

Chapter 4

LIVE LOADS

4.1 DEFINITIONS

BALCONY (EXTERIOR): An exterior floor projecting from and supported by a structure without additional independent supports.

DECK: An exterior floor supported on at least two opposing sides by an adjacent structure and/or posts, piers, or other independent supports.

FIXED LADDER: A ladder that is permanently attached to a structure, building, or equipment.

GRAB BAR SYSTEM: A bar provided to support body weight in locations such as toilets, showers, and tub enclosures.

GUARDRAIL SYSTEM: A system of building components near open sides of an elevated surface for the purpose of minimizing the possibility of a fall from the elevated surface by people, equipment, or material.

HANDRAIL: A rail grasped by hand for guidance and support. A handrail assembly includes the handrail, supporting attachments, and structures.

LIVE LOAD: A load produced by the use and occupancy of the building or other structure that does not include construction or environmental loads, such as wind load, snow load, rain load, earthquake load, flood load, or dead load.

ROOF LIVE LOAD: A load on a roof produced (1) during maintenance by workers, equipment, and materials and (2) during the life of the structure by movable objects, such as planters or other similar small decorative appurtenances that are not occupancy related.

VEHICLE BARRIER SYSTEM: A system of building components near open sides of a garage floor or ramp, or building walls that act as restraints for vehicles.

4.2 UNIFORMLY DISTRIBUTED LOADS

4.2.1 Required Live Loads. The live loads used in the design of buildings and other structures shall be the maximum loads expected by the intended use or occupancy, but shall in no case be less than the minimum uniformly distributed unit loads required by Table 4-1.

4.2.2 Provision for Partitions. In office buildings or other buildings where partitions will be erected or rearranged, provision for partition weight shall be made, whether or not partitions are shown on the plans. Partition load shall not be less than 15 psf.

EXCEPTION: A partition live load is not required where the minimum specified live load exceeds 80 psf (3.83 kN/m²).

4.3 CONCENTRATED LOADS

Floors, roofs, and other similar surfaces shall be designed to support safely the uniformly distributed live loads prescribed in

Section 4.2 or the concentrated load, in pounds or kilonewtons (kN), given in Table 4-1, whichever produces the greater load effects. Unless otherwise specified, the indicated concentration shall be assumed to be uniformly distributed over an area 2.5 ft (762 mm) square [6.25 ft² (0.58 m²)] and shall be located so as to produce the maximum load effects in the structural members.

4.4 LOADS ON HANDRAILS, GUARDRAIL SYSTEMS, GRAB BAR SYSTEMS, VEHICLE BARRIER SYSTEMS, AND FIXED LADDERS

4.4.1 Loads on Handrails and Guardrail Systems. All handrail assemblies and guardrail systems shall be designed to resist a single concentrated load of 200 lb (0.89 kN) applied in any direction at any point along the top and to transfer this load through the supports to the structure.

Further, all handrail assemblies and guardrail systems shall be designed to resist a load of 50 lb/ft (pound-force per linear foot) (0.73 kN/m) applied in any direction at the top and to transfer this load through the supports to the structure. This load need not be assumed to act concurrently with the load specified in the preceding paragraph, and this load need not be considered for the following occupancies:

1. One- and two-family dwellings.
2. Factory, industrial, and storage occupancies, in areas that are not accessible to the public and that serve an occupant load not greater than 50.

Intermediate rails (all those except the handrail), balusters, and panel fillers shall be designed to withstand a horizontally applied normal load of 50 lb (0.22 kN) on an area not to exceed 1 ft square (305 mm square) including openings and space between rails. Reactions due to this loading are not required to be superimposed with those of either preceding paragraph.

4.4.2 Loads on Grab Bar Systems. Grab bar systems shall be designed to resist a single concentrated load of 250 lb (1.11 kN) applied in any direction at any point.

4.4.3 Loads on Vehicle Barrier Systems. Vehicle barrier systems for passenger cars shall be designed to resist a single load of 6,000 lb (26.70 kN) applied horizontally in any direction to the barrier system, and shall have anchorages or attachments capable of transferring this load to the structure. For design of the system, the load shall be assumed to act at a minimum height of 1 ft 6 in. (460 mm) above the floor or ramp surface on an area not to exceed 1 foot square (305 mm square), and is not required to be assumed to act concurrently with any handrail or guardrail loadings specified in Section 4.4.1. Garages accommodating trucks and buses shall be designed in accordance with an approved method, which contains provision for traffic railings.

4.4.4 Loads on Fixed Ladders. The minimum design live load on fixed ladders with rungs shall be a single concentrated load

of 300 lb (1.33 kN), and shall be applied at any point to produce the maximum load effect on the element being considered. The number and position of additional concentrated live load units shall be a minimum of 1 unit of 300 lb (1.33 kN) for every 10 ft (3,048 mm) of ladder height.

Where rails of fixed ladders extend above a floor or platform at the top of the ladder, each side rail extension shall be designed to resist a concentrated live load of 100 lb (0.445 kN) in any direction at any height up to the top of the side rail extension. Ship ladders with treads instead of rungs shall have minimum design loads as stairs, defined in Table 4-1.

4.5 LOADS NOT SPECIFIED

For occupancies or uses not designated in Sections 4.2 or 4.3, the live load shall be determined in accordance with a method approved by the authority having jurisdiction.

4.6 PARTIAL LOADING

The full intensity of the appropriately reduced live load applied only to a portion of a structure or member shall be accounted for if it produces a more unfavorable effect than the same intensity applied over the full structure or member. Roof live loads are to be distributed as specified in Table 4-1.

4.7 IMPACT LOADS

The live loads specified in Sections 4.2.1 and 4.4.2 shall be assumed to include adequate allowance for ordinary impact conditions. Provision shall be made in the structural design for uses and loads that involve unusual vibration and impact forces.

4.7.1 Elevators. All elevator loads shall be increased by 100 percent for impact and the structural supports shall be designed within the limits of deflection prescribed by ANSI A17.2 and ANSI/ASME A17.1.

4.7.2 Machinery. For the purpose of design, the weight of machinery and moving loads shall be increased as follows to allow for impact: (1) elevator machinery, 100 percent; (2) light machinery, shaft- or motor-driven, 20 percent; (3) reciprocating machinery or power-driven units, 50 percent; and (4) hangers for floors or balconies, 33 percent. All percentages shall be increased where specified by the manufacturer.

4.8 REDUCTION IN LIVE LOADS

Except for roof uniform live loads, all other minimum uniformly distributed live loads, L_o in Table 4-1, may be reduced according to the following provisions.

4.8.1 General. Subject to the limitations of Sections 4.8.2 through 4.8.5, members for which a value of $K_{LL}A_T$ is 400 ft² (37.16 m²) or more are permitted to be designed for a reduced live load in accordance with the following formula:

$$L = L_o \left(0.25 + \frac{15}{\sqrt{K_{LL}A_T}} \right) \quad (4-1)$$

In SI:

$$L = L_o \left(0.25 + \frac{4.57}{\sqrt{K_{LL}A_T}} \right)$$

where

L = reduced design live load per ft² (m²) of area supported by the member

L_o = unreduced design live load per ft² (m²) of area supported by the member (see Table 4-1)

K_{LL} = live load element factor (see Table 4-2)

A_T = tributary area in ft² (m²)

L shall not be less than $0.50L_o$ for members supporting one floor and L shall not be less than $0.40L_o$ for members supporting two or more floors.

4.8.2 Heavy Live Loads. Live loads that exceed 100 lb/ft² (4.79 kN/m²) shall not be reduced.

EXCEPTION: Live loads for members supporting two or more floors may be reduced by 20 percent.

4.8.3 Passenger Car Garages. The live loads shall not be reduced in passenger car garages.

EXCEPTION: Live loads for members supporting two or more floors may be reduced by 20 percent.

4.8.4 Special Occupancies. Live loads of 100 lb/ft² (4.79 kN/m²) or less shall not be reduced in public assembly occupancies.

4.8.5 Limitations on One-Way Slabs. The tributary area, A_T , for one-way slabs shall not exceed an area defined by the slab span times a width normal to the span of 1.5 times the slab span.

4.9 REDUCTION IN ROOF LIVE LOADS

The minimum uniformly distributed roof live loads, L_o in Table 4-1, are permitted to be reduced according to the following provisions.

4.9.1 Flat, Pitched, and Curved Roofs. Ordinary flat, pitched, and curved roofs are permitted to be designed for a reduced roof live load, as specified in Eq. 4-2 or other controlling combinations of loads, as discussed in Chapter 2, whichever produces the greater load. In structures such as greenhouses, where special scaffolding is used as a work surface for workmen and materials during maintenance and repair operations, a lower roof load than specified in Eq. 4-2 shall not be used unless approved by the authority having jurisdiction. On such structures, the minimum roof live load shall be 12 psf (0.58 kN/m²).

$$L_r = L_o R_1 R_2 \quad \text{where } 12 \leq L_r \leq 20 \quad (4-2)$$

In SI:

$$L_r = L_o R_1 R_2 \quad \text{where } 0.58 \leq L_r \leq 0.96$$

where

L_r = reduced roof live load per ft² (m²) of horizontal projection in pounds per ft² (kN/m²)

The reduction factors R_1 and R_2 shall be determined as follows:

$$R_1 = \begin{cases} 1 & \text{for } A_t \leq 200 \text{ ft}^2 \\ 1.2 - 0.001A_t & \text{for } 200 \text{ ft}^2 < A_t < 600 \text{ ft}^2 \\ 0.6 & \text{for } A_t \geq 600 \text{ ft}^2 \end{cases}$$

In SI:

$$R_1 = \begin{cases} 1 & \text{for } A_t \leq 18.58 \text{ m}^2 \\ 1.2 - 0.011A_t & \text{for } 18.58 \text{ m}^2 < A_t < 55.74 \text{ m}^2 \\ 0.6 & \text{for } A_t \geq 55.74 \text{ m}^2 \end{cases}$$

where A_t = tributary area in ft^2 (m^2) supported by any structural member and

$$R_2 = \begin{cases} 1 & \text{for } F \leq 4 \\ 1.2 - 0.05F & \text{for } 4 < F < 12 \\ 0.6 & \text{for } F \geq 12 \end{cases}$$

where, for a pitched roof, F = number of inches of rise per foot (in SI: $F = 0.12 \times \text{slope}$, with slope expressed in percentage points) and, for an arch or dome, F = rise-to-span ratio multiplied by 32.

4.9.2 Special Purpose Roofs. Roofs that have an occupancy function, such as roof gardens, assembly purposes, or other special purposes are permitted to have their uniformly distributed live load reduced in accordance with the requirements of Section 4.8.

4.10 CRANE LOADS

The crane live load shall be the rated capacity of the crane. Design loads for the runway beams, including connections and support brackets, of moving bridge cranes and monorail cranes shall include the maximum wheel loads of the crane and the vertical impact, lateral, and longitudinal forces induced by the moving crane.

4.10.1 Maximum Wheel Load. The maximum wheel loads shall be the wheel loads produced by the weight of the bridge, as applicable, plus the sum of the rated capacity and the weight of the trolley with the trolley positioned on its runway at the location where the resulting load effect is maximum.

4.10.2 Vertical Impact Force. The maximum wheel loads of the crane shall be increased by the percentages shown in the following text to determine the induced vertical impact or vibration force:

Monorail cranes (powered)	25
Cab-operated or remotely operated bridge cranes (powered)	25
Pendant-operated bridge cranes (powered)	10
Bridge cranes or monorail cranes with hand-gearred bridge, trolley, and hoist	0

4.10.3 Lateral Force. The lateral force on crane runway beams with electrically powered trolleys shall be calculated as 20 percent of the sum of the rated capacity of the crane and the weight of the hoist and trolley. The lateral force shall be assumed to act horizontally at the traction surface of a runway beam, in either direction perpendicular to the beam, and shall be distributed with due regard to the lateral stiffness of the runway beam and supporting structure.

4.10.4 Longitudinal Force. The longitudinal force on crane runway beams, except for bridge cranes with hand-gearred bridges, shall be calculated as 10 percent of the maximum wheel loads of the crane. The longitudinal force shall be assumed to act horizontally at the traction surface of a runway beam in either direction parallel to the beam.

4.11 CONSENSUS STANDARDS AND OTHER REFERENCED DOCUMENTS

This section lists the consensus standards and other documents which are adopted by reference within this chapter:

ANSI
American National Standards Institute
25 West 43rd Street, 4th Floor
New York, NY 10036

ANSI A17.2
 Section 4.7.1
 American National Standard Practice for the Inspection of Elevators, Escalators, and Moving Walks (Inspectors' Manual), 1988.

ASME
American Society of Mechanical Engineers
Three Park Avenue
New York, NY 10016-5900

ANSI/ASME A17.1
 Section 4.7.1
 American National Standard Safety Code for Elevators and Escalators, 1993.

TABLE 4-1 MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS, L_o , AND MINIMUM CONCENTRATED LIVE LOADS

Occupancy or Use	Uniform psf (kN/m ²)	Conc. lb (kN)
Apartments (see <i>Residential</i>)		
Access floor systems		
Office use	50 (2.4)	2,000 (8.9)
Computer use	100 (4.79)	2,000 (8.9)
Armories and drill rooms	150 (7.18)	
Assembly areas and theaters		
Fixed seats (fastened to floor)	60 (2.87)	
Lobbies	100 (4.79)	
Movable seats	100 (4.79)	
Platforms (assembly)	100 (4.79)	
Stage floors	150 (7.18)	
Balconies (exterior)	100 (4.79)	
On one- and two-family residences only, and not exceeding 100 ft ² (9.3 m ²)	60 (2.87)	
Bowling alleys, poolrooms, and similar recreational areas	75 (3.59)	
Catwalks for maintenance access	40 (1.92)	300 (1.33)
Corridors		
First floor	100 (4.79)	
Other floors, same as occupancy served except as indicated		
Dance halls and ballrooms	100 (4.79)	
Decks (patio and roof)		
Same as area served, or for the type of occupancy accommodated		
Dining rooms and restaurants	100 (4.79)	
Dwellings (see <i>Residential</i>)		
Elevator machine room grating (on area of 4 in. ² [2,580 mm ²])		300 (1.33)
Finish light floor plate construction (on area of 1 in. ² [645 mm ²])		200 (0.89)
Fire escapes	100 (4.79)	
On single-family dwellings only	40 (1.92)	
Fixed ladders	See Section 4.4	
Garages (passenger vehicles only)	40 (1.92) ^{a,b}	
Trucks and buses		
Grandstands (see <i>Stadiums and arenas, Bleachers</i>)		
Gymnasiums—main floors and balconies	100 (4.79)	
Handrails, guardrails, and grab bars	See Section 4.4	
Hospitals		
Operating rooms, laboratories	60 (2.87)	1,000 (4.45)
Patient rooms	40 (1.92)	1,000 (4.45)
Corridors above first floor	80 (3.83)	1,000 (4.45)
Hotels (see <i>Residential</i>)		
Libraries		
Reading rooms	60 (2.87)	1,000 (4.45)
Stack rooms	150 (7.18) ^c	1,000 (4.45)
Corridors above first floor	80 (3.83)	1,000 (4.45)
Manufacturing		
Light	125 (6.00)	2,000 (8.90)
Heavy	250 (11.97)	3,000 (13.40)
Marquees	75 (3.59)	
Office Buildings		
File and computer rooms shall be designed for heavier loads based on anticipated occupancy		
Lobbies and first-floor corridors	100 (4.79)	2,000 (8.90)
Offices	50 (2.40)	2,000 (8.90)
Corridors above first floor	80 (3.83)	2,000 (8.90)
Penal Institutions		
Cell blocks	40 (1.92)	
Corridors	100 (4.79)	
Residential		
Dwellings (one- and two-family)		
Uninhabitable attics without storage	10 (0.48)	
Uninhabitable attics with storage	20 (0.96)	
Habitable attics and sleeping areas	30 (1.44)	
All other areas except stairs and balconies	40 (1.92)	
Hotels and multifamily houses		
Private rooms and corridors serving them	40 (1.92)	
Public rooms and corridors serving them	100 (4.79)	
Reviewing stands, grandstands, and bleachers	100 (4.79) ^d	

TABLE 4-1 MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS, L_o , AND MINIMUM CONCENTRATED LIVE LOADS (continued)

Occupancy or Use	Uniform psf (kN/m ²)	Conc. lb (kN)
Roofs		
Ordinary flat, pitched, and curved roofs	20 (0.96) ^h	
Roofs used for promenade purposes	60 (2.87)	
Roofs used for roof gardens or assembly purposes	100 (4.79)	
Roofs used for other special purposes	<i>i</i>	<i>i</i>
Awnings and canopies		
Fabric construction supported by a lightweight rigid skeleton structure	5 (0.24) nonreduceable	
All other construction	20 (0.96)	
Primary roof members, exposed to a work floor		
Single panel point of lower chord of roof trusses or any point along primary structural members supporting roofs over manufacturing, storage warehouses, and repair garages		2,000 (8.9)
All other occupancies		300 (1.33)
All roof surfaces subject to maintenance workers		300 (1.33)
Schools		
Classrooms	40 (1.92)	1,000 (4.45)
Corridors above first floor	80 (3.83)	1,000 (4.45)
First-floor corridors	100 (4.79)	1,000 (4.45)
Scuttles, skylight ribs, and accessible ceilings		200 (0.89)
Sidewalks, vehicular driveways, and yards subject to trucking	250 (11.97) ^e	8,000 (35.60) ^f
Stadiums and arenas		
Bleachers	100 (4.79) ^d	
Fixed seats (fastened to floor)	60 (2.87) ^d	
Stairs and exit ways	100 (4.79)	^g
One- and two-family residences only	40 (1.92)	
Storage areas above ceilings	20 (0.96)	
Storage warehouses (shall be designed for heavier loads if required for anticipated storage)		
Light	125 (6.00)	
Heavy	250 (11.97)	
Stores		
Retail		
First floor	100 (4.79)	1,000 (4.45)
Upper floors	75 (3.59)	1,000 (4.45)
Wholesale, all floors	125 (6.00)	1,000 (4.45)
Vehicle barriers	See Section 4.4	
Walkways and elevated platforms (other than exit ways)	60 (2.87)	
Yards and terraces, pedestrian	100 (4.79)	

^aFloors in garages or portions of a building used for the storage of motor vehicles shall be designed for the uniformly distributed live loads of Table 4-1 or the following concentrated load: (1) for garages restricted to passenger vehicles accommodating not more than nine passengers, 3,000 lb (13.35 kN) acting on an area of 4.5 in. by 4.5 in. (114 mm by 114 mm) footprint of a jack; and (2) for mechanical parking structures without slab or deck that are used for storing passenger car only, 2,250 lb (10 kN) per wheel.

^bGarages accommodating trucks and buses shall be designed in accordance with an approved method, which contains provisions for truck and bus loadings.

^cThe loading applies to stack room floors that support nonmobile, double-faced library book stacks subject to the following limitations: (1) The nominal book stack unit height shall not exceed 90 in. (2290 mm); (2) the nominal shelf depth shall not exceed 12 in. (305 mm) for each face; and (3) parallel rows of double-faced book stacks shall be separated by aisles not less than 36 in. (914 mm) wide.

^dIn addition to the vertical live loads, the design shall include horizontal swaying forces applied to each row of the seats as follows: 24 lb per linear ft of seat applied in a direction parallel to each row of seats and 10 lb per linear ft of seat applied in a direction perpendicular to each row of seats. The parallel and perpendicular horizontal swaying forces need not be applied simultaneously.

^eOther uniform loads in accordance with an approved method, which contains provisions for truck loadings, shall also be considered where appropriate.

^fThe concentrated wheel load shall be applied on an area of 4.5 in. by 4.5 in. (114 mm by 114 mm) footprint of a jack.

^gMinimum concentrated load on stair treads (on area of 4 in.² [2,580 mm²]) is 300 lb (1.33 kN).

^hWhere uniform roof live loads are reduced to less than 20 lb/ft² (0.96 kN/m²) in accordance with Section 4.9.1 and are applied to the design of structural members arranged so as to create continuity, the reduced roof live load shall be applied to adjacent spans or to alternate spans, whichever produces the greatest unfavorable effect.

ⁱRoofs used for other special purposes shall be designed for appropriate loads as approved by the authority having jurisdiction.

TABLE 4-2 LIVE LOAD ELEMENT FACTOR, K_{LL}

Element	K_{LL} ^a
Interior columns	4
Exterior columns without cantilever slabs	4
Edge columns with cantilever slabs	3
Corner columns with cantilever slabs	2
Edge beams without cantilever slabs	2
Interior beams	2
All other members not identified including:	1
Edge beams with cantilever slabs	
Cantilever beams	
One-way slabs	
Two-way slabs	
Members without provisions for continuous shear transfer normal to their span	

^aIn lieu of the preceding values, K_{LL} is permitted to be calculated.

