

DRAFT FOR THE PROPOSED AMENDED PART 23 LIVE AND DEAD LOADS OF THE BOSTON BUILDING CODE

BY FRANK H. WHELAN

AT THE request of Mayor Hynes and under the sponsorship of the Building Commissioner, a meeting was held on December 11, 1958 at the City of Boston Building Department to organize a committee to draft a revision of Part 23 of the Boston Building Code. The members of the Committee are Frank H. Whelan, Chairman, Lawrence Burke, Vice-Chairman, Professor John M. Biggs, Miles N. Clair, Harry J. Keefe, William J. LeMessurier and David Mathoff, Secretary.

The separate sections of Part 23 were studied by the Committee and resulting recommendations were discussed, revised and approved, one by one, at the subsequent meetings.

On April 17, 1959, a copy of the final revision was distributed to several engineers for constructive criticism and on May 25, an open meeting of the Committee was held at Boston City Hall so all interested persons might give their views on the proposed revisions.

The final draft as presented here meets the approval of the Committee and will be submitted to the Building Commissioner for further action.

PART 23

LIVE AND DEAD LOADS

Section

- 2301—Design for Loads.
- 2302—Dead and Live Loads.
- 2303—Weights of Materials.
- 2304—Loads from Partitions.
- 2305—Live Loads on Floors.
- 2306—Special Concentrations.
- 2307—Partial Loadings.
- 2308—Impact.
- 2309—Lateral and Uplift Forces.
- 2310—Reduction of Live Loads.

- 2311—Roof Loads.
 2312—Wind Loads.
 2313—Load Tests of Structure.

SECTION 2301 DESIGN FOR LOADS

All buildings and other structures and parts thereof shall be designed to support the loads and withstand the forces, to which they are subject; that is, live, dead and wind loads as required in this part without exceeding the stresses allowed elsewhere in this code for the various materials.

SECTION 2302 DEAD AND LIVE LOADS

(a) The dead loads of a building shall include all the forces due to weight of the walls, permanent partitions, floors, roofs, framing and all other permanent stationary construction and fixed service equipment entering into and becoming part of the building.

(b) The live loads shall include all loads other than dead load.

SECTION 2303 WEIGHTS OF MATERIALS

(a) The actual weights of the elements of construction and of materials to be supported shall be used in calculation of loads. The materials listed in the following table, in the absence of other data, shall be assumed to weigh not less than there indicated:

| | Pounds per Cubic Foot |
|-----------------------------------------------|--------------------------|
| Brick (face, clay, shale or concrete) masonry | 140 |
| Brick (common) masonry | 120 |
| Cast iron | 450 |
| Cast stone masonry | 144 |
| Brick (sand, lime) | 113 |
| Gypsum | 37 |
| Cinders, dry, in bulk | 45 |
| Cinder fill | 60 |
| Clay tile masonry | 54 |
| Sand-cinder concrete, fill | 100 |
| Glass block masonry | 54 |
| Sand-cinder concrete, structural | 110 |
| Stone or gravel concrete, plain | 144 |
| Stone or gravel concrete, reinforced | 150 |
| Common earth, dry and packed | 100 |
| Sand and gravel (compacted) | 120 |
| Granite masonry | 165 |

| | |
|--------------------------------------------|---------------------------|
| Limestone masonry | 160 |
| Marble masonry | 160 |
| Sandstone masonry | 144 |
| Steel | 490 |
| Timber | 40 |
| Water (fresh) | 62.4 |
| | Pounds per Square Foot |
| Plaster on metal lath exclusive of furring | 8 |
| Roofing, tar and gravel | 6 |

SECTION 2304 LOADS FROM PARTITIONS

(a) In buildings in which permanent partitions occur, their weight shall be counted as affecting the design of all supporting structural members, including columns and foundations, as part of the dead load; and in those portions of buildings used for office occupancy, in which the prescribed live load does not exceed fifty pounds per square foot, allowance for partition weight shall always be made, whether or not partitions are shown on plans.

(b) If a lay-out of partitions is included in the building plans, the weights of the partitions and their locations shall be determined in accordance therewith, or such lay-out may be used to determine an equivalent load per square foot of floor to be applied uniformly as a super-imposed dead load for purposes of design. But the allowance for partition weight in portions of buildings given to office occupancy when expressed in pounds per square foot of floor, shall in no case be less than a minimum of two pounds for each foot of story height for each square foot of floor.

(c) In estimating loading from actual weights of partitions, it may be assumed that the partition occupies a space one foot wide, and a deduction may be made of the live load displaced on this width.

(d) Arch action of partitions shall not be assumed to relieve the supporting members.

SECTION 2305 LIVE LOADS ON FLOORS

The live loads assumed on floors for purposes of design shall be the greatest loads that will probably be produced, by the intended occupancies, but the following distributed live loads, in pounds per square foot, shall be taken as the minimum for the occupancies named.

For occupancies not listed, the design engineer shall submit in

writing the proposed design live load to the Building Commissioner for approval.

| | Pounds per Square Foot |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| Domestic Occupancy: all parts of private dwellings, rooms and suites in apartment houses, lodging houses and clubs; private, ward or dormitory rooms in hospitals, asylums, educational and religious institutions, including corridors giving access thereto; and bedrooms of hotels | 40 |
| Office Buildings: | |
| Basement | 100 |
| First Floor | 80 |
| Upper Floors | 50* |
| Church Auditoriums: with fixed seats, including aisles, sanctuary or chancel, sacristies, choirs and chapels | 60 |
| Class Rooms: not exceeding nine hundred square feet in area, or larger size rooms where fixed seats are used | 50 |
| Kitchen, other than domestic, and school laboratories | 100 |
| Theatre Auditorium and Assembly Halls:† with fixed seats, including aisles and passageways | 75 |
| Theatre Stages: gridirons and fly galleries | 150 |
| Public Occupancy: lobbies, foyers, vestibules and similar public spaces of hotels, theatres, churches, clubs, and public buildings; assembly halls, including class and lecture rooms exceeding nine hundred square feet in area, without fixed seats; dance halls, public dining rooms and restaurants, public rooms for social purposes, skating rinks, gymnasiums | 100 |
| Bleachers: | |
| Grandstands and temporary grandstands | 150 |
| Corridors: | |
| In theatres and serving assembly halls | 100 |
| In school buildings | 75 |
| Other corridors—same loading as heaviest occupancy to which they provide access. | |
| Fire escapes and exterior balconies: in theatres and serving assembly halls | 100 |
| In other buildings | 75 |
| Stairs:† same loading as heaviest occupancy to which they give access, but maximum required | 100 |

* See Section 2304.

† For special floor concentrations and lateral thrusts on stair and balcony rails, see Sections 2306 and 2309.

Stores:

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|--------------------------------------------------------------------|-----|
| For light merchandise, first and basement floors | 100 |
| For light merchandise, above first floor, including mezzanine | 75 |
| For heavy merchandise, all floors | 125 |

Storage:

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| Light storage | 125 |
| Heavy storage | 250 |

Manufacturing:

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|----------------------------------|-----|
| Light manufacturing | 75 |
| Intermediate manufacturing | 150 |
| Heavy manufacturing | 250 |

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|--------------------|----|
| Locker Rooms | 75 |
|--------------------|----|

Garages:† including apparatus rooms of fire stations:

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Class A—Floors used for vehicles exceeding 20,000 lbs. in weight, including loads; and first or street floors of garages except those limited exclusively to passenger vehicles of not more than 9 persons capacity | 250 |
| Class B—Floors not included in Class A and first or street floors of garages limited to passenger vehicles exclusively weighing not more than 9,000 lbs. | 150 |
| Class C—Floors above the first or street floors for passenger vehicles weighing less than 6,000 lbs. | 100 |

A floor connected directly with the street or by a ramp or driveway not more than eight feet high shall be regarded as a first or street floor.

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| Sidewalks† | 250 |
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|------------------|-----|
| Driveways† | 250 |
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All plans filed for permit shall include a list or notation of the live loads used in design.

SECTION 2306 SPECIAL CONCENTRATIONS

In the design of floors and structural systems, consideration shall be given to the effects of known or probable concentrations of load to which they are subjected; and in structures designed for the occupancies listed herein, floors shall be made capable of carrying the prescribed distributed loads or the following minimum concentrations, whichever may result in the greater stresses. The concentrations indicated shall be assumed to occupy two and one-half feet square, and be so placed as to produce maximum stresses in the members affected.

† For special floor concentrations and lateral thrusts on stair and balcony rails, see Sections 2306 and 2309.

(1) For office floors including corridors, theatre stages, gridirons and fly galleries and corridors serving them a load of two thousand pounds.

(2) For portions of garages subject to Class A loading, a concentrated load of twenty thousand pounds, and for Class B loading, ten thousand pounds.

(3) For sidewalks, a concentrated load of 12,000 pounds.

(4) For driveways, and for trucking spaces within the limits of a structure, a concentrated load of twenty thousand pounds.

(5) For structural supports of ceilings under accessible spaces, for trap doors and skylights a concentrated load of two hundred pounds.

(6) That portion of hangars subject to concentrated loads shall be designed to accommodate the heaviest vehicle housed therein.

(7) For elevator machine room grating (on an area of four square inches), a load of three hundred pounds.

(8) For stair treads (on center of tread), a load of three hundred pounds.

(9) For exposed metal light floor plate construction (on an area of one square inch), a load of two hundred pounds.

SECTION 2307 PARTIAL LOADINGS

(a) The effect of a partial live load on a structure taking into account its construction, connections, and rigidity, which will produce maximum stress in any member, shall be provided for in the design, as well as full live loading.

(b) The partial loading shall also conform to the design requirements of other sections of this code.

(c) For snow load requirements, see Section 2311.

SECTION 2308 IMPACT

The live loads prescribed herein may be assumed to include a sufficient allowance to cover the effects of ordinary impact. For special occupancies and loadings involving unusual impacts, such as those resulting from moving loads, machinery, elevators and crane-ways, provisions shall be made by suitably increasing the live load. In the case of machinery care shall be taken to avoid near resonant conditions.

SECTION 2309 LATERAL AND UPLIFT FORCES

(a) In the design of basement walls and similar approximately vertical structures below grade, the forces due to lateral pressure of adjacent soil shall be calculated. Due allowance shall be made for possible surcharge from fixed or moving loads. When a portion or the whole of the adjacent soil is below a free water surface, calculations shall be based on the weight of the soil as diminished by buoyancy, plus full hydrostatic pressure.

(b) In the design of basement floors and similar approximately horizontal structures below grade, the upward pressure of water, if any, in the supporting soil, shall be taken as the full hydrostatic pressure applied over the entire area.

(c) Balcony and stairway railings, exterior and interior, shall be designed to resist a horizontal thrust of twenty pounds per linear foot applied at the top of the rail.

SECTION 2310 REDUCTION OF LIVE LOADS

(a) Roof Live Loads—No reduction shall be applied to the roof live load.

(b) Live Loads 100 Pounds per Square Foot or Less—For uniformly distributed live loads of 100 pounds or less per square foot, the design live load on any member (not including one-way slabs) supporting 150 square feet or more may be reduced at the rate of 0.06 percent per square foot of area supported by the member, except that no reduction shall be made for areas to be occupied as places of public assembly. The reduction shall exceed neither R as determined by the following formula, nor 50 per cent:

$$R = 100 \times \frac{D + L}{5L}$$

in which

R = reduction in percent

D = dead load per square foot of area supported by the member

L = design live load per square foot of area supported by the member.

(c) Live Loads Exceeding 100 Pounds per Square Foot—For live loads exceeding 100 pounds per square foot, no reduction shall be made, except that the design live loads on columns may be reduced by $\frac{1}{2}$ the quantity specified in (b).

SECTION 2311 ROOF LOADS

(a) Flat roofs, and roofs having a rise of two inches or less per foot of run shall be designed to support a vertical snow load of thirty pounds per square foot of horizontal projection. Roofs used as roof gardens, or for other such purposes shall be designed as floors to support the load prescribed for corresponding occupancies.

(b) Roofs having a rise of more than two and less than twelve inches per foot of run shall be designed for a vertical snow load of (34-2r) pounds per square foot of horizontal projection in which r is the rise in inches per foot of run.

(c) Roofs having a rise of twelve inches or more per foot of run shall be designed for a vertical live load of ten pounds per square foot of horizontal projection.

(d) Roof structures or portions thereof shall be designed for stresses produced by partial snow loading whenever such stresses exceed those produced by full snow loading. In such cases the partial snow load may be assumed equal to two-thirds of the load required by paragraph a, b, or c of this section.

(e) All roofs shall be designed for the wind loads specified in Section 2312. Two-thirds of the wind load required by Section 2312 shall be combined with two-thirds of the snow load required by paragraph a, b, c or d of this section, whenever such a combination produces higher stresses than those existing with wind or snow load acting separately.

SECTION 2312 WIND LOADS

(a) All buildings shall be designed to resist wind forces applied to both walls and roofs without exceeding the stresses allowed in this act.

(b) The design wind pressure P in pounds per square foot shall vary with the height above the average ground elevation adjacent to the base of the structure in accordance with the following table: In the case of a sloping roof the height shall be the average height of the roof.

| Height in Feet | P in Lbs. per Square Foot |
|----------------|------------------------------|
| 0— 25 | 20 |
| 25— 50 | 25 |
| 50— 100 | 30 |
| 100— 150 | 35 |
| 150— 400 | 45 |
| 400— 700 | 55 |
| 700—1500 | 65 |

(c) Wind pressure on the elements of a building shall not be less than the following values:

| | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| Total horizontal pressure on the walls of rectangular buildings (combining the effect of pressure on the windward wall and suction on the leeward wall) | 1.0 P |
| Total horizontal pressure acting simultaneously on each of any two perpendicular walls of a rectangular building (combining the effect of pressure on the windward walls and suction on the leeward walls) | .7 P |
| Pressure in or out on an exterior wall | 1.0 P |
| ** Total suction on the entire surface of all roofs | 1.2 P |
| Pressure normal to windward surface only of roofs with slopes equal to or greater than 30 degrees (to be combined with zero pressure on leeward slope) | .9 P |
| Uplift on eaves, cornices or other local projections, and fastenings of roof coverings | 1.5 P |
| Total pressure on gross area of signs with less than 25% openings | 1.2 P |
| Total pressure on net area of signs with more than 25% openings | 1.6 P |
| Total pressure on projected area of round chimneys or tanks | .7 P |

(d) As an alternative to the provisions of Section 2312 (c) and with the approval of the Building Commissioner, wind force on a building may be based on shape coefficients obtained from wind tunnel tests of models or by other approved methods. Such shape coefficients shall include the full effect of openings in wall or roof surfaces. In such cases the velocity pressure "q" to be used at any height shall be taken as .77 P where P is given by the table in paragraph 2312 (b).

(e) Where dead load forces reduce the effect of wind loads, two-thirds of dead loads shall be used in calculating the net effect of wind. Roofs and walls shall be anchored against uplifting or overturning when such forces exceed two-thirds of counter-balancing dead load forces.

SECTION 2313 LOAD TESTS OF STRUCTURES

(a) The Commissioner shall have the right to order tests under load or other tests of any portion of a structure when the conditions have been such as to leave reasonable doubt as to the adequacy of the structure to serve the purpose for which it was intended. Such tests shall not be required to be made on any concrete or masonry construction until it is at least sixty days old.

** Resulting from wind parallel to the ridge in the case of gable roofs.

(b) In such tests, the member or portion of the structure under test shall be subjected to a total load, including its own weight, which shall equal the total dead load plus twice the live load for which it is required to be designed. This load shall be left in position for a period of twenty-four hours before removal. The structure, if a floor or portion thereof, shall be considered to have passed the test if within twenty-four hours after the removal of the load such floor or roof recovers three quarters of the maximum deflection under the test load. If the member or portion of the structure shows evident failure or fails to meet the recovery requirement, it shall be rebuilt or may be modified as is necessary to make the structure adequate for the rated capacity, except that, where lawful, and where the structure is undamaged, a lower rating may be established.