

TABLE 16B-O—HORIZONTAL FORCE FACTOR, C_p

ELEMENTS OF STRUCTURES, NONSTRUCTURAL COMPONENTS AND EQUIPMENT ¹	VALUE OF C_p	FOOTNOTE
1. Elements of structures		
1. Walls including the following:		
a. Unbraced (cantilevered) parapets	2.00	
b. Other exterior walls above the ground floor	0.75	2
c. All interior bearing and nonbearing walls and partitions	0.75	11
d. Masonry or concrete fences over 6 feet (1829 mm) high	0.75	
2. Penthouse (except when framed by an extension of the structural frame)	0.75	
3. Connections for prefabricated structural elements other than walls, with force applied at center of gravity	0.75	4,12
4. Diaphragms	—	5
2. Nonstructural components		
1. Exterior and interior ornamental appendages	2.00	12
2. Chimneys, stacks, trussed towers and tanks on legs:		
a. Supported on or projecting as an unbraced cantilever above the roof more than one half their total height	2.00	
b. All others, including those supported below the roof with unbraced projection above the roof less than one half its height, or braced or guyed to the structural frame at or above their centers of mass	0.75	
3. Signs and billboards	2.00	
4. Storage racks (include contents) with upper storage level more than 5 feet (1524 mm) in height	0.75	10,17
5. Anchorage for permanent floor-supported cabinets and book stacks more than 5 feet (1524 mm) in height (include contents)	0.75	12,16,17
6. Anchorage for suspended ceilings and light fixtures	0.75	4,6,7,11,18,19
7. Access floor systems	0.75	4,9,12
8. Wall hung cabinets and storage shelving (plus contents)	0.75	
3. Equipment		
1. Tanks and vessels (include contents), including support systems and anchorage	0.75	12,16
2. Electrical, mechanical and plumbing equipment and associated conduit, ductwork and piping, and machinery. <i>In hospitals and essential services buildings, this includes all piping, electrical conduits, cable trays and air-handling ducting necessary to the continuing operation of the facility</i>	0.75	8,12
3. Anchorage of emergency power supply systems, essential communications equipment, battery racks and fuel tanks necessary for operation of such equipment	1.0	12,13
4. Anchorage of hospital equipment when permanently attached to the building utility services such as surgical, morgue and recovery room fixtures, radiology equipment, medical gas containers, food service fixtures, essential laboratory equipment, TV supports, etc.	0.75	12
5. Power cable-driven elevators or hydraulic elevators with lifts over 5 feet (1524 mm):		20
a. Hoistway structural framing providing the support for guide rail brackets		
b. Guide rails and guide rail brackets		
c. Car and counterweight auxiliary guiding members or retainer plates		
d. Driving machinery, pump unit tanks operating devices and control equipment cabinets		

¹See Section 1630B.2 for items supported at or below grade for formula using C_p and for definitions. Horizontal forces are to be applied in any horizontal direction. The value of C_p shall not be reduced for all walls. Welded, bolted or other intermittent connections such as inserts for anchorage of nonstructural components shall not be allowed the one-third increase in allowable stress permitted in Section 1603B.5.

²See Section 1631B.2.4 and Section 1630B.2.

³(Deleted)

⁴Applies to Seismic Zones 2, 3 and 4 only.

⁵See Section 1631B.2.9.

⁶Ceiling weight shall include all light fixtures and other equipment or partitions which are laterally supported by the ceiling. For purposes of determining the seismic force, a ceiling weight of not less than 4 pounds per square foot (19.5 kg/m²) shall be used.

⁷Ceilings constructed of lath and plaster or gypsum board screw or nail attached to suspended members that support a ceiling at one level extending from wall to wall need not be analyzed provided that the minimum distance between opposing walls is not over 50 feet (15 240 mm) apart.

⁸Equipment includes, but is not limited to, boiler, chiller, heat exchanger, pump, air-handling unit, cooling tower, control panel, motor, switch gear, transformer and life-safety equipment. It includes major conduit, ducting and piping serving such machinery and equipment and fire sprinkler systems. See Section 1630B.2 for additional requirements for determining C_p for nonrigid or flexibly mounted equipment.

⁹ W_p for access floor systems shall be the dead load of the access floor system plus 25 percent of the floor live load plus a 10 psf (0.479 kN/m²) partition load allowance.

¹⁰In lieu of the tabulated values, steel storage racks may be designed in accordance with Chapter 22B, Division VI, subject to the limitations of Sections 1630B.5 and 1632B.5, Item 3.

¹¹Light fixtures and mechanical services installed in metal suspension systems for acoustical tile and lay-in panel ceilings shall be independently supported from the structure above as specified in UBC Standard 25-2, Part III. See also Section 1610B.2 for minimum load and deflection criteria for interior partitions.

¹²The component anchorage shall be designed for the horizontal force, F_p , acting simultaneously with a vertical seismic force equal to one third of the horizontal force, F_p .

¹³Emergency equipment should be located where there is the least likelihood of damage due to earthquake. Such equipment should be located at ground level, and where it can be easily maintained to assure its operation during an emergency.

(Continued)

FOOTNOTES TO TABLE 16B-O—(Continued)

- 14(Deleted)
 15(Deleted)
 16Floor-supported storage racks, cabinets or book stacks not more than 5 feet (1524 mm) in height need not be anchored if the width of the supporting base or width between the exterior legs is equal to or greater than two thirds the height. In addition to gravity loads, storage racks or cabinets shall be designed and constructed to resist the horizontal force, F_p , with the base assumed to be anchored.
 17Mobile storage racks or cabinets mounted on wheels and not restrained by fixed tracks are not subject to approval by the enforcement agency when the rack or cabinet is not more than 5 feet (1524 mm) in height and the width of the supporting base or width between the exterior legs/wheels is equal to or greater than two thirds the height. All such racks or cabinets shall be restrained to prevent movement when not in use. Movable storage racks or cabinets mounted on wheels or glides restrained by fixed tracks shall be designed and constructed to resist the horizontal force, F_p , with the base of the rack or cabinet assumed to be anchored. Provisions shall be made to resist translation perpendicular to the track and overturning both perpendicular and parallel to the track.
 18Suspension systems for light fixtures which have passed shaking table tests approved by the enforcement agency, or which, as installed, are free to swing a minimum of 45 degrees from the vertical in all directions without contacting obstructions, shall be assumed to comply with the lateral-force requirements of Section 1630B.2. Unless of the cable type, free-swinging suspension systems shall have a safety wire or cable attached to the fixture and structure at each support capable of supporting four times the supported load.
 19For suspended and surface-mounted light fixtures, the product of IC_p need not exceed 1.2 for any value of I .
 20See Section 1631B.2.13 for requirements.

TABLE 16B-P— R_W FACTORS FOR NONBUILDING STRUCTURES

STRUCTURE TYPE	R_W
1. Vessels, including tanks and pressurized spheres, on braced or unbraced legs.	3
2. Cast-in-place concrete silos and chimneys having walls continuous to the foundation.	5
3. Distributed mass cantilever structures such as stacks, chimneys, silos and skirt-supported vertical vessels.	4
4. Trussed towers (freestanding or guyed), guyed stacks and chimneys.	4
5. Inverted pendulum-type structures.	
5.1 Single-column structures	3
5.2 Multicolumn structures with strut ties capable of developing the capacity of the column	4
6. Cooling towers.	5
7. Bins and hoppers on braced or unbraced legs.	4
8. Storage racks.	5
9. Signs and billboards.	5
10. Amusement structures and monuments.	3
11. All other self-supporting structures not otherwise covered.	4

* the attachments for permanent equipment supported by a structure shall be designed to resist the total design seismic forces prescribed in Section 1630B.2.

Attachments shall include anchorages and required bracing. *Welded, bolted or other intermittent connections, such as inserts for anchorage of nonstructural components, shall not be allowed the one-third increase in allowable stresses permitted in Section 1603B.5.* Friction resulting from gravity loads shall not be considered to provide resistance to seismic forces.

When the structural failure of the lateral force-resisting systems of nonrigid equipment would cause a life hazard, such systems shall be designed to resist the seismic forces prescribed in Section 1630B.2.

When allowable design stresses and other acceptance criteria are not contained in or referenced by this code, such criteria shall be obtained from approved national standards *approved by the enforcement agency.*

1630B.2 Design for Total Lateral Force. The total design lateral seismic force, F_p , shall be determined from the following formula:

$$F_p = Z I_p C_p W_p \quad (30B-1)$$

The values of Z and I_p shall be the values used for the structure from Tables 16B-I and 16B-K. *For elevator-related equipment, see Part 7, Title 24, California Code of Regulations in addition to Table 16B-O.*

The coefficient C_p is for elements and components and for rigid and rigidly supported equipment. Rigid or rigidly supported equipment is defined as having a fundamental period less than or equal to 0.06 second. Nonrigid or flexibly supported equipment is defined as a system having a fundamental period, including the equipment, greater than 0.06 second.

The lateral forces calculated for nonrigid or flexibly supported equipment supported by a structure and located above grade shall be determined considering the dynamic properties of both the equipment and the structure which supports it, but the value shall not be less than that listed in Table 16B-O. In the absence of an analysis or empirical data, the value of C_p for nonrigid components or flexibly supported equipment shall be taken as four times the value listed in Table 16B-O, but not to exceed 3.0. *The factor of four should be used only on lumped mass single degree of freedom type components. If the supported item is closely restrained so that resonance is not possible, C_p may be taken as twice the value listed in Table 16B-O, but need not exceed 2.0.*

EXCEPTION: Piping, ducting and conduit systems which are constructed of ductile materials and connections may use the values of C_p from Table 16B-O.

The value of C_p for elements, components and equipment laterally self-supported at or below ground level may be two thirds of the value set forth in Table 16B-O. However, the design lateral forces for an element or component or piece of equipment shall not be less than would be obtained by treating the item as an independent structure and using the provisions of Section 1632B.

The design lateral forces determined using Formula (30B-1) shall be distributed in proportion to the mass distribution of the element or component.

Forces determined using Formula (30B-1) shall be used to design members and connections which transfer these forces to the seismic-resisting systems.

For applicable forces in connectors for exterior panels and diaphragms, refer to Sections 1631B.2.4 and 1631B.2.9.

Forces shall be applied in the horizontal directions, which result in the most critical loadings for design.

The design and detailing of anchorages or restraints for architectural components and mechanical and electrical systems shall accommodate the structure drifts as computed in accordance with Section 1631B.2.4 or determined by the wind forces given in Division II — Wind Design multiplied by 2.

1630B.3 Specifying Lateral Forces. Design specifications for equipment shall either specify the design lateral forces prescribed herein or reference these provisions.

1630B.4 Relative Motion of Equipment Attachments. For equipment in Categories I and II buildings as defined in Table 16B-K, the lateral-force design shall consider the effects of relative motion of the points of attachment to the structure (drift).

1630B.5 Alternative Designs. Where an approved national standard or approved physical test data provide a basis for the earthquake-resistant design of a particular type of equipment or other nonstructural component, such a standard or data may be accepted as a basis for design of the items with the following limitations:

1. These provisions shall provide minimum values for the design of the anchorage and the members and connections which transfer the forces to the seismic-resisting system.

2. The force, F_p , and the overturning moment used in the design of the nonstructural component shall not be less than 80 percent of the values that would be obtained using these provisions.

1630B.6 HVAC Ductwork, Plumbing/Piping and Conduit Systems. *All pipes, ducts and conduits shall be braced to resist the forces prescribed in Section 1630B.2. Ductwork shall be constructed in accordance with provisions contained in Part 4, Title 24, California Mechanical Code. Pipes and their connections constructed of ductile materials (copper, ductile iron, steel or aluminum) with brazed or welded or screwed connections shall have brace spacing not exceeding that specified in Section 1630B.5 or other standards approved by the enforcement agency. Pipes and their connections, constructed of nonductile materials (e.g., cast iron, no-hub pipe and plastic), shall have the brace spacing reduced to one-half of the spacing allowed for ductile material in accordance with Section 1630B.5 or other standards approved by the enforcement agency.*

Seismic restraints may be omitted for the following conditions:

1. Fuel piping less than 1 inch (25 mm) inside diameter.
2. All other piping less than 2.5 inches (64 mm) inside diameter, except medical gas including vacuum piping, or

All piping suspended by individual hangers 12 inches (305 mm) or less in length from the top of pipe to the bottom of the structural support for the hanger, or

All electrical conduits less than 2.5 inches (64 mm) trade size.

3. All rectangular air-handling ducts less than 6 square feet (0.56 m²) in cross-sectional area, or

All round air-handling ducts less than 28 inches (711 mm) in diameter, or

All ducts suspended by hangers 12 inches (305 mm) or less in length from the top of the duct to the bottom of the structural support for the hanger.

For rigidly supported piping, electrical conduit, cable trays or air-handling ducts, the product of $I C_p$ need not exceed 1.2 for any value of I .

1630B.6.1 *All trapeze assemblies supporting pipes, ducts and conduits shall be braced to resist the forces of Section 1630B.2, considering the total weight of the elements on the trapeze.*

Pipes, ducts and conduits supported by a trapeze where none of those elements would individually be braced need not be braced if connections to the pipe/conduit/ductwork or directional changes do not restrict the movement of the trapeze. If this flexibility is not provided, bracing will be required when the aggregate weight of the pipes and conduits exceed 10 lb./ft. (146 N/m). The weight shall be determined assuming all pipes and conduits are filled with water.

SECTION 1631B — DETAILED SYSTEMS DESIGN REQUIREMENTS

1631B.1 General. All structural framing systems shall comply with the requirements of Section 1627B. Only the elements of the designated seismic-force-resisting system shall be used to resist design forces. The individual components shall be designed to resist the prescribed design seismic forces acting on them. The components shall also comply with the specific requirements for the material contained in Chapters 19B through 23B. In addition, such framing systems and components shall comply with the detailed system design requirements contained in Section 1631B.

All building components in Seismic Zones * * * 3 and 4 shall be designed to resist the effects of the seismic forces prescribed herein and the effects of gravity loadings from dead, floor live and snow loads.

Consideration shall be given to design for uplift effects caused by seismic loads. For materials which use working stress procedures, dead loads shall be multiplied by 0.85 when used to reduce uplift.

In Seismic Zones * * * 3 and 4, provision shall be made for the effects of earthquake forces acting in a direction other than the principal axes in each of the following circumstances:

The structure has plan irregularity Type 5 as given in Table 16B-M.

The structure has plan irregularity Type 1 as given in Table 16B-M for both major axes.

A column of a structure forms part of two or more intersecting lateral-force-resisting systems.

EXCEPTION: If the axial load in the column due to seismic forces acting in either direction is less than 20 percent of the column allowable axial load.

The requirement that orthogonal effects be considered may be satisfied by designing such elements for 100 percent of the prescribed seismic forces in one direction plus 30 percent of the prescribed forces in the perpendicular direction. The combination requiring the greater component strength shall be used for design. Alternatively, the effects of the two orthogonal directions may be combined on a square root of the sum of the squares (SRSS) basis. When the SRSS method of combining directional effects is used, each term computed shall be assigned the sign that will result in the most conservative result.

1631B.2 Structural Framing Systems.

1631B.2.1 General. Four types of general building framing systems defined in Section 1627B.6 are recognized in these provisions and shown in Table 16B-N. Each type is subdivided by the types of vertical elements used to resist lateral seismic forces. Special framing requirements are given in this section and in Chapters 19B through 23B.

1631B.2.2 Detailing for combinations of systems. For components common to different structural systems, the more restrictive detailing requirements shall be used.

1631B.2.3 Connections. Connections which resist seismic forces shall be designed and detailed on the drawings.

1631B.2.4 Deformation compatibility. All structural framing elements and their connections not required by design to be part of the lateral-force-resisting system shall be designed and detailed to be adequate to maintain support of design dead plus live loads when subjected to the expected deformations caused by seismic forces. P-delta effects on such elements shall be accounted for. Expected deformations shall be estimated as the greater of $3(R_w/8)$ times the computed elastic deformations at design seismic forces or the deformation induced by a story drift of 0.0025 times the story height. When computing expected deformations, the stiffening effect of those elements not part of the lateral-force-resisting system shall be neglected.

For elements not part of the lateral-force-resisting system, the forces induced by the expected deformations may be considered as ultimate or factored forces. When computing the forces induced by expected deformations, the restraining effects of adjoining rigid structural and nonstructural elements shall be considered and a rational value of member end restraint stiffness shall be used. Inelastic deformations of members and connections may be considered in the evaluation, provided the assumed calculated capacities are consistent with member and connection design and detailing.

For concrete and masonry elements that are part of the lateral-force-resisting system, flexural and shear stiffness properties shall not exceed one-half of the gross section properties unless a rational cracked-section analysis is performed. Additional deformations which may result from foundation flexibility and diaphragm deformations shall be considered. For concrete elements not part of the lateral-force-resisting system, see Section 1921B.7.

1631B.2.4.1 Adjoining rigid elements. Moment-resisting frames and shear walls may be enclosed by or adjoined by more rigid elements provided it can be shown that the participation or failure of the more rigid elements will not impair the vertical or lateral-load-resisting ability of the gravity load and lateral-force-resisting systems. The effects of adjoining rigid elements shall be considered when assessing whether a structure shall be designated regular or irregular in Section 1627B.5.1.

1631B.2.4.2 Exterior elements. Exterior nonbearing, nonshear wall panels or elements which are attached to or enclose the exterior shall be designed to resist the forces per Formula (30B-1) and shall accommodate movements of the structure resulting from lateral forces or temperature changes. Such elements shall be supported by means of cast-in-place concrete or by mechanical connections and fasteners in accordance with the following provisions:

1. Connections and panel joints shall allow for a relative movement between stories of not less than two times story drift caused by wind, $3(R_w/8)$ times the calculated elastic story drift caused by design seismic forces, or $1/2$ inch (13 mm), whichever is greater.
2. Connections to permit movement in the plane of the panel for story drift shall be sliding connections using slotted or oversize holes, connections which permit movement by bending of steel, or other connections providing equivalent sliding and ductility capacity.
3. Bodies of connections shall have sufficient ductility and rotation capacity so as to preclude fracture of the concrete or brittle failures at or near welds.
4. The body of the connection shall be designed for one and one-third times the force determined by Formula (30B-1).