18.1 * Protection of Piping Against Damage Where Subject to Earthquakes.

18.1.1

Where water-based fire protection systems are required to be protected against damage from earthquakes, the requirements of Chapter 18 shall apply, unless the requirements of 18.1.2 are met.

18.1.2

Alternative methods of providing earthquake protection of sprinkler systems based on a seismic analysis certified by a registered professional engineer such that system performance will be at least equal to that required by ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, for components required to function for life-safety purposes after an earthquake under expected seismic forces shall be permitted.

18.1.3 Obstructions to Sprinklers.

Braces and restraints shall not obstruct sprinklers and shall comply with the obstruction rules of Chapters 10 through 14.

18.2 * Flexible Couplings.

18.2.1

Flexible couplings joining grooved end pipe shall be provided as flexure joints to allow individual sections of piping $2\frac{1}{2}$ in. (65 mm) or larger to move differentially with the individual sections of the building to which it is attached.

18.2.2

A listed flexible coupling or fitting used for seismic protection shall allow axial displacement, rotation, and at least 1 degree of angular movement of the pipe without inducing harm on the pipe. For pipe diameters of 8 in. (200 mm) and larger, the angular movement is permitted to be less than 1 degree but not less than 0.5 degree.

18.2.3

Flexible couplings shall be arranged to coincide with structural separations within a building.

18.2.4

Systems having more flexible couplings than required by this section shall be provided with additional sway bracing as required in 18.5.5.9.

18.2.4.1

The flexible couplings shall be installed as follows:

(1)* Within 24 in. (600 mm) of the top and bottom of all risers, unless the following provisions are met:
  - (a) In risers less than 3 ft (900 mm) in length, flexible couplings shall be permitted to be omitted.
  - (b) In risers 3 ft to 7 ft (900 mm to 2100 mm) in length, one flexible coupling shall be adequate.

(2) Within 12 in. (300 mm) above and within 24 in. (600 mm) below the floor in multistory buildings, unless the provision in 18.2.4.1(3) is met.

(3)* In risers up to 7 ft (2.1 m) in length terminating above the roof assembly or top landing, the flexible coupling shall not be required above the landing or roof assembly.

(4) On both sides of concrete or masonry walls within 1 ft (300 mm) of the wall surface, unless clearance is provided in accordance with Section 18.4.

(5)* Within 24 in. (600 mm) of building expansion joints.

(6) Within 24 in. (600 mm) of the top of drops exceeding 15 ft (4.6 m) in length to portions of systems supplying more than one sprinkler, regardless of pipe size.

(7) Within 24 in. (600 mm) above and 24 in. (600 mm) below any intermediate points of support for a riser or other vertical pipe.

18.2.4.2

When the flexible coupling below the floor is above the tie-in main to the main supplying that floor, a flexible coupling shall be provided in accordance with one of the following:

(1)* On the horizontal portion within 24 in. (600 mm) of the tie-in where the tie-in is horizontal
(2)* On the vertical portion of the tie-in where the tie-in incorporates a riser

18.2.5 * Flexible Couplings for Drops.

Flexible couplings for drops to hose lines, rack sprinklers, mezzanines, and free-standing structures shall be installed regardless of pipe sizes as follows:

(1) Within 24 in. (600 mm) of the top of the drop
(2) Within 24 in. (600 mm) above the uppermost drop support attachment, where drop supports are provided to the structure, rack, or mezzanine
(3) Within 24 in. (600 mm) above the bottom of the drop where no additional drop support is provided

18.3 * Seismic Separation Assembly.

18.3.1

An approved seismic separation assembly shall be installed where sprinkler piping, regardless of size, crosses building seismic separation joints at ground level and above.

18.3.2

Seismic separation assemblies shall consist of flexible fittings or flexible piping so as to allow movement sufficient to accommodate closing of the separation, opening of the separation to twice its normal size, and movement relative to the separation in the other two dimensions in an amount equal to the separation distance.

18.3.3 *

The seismic separation assembly shall include a four-way brace upstream and downstream within 6 ft (1.8 m) of the seismic separation assembly.

18.3.4

Bracing shall not be attached to the seismic separation assembly.

18.4 * Clearance.

18.4.1 *

Clearance shall be provided around all piping extending through walls, floors, platforms, and foundations, including drains, fire department connections, and other auxiliary piping.

18.4.2

Unless any of the requirements of 18.4.3 through 18.4.7 or 18.4.10 are met, where pipe passes through holes in platforms, foundations, walls, or floors, the holes shall be sized such that the diameter of the holes is nominally 2 in. (50 mm) larger than the pipe for pipe 1 in. (25 mm) nominal to 3½ in. (90 mm) nominal and 4 in. (100 mm) larger than the pipe for pipe 4 in. (100 mm) nominal and larger.

18.4.3

Where clearance is provided by a pipe sleeve, a nominal diameter 2 in. (50 mm) larger than the nominal diameter of the pipe shall be acceptable for pipe sizes 1 in. (25 mm) through 3½ in. (90 mm), and the clearance provided by a pipe sleeve of nominal diameter 4 in. (100 mm) larger than the nominal diameter of the pipe shall be acceptable for pipe sizes 4 in. (100 mm) and larger.

18.4.4

No clearance shall be required for piping passing through gypsum board or equally frangible construction.

18.4.5

No clearance shall be required if flexible couplings are located within 1 ft (300 mm) of each side of a wall or if the requirements of 18.2.4.1(2) are met.

18.4.6

No clearance shall be required where horizontal piping passes perpendicularly through successive studs or joists that form a wall or floor/ceiling assembly.

18.4.7

No clearance shall be required where nonmetallic pipe has been demonstrated to have inherent flexibility equal to or greater than the minimum provided by flexible couplings located within 1 ft (300 mm) of each side of a wall, floor, platform, or foundation.

18.4.8

Where required, the clearance shall be filled with a flexible material that is compatible with the piping material.

18.4.9

The installed horizontal and upward vertical clearance between horizontal sprinkler piping and structural members not penetrated or used, collectively or independently, to support the piping shall be at least 2 in. (50 mm).

18.4.10 *

No clearance shall be required where piping is supported by holes through structural members as permitted by 17.1.7.3.

18.4.11 *

The installed clearance between a sprinkler and structural elements not used collectively or independently to support the sprinklers shall be at least 3 in. (75 mm).

18.4.11.1

Where sprinklers are installed using flexible sprinkler hose, clearance for the sprinkler shall not be required.

18.4.12

Clearance shall not be required for piping that is vertically supported by the bottom edge of holes through structural members as permitted by 17.1.7.3.

18.4.13

No horizontal clearance (tight fit) shall be provided for piping that is laterally supported by the side edges of holes through structural members.

18.4.13.1

Clearance shall be permitted where piping is secured to the structural member with an approved hanger or restraint.

18.5 * Sway Bracing.

18.5.1 General.

18.5.1.1

The system piping shall be braced to resist both lateral and longitudinal horizontal seismic loads and to prevent vertical motion resulting from seismic loads.

18.5.1.2

The structural components to which bracing is attached shall be determined to be capable of resisting the added applied seismic loads.

18.5.1.3 *

Horizontal loads on system piping shall be determined in accordance with 18.5.9.

18.5.1.4 *

A shared support assembly shall be permitted to support both the gravity loads addressed in 17.1.4.1 and the seismic loads addressed in 18.5.9.

18.5.1.4.1

When a shared support assembly is used to support gravity and seismic loads, the structure shall be designed to support these loads for all pipe and distribution systems on the structure using either 18.5.9.3 or 18.5.9.4 with an importance factor, *Ip*, of 1.5 being applied to all of the distribution systems.

18.5.1.5 *

If a shared support assembly is used to support sprinkler pipe and other distribution systems per 17.1.4.1 and that assembly does not provide seismic resistance as required in 18.5.1.4, the following shall be met:

(1) The sprinkler pipe shall be braced using the method in 18.5.6 with the zone of influence including the water-filled sprinkler pipe and all other distribution systems that are not independently equipped with seismic protection and attached to the shared support assembly.
(2) The sprinkler sway bracing attachment shall be connected to the same building or structure as the shared support assembly.

18.5.1.6

Bracing requirements of Section 18.5 shall not apply to drain piping downstream of the drain valve.

18.5.2 Listing.

18.5.2.1

Sway bracing assemblies shall be listed for a maximum load rating, unless the requirements of 18.5.2.2 are met.

18.5.2.2

Where sway bracing utilizing pipe, angles, flats, or rods as shown in Table 18.5.11.8(a) through Table 18.5.11.8(f) is used, the components shall not require listing.

18.5.2.2.1

Bracing fittings and connections used with those specific materials shall be listed.

18.5.2.3 *

The listed load rating shall be reduced as shown in Table 18.5.2.3 to determine the allowable load for installations where the brace is less than 90 degrees from vertical.

Table 18.5.2.3 Listed Horizontal Load Adjustment

Brace Angle Degrees from Vertical	Allowable Horizontal Load
30 to 44	Listed load rating divided by 2.000
45 to 59	Listed load rating divided by 1.414
60 to 89	Listed load rating divided by 1.155
90	Listed load rating

18.5.2.3.1 *

Maximum allowable horizontal loads shall be determined by testing at angles of 30, 45, 60, and 90 degrees from vertical and confirmed to be equal to or greater than those calculated using 18.5.2.3.

18.5.2.3.2

For attachments to structures, additional tests shall be performed at 0 degrees.

18.5.3 Component Material.

18.5.3.1

Unless permitted by 18.5.3.2, components of sway brace assemblies shall be ferrous.

18.5.3.2

Nonferrous components that have been proven by fire tests to be adequate for the hazard application, that are listed for this purpose, and that are in compliance with the other requirements of this section shall be acceptable.

18.5.4 Sway Bracing Design.

18.5.4.1

Sway braces shall be designed to withstand forces in tension and compression, unless the requirements of 18.5.4.2 are met.

18.5.4.2 *

Tension-only bracing systems shall be permitted for use where listed for this service and where installed in accordance with their listing limitations, including installation instructions.

18.5.4.3

For all braces, whether or not listed, the maximum allowable load shall be based on the weakest component of the brace with safety factors.

18.5.5 * Lateral Sway Bracing.

18.5.5.1 *

Lateral sway bracing shall be provided on all feed and cross mains regardless of size and all branch lines and other piping with a diameter of 2½ in. (65 mm) and larger.

18.5.5.1.1

Where branch lines are not provided with lateral sway bracing, they shall be provided with restraint in accordance with Section 18.6.

18.5.5.2 *

The spacing between lateral sway braces shall be in accordance with either Table 18.5.5.2(a) through Table 18.5.5.2(n) or 18.5.5.3, based on the piping material of the sprinkler system.

Table 18.5.5.2(a) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 30 ksi) Schedule 10 Steel Pipe

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (ft)				
	≤20	>20 and ≤25	>25 and ≤30	>30 and ≤35	>35 and ≤40
1	68	54	45	39	32
1¼	107	86	71	60	51
1½	147	117	96	83	70
2	237	190	156	133	111
2½	389	311	255	219	183
3	586	469	384	330	276
3½	777	622	510	437	366
4	991	793	650	557	467
5	1706	1365	1118	959	803
6*	2448	1959	1605	1376	1152

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 35 ksi. An F_y = 30 ksi was used as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(b) Maximum Load (F_{pw}) in Zone of Influence (N), (F_y = 207 N/mm^2) Schedule 10 Steel Pipe

Diameter of Pipe (mm) Being Braced	Lateral Sway Brace Spacing (m)				
	≤6.1	>6.1 and ≤7.6	>7.6 and ≤9.1	>9.1 and ≤11	12
25	302	240	200	173	142
32	476	383	316	267	227
40	654	520	427	369	311
50	1054	845	694	592	494
60	1730	1383	1134	974	814

Diameter of Pipe (mm) Being Braced	Lateral Sway Brace Spacing (m)				
	≤6.1	>6.1 and ≤7.6	>7.6 and ≤9.1	>9.1 and ≤11	12
80	2607	2086	1708	1468	1228
90	3456	2767	2269	1944	1628
100	4408	3527	2891	2478	2077
125	7589	6072	4973	4266	3572
150*	10889	8714	7139	6121	5124

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 241 N/mm^2. An F_y = 207 N/mm^2 was used also as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(c) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y= 30 ksi) Schedule 40 Steel Pipe

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (ft)				
	≤20	>20 and ≤25	>25 and ≤30	>30 and ≤35	>35 and ≤40
1	74	59	48	42	35
1¼	130	104	85	73	61
1½	186	149	122	105	88
2	316	253	207	177	149
2½	597	477	391	336	281
3	968	775	635	544	456
3½	1345	1076	882	756	633
4	1807	1446	1185	1016	850
5	3068	2454	2011	1724	1444
6*	4784	3827	3136	2688	2251

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 35 ksi. An F_y = 30 ksi was used as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(d) Maximum Load (F_{pw}) in Zone of Influence (N), (F_y = 207 N/mm^2) Schedule 40 Steel Pipe

Diameter of Pipe (mm) Being Braced	Lateral Sway Brace Spacing (m)				
	≤6.1	>6.1 and ≤7.6	>7.6 and ≤9.1	>9.1 and ≤11	12
25	329	262	214	187	156
32	578	463	378	325	271
40	827	663	543	467	391
50	1406	1125	921	787	663
60	2656	2122	1739	1495	1250
80	4306	3447	2825	2420	2028
90	5983	4786	3923	3363	2816

Diameter of Pipe (mm) Being Braced	Lateral Sway Brace Spacing (m)				
	≤6.1	>6.1 and ≤7.6	>7.6 and ≤9.1	>9.1 and ≤11	12
100	8038	6432	5271	4519	3781
125	13647	10916	8945	7669	6423
150*	21280	17023	13950	11957	10013

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 241 N/mm^2. An F_y = 207 N/mm^2 was used also as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(e) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 30 ksi) Schedule 5 Steel Pipe

Diameter of Pipe (in.) Being Braced	Lateral Sway Brace Spacing (ft)				
	≤20	>20 and ≤25	>25 and ≤30	>30 and ≤35	>35 and ≤40
1	44	34	28	25	20
1¼	71	57	47	40	34
1½	94	76	62	53	45
2	150	120	98	84	71
2½	279	223	183	157	131
3	419	335	275	236	197
3½	552	442	362	310	260
4*	704	563	461	396	331

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 35 ksi. An F_y = 30 ksi was used as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(f) Maximum Load (F_{pw}) in Zone of Influence (N), (F_y = 207 N/mm^2) Schedule 5 Steel Pipe

Diameter of Pipe (mm) Being Braced	Lateral Sway Brace Spacing (m)				
	≤6.1	>6.1 and ≤7.6	>7.6 and ≤9.1	>9.1 and ≤11	12
25	196	151	125	111	89
32	316	254	209	178	151
40	418	338	276	236	200
50	667	534	436	374	316
60	1241	992	814	698	583
80	1864	1490	1223	1050	876
90	2455	1966	1610	1379	1157
100*	3132	2504	2051	1761	1472

Note: ASTM A106 Grade B or ASTM A53 Grade B has an F_y = 241 N/mm^2. An F_y = 207 N/mm^2 was used also as a conservative value to account for differences in material properties as well as other operational stresses.

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(g) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 8 ksi) CPVC Pipe

	Lateral Sway Brace Spacing (ft)				
Diameter of Pipe (in.) Being Braced	≤20	>20 and ≤25	>25 and ≤30	>30 and ≤35	>35 and ≤40
¾	10	8	7	5	5
1	17	14	11	10	8
1¼	34	28	23	19	16
1½	51	41	34	28	24
2	98	79	64	53	47
2½	174	139	114	94	82
3	313	251	205	169	148

Table 18.5.5.2(h) Maximum Load (F_{pw}) in Zone of Influence (N), (F_y = 55 N/mm^2) CPVC Pipe

	Lateral Sway Brace Spacing (m)				
Diameter of Pipe (mm) Being Braced	≤6.1	>6.1 and ≤7.6	>7.6 and ≤9.1	>9.1 and ≤11	12
20	44	36	31	22	22
25	76	62	49	44	36
32	151	125	102	85	71
40	227	182	151	125	107
50	436	351	285	236	209
60	774	618	507	418	365
80	1392	1117	912	752	658

Table 18.5.5.2(i) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 30 ksi) Type M Copper Tube (with Soldered Joints)

	Lateral Sway Brace Spacing (ft)				
Diameter of Pipe (in.) Being Braced	≤20	>20 and ≤25	>25 and ≤30	>30 and ≤35	>35 and ≤40
¾	10	8	7	6	5
1	18	15	12	10	9
1¼	33	26	22	17	16
1½	53	42	34	28	25
2*	110	88	72	59	52

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(j) Maximum Load (F_{pw}) in Zone of Influence (N), (F_y = 207 N/mm^2) Type M Copper Tube (with Soldered Joints)

	Lateral Sway Brace Spacing (m)				
Diameter of Pipe (mm) Being Braced	≤6.1	>6.1 and ≤7.6	>7.6 and ≤9.1	>9.1 and ≤11	12
20	44	36	31	27	22
25	80	67	53	44	40

Diameter of Pipe (mm) Being Braced	Lateral Sway Brace Spacing (m)				
	≤6.1	>6.1 and ≤7.6	>7.6 and ≤9.1	>9.1 and ≤11	12
32	147	116	98	76	71
40	236	187	151	125	111
50*	489	391	320	262	231

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(k) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 9 ksi) Type M Copper Tube (with Brazed Joints)

Diameter of Pipe (in.) Being Braced	Lateral Sway Spacing (ft)				
	≤20	>20 and ≤25	>25 and ≤30	>30 and ≤35	>35 and ≤40
¾	4	4	3	2	2
1	7	6	5	4	4
1¼	13	10	8	8	7
1½	20	17	14	12	10
2*	43	34	28	24	20

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(l) Maximum Load (F_{pw}) in Zone of Influence (N), (F_y = 62 N/mm^2) Type M Copper Tube (with Brazed Joints)

Diameter of Pipe (mm) Being Braced	Lateral Sway Spacing (m)				
	≤6.1	>6.1 and ≤7.6	>7.6 and ≤9.1	>9.1 and ≤11	12
20	18	18	13	9	9
25	31	27	22	18	18
32	58	44	36	36	31
40	89	76	62	53	44
50*	191	151	125	107	89

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(m) Maximum Load (F_{pw}) in Zone of Influence (lb), (F_y = 9 ksi) Red Brass Pipe (with Brazed Joints)

Diameter of Pipe (in.) Being Braced	Lateral Sway Spacing (ft)				
	≤20	>20 and ≤25	>25 and ≤30	>30 and ≤35	>35 and ≤40
¾	21	17	14	12	10
1	37	30	25	22	18
1¼	71	57	47	40	34
1½	98	79	64	55	47
2*	165	133	108	93	78

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

Table 18.5.5.2(n) Maximum Load (F_{pw}) in Zone of Influence (N), (F_y = 62 N/mm^2) Red Brass Pipe (with Brazed Joints)

Diameter of Pipe (mm) Being Braced	Lateral Sway Spacing (m)				
	≤6.1	>6.1 and ≤7.6	>7.6 and ≤9.1	>9.1 and ≤11	12
20	93	76	62	53	44
25	165	133	111	98	80
32	316	254	209	178	151
40	436	351	285	245	209
50*	734	592	480	414	347

*Larger load values for larger diameter pipe can be used when justified by engineering analysis.

18.5.5.2.1

Specially listed nonstandard pipe shall be permitted using the values in Table 18.5.5.2(e) and Table 18.5.5.2(f) or with values provided by the manufacturer.

18.5.5.2.2

Spacing shall not exceed a maximum interval of 40 ft (12 m) on center.

18.5.5.2.3

The maximum permissible load in the zone of influence of a sway brace shall not exceed the values given in Table 18.5.5.2(a) through Table 18.5.5.2(n) or the values calculated in accordance with 18.5.5.3.

18.5.5.2.4

When determining permissible loads in accordance with 18.5.5.2 or 18.5.5.2.1 on a main with varying sizes, the allowable load shall be based on the smallest pipe size within the zone of influence.

18.5.5.3

The maximum load (F_{pw}) in the zone of influence for specially listed pipe shall be calculated. *(See Annex E.)*

18.5.5.4

The requirements of 18.5.5.1 shall not apply to 2½ in. (65 mm) starter pieces that do not exceed 12 ft (3.7 m) in length.

18.5.5.5

The distance between the last brace and the end of the pipe shall not exceed 6 ft (1.8 m).

18.5.5.6

Where there is a change in direction of the piping, the cumulative distance between consecutive lateral sway braces shall not exceed the maximum permitted distance in accordance with 18.5.5.2.2.

18.5.5.7

The last length of pipe at the end of a feed or cross main shall be provided with a lateral brace.

18.5.5.8

Lateral braces shall be allowed to act as longitudinal braces if they are within 24 in. (600 mm) of the centerline of the piping braced longitudinally and the lateral brace is on a pipe of equal or greater size than the pipe being braced longitudinally.

18.5.5.9

Where flexible couplings are installed on mains other than as required in Section 18.2, a lateral brace shall be provided within 24 in. (600 mm) of every other coupling, including flexible couplings at grooved fittings, but not more than 40 ft (12 m) on center.

18.5.5.10 *

The lateral sway bracing required by 18.5.5 shall be permitted to be omitted when 18.5.5.10.1 for branch lines or 18.5.5.10.2 for mains is met.

18.5.5.10.1

Branch lines shall comply with the following:

(1)* The branch lines shall be individually supported within 6 in. (150 mm) of the structure, measured between the top of the pipe and the point of attachment to the building structure.
(2) At least 75 percent of all the hangers on the branch line shall meet the requirements of 18.5.5.10.1(1).
(3) Consecutive hangers on the branch line shall not be permitted to exceed the limitation in 18.5.5.10.1(1).

18.5.5.10.2

Mains shall comply with all the following:

(1)* The main piping shall be individually supported within 6 in. (150 mm) of the structure, measured between the top of the pipe and the point of attachment to the building structure.
(2) At least 75 percent of all the hangers on the main shall meet the requirements of 18.5.5.10.2(1).
(3) Consecutive hangers on the main shall not be permitted to exceed the limitation in 18.5.5.10.2(1)
(4) The seismic coefficient (C_p) shall not exceed 0.5.
(5) The nominal pipe diameter shall not exceed 6 in. (150 mm) for feed mains and 4 in. (100 mm) for cross mains.
(6) Hangers shall not be omitted in accordance with 17.4.4.3, 17.4.4.4, or 17.4.4.5.

18.5.5.10.3

Branch lines permitted to omit lateral sway bracing by 18.5.5.10 shall not be omitted from load calculations for the mains serving them in 18.5.9.6.

18.5.5.11 *

The lateral sway bracing required by 18.5.5 shall be permitted to be omitted when 18.5.5.11.1 for branch lines or 18.5.5.11.2 for mains is met.

18.5.5.11.1

Branch lines shall comply with the following:

(1) The branch lines shall be individually supported by wraparound u-hooks or u-hooks arranged to keep pipe tight to the structural element, provided the legs are bent out at least 30 degrees from the vertical and the maximum length of each leg and the rod size satisfies the conditions of Table 18.5.11.8(a) through Table 18.5.11.8(f), or the length of the rod shall be calculated.
(2) At least 75 percent of all the hangers on the branch line shall meet the requirements of 18.5.5.11.1(1).
(3) Consecutive hangers on the branch line shall not be permitted to exceed the limitation in 18.5.5.11.1(1).

18.5.5.11.2

Mains shall comply with all the following:

(1) The main piping shall be individually supported by wraparound u-hooks or u-hooks arranged to keep pipe tight to the structural element provided the legs are bent out at least 30 degrees from the vertical and the maximum length of each leg and rod size satisfies the conditions of Table 18.5.11.8(a) through Table 18.5.11.8(f).
(2) At least 75 percent of all the hangers on the main shall meet the requirements of 18.5.5.11.2(1).
(3) Consecutive hangers on the main shall not be permitted to exceed the limitation in 18.5.5.11.2(1).
(4) The seismic coefficient (C_p) shall not exceed 0.5.
(5) The nominal pipe diameter shall not exceed 6 in. (150 mm) for feed mains and 4 in. (100 mm) for cross mains.
(6) Hangers shall not be omitted in accordance with 17.4.4.3, 17.4.4.4, or 17.4.4.5.

18.5.6 * Longitudinal Sway Bracing.

18.5.6.1

Longitudinal sway bracing spaced at a maximum of 80 ft (24 m) on center shall be provided for feed and cross mains.

18.5.6.2

Unless the requirements of 18.5.9.6 are met, longitudinal sway bracing shall be provided on branch lines at a maximum spacing of 80 ft (24 m) on center.

18.5.6.3

Longitudinal braces shall be allowed to act as lateral braces if they are within 24 in. (600 mm) of the centerline of the piping braced laterally.

18.5.6.4

The distance between the last brace and the end of the pipe or a change in direction shall not exceed 40 ft (12 m).

18.5.7 Pipe with Change(s) in Direction.

18.5.7.1

Each run of pipe between changes in direction shall be provided with both lateral and longitudinal bracing, unless the requirements of 18.5.7.2 are met.

18.5.7.2 *

Pipe runs less than 12 ft (3.7 m) in length shall be permitted to be supported by the braces on adjacent runs of pipe.

18.5.8 Sway Bracing of Risers.

18.5.8.1 *

Tops of risers exceeding 36 in. (900 mm) in length shall be provided with a four-way brace located on the topmost section of vertical piping, but not more than 24 in. (600 mm) below the top coupling.

18.5.8.1.1

The four-way brace shall not be required for risers up to 7 ft (2.1 m) in length that terminate above the roof assembly or top landing. *[See Figure A.18.2.4.1(3).]*

18.5.8.2

Riser nipples shall be permitted to omit the four-way brace required by 18.5.8.1.

18.5.8.3

When a four-way brace at the top of a riser is attached on the horizontal piping, it shall be within 24 in. (600 mm) of the centerline of the riser and the loads for that brace shall include both the vertical and horizontal pipe.

18.5.8.4

Distance between four-way braces for risers shall not exceed 25 ft (7.6 m).

18.5.8.5

Four-way bracing shall not be required where risers penetrate intermediate floors in multistory buildings where the clearance does not exceed the limits of Section 18.4.

18.5.9 * Horizontal Seismic Loads.

18.5.9.1 *

The horizontal seismic load for the braces shall be as determined in 18.5.9.6 or 18.5.9.7, or as required by the authority having jurisdiction.

18.5.9.2

The weight of the system being braced (W_p) shall be taken as 1.15 times the weight of the water-filled piping. *(See A.18.5.9.1.)*

18.5.9.3

The horizontal force, F_{pw}, acting on the brace shall be taken as $F_{pw} = C_p W_p$, where $C_p = 0.754\ S_{DS}$, and S_{DS} is the short period response parameter.

18.5.9.3.1 *

The value of S_{DS} shall be obtained from the AHJ or the ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures,* Hazard Tool.

18.5.9.3.2 *

The value of S_{DS} shall be determined using the ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, default site soil class unless 18.5.9.3.2.1 is met.

18.5.9.3.2.1 *

The use of a site class–specific value of S_{DS}, obtained from the authority having jurisdiction, shall be permitted.

18.5.9.3.3 *

Where the height of the component attachment to the structure is between 51 percent and 75 percent of the average roof height, the C_p value shall be permitted to be multiplied by a factor of 0.875.

18.5.9.3.4

Where the height of the component attachment to the structure is less than 50 percent of the average roof height, the C_p value shall be permitted to be multiplied by a factor of 0.75. *(See Figure A.18.5.9.3.3.)*

18.5.9.4 *

The horizontal force, F_{pw}, acting on the brace and the F_{pw} versus brace spacing limits based on piping stresses shall be permitted to be determined in accordance with 13.3.1 of ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, multiplied by 0.7 to convert to allowable stress design (ASD).

18.5.9.5 *

Where data for determining C_p are not available, the horizontal seismic force acting on the braces shall be determined as specified in 18.5.9.3 with C_p = 0.5.

18.5.9.6 *

The zone of influence for lateral braces shall include all branch lines, drops, sprigs, and mains tributary to the brace, except branch lines that are provided with longitudinal bracing.

18.5.9.6.1 *

When riser nipples are provided in systems requiring seismic protection, they shall satisfy the requirements of 18.5.9.6.2 unless the following requirements are met:

(1) Where riser nipples are 4 ft (1.2 m) or less in length and C_p is 0.3 or less
(2) Where riser nipples are 3 ft (900 mm) or less in length and C_p is less than 0.4
(3) Where riser nipples are 2 ft (600 mm) or less in length and C_p is less than is 0.6

18.5.9.6.2

If the calculated value as determined by the following equation is equal to or greater than the allowable yield strength of the riser nipple, F_y, the longitudinal seismic load of each line shall be evaluated individually, and branch lines shall be provided with longitudinal sway bracing in accordance with 18.5.6:

$$1.65\ \frac{\left(H_r \cdot W_p \cdot C_p\right)}{S} \geq F_y \qquad [18.5.9.6.2]$$

where:

H_r = length of riser nipple piping (in.)

W_p = tributary weight (lb) for the branch line or portion of branch line within the zone of influence including the riser nipple

C_p = seismic coefficient

S = sectional modulus of the riser nipple pipe

F_y = allowable yield strength of 30,000 psi (2070 bar) for steel, 30,000 psi (2070 bar) for copper (soldered), and 8000 psi (550 bar) for CPVC

18.5.9.7

The zone of influence for longitudinal braces shall include all mains tributary to the brace.

18.5.10 Net Vertical Forces.

Where the C_p exceeds 0.5 and the brace angle is less than 45 degrees from vertical or where the C_p exceeds 1.0 and the brace angle is less than 60 degrees from vertical, the braces shall be arranged to resist the net vertical force produced by the horizontal load.

18.5.11 * Sway Brace Installation.

18.5.11.1 *

Bracing shall be attached directly to the system pipe.

18.5.11.2

Sway bracing shall be tight.

18.5.11.3

For individual braces, the slenderness ratio *(l/r)* shall not exceed 300, where *l* is the length of the brace and *r* is the least radius of gyration.

18.5.11.4

Where threaded pipe is used as part of a sway brace assembly, it shall not be less than Schedule 30.

18.5.11.5

All parts and fittings of a brace shall lie in a straight line to avoid eccentric loadings on fittings and fasteners.

18.5.11.6

For longitudinal braces only, the brace shall be permitted to be connected to a tab welded to the pipe in conformance to 7.5.2.

18.5.11.7

For tension-only braces, two tension-only brace components opposing each other must be installed at each lateral or longitudinal brace location.

18.5.11.8

The loads determined in 18.5.9 shall not exceed the lesser of the maximum allowable loads provided in Table 18.5.11.8(a) through Table 18.5.11.8(f), and the manufacturer's certified maximum allowable horizontal loads for brace angles of 30 to 44 degrees, 45 to 59 degrees, 60 to 89 degrees, or 90 degrees.

Table 18.5.11.8(a) Maximum Horizontal Loads for Sway Braces with *l/r* = 100 for Steel Braces with F_y = 36 ksi

Brace Shape and Size (in.)		Area (in.^{2})	Least Radius of Gyration *(r)* (in.)	Maximum Length for *l/r* = 100		Maximum Horizontal Load (lb)		
						Brace Angle		
				ft	in.	30°to 44°Angle from Vertical	45°to 59°Angle from Vertical	60°to 90°Angle from Vertical
Pipe Schedule 40	1	0.494	0.421	3	6	3,150	4,455	5,456
	1¼	0.669	0.540	4	6	4,266	6,033	7,389
	1½	0.799	0.623	5	2	5,095	7,206	8,825
	2	1.07	0.787	6	6	6,823	9,650	11,818
Angles	1½ × 1½ × ¼	0.688	0.292	2	5	4,387	6,205	7,599
	2 × 2 × ¼	0.938	0.391	3	3	5,982	8,459	10,360
	2½ × 2 × ¼	1.06	0.424	3	6	6,760	9,560	11,708
	2½ × 2½ × ¼	1.19	0.491	4	1	7,589	10,732	13,144

Brace Shape and Size (in.)		Area (in.^{2})	Least Radius of Gyration *(r)* (in.)	Maximum Length for *l/r* = 100		Maximum Horizontal Load (lb)		
						Brace Angle		
				ft	in.	30°to 44°Angle from Vertical	45°to 59°Angle from Vertical	60°to 90°Angle from Vertical
	3 × 2½ × ¼	1.31	0.528	4	4	8,354	11,814	14,469
	3 × 3 × ¼	1.44	0.592	4	11	9,183	12,987	15,905
Rods (all thread)	⅜	0.07	0.075	0	7	446	631	773
	½	0.129	0.101	0	10	823	1,163	1,425
	⅝	0.207	0.128	1	0	1,320	1,867	2,286
	¾	0.309	0.157	1	3	1,970	2,787	3,413
	⅞	0.429	0.185	1	6	2,736	3,869	4,738
Rods (threaded at ends only)	⅜	0.11	0.094	0	9	701	992	1,215
	½	0.196	0.125	1	0	1,250	1,768	2,165
	⅝	0.307	0.156	1	3	1,958	2,769	3,391
	¾	0.442	0.188	1	6	2,819	3,986	4,882
	⅞	0.601	0.219	1	9	3,833	5,420	6,638
Flats	1½ × ¼	0.375	0.0722	0	7	2,391	3,382	4,142
	2 × ¼	0.5	0.0722	0	7	3,189	4,509	5,523
	2 × ⅜	0.75	0.1082	0	10	4,783	6,764	8,284

Table 18.5.11.8(b) Maximum Horizontal Loads for Sway Braces with *l/r* = 200 for Steel Braces with F_y = 36 ksi

Brace Shape and Size (in.)		Area (in.^{2})	Least Radius of Gyration *(r)* (in.)	Maximum Length for *l/r* = 200		Maximum Horizontal Load (lb)		
						Brace Angle		
				ft	in.	30°to 44°Angle from Vertical	45°to 59°Angle from Vertical	60°to 90°Angle from Vertical
Pipe Schedule 40	1	0.494	0.421	7	0	926	1310	1604
	1¼	0.669	0.540	9	0	1254	1774	2173
	1½	0.799	0.623	10	4	1498	2119	2595
	2	1.07	0.787	13	1	2006	2837	3475

Brace Shape and Size (in.)		Area (in.^{2})	Least Radius of Gyration *(r)* (in.)	Maximum Length for *l/r* = 200		Maximum Horizontal Load (lb)		
						Brace Angle		
				ft	in.	30°to 44°Angle from Vertical	45°to 59°Angle from Vertical	60°to 90°Angle from Vertical
Angles	1½ × 1½ × ¼	0.688	0.292	4	10	1290	1824	2234
	2 × 2 × ¼	0.938	0.391	6	6	1759	2487	3046
	2½ × 2 × ¼	1.06	0.424	7	0	1988	2811	3442
	2½ × 2½ × ¼	1.19	0.491	8	2	2231	3155	3865
	3 × 2½ × ¼	1.31	0.528	8	9	2456	3474	4254
	3 × 3 × ¼	1.44	0.592	9	10	2700	3818	4677
Rods (all thread)	⅜	0.07	0.075	1	2	131	186	227
	½	0.129	0.101	1	8	242	342	419
	⅝	0.207	0.128	2	1	388	549	672
	¾	0.309	0.157	2	7	579	819	1004
	⅞	0.429	0.185	3	0	804	1138	1393
Rods (threaded at ends only)	⅜	0.11	0.094	1	6	206	292	357
	½	0.196	0.125	2	0	368	520	637
	⅝	0.307	0.156	2	7	576	814	997
	¾	0.442	0.188	3	1	829	1172	1435
	⅞	0.601	0.219	3	7	1127	1594	1952
Flats	1½ × ¼	0.375	0.0722	1	2	703	994	1218
	2 × ¼	0.5	0.0722	1	2	938	1326	1624
	2 × ⅜	0.75	0.1082	1	9	1406	1989	2436

Table 18.5.11.8(c) Maximum Horizontal Loads for Sway Braces with *l/r* = 300 for Steel Braces with F_y = 36 ksi

Brace Shape and Size (in.)		Area (in.^{2})	Least Radius of Gyration *(r)* (in.)	Maximum Length for *l/r* = 300		Maximum Horizontal Load (lb)		
						Brace Angle		
				ft	in.	30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Pipe Schedule 40	1	0.494	0.421	10	6	412	582	713
	1¼	0.669	0.540	13	6	558	788	966
	1½	0.799	0.623	15	6	666	942	1153
	2	1.07	0.787	19	8	892	1261	1544
Angles	1½ × 1½ × ¼	0.688	0.292	7	3	573	811	993
	2 × 2 × ¼	0.938	0.391	9	9	782	1105	1354
	2½ × 2 × ¼	1.06	0.424	10	7	883	1249	1530
	2½ × 2½ × ¼	1.19	0.491	12	3	992	1402	1718
	3 × 2½ × ¼	1.31	0.528	13	2	1092	1544	1891
	3 × 3 × ¼	1.44	0.592	14	9	1200	1697	2078
Rods (all thread)	⅜	0.07	0.075	1	10	58	82	101
	½	0.129	0.101	2	6	108	152	186
	⅝	0.207	0.128	3	2	173	244	299
	¾	0.309	0.157	3	11	258	364	446
	⅞	0.429	0.185	4	7	358	506	619
Rods (threaded at ends only)	⅜	0.11	0.094	2	4	92	130	159
	½	0.196	0.125	3	1	163	231	283
	⅝	0.307	0.156	3	10	256	362	443
	¾	0.442	0.188	4	8	368	521	638
	⅞	0.601	0.219	5	5	501	708	867
Flats	1½ × ¼	0.375	0.0722	1	9	313	442	541
	2 × ¼	0.5	0.0722	1	9	417	589	722
	2 × ⅜	0.75	0.1082	2	8	625	884	1083

Table 18.5.11.8(d) Maximum Horizontal Loads for Sway Braces with *l/r* = 100 for Steel Braces with F_y = 248 N/mm²

Brace Shape and Size (mm)		Area (mm²)	Least Radius of Gyration *(r)* (mm)	Maximum Length for *l/r* = 100		Maximum Horizontal Load (kg) Brace Angle		
				meters	mm	30°to 44°Angle from Vertical	45°to 59°Angle from Vertical	60°to 90°Angle from Vertical
Pipe Schedule 40	25	318.7	11	1.0	150	1,429	2,021	2,475
	32	431.6	14	1.2	150	1,935	2,737	3,352
	40	515.5	16	1.5	50	2,311	3,269	4,003
	50	690.3	20	1.8	150	3,095	4,377	5,361
Angles	40 × 40 × 6	443.9	7	0.6	125	1,990	2,815	3,447
	50 × 50 × 6	605.2	10	1.0	75	2,713	3,837	4,699
	65 × 50 × 6	683.9	11	1.0	150	3,066	4,336	5,311
	65 × 65 × 6	767.7	12	1.2	25	3,442	4,868	5,962
	80 × 65 × 6	845.2	13	1.2	100	3,789	5,359	6,563
	80 × 80 × 6	929.0	15	1.2	275	4,165	5,891	7,214
Rods (all thread)	10	45.2	2	0.0	175	202	286	351
	15	83.2	3	0.0	250	373	528	646
	16	133.5	3	0.3	0	599	847	1,037
	20	199.4	4	0.3	75	894	1,264	1,548
	22	276.8	5	0.3	150	1,241	1,755	2,149
Rods (threaded at ends only)	10	71.0	2	0.0	225	318	450	551
	15	126.5	3	0.3	0	567	802	982
	16	198.1	4	0.3	75	888	1,256	1,538
	20	285.2	5	0.3	150	1,279	1,808	2,214
	22	387.7	5	0.3	225	1,739	2,458	3,011
Flats	40 × 6	241.9	2	0.0	175	1,085	1,534	1,879
	50 × 6	322.6	2	0.0	175	1,447	2,045	2,505
	50 × 10	483.9	3	0.0	250	2,170	3,068	3,758

Table 18.5.11.8(e) Maximum Horizontal Loads for Sway Braces with l/r = 200 for Steel Braces with F_y = 248 N/mm^2

Brace Shape and Size (mm)		Area (mm^2)	Least Radius of Gyration *(r)* (mm)	Maximum Length for l/r = 200		Maximum Horizontal Load (kg)		
						Brace Angle		
				meters	mm	30°to 44°Angle from Vertical	45°to 59°Angle from Vertical	60°to 90°Angle from Vertical
Pipe Schedule 40	25	318.7	11	2.1	0	420	594	728
	32	431.6	14	2.7	0	569	805	986
	40	515.5	16	3	100	679	961	1177
	50	690.3	20	4.0	25	910	1287	1576
Angles	40 × 40 × 6	443.9	7	1.2	250	585	827	1013
	50 × 50 × 6	605.2	10	1.8	150	798	1128	1382
	65 × 50 × 6	683.9	11	2.1	0	902	1275	1561
	65 × 65 × 6	767.7	12	2.4	50	1012	1431	1753
	80 × 65 × 6	845.2	13	2.4	225	1114	1576	1930
	80 × 80 × 6	929.0	15	2.7	250	1225	1732	2121
Rods (all thread)	10	45.2	2	0.3	50	59	84	103
	15	83.2	3	0.3	200	110	155	190
	16	133.5	3	0.6	25	176	249	305
	20	199.4	4	0.6	175	263	371	455
	22	276.8	5	0.9	0	365	516	632
Rods (threaded at ends only)	10	71.0	2	0.3	150	93	132	162
	15	126.5	3	0.6	0	167	236	289
	16	198.1	4	0.6	175	261	369	452
	20	285.2	5	0.9	25	376	532	651
	22	387.7	5	0.9	175	511	723	885
Flats	40 × 6	241.9	2	0.3	50	319	451	552
	50 × 6	322.6	2	0.3	50	425	601	737
	50 × 10	483.9	3	0.3	225	638	902	1105

Table 18.5.11.8(f) Maximum Horizontal Loads for Sway Braces with *l/r* = 300 for Steel Braces with F_y = 248 N/mm²

Brace Shape and Size (mm)		Area (mm²)	Least Radius of Gyration *(r)* (mm)	Maximum Length for *l/r* = 300		Maximum Horizontal Load (kg)		
						Brace Angle		
				meters	mm	30°to 44°Angle from Vertical	45°to 59°Angle from Vertical	60°to 90°Angle from Vertical
Pipe Schedule 40	25	318.7	10.5	3	150	187	264	323
	32	431.6	13.5	4	150	253	357	438
	40	515.5	15.6	4.6	150	302	427	523
	50	690.3	19.7	5.8	200	405	572	700
Angles	40 × 40 × 6	443.9	7.3	2.1	75	260	368	450
	50 × 50 × 6	605.2	9.8	2.7	225	355	501	614
	65 × 50 × 6	683.9	10.6	3	175	401	567	694
	65 × 65 × 6	767.7	12.3	3.7	75	450	636	779
	80 × 65 × 6	845.2	13.2	4	50	495	700	858
	80 × 80 × 6	929.0	14.8	4.3	225	544	770	943
Rods (all thread)	10	45.2	1.9	0.3	250	26	37	46
	15	83.2	2.5	0.6	150	49	69	84
	16	133.5	3.2	0.9	50	79	111	136
	20	199.4	3.9	0.9	275	117	165	202
	22	276.8	4.6	1.2	175	162	230	281
Rods (threaded at ends only)	10	71.0	2.4	0.6	100	42	59	72
	15	126.5	3.1	0.9	25	74	105	128
	16	198.1	3.9	0.9	250	116	164	201
	20	285.2	4.7	1.2	200	167	236	289
	22	387.7	5.5	1.5	125	227	321	393
Flats	40 × 6	241.9	1.8	0.3	225	142	200	245
	50 × 6	322.6	1.8	0.3	225	189	267	327
	50 × 10	483.9	2.7	0.6	200	283	401	491

18.5.11.9 *

Other pipe schedules and materials not specifically included in Table 18.5.11.8(a) through Table 18.5.11.8(f) shall be permitted to be used if certified by a registered professional engineer to support the loads determined in accordance with the criteria in the tables.

18.5.11.9.1

Calculations shall be submitted where required by the authority having jurisdiction.

18.5.11.10

C-type clamps including beam and large flange clamps, with or without restraining straps, shall not be used to attach braces to the building structure.

18.5.11.11

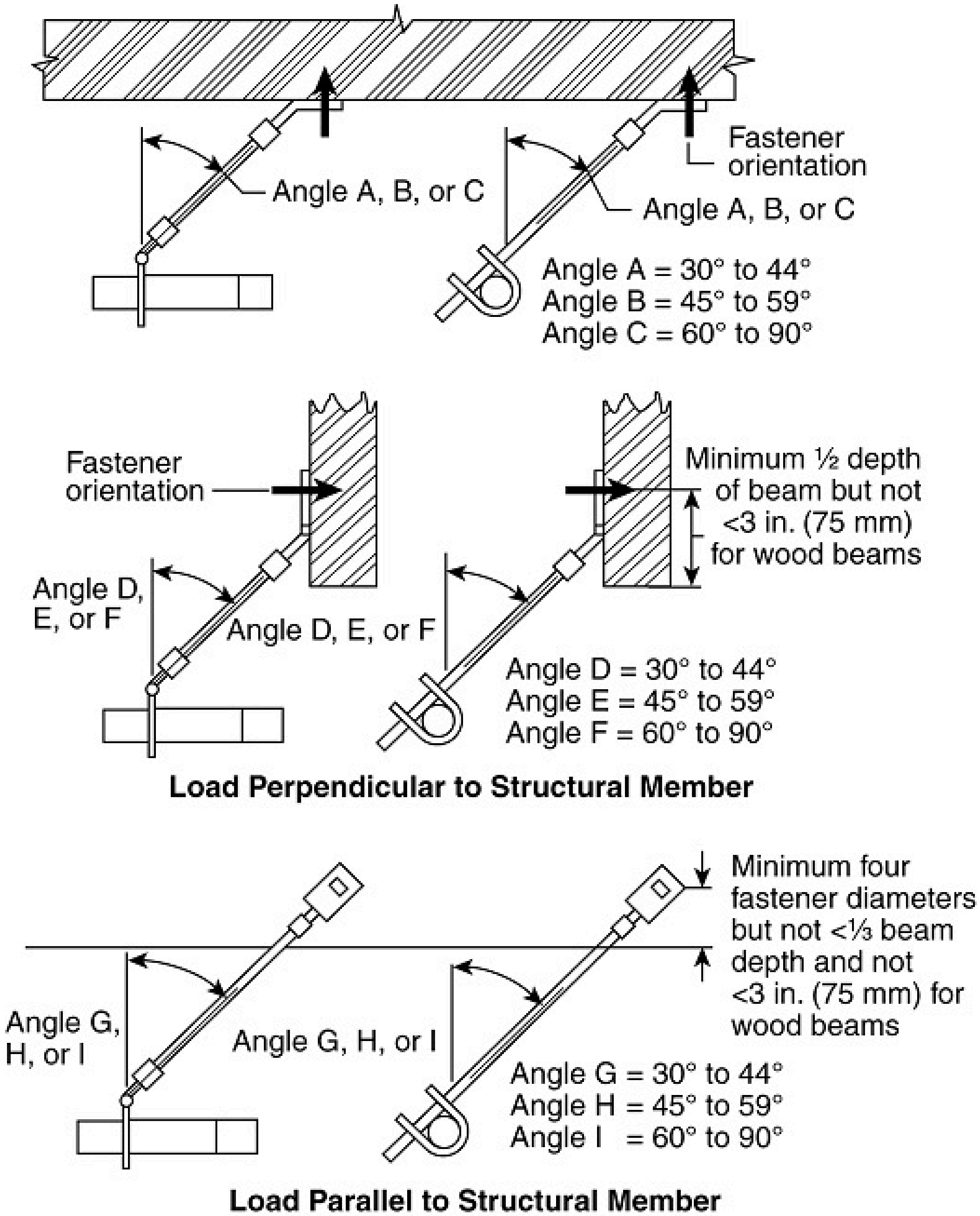
Powder-driven fasteners shall not be used to attach braces to the building structure, unless they are specifically listed for service in resisting lateral loads in areas subject to earthquakes.

18.5.12 * Fasteners.

18.5.12.1

The designated angle category for the fastener(s) used in the sway brace installation shall be determined in accordance with Figure 18.5.12.1.

Figure 18.5.12.1 Designation of Angle Category Based on Angle of Sway Brace and Fastener Orientation.



18.5.12.2 *

For individual fasteners, unless alternative allowable loads are determined and certified by a registered professional engineer, the loads determined in 18.5.9 shall not exceed the allowable loads provided in Table 18.5.12.2(a) through Table 18.5.12.2(m) or 18.5.12.7.

Table 18.5.12.2(a) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Lightweight Cracked Concrete on Metal Deck

Max F_{pw} (lb) for Wedge Anchors in 3000 psi Sand Lightweight Cracked Concrete on $4\frac{1}{2}$ in. Flute Width Metal Deck												
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F	G	H	I
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr* ≤ 1.1	*Pr* ≤ 1.4	*Pr* ≤ 0.9	*Pr* ≤ 0.8
$\frac{3}{8}$	2.375	6.25	1	123	183	233	—	—	—	—	—	—
$\frac{1}{2}$	3.750	6.25	1	147	231	310	—	—	—	—	—	—

Max F_{pw} (lb) for Wedge Anchors in 3000 psi Sand Lightweight Cracked Concrete on 4 1/2 in. Flute Width Metal Deck												
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F	G	H	I
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr* ≤ 1.1	*Pr* ≤ 1.4	*Pr* ≤ 0.9	*Pr* ≤ 0.8
5/8	3.875	6.25	1	188	292	387	—	—	—	—	—	—
3/4	4.500	6.25	1	255	380	486	—	—	—	—	—	—
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F	G	H	I
				2.0 < *Pr* ≤ 3.5	1.1 < *Pr* ≤ 1.8	0.7 < *Pr* ≤ 1.0	1.2 < *Pr* ≤ 1.7	1.1 < *Pr* ≤ 1.8	1.1 < *Pr* ≤ 2.0	1.4 < *Pr* ≤ 1.9	0.9 < *Pr* ≤ 1.3	0.8 < *Pr* ≤ 1.1
3/8	2.375	6.25	1	79	133	193	—	—	—	—	—	—
1/2	3.750	6.25	1	86	160	247	—	—	—	—	—	—
5/8	3.875	6.25	1	113	204	311	—	—	—	—	—	—
3/4	4.500	6.25	1	165	275	402	—	—	—	—	—	—
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F	G	H	I
				3.5 < *Pr* ≤ 5.0	1.8 < *Pr* ≤ 2.5	1.0 < *Pr* ≤ 1.3	1.7 < *Pr* ≤ 2.2	1.8 < *Pr* ≤ 2.5	2.0 < *Pr* ≤ 2.9	1.9 < *Pr* ≤ 2.4	1.3 < *Pr* ≤ 1.7	1.1 < *Pr* ≤ 1.4
3/8	2.375	6.25	1	56	104	165	—	—	—	—	—	—
1/2	3.750	6.25	1	60	121	205	—	—	—	—	—	—
5/8	3.875	6.25	1	79	157	260	—	—	—	—	—	—
3/4	4.500	6.25	1	116	216	343	—	—	—	—	—	—
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F	G	H	I
				5.0 < *Pr* ≤ 6.5	2.5 < *Pr* ≤ 3.2	1.3 < *Pr* ≤ 1.6	2.2 < *Pr* ≤ 2.7	2.5 < *Pr* ≤ 3.2	2.9 < *Pr* ≤ 3.8	2.4 < *Pr* ≤ 2.9	1.7 < *Pr* ≤ 2.1	1.4 < *Pr* ≤ 1.7
3/8	2.375	6.25	1	43	85	144	—	—	—	—	—	—
1/2	3.750	6.25	1	46	94	175	—	—	—	—	—	—
5/8	3.875	6.25	1	60	124	224	—	—	—	—	—	—
3/4	4.500	6.25	1	89	177	299	—	—	—	—	—	—

Pr: Prying factor range *(see A.18.5.12.2 for additional information).*

Table 18.5.12.2(b) Maximum Load for Wedge Anchors in 3000 psi (207 bar) Lightweight Cracked Concrete

Max F_{pw} (lb) for Wedge Anchors in 3000 psi Lightweight Cracked Concrete												
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr* ≤ 1.1	*Pr* ≤ 1.4	*Pr* ≤ 0.9	*Pr* ≤ 0.8
3/8	2.375	5	4	142	216	280	162	216	256	139	208	244

Max F_{pw} (lb) for Wedge Anchors in 3000 psi Lightweight Cracked Concrete												
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr* ≤ 1.1	*Pr* ≤ 1.4	*Pr* ≤ 0.9	*Pr* ≤ 0.8
½	3.750	6	6	200	314	419	243	314	362	209	312	365
⅝	3.875	6	6	259	394	512	297	394	467	255	380	446
¾	4.500	7	8	356	552	731	424	552	641	365	544	636
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				2.0 < *Pr* ≤ 3.5	1.1 < *Pr* ≤ 1.8	0.7 < *Pr* ≤ 1.0	1.2 < *Pr* ≤ 1.7	1.1 < *Pr* ≤ 1.8	1.1 < *Pr* ≤ 2.0	1.4 < *Pr* ≤ 1.9	0.9 < *Pr* ≤ 1.3	0.8 < *Pr* ≤ 1.1
⅜	2.375	5	4	89	154	229	133	154	157	117	170	204
½	3.750	6	6	119	218	335	195	218	209	172	250	299
⅝	3.875	6	6	163	281	418	244	281	286	215	311	373
¾	4.500	7	8	214	386	588	343	386	376	303	438	525
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				3.5 < *Pr* ≤ 5.0	1.8 < *Pr* ≤ 2.5	1.0 < *Pr* ≤ 1.3	1.7 < *Pr* ≤ 2.2	1.8 < *Pr* ≤ 2.5	2.0 < *Pr* ≤ 2.9	1.9 < *Pr* ≤ 2.4	1.3 < *Pr* ≤ 1.7	1.1 < *Pr* ≤ 1.4
⅜	2.375	5	4	62	119	194	113	119	108	101	144	175
½	3.750	6	6	83	167	279	163	167	144	147	208	254
⅝	3.875	6	6	113	218	354	207	218	197	186	263	320
¾	4.500	7	8	150	297	492	288	297	259	259	367	447
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				5.0 < *Pr* ≤ 6.5	2.5 < *Pr* ≤ 3.2	1.3 < *Pr* ≤ 1.6	2.2 < *Pr* ≤ 2.7	2.5 < *Pr* ≤ 3.2	2.9 < *Pr* ≤ 3.8	2.4 < *Pr* ≤ 2.9	1.7 < *Pr* ≤ 2.1	1.4 < *Pr* ≤ 1.7
⅜	2.375	5	4	47	97	168	98	97	82	89	125	154
½	3.750	6	6	63	130	239	140	130	109	128	178	220
⅝	3.875	6	6	87	178	306	179	178	150	163	228	281
¾	4.500	7	8	115	234	422	248	234	197	226	315	389

Pr: Prying factor range *(see A.18.5.12.2 for additional information)*.

Table 18.5.12.2(c) Max F_{pw} (lb) for Maximum Load for Wedge Anchors in 3000 psi (207 bar) Normal Weight Cracked Concrete

Max F_{pw} (lb) for Wedge Anchors in 3000 psi Normal Weight Cracked Concrete												
Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				Pr < 2.0	*Pr* < 1.1	*Pr* < 0.7	*Pr* < 1.2	*Pr* < 1.1	*Pr* < 1.1	*Pr* < 1.4	*Pr* < 0.9	*Pr* < 0.8

Max F_{pw} (lb) for Wedge Anchors in 3000 psi Normal Weight Cracked Concrete												
				A	B	C	D	E	F	G	H	I
Diameter (in.)	**Min. Nom. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	***Pr*** **< 2.0**	***Pr*** **< 1.1**	***Pr*** **< 0.7**	***Pr*** **< 1.2**	***Pr*** **< 1.1**	***Pr*** **< 1.1**	***Pr*** **< 1.4**	***Pr*** **< 0.9**	***Pr*** **< 0.8**
3/8	2.375	5	4	189	274	342	197	274	340	170	251	297
1/2	3.750	6	6	272	423	563	326	423	490	281	419	490
5/8	3.875	6	6	407	623	814	472	623	733	406	605	709
3/4	4.500	7	8	613	940	1232	715	940	1104	615	916	1073
				A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Diameter (in.)	**Min. Nom. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**2.0 <** ***Pr*** **≤ 3.5**	**1.1 <** ***Pr*** **≤ 1.8**	**0.7 <** ***Pr*** **≤ 1.0**	**1.2 <** ***Pr*** **≤ 1.7**	**1.1 <** ***Pr*** **≤ 1.8**	**1.1 <** ***Pr*** **≤ 2.0**	**1.4 <** ***Pr*** **≤ 1.9**	**0.9 <** ***Pr*** **≤ 1.3**	**0.8 <** ***Pr*** **≤ 1.1**
3/8	2.375	5	4	125	203	288	167	203	219	147	212	256
1/2	3.750	6	6	162	295	451	263	295	285	233	337	403
5/8	3.875	6	6	252	441	662	386	441	442	341	492	590
3/4	4.500	7	8	378	665	999	583	665	662	515	744	892
				A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Diameter (in.)	**Min. Nom. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**3.5 <** ***Pr*** **≤ 5.0**	**1.8 <** ***Pr*** **≤ 2.5**	**1.0 <** ***Pr*** **≤ 1.3**	**1.7 <** ***Pr*** **≤ 2.2**	**1.8 <** ***Pr*** **≤ 2.5**	**2.0 <** ***Pr*** **≤ 2.9**	**1.9 <** ***Pr*** **≤ 2.4**	**1.3 <** ***Pr*** **≤ 1.7**	**1.1 <** ***Pr*** **≤ 1.4**
3/8	2.375	5	4	92	162	249	145	162	159	130	184	225
1/2	3.750	6	6	113	226	377	220	226	196	199	281	342
5/8	3.875	6	6	176	341	557	326	341	304	293	415	506
3/4	4.500	7	8	264	514	841	493	514	456	443	627	763
				A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Diameter (in.)	**Min. Nom. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**5.0 <** ***Pr*** **≤ 6.5**	**2.5 <** ***Pr*** **≤ 3.2**	**1.3 <** ***Pr*** **≤ 1.6**	**2.2 <** ***Pr*** **≤ 2.7**	**2.5 <** ***Pr*** **≤ 3.2**	**2.9 <** ***Pr*** **≤ 3.8**	**2.4 <** ***Pr*** **≤ 2.9**	**1.7 <** ***Pr*** **≤ 2.1**	**1.4 <** ***Pr*** **≤ 1.7**
3/8	2.375	5	4	70	134	220	128	134	121	116	162	200
1/2	3.750	6	6	87	178	323	190	178	149	173	241	298
5/8	3.875	6	6	135	276	481	283	276	232	258	359	442
3/4	4.500	7	8	203	413	725	426	413	348	389	541	667

Pr: Prying factor range *(see A.18.5.12.2 for additional information)*.

Table 18.5.12.2(d) Maximum Load for Wedge Anchors in 4000 psi (276 bar) Normal Weight Cracked Concrete

Max F_{pw} (lb) for Wedge Anchors in 4000 psi Normal Weight Cracked Concrete

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr* ≤ 1.1	*Pr* ≤ 1.4	*Pr* ≤ 0.9	*Pr* ≤ 0.8
3/8	2.375	5	4	206	293	360	208	293	370	179	264	313
1/2	3.750	6	6	304	466	610	353	466	548	304	453	531
5/8	3.875	6	6	469	716	935	542	716	844	467	694	814
3/4	4.500	7	8	657	997	1293	750	997	1182	646	959	1125
Diameter (in.)	**Min. Nom. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				2.0 < *Pr* ≤ 3.5	**1.1 < *Pr* ≤ 1.8**	**0.7 < *Pr* ≤ 1.0**	**1.2 < *Pr* ≤ 1.7**	**1.1 < *Pr* ≤ 1.8**	**1.1 < *Pr* ≤ 2.0**	**1.4 < *Pr* ≤ 1.9**	**0.9 < *Pr* ≤ 1.3**	**0.8 < *Pr* ≤ 1.1**
3/8	2.375	5	4	138	221	307	178	221	242	157	226	272
1/2	3.750	6	6	188	330	495	289	330	330	255	368	442
5/8	3.875	6	6	291	508	761	444	508	511	392	566	678
3/4	4.500	7	8	414	711	1057	617	711	725	544	786	942
Diameter (in.)	**Min. Nom. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				3.5 < *Pr* ≤ 5.0	**1.8 < *Pr* ≤ 2.5**	**1.0 < *Pr* ≤ 1.3**	**1.7 < *Pr* ≤ 2.2**	**1.8 < *Pr* ≤ 2.5**	**2.0 < *Pr* ≤ 2.9**	**1.9 < *Pr* ≤ 2.4**	**1.3 < *Pr* ≤ 1.7**	**1.1 < *Pr* ≤ 1.4**
3/8	2.375	5	4	103	177	268	156	177	179	139	197	241
1/2	3.750	6	6	131	255	417	244	255	227	219	310	378
5/8	3.875	6	6	203	393	641	375	393	352	337	477	582
3/4	4.500	7	8	289	553	894	524	553	500	470	665	810
Diameter (in.)	**Min. Nom. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				5.0 < *Pr* ≤ 6.5	**2.5 < *Pr* ≤ 3.2**	**1.3 < *Pr* ≤ 1.6**	**2.2 < *Pr* ≤ 2.7**	**2.5 < *Pr* ≤ 3.2**	**2.9 < *Pr* ≤ 3.8**	**2.4 < *Pr* ≤ 2.9**	**1.7 < *Pr* ≤ 2.1**	**1.4 < *Pr* ≤ 1.7**
3/8	2.375	5	4	80	148	237	139	148	138	125	175	216
1/2	3.750	6	6	100	205	360	211	205	173	192	268	330
5/8	3.875	6	6	156	319	554	325	319	268	296	413	509
3/4	4.500	7	8	222	452	774	455	452	381	414	577	711

Pr: Prying factor range *(see A.18.5.12.2 for additional information)*.

Table 18.5.12.2(e) Maximum Load for Wedge Anchors in 6000 psi (414 bar) Normal Weight Cracked Concrete

Max F_{pw} (lb) for Wedge Anchors in 6000 psi Normal Weight Cracked Concrete

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr* ≤ 1.1	*Pr* ≤ 1.4	*Pr* ≤ 0.9	*Pr* ≤ 0.8
3/8	2.375	5	4	225	313	379	219	313	402	189	277	329
1/2	3.750	6	6	354	529	676	392	529	637	337	500	589
5/8	3.875	6	6	546	812	1036	601	812	981	517	766	902
3/4	4.500	7	8	763	1127	1429	829	1127	1370	714	1055	1243

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				2.0 < *Pr* ≤ 3.5	1.1 < *Pr* ≤ 1.8	0.7 < *Pr* ≤ 1.0	1.2 < *Pr* ≤ 1.7	1.1 < *Pr* ≤ 1.8	1.1 < *Pr* ≤ 2.0	1.4 < *Pr* ≤ 1.9	0.9 < *Pr* ≤ 1.3	0.8 < *Pr* ≤ 1.1
3/8	2.375	5	4	153	240	327	190	240	267	167	240	289
1/2	3.750	6	6	228	382	559	326	382	400	287	414	498
5/8	3.875	6	6	353	589	859	500	589	617	441	636	764
3/4	4.500	7	8	496	822	1190	693	822	868	611	881	1058

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				3.5 < *Pr* ≤ 5.0	1.8 < *Pr* ≤ 2.5	1.0 < *Pr* ≤ 1.3	1.7 < *Pr* ≤ 2.2	1.8 < *Pr* ≤ 2.5	2.0 < *Pr* ≤ 2.9	1.9 < *Pr* ≤ 2.4	1.3 < *Pr* ≤ 1.7	1.1 < *Pr* ≤ 1.4
3/8	2.375	5	4	115	194	288	168	194	200	149	211	258
1/2	3.750	6	6	161	299	477	279	299	278	250	354	431
5/8	3.875	6	6	249	462	733	429	462	431	384	544	663
3/4	4.500	7	8	354	647	1019	596	647	612	534	756	921

Diameter (in.)	Min. Nom. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				5.0 < *Pr* ≤ 6.5	2.5 < *Pr* ≤ 3.2	1.3 < *Pr* ≤ 1.6	2.2 < *Pr* ≤ 2.7	2.5 < *Pr* ≤ 3.2	2.9 < *Pr* ≤ 3.8	2.4 < *Pr* ≤ 2.9	1.7 < *Pr* ≤ 2.1	1.4 < *Pr* ≤ 1.7
3/8	2.375	5	4	91	163	257	150	163	157	135	189	233
1/2	3.750	6	6	123	246	415	243	246	212	221	308	380
5/8	3.875	6	6	192	380	639	375	380	329	341	475	585
3/4	4.500	7	8	272	533	891	523	533	467	475	662	815

Pr: Prying factor range *(see A.18.5.12.2 for additional information)*.

Table 18.5.12.2(f) Maximum Load for Metal Deck Inserts in 3000 psi (207 bar) Lightweight Cracked Concrete on Metal Deck

Max F_{pw} (lb) for Metal Deck Inserts in 3000 psi Sand Lightweight Cracked Concrete on 4½ in. Flute Width Metal Deck

Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Max. Flute Center Offset (in.)	A	B	C	D	E	F	G	H	I
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr* ≤ 1.1	*Pr* ≤ 1.4	*Pr* ≤ 0.9	*Pr* ≤ 0.8
⅜	1.750	6.25	1	135	192	236	—	—	—	—	—	—
½	1.750	6.25	1	138	199	247	—	—	—	—	—	—
⅝	1.750	6.25	1	138	199	247	—	—	—	—	—	—
¾	1.750	6.25	1	164	257	344	—	—	—	—	—	—
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Max. Flute Center Offset (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				2.0 < *Pr* ≤ 3.5	**1.1 < *Pr* ≤ 1.8**	**0.7 < *Pr* ≤ 1.0**	**1.2 < *Pr* ≤ 1.7**	**1.1 < *Pr* ≤ 1.8**	**1.1 < *Pr* ≤ 2.0**	**1.4 < *Pr* ≤ 1.9**	**0.9 < *Pr* ≤ 1.3**	**0.8 < *Pr* ≤ 1.1**
⅜	1.750	6.25	1	90	144	201	—	—	—	—	—	—
½	1.750	6.25	1	91	148	209	—	—	—	—	—	—
⅝	1.750	6.25	1	91	148	209	—	—	—	—	—	—
¾	1.750	6.25	1	97	178	275	—	—	—	—	—	—
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Max. Flute Center Offset (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				3.5 < *Pr* ≤ 5.0	**1.8 < *Pr* ≤ 2.5**	**1.0 < *Pr* ≤ 1.3**	**1.7 < *Pr* ≤ 2.2**	**1.8 < *Pr* ≤ 2.5**	**2.0 < *Pr* ≤ 2.9**	**1.9 < *Pr* ≤ 2.4**	**1.3 < *Pr* ≤ 1.7**	**1.1 < *Pr* ≤ 1.4**
⅜	1.750	6.25	1	67	115	175	—	—	—	—	—	—
½	1.750	6.25	1	67	118	181	—	—	—	—	—	—
⅝	1.750	6.25	1	67	118	181	—	—	—	—	—	—
¾	1.750	6.25	1	67	136	229	—	—	—	—	—	—
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Max. Flute Center Offset (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				5.0 < *Pr* ≤ 6.5	**2.5 < *Pr* ≤ 3.2**	**1.3 < *Pr* ≤ 1.6**	**2.2 < *Pr* ≤ 2.7**	**2.5 < *Pr* ≤ 3.2**	**2.9 < *Pr* ≤ 3.8**	**2.4 < *Pr* ≤ 2.9**	**1.7 < *Pr* ≤ 2.1**	**1.4 < *Pr* ≤ 1.7**
⅜	1.750	6.25	1	52	96	155	—	—	—	—	—	—
½	1.750	6.25	1	52	98	160	—	—	—	—	—	—
⅝	1.750	6.25	1	52	98	160	—	—	—	—	—	—
¾	1.750	6.25	1	52	106	196	—	—	—	—	—	—

Pr: Prying factor range *(see A.18.5.12.2 for additional information)*.

Table 18.5.12.2(g) Maximum Load for Wood Form Inserts in 3000 psi (207 bar) Lightweight Cracked Concrete

Max F_{pw} (lb) for Wood Form Inserts in 3000 psi Lightweight Cracked Concrete												
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				***Pr* ≤ 2.0**	***Pr* ≤ 1.1**	***Pr* ≤ 0.7**	***Pr* ≤ 1.2**	***Pr* ≤ 1.1**	***Pr* ≤ 1.1**	***Pr* ≤ 1.4**	***Pr* ≤ 0.9**	***Pr* ≤ 0.8**
3/8	1.100	4	6	224	316	387	223	316	401	193	283	336
1/2	1.690	4	6	252	376	480	278	376	454	239	355	418
5/8	1.750	4	8	252	376	480	278	376	454	239	355	418
3/4	1.750	4	8	252	376	480	278	376	454	239	355	418
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				2.0 < *Pr* ≤ 3.5	**1.1 < *Pr* ≤ 1.8**	**0.7 < *Pr* ≤ 1.0**	**1.2 < *Pr* ≤ 1.7**	**1.1 < *Pr* ≤ 1.8**	**1.1 < *Pr* ≤ 2.0**	**1.4 < *Pr* ≤ 1.9**	**0.9 < *Pr* ≤ 1.3**	**0.8 < *Pr* ≤ 1.1**
3/8	1.100	4	6	150	239	331	192	239	264	169	243	293
1/2	1.690	4	6	163	272	398	231	272	286	204	294	354
5/8	1.750	4	8	163	272	398	231	272	286	204	294	354
3/4	1.750	4	8	163	272	398	231	272	286	204	294	354
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				3.5 < *Pr* ≤ 5.0	**1.8 < *Pr* ≤ 2.5**	**1.0 < *Pr* ≤ 1.3**	**1.7 < *Pr* ≤ 2.2**	**1.8 < *Pr* ≤ 2.5**	**2.0 < *Pr* ≤ 2.9**	**1.9 < *Pr* ≤ 2.4**	**1.3 < *Pr* ≤ 1.7**	**1.1 < *Pr* ≤ 1.4**
3/8	1.100	4	6	113	193	290	169	193	196	150	213	260
1/2	1.690	4	6	115	213	339	198	213	199	178	251	307
5/8	1.750	4	8	115	213	339	198	213	199	178	251	307
3/4	1.750	4	8	115	213	339	198	213	199	178	251	307
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				5.0 < *Pr* ≤ 6.5	**2.5 < *Pr* ≤ 3.2**	**1.3 < *Pr* ≤ 1.6**	**2.2 < *Pr* ≤ 2.7**	**2.5 < *Pr* ≤ 3.2**	**2.9 < *Pr* ≤ 3.8**	**2.4 < *Pr* ≤ 2.9**	**1.7 < *Pr* ≤ 2.1**	**1.4 < *Pr* ≤ 1.7**
3/8	1.100	4	6	88	161	257	150	161	152	135	190	234
1/2	1.690	4	6	88	175	296	173	175	152	157	219	271
5/8	1.750	4	8	88	175	296	173	175	152	157	219	271
3/4	1.750	4	8	88	175	296	173	175	152	157	219	271

Pr: Prying factor range *(see A.18.5.12.2 for additional information)*.

Table 18.5.12.2(h) Maximum Load for Wood Form Inserts in 3000 psi (207 bar) Normal Weight Cracked Concrete

Max F_{pw} (lb) for Wood Form Inserts in 3000 psi Normal Weight Cracked Concrete												
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				***Pr* ≤ 2.0**	***Pr* ≤ 1.1**	***Pr* ≤ 0.7**	***Pr* ≤ 1.2**	***Pr* ≤ 1.1**	***Pr* ≤ 1.1**	***Pr* ≤ 1.4**	***Pr* ≤ 0.9**	***Pr* ≤ 0.8**

Max F_{pw} (lb) for Wood Form Inserts in 3000 psi Normal Weight Cracked Concrete												
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				***Pr* ≤ 2.0**	***Pr* ≤ 1.1**	***Pr* ≤ 0.7**	***Pr* ≤ 1.2**	***Pr* ≤ 1.1**	***Pr* ≤ 1.1**	***Pr* ≤ 1.4**	***Pr* ≤ 0.9**	***Pr* ≤ 0.8**
3/8	1.100	4	6	248	342	411	237	342	444	205	300	357
1/2	1.690	4	6	297	443	565	327	443	535	282	418	492
5/8	1.750	4	8	297	443	565	327	443	535	282	418	492
3/4	1.750	4	8	297	443	565	327	443	535	282	418	492
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				2.0 < *Pr* ≤ 3.5	**1.1 < *Pr* ≤ 1.8**	**0.7 < *Pr* ≤ 1.0**	**1.2 < *Pr* ≤ 1.7**	**1.1 < *Pr* ≤ 1.8**	**1.1 < *Pr* ≤ 2.0**	**1.4 < *Pr* ≤ 1.9**	**0.9 < *Pr* ≤ 1.3**	**0.8 < *Pr* ≤ 1.1**
3/8	1.100	4	6	170	264	357	207	264	298	182	261	315
1/2	1.690	4	6	192	321	468	272	321	336	240	347	416
5/8	1.750	4	8	192	321	468	272	321	336	240	347	416
3/4	1.750	4	8	192	321	468	272	321	336	240	347	416
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				3.5 < *Pr* ≤ 5.0	**1.8 < *Pr* ≤ 2.5**	**1.0 < *Pr* ≤ 1.3**	**1.7 < *Pr* ≤ 2.2**	**1.8 < *Pr* ≤ 2.5**	**2.0 < *Pr* ≤ 2.9**	**1.9 < *Pr* ≤ 2.4**	**1.3 < *Pr* ≤ 1.7**	**1.1 < *Pr* ≤ 1.4**
3/8	1.100	4	6	129	215	315	184	215	224	163	231	282
1/2	1.690	4	6	135	251	399	233	251	235	209	296	361
5/8	1.750	4	8	135	251	399	233	251	235	209	296	361
3/4	1.750	4	8	135	251	399	233	251	235	209	296	361
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				5.0 < *Pr* ≤ 6.5	**2.5 < *Pr* ≤ 3.2**	**1.3 < *Pr* ≤ 1.6**	**2.2 < *Pr* ≤ 2.7**	**2.5 < *Pr* ≤ 3.2**	**2.9 < *Pr* ≤ 3.8**	**2.4 < *Pr* ≤ 2.9**	**1.7 < *Pr* ≤ 2.1**	**1.4 < *Pr* ≤ 1.7**
3/8	1.100	4	6	104	181	282	165	181	179	148	208	256
1/2	1.690	4	6	104	207	348	204	207	179	185	258	319
5/8	1.750	4	8	104	207	348	204	207	179	185	258	319
3/4	1.750	4	8	104	207	348	204	207	179	185	258	319

Pr: Prying factor range *(see A.18.5.12.2 for additional information)*.

Table 18.5.12.2(i) Maximum Load for Wood Form Inserts in 4000 psi (276 bar) Normal Weight Cracked Concrete

Max F_{pw} (lb) for Wood Form Inserts in 4000 psi Normal Weight Cracked Concrete												
Diameter (in.)	**Min. Effect. Embedment (in.)**	**Min. Slab Thickness (in.)**	**Min. Edge Distance (in.)**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
				***Pr* ≤ 2.0**	***Pr* ≤ 1.1**	***Pr* ≤ 0.7**	***Pr* ≤ 1.2**	***Pr* ≤ 1.1**	***Pr* ≤ 1.1**	***Pr* ≤ 1.4**	***Pr* ≤ 0.9**	***Pr* ≤ 0.8**

Max F_{pw} (lb) for Wood Form Inserts in 4000 psi Normal Weight Cracked Concrete

Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				$Pr \le 2.0$	$Pr \le 1.1$	$Pr \le 0.7$	$Pr \le 1.2$	$Pr \le 1.1$	$Pr \le 1.1$	$Pr \le 1.4$	$Pr \le 0.9$	$Pr \le 0.8$
3/8	1.100	4	6	270	364	431	249	364	482	215	313	374
1/2	1.690	4	6	335	493	623	361	493	602	311	459	541
5/8	1.750	4	8	344	511	653	378	511	618	326	482	568
3/4	1.750	4	8	344	511	653	378	511	618	326	482	568
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				$2.0 < Pr \le 3.5$	$1.1 < Pr \le 1.8$	$0.7 < Pr \le 1.0$	$1.2 < Pr \le 1.7$	$1.1 < Pr \le 1.8$	$1.1 < Pr \le 2.0$	$1.4 < Pr \le 1.9$	$0.9 < Pr \le 1.3$	$0.8 < Pr \le 1.1$
3/8	1.100	4	6	188	287	379	220	287	330	193	277	334
1/2	1.690	4	6	218	361	520	303	361	382	266	384	462
5/8	1.750	4	8	222	371	541	315	371	389	278	400	481
3/4	1.750	4	8	222	371	541	315	371	389	278	400	481
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				$3.5 < Pr \le 5.0$	$1.8 < Pr \le 2.5$	$1.0 < Pr \le 1.3$	$1.7 < Pr \le 2.2$	$1.8 < Pr \le 2.5$	$2.0 < Pr \le 2.9$	$1.9 < Pr \le 2.4$	$1.3 < Pr \le 1.7$	$1.1 < Pr \le 1.4$
3/8	1.100	4	6	145	236	338	197	236	251	175	247	302
1/2	1.690	4	6	157	284	446	261	284	271	233	330	403
5/8	1.750	4	8	157	290	461	270	290	271	242	342	417
3/4	1.750	4	8	157	290	461	270	290	271	242	342	417
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				$5.0 < Pr \le 6.5$	$2.5 < Pr \le 3.2$	$1.3 < Pr \le 1.6$	$2.2 < Pr \le 2.7$	$2.5 < Pr \le 3.2$	$2.9 < Pr \le 3.8$	$2.4 < Pr \le 2.9$	$1.7 < Pr \le 2.1$	$1.4 < Pr \le 1.7$
3/8	1.100	4	6	117	201	305	178	201	202	160	224	275
1/2	1.690	4	6	120	234	390	229	234	207	207	290	357
5/8	1.750	4	8	120	239	402	236	239	207	214	299	368
3/4	1.750	4	8	120	239	402	236	239	207	214	299	368

Pr: Prying factor range *(see A.18.5.12.2 for additional information)*.

Table 18.5.12.2(j) Maximum Load for Wood Form Inserts in 6000 psi (414 bar) Normal Weight Cracked Concrete

Max F_{pw} (lb) for Wood Form Inserts in 6000 psi Normal Weight Cracked Concrete

Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				$Pr \le 2.0$	$Pr \le 1.1$	$Pr \le 0.7$	$Pr \le 1.2$	$Pr \le 1.1$	$Pr \le 1.1$	$Pr \le 1.4$	$Pr \le 0.9$	$Pr \le 0.8$

Max F_{pw} (lb) for Wood Form Inserts in 6000 psi Normal Weight Cracked Concrete												
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				Pr ≤ 2.0	*Pr* ≤ 1.1	*Pr* ≤ 0.7	*Pr* ≤ 1.2	*Pr* ≤ 1.1	*Pr* ≤ 1.1	*Pr* ≤ 1.4	*Pr* ≤ 0.9	*Pr* ≤ 0.8
3⁄8	1.100	4	6	302	395	458	264	395	537	228	332	397
1⁄2	1.690	4	6	385	551	680	394	551	690	339	499	591
5⁄8	1.750	4	8	421	627	800	463	627	756	399	591	696
3⁄4	1.750	4	8	421	627	800	463	627	756	399	591	696
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				2.0 < *Pr* ≤ 3.5	1.1 < *Pr* ≤ 1.8	0.7 < *Pr* ≤ 1.0	1.2 < *Pr* ≤ 1.7	1.1 < *Pr* ≤ 1.8	1.1 < *Pr* ≤ 2.0	1.4 < *Pr* ≤ 1.9	0.9 < *Pr* ≤ 1.3	0.8 < *Pr* ≤ 1.1
3⁄8	1.100	4	6	216	319	409	237	319	379	207	297	360
1⁄2	1.690	4	6	256	413	578	336	413	449	296	426	512
5⁄8	1.750	4	8	272	454	662	386	454	476	340	491	589
3⁄4	1.750	4	8	272	454	662	386	454	476	340	491	589
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				3.5 < *Pr* ≤ 5.0	1.8 < *Pr* ≤ 2.5	1.0 < *Pr* ≤ 1.3	1.7 < *Pr* ≤ 2.2	1.8 < *Pr* ≤ 2.5	2.0 < *Pr* ≤ 2.9	1.9 < *Pr* ≤ 2.4	1.3 < *Pr* ≤ 1.7	1.1 < *Pr* ≤ 1.4
3⁄8	1.100	4	6	169	267	370	215	267	292	190	270	329
1⁄2	1.690	4	6	192	330	503	293	330	332	262	371	452
5⁄8	1.750	4	8	192	356	565	331	356	332	296	419	511
3⁄4	1.750	4	8	192	356	565	331	356	332	296	419	511
Diameter (in.)	Min. Effect. Embedment (in.)	Min. Slab Thickness (in.)	Min. Edge Distance (in.)	A	B	C	D	E	F	G	H	I
				5.0 < *Pr* ≤ 6.5	2.5 < *Pr* ≤ 3.2	1.3 < *Pr* ≤ 1.6	2.2 < *Pr* ≤ 2.7	2.5 < *Pr* ≤ 3.2	2.9 < *Pr* ≤ 3.8	2.4 < *Pr* ≤ 2.9	1.7 < *Pr* ≤ 2.1	1.4 < *Pr* ≤ 1.7
3⁄8	1.100	4	6	138	229	337	196	229	238	176	246	303
1⁄2	1.690	4	6	147	275	445	260	275	253	235	328	405
5⁄8	1.750	4	8	147	293	493	289	293	253	263	366	451
3⁄4	1.750	4	8	147	293	493	289	293	253	263	366	451

Pr: Prying factor range *(see A.18.5.12.2 for additional information)*.

Table 18.5.12.2(k) Maximum Load for Connections to Steel Using Unfinished Steel Bolts

Connections to Steel (Values Assume Bolt Perpendicular to Mounting Surface)																	
Diameter of Unfinished Steel Bolt (in.)																	
1⁄4									3⁄8								
A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I

Connections to Steel (Values Assume Bolt Perpendicular to Mounting Surface)																	
400	500	600	300	500	650	325	458	565	900	1200	1400	800	1200	1550	735	1035	1278
Diameter of Unfinished Steel Bolt (in.)																	
$\frac{1}{2}$									**$\frac{5}{8}$**								
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
1600	2050	2550	1450	2050	2850	1300	1830	2260	2500	3300	3950	2250	3300	4400	2045	2880	3557

Table 18.5.12.2(l) Maximum Load for Through-Bolts in Sawn Lumber or Glue-Laminated Timbers

Through-Bolts in Sawn Lumber or Glue-Laminated Timbers (Load Perpendicular to Gr																							
		Bolt Diameter (in.)																					
		$\frac{1}{2}$									**$\frac{5}{8}$**												
Length of Bolt in Timber (in.)		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**A**	**B**	**C**	**D**
	$1\frac{1}{2}$	115	165	200	135	230	395	130	215	310	135	190	235	155	270	460	155	255	380	155	220	270	180
	$2\frac{1}{2}$	140	200	240	160	280	480	165	275	410	160	225	280	185	320	550	190	320	495	180	255	310	205
	$3\frac{1}{2}$	175	250	305	200	350	600	200	330	485	200	285	345	230	400	685	235	405	635	220	310	380	255
	$5\frac{1}{2}$	—	—	—	—	—	—	—	—	—	280	395	485	325	560	960	315	515	735	310	440	535	360

Note: Wood fastener maximum capacity values are based on the 2001 National Design Specifications (NDS) for wood with a specific gravity of 0.35. Values for other types of wood can be obtained by multiplying the above values by the factors in Table 18.5.12.2(n).

Table 18.5.12.2(m) Maximum Load for Lag Screws and Lag Bolts in Wood

Lag Screws and Lag Bolts in Wood (Load Perpendicular to Grain — Holes Predrilled Using Goc																							
		Lag Bolt Diameter (in.)																					
		$\frac{3}{8}$									**$\frac{1}{2}$**												
Length of Bolt in Timber (in.)		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**A**	**B**	**C**	**D**
	$3\frac{1}{2}$	165	190	200	170	220	310	80	120	170	—	—	—	—	—	—	—	—	—	—	—	—	—
	$4\frac{1}{2}$	180	200	200	175	235	350	80	120	170	300	355	380	315	400	550	145	230	325	—	—	—	—
	$5\frac{1}{2}$	190	200	200	175	245	380	80	120	170	320	370	380	320	420	610	145	230	325	435	525	555	425
	$6\frac{1}{2}$	195	205	200	175	250	400	80	120	170	340	375	380	325	435	650	145	230	325	465	540	555	430

Note: Wood fastener maximum capacity values are based on the 2001 National Design Specifications (NDS) for wood with a specific gravity of 0.35. Values for other types of wood can be obtained by multiplying the above values by the factors in Table 18.5.12.2(n).

Table 18.5.12.2(n) Factors for Wood Based on Specific Gravity

Specific Gravity of Wood	Multiplier
0.36 thru 0.49	1.17
0.50 thru 0.65	1.25
0.66 thru 0.73	1.50

18.5.12.3 *

The type of fasteners used to secure the bracing assembly to the structure shall be limited to those shown in Table 18.5.12.2(a) through Table 18.5.12.2(m) or to listed devices.

18.5.12.4 *

For connections to wood, through-bolts with washers on each end shall be used, unless the requirements of 18.5.12.5 are met.

18.5.12.5

Where it is not practical to install through-bolts due to the thickness of the wood member in excess of 12 in. (300 mm) or inaccessibility, lag screws shall be permitted and holes shall be pre-drilled $^{1}/_{8}$ in. (3 mm) smaller than the maximum root diameter of the lag screw.

18.5.12.6

Holes for through-bolts and similar listed attachments shall be $^{1}/_{16}$ in. (1.6 mm) greater than the diameter of the bolt.

18.5.12.6.1

The requirements of 18.5.12 shall not apply to other fastening methods, which shall be acceptable for use if certified by a registered professional engineer to support the loads determined in accordance with the criteria in 18.5.9.

18.5.12.6.2

Calculations shall be submitted where required by the authority having jurisdiction.

18.5.12.7 * Concrete Anchors.

18.5.12.7.1 *

Post-installed concrete anchors shall be prequalified for seismic applications in accordance with ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*, and installed in accordance with the manufacturer's instructions.

18.5.12.7.2

Unless the requirements of 18.5.12.7.3 are met, concrete anchors shall be based on concrete strength, anchor type, designated angle category A through I, prying factor (*Pr*) range, and allowable maximum load.

18.5.12.7.2.1

Sway brace manufacturers shall provide prying factors (*Pr*) based on the geometry of the structure attachment fitting and the designated angle category A through I as shown in Figure 18.5.12.1.

18.5.12.7.2.2

Where the prying factor *(Pr)* for the fitting is unknown, the largest *Pr* range in Table 18.5.12.2(a) through Table 18.5.12.2(j) for the concrete strength and designated angle category A through I shall be used.

18.5.12.7.3

The allowable maximum load shall be permitted to be calculated.

18.5.12.7.3.1

Allowable concrete anchor loads shall be permitted to be determined using approved software that considers the effects of prying for concrete anchors.

18.5.12.7.3.2

Anchors shall be seismically prequalified per 18.5.12.7.1.

18.5.12.7.3.3

Allowable maximum loads shall be based on anchor capacities given in approved evaluation service reports, where the calculation of allowable stress design (ASD) allowable shear and tension values are determined in accordance with Chapter 17 of ACI 318, *Building Code Requirements for Structural Concrete and Commentary,* and include the effects of prying, the brace angle, and the over strength factor (Ω_{0p} =2.0).

18.5.12.7.3.4 *

The shear and tension values determined in 18.5.12.7.3.3 shall be multiplied by 0.43.

18.5.12.7.4

Concrete anchors shall be acceptable for use where designed in accordance with the requirements of the applicable building code and certified by a registered professional engineer.

18.5.12.7.5 *

Headed cast-in specialty inserts (i.e., concrete inserts) as prescribed in Table 18.5.12.2(a) through Table 18.5.12.2(j) shall be prequalified for seismic applications in accordance with ICC-ES AC446, *Acceptance Criteria for Headed Cast-in Specialty Inserts in Concrete*, and installed in accordance with the manufacturer's instructions.

18.5.13 Braces to Buildings with Differential Movement.

A length of pipe shall not be braced to sections of the building that will move differentially.

18.6 Restraint of Branch Lines.

18.6.1 *

Restraint is considered a lesser degree of resisting loads than bracing and shall be provided by use of one of the following:

(1) Listed sway brace assembly
(2) Wraparound U-hook satisfying the requirements of 18.5.5.11
(3) No. 12, 440 lb (200 kg) wire installed at least 45 degrees from the vertical plane and anchored on both sides of the pipe
(4) CPVC hangers listed to provide restraint
(5)* Hanger not less than 45 degrees from vertical installed within 6 in. (150 mm) of the vertical hanger arranged for restraint against upward movement, provided it is utilized such that l/r does not exceed 400, where the rod extends to the pipe or a surge clip has been installed
(6) Other approved means

18.6.2 Wire Restraint.

18.6.2.1

Wire used for restraint shall be located within 2 ft (600 mm) of a hanger.

18.6.2.2

The hanger closest to a wire restraint shall be of a type that resists upward movement of a branch line.

18.6.3

The end sprinkler on a branch line shall be restrained.

18.6.3.1

The location of the restraint from end of the line shall not be greater than 36 in. (900 mm) for 1 in. (25 mm) pipe, 48 in. (1200 mm) for 1¼ in. (32 mm) pipe, and 60 in. (1.5 m) for 1½ in. (40 mm) or larger pipe.

18.6.4 *

Branch lines shall be laterally restrained at intervals not exceeding those specified in Table 18.6.4(a) or Table 18.6.4(b) based on branch line diameter and the value of C_p.

Table 18.6.4(a) Maximum Spacing [ft (m)] of Steel Pipe Restraints

	Seismic Coefficient, C_p			
Pipe [in. (mm)]	$C_p \leq 0.50$	$0.5 < C_p \leq 0.71$	$0.71 < C_P \leq 1.40$	$C_P > 1.40$
½ (15)	26 (8.1)	23 (6.9)	16 (4.7)	14 (4.3)
¾ (20)	30 (9.0)	25 (7.6)	18 (5.5)	16 (4.7)
1 (25)	33 (10.2)	28 (8.5)	20 (6.2)	17 (5.2)
1¼ (32)	36 (10.9)	30 (9.3)	21 (6.4)	19 (5.7)
1½ (40)	38 (11.6)	32 (9.7)	23 (6.9)	19 (5.9)

Pipe [in. (mm)]	Seismic Coefficient, C_p			
	$C_p \leq 0.50$	$0.5 < C_p \leq 0.71$	$0.71 < C_P \leq 1.40$	$C_P > 1.40$
2 (53)	41 (12.6)	35 (10.7)	24 (7.4)	21 (6.4)

Table 18.6.4(b) Maximum Spacing [ft (m)] of CPVC, Copper, and Red Brass Pipe Restraints

Pipe [in. (mm)]	Seismic Coefficient, C_p			
	$C_p \leq 0.50$	$0.5 < C_p \leq 0.71$	$0.71 < C_P \leq 1.40$	$C_P > 1.40$
½ (15)	20 (6.2)	17 (5.2)	12 (3.8)	10 (3.1)
¾ (20)	24 (7.4)	20 (6.2)	14 (4.3)	12 (3.6)
1 (25)	26 (8.1)	22 (6.6)	16 (4.7)	13 (4.0)
1¼ (32)	29 (8.8)	24 (7.4)	17 (5.2)	15 (4.5)
1½ (40)	31 (9.5)	26 (8.1)	19 (5.7)	16 (4.7)
2 (53)	35 (10.7)	30 (9.0)	21 (6.4)	18 (5.5)

18.6.5

Where the branch lines are supported by rods less than 6 in. (150 mm) long measured between the top of the pipe and the point of attachment to the building structure, the requirements of 18.6.1 through 18.6.4 shall not apply and additional restraint shall not be required for the branch lines.

18.6.6 *

Sprigs 4 ft (1.2 m) or longer shall be restrained against lateral movement.

18.6.7

Drops, armovers, and flexible sprinkler hose fittings shall not require restraint.

18.7 Hangers and Fasteners Subject to Earthquakes.

18.7.1

Where seismic protection is provided, C-type clamps (including beam and large flange clamps) used to attach hangers to the building structure shall be equipped with a restraining strap unless the provisions of 18.7.1.1 are satisfied.

18.7.1.1

As an alternative to the installation of a required restraining strap, a device investigated and specifically listed to restrain the clamp to the structure is permitted where the intent of the device is to resist the worst-case expected horizontal load.

18.7.2

The restraining strap shall be listed for use with a C-type clamp or shall be a steel strap of not less than 16 gauge (1.57 mm) thickness and not less than 1 in. (25 mm) wide for pipe diameters 8 in. (200 mm) or less and 14 gauge (1.98 mm) thickness and not less than 1¼ in. (32 mm) wide for pipe diameters greater than 8 in. (200 mm).

18.7.3

The restraining strap shall wrap around the beam flange not less than 1 in. (25 mm).

18.7.4

A lock nut on a C-type clamp shall not be used as a method of restraint.

18.7.5

A lip on a “C” or “Z” purlin shall not be used as a method of restraint.

18.7.6

Where purlins or beams do not provide a secure lip to a restraining strap, the strap shall be through-bolted or secured by a self-tapping screw.

18.7.7

In areas where the horizontal force factor exceeds 0.50 W_p, powder-driven studs shall be permitted to attach hangers to the building structure where they are specifically listed for use in areas subject to earthquakes.

18.7.8 *

Where seismic protection is provided, concrete anchors used to secure hangers to the building structure shall be in accordance with ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*, and installed in accordance with manufacturer's instructions.

18.7.9

Where seismic protection is provided, cast-in-place anchors used to secure hangers to the building structure shall be in accordance with ICC-ES AC446, *Acceptance Criteria for Headed Cast-in Specialty Inserts in Concrete,* and installed in accordance with manufacturer’s instructions.

18.8 * Pipe Stands Subject to Earthquakes.

18.8.1

In areas where the horizontal force factor exceeds 0.5 W_p, pipe stands over 4 ft (1.2 m) in height shall be certified by a registered professional engineer to be adequate for the seismic forces.

18.8.2

Where seismic protection is provided, concrete anchors used to secure pipe stands to their bases shall be in accordance with ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary*, and shall be installed in accordance with manufacturer’s instructions.