw = 13.2 in.², φRn = 386 kips > 96.0 kips".	New `support_shear_rupture` check: φ 0.60 Fu (2 l t) against the resultant, with t/2 when connections frame into both sides of a web.	602 / 386 / 269.1 kips (II.A-17B / II.A-19B / SDS2 II.A-18): PASS.
G2	Beam tension under axial load	II.A-17B, p. IIA-192: "U = (d − 2tf) tw / Ag = 0.407 … the minimum value of U is the ratio of the gross area of the connected element to the member gross area." II.A-19B, pp. IIA-217/218: "U is determined from AISC *Specification* Table D3.1, Case 2 … x̄ = Zy/A = 1.17 in.; U = 1 − x̄/l = 0.610".	New `beam_tension_yield` (Fy Ag) and `beam_tension_rupture` (Fu An U, with U = max(1 − x̄/l, Aw/Ag)) checks for P > 0. Coped beams use the reduced section and U = Aw/Ag.	662 / 256 kips (II.A-17B) and 792 / 450 kips (II.A-19B): PASS.
G3	Plate flexure, conventional configuration	II.A-17B, p. IIA-185: "Mn = Fy Zx ≤ 1.5 Fy Sx … φMn = 1,180 kip-in.", with F11.2 lateral-torsional buckling at Cb = 1.84 and Lb = a. II.A-17B, p. IIA-188: "Mn = Fu Znet (*Manual* Eq. 9-8) … φMn = 840 kip-in."	New `plate_flexure_conv` (F11 with Lb = a, Cb = 1.84) and `plate_flex_rupture_conv` (Fu Znet) checks, with Mr = Vr e. The extended plate's Mc now also uses F11 (II.A-19A: Lb d/t² = 432, F11.2(b), Mn = Mp).	1,180 / 840 kip-in. (II.A-17B), 456 kips as φMn/e (M&T 2011), 249 kips (SDS2): PASS.

Remaining deviations (method or source differences; overall result unchanged)

#	Deviation	Examples	Cause	Effect	Action
D9	Tearout lc measured along the resultant	II.A-17B, II.A-19B	ILX ray-casts lc along the line of action of the resultant (`_clear_distance`, the II.A-1B method). In II.A-17B and II.A-19B, AISC takes the smaller edge distance less a ¼ in. underrun as a worst case, noting that "if a computer program is available, the true lc can be calculated".	Per-bolt tearout is 45 % to 126 % higher. It governs in neither example: the bolt group is controlled by shear.	None. This is a method difference that AISC permits.
D10	IC at the true load angle vs. Table 7-7 at 30°	II.A-19B	AISC interpolates Table 7-7 at 30° "conservatively"; ILX solves at θ = 38.7°. At 30°, ILX gives C = 3.517 against 3.53 (component benchmark PASS).	Bolt group 119.8 vs. 112 kips (+7 %).	None. This is a method difference, and ILX's is the more exact.
D11	Single-angle eccentricity	II.A-28A	AISC neglects e on the 4 in. beam leg (e ≤ 3 in., Manual Fig. 10-15). For the support leg it conservatively uses Table 10-11 C = 3.07, a value tabulated at e = 2½ in.; ILX gives 3.065 at that e (PASS). ILX applies e = g + tw/2 = 1.90 on the support leg (C = 3.369) and e = a = 2½ on the beam leg.	Support-leg group 60.3 vs. 55.0 (+10 %); beam-leg group 54.8 vs. 68.5 (−20 %). ILX's governing value (54.8) is within 0.3 % of AISC's 55.0, but on the other leg.	**Decide** whether to adopt the Fig. 10-15 rule.
D12	Beam-web top-bolt le	II.A-28A	AISC "conservatively" uses le = 1¼ in.; the drawn lev is 1½ in.	19.2 vs. 14.8 kips per bolt. Does not govern.	None.
D13	Code edition (A490-N Fnv)	M&H 2009	The paper used 360-05: Fnv = 60 ksi, φrv = 35.3, and 1.25 Fv in Mmax. 360-22 gives Group 150-N Fnv = 68 ksi and φrv = 40.1.	φrv +13 %; Mmax and tmax +0.9 to +1.1 % (these rows use a ±1.2 % band).	None. ILX is correct for 360-22.
D14	AISC Table 10-10c tolerance	II.A-18	The text says leh = 2¼, but the tabulated bottom-edge term back-calculates to leh = 2.0.	At leh = 2¼, ILX gives 91.8 (+4 %); at 2.0 it gives 88.1 (PASS).	None. Documented.
D15	Tearout between holes omitted in the 2009 paper	M&H 2009	Per 360-22 J3.11a, the tearout between holes (lc = s − dh) governs.	Bolt group 94.2 vs. 100.8 kips (C × min, the paper's method).	None. ILX is correct per Spec.
D16	Net-area hole allowance in the 2009 paper	M&H 2009	The paper used dh = 1⅛ in.; B4.3b requires dh + 1/16 in.	Shear rupture 212 vs. 219; block shear 345 vs. 355 kips.	None. ILX is correct.
D17	Weld return length on the welded single angle	II.A-29	AISC enters Table 8-10 with kl = 4 in. although the 3-in. leg of the L4×3×3/8 is welded; ILX returns the weld across the welded leg (kl = 3 in.).	kl, k, a differ (3.000 / 0.261 / 0.250 vs. 4.000 / 0.348 / 0.319); C = 2.203 vs. 2.19 and φRn = 56.99 vs. 56.7 kips PASS.	None. Documented.

Governing-state ties. In II.A-17A, II.A-18 and SDS2 II.A-18, AISC itself prints 58.5 kips both for the shear transfer at the bolt holes (Part A/B) and for the plate shear rupture (Table 10-10a). ILX's IC solution gives C = 3.556 against the interpolated 3.54, so its bolt group is 0.3 % higher and the plate shear rupture becomes the highest ratio. `test_governing_limit_state` accepts a published governing check whose ratio is within the 1 % force tolerance of ILX's highest ratio.

Also in M&H 2009: ILX applies the Manual 15th/16th Ed. flexural-rupture interaction, which the 2009 paper predates (ratio 1.025, NG), together with D15. The overall NG is therefore expected under the current Manual. The test records it as a strict expected failure with this explanation.

Coverage gaps (limit states the published examples check and ILX does not)

#	Limit state	Examples	Action
(resolved)	Welded-to-support single angle (bolted to the beam)	II.A-29	Now a single_angle configuration (support_side = weld, L-shaped weld by the IC method); II.A-29 is compared end to end (D17: the example's weld return kl = 4 in.). Formerly G4.
(resolved)	B3.9(c) column-bracing integrity	II.A-17C	Now checked (`brace_P`, integrity_brace / integrity_brace_note). Formerly G6.
(resolved)	All-bolted single-plate beam splice	SDS2 II.A-20	Now the `shear_splice` connection type, verified against AISC II.A-20 and II.A-21 (§6A). Formerly listed here as G5; G5 is now the seated HSS-wall gap (§6C).

Agreements worth noting

Area	Result
Plate and angle element checks	Shear yield, shear rupture, block shear (all three shapes and their interaction), tension yield and rupture, flexural yield and rupture, and Znet: all PASS in every example.
Plate interactions	Manual Eqs. 10-8, 12-2 and 12-3: all PASS (II.A-17B, II.A-19A, II.A-19B).
Extended procedure	C′, Mmax, tmax, interaction and buckling λ: all PASS (II.A-19A, II.A-19B, M&H 2009).
Column-web yield line	Manual Eq. 9-45: w = 11.4 in. and φRn = 42.3 kips (AISC 42.4); NG for the published reason.
Coped beam (Dowswell 2018 method)	Every intermediate (Snet, Znet, k, f, k1, λ, λp, Mn) and the final φMn: PASS in both Dowswell (2018) and II.A-28A.

Area	Result
SDS2	All 17 SDS2 values PASS. ILX "split" reproduces SDS2's concentric-bearing shear transfer (63.7 kips), and ILX at leh = 2.5 reproduces SDS2's web block shear (95.4).
Muir & Thornton (2011)	Fully reproduced with the optional C × min method (113 kips), the paper's own.

10. How to rerun

```
cd backend
.venv/Scripts/python -m pytest -q                                  # full suite
.venv/Scripts/python -m pytest -q tests/test_verification_examples.py tests/test_verification_components.py
.venv/Scripts/python -m tests.test_verification_examples   > examples.md    # regenerate §4 and §6
.venv/Scripts/python -m tests.test_verification_components > components.md  # regenerate §5
.venv/Scripts/python -m pytest -q tests/test_verification_*.py                # every type's golden examples
cd ..
backend/.venv/Scripts/python tools/export_verification.py --check            # results.json for the app (§6C)
```

When a deviation is fixed, its strict expected failures will pass unexpectedly (XPASS) and the suite turns red. Remove the `xfail` from those rows and regenerate the tables. Only the `Case` data and its `xfail` reasons need editing.

Still to do for the next issue:

- Apply the AISC v16.0 errata (May 2025) to the transcribed values (research/09, S1).
- Transcribe the full Manual Table 7-6 and Tables 10-10a/b for sweep tests.
- Add the IDEA StatiCa / University of Tennessee parametric cases once numeric values are obtained.

11. References

- AISC (2022), *Specification for Structural Steel Buildings*, ANSI/AISC 360-22.
- AISC (2023), *Steel Construction Manual*, 16th Ed.
- AISC (2023), *Companion to the AISC Steel Construction Manual*, Vol. 1: Design Examples, v16.0. Examples II.A-17A, 17B, 18, 19A, 19B, 28A and 29.
- SDS2, *AISC 16th Ed. Verification Problem II.A-18*, https://techsupport.sds2.com/main/Engineering/AISC16/AISC-II.A-18.htm.
- Muir, L.S. and Thornton, W.A. (2011), "The Development of a New Design Procedure for Conventional Single-Plate Shear Connections," *Engineering Journal*, 48(2).
- Muir, L.S. and Hewitt, C.M. (2009), "Design of Unstiffened Extended Single-Plate Shear Connections," *Engineering Journal*, 46(2).
- Dowswell, B. (2018), "Local Strength of Single-Coped Beams," *Engineering Journal*, 55(4).

ILX Connection is a design aid. The engineer of record remains responsible for the design and for judging whether these comparisons are adequate. All values are generated by the verification tests at release time; none are typed by hand.