GRAVITY LOAD PROVISIONS OF BNBC-2020

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BNBC-2020 Part 6, Chapter 1 DEFINITIONS AND GENERAL REQUIREMENTS

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(a) Temperature Effects (Sec 2.6.4).
(b) Soil and Hydrostatic Pressure (Sec 2.6.5).
(c) Impacts and Collisions
(d) Explosions (Sec 2.6.6).
(e) Fire
(f) Vertical Forces on Air Raid Shelters (Sec 2.6.7).
(g) Loads on Helicopter Landing Areas (Sec 2.6.8).
(h) Erection and Construction Loads (Sec 2.6.9).
(i) Moving Loads for Crane Movements
(j) Creep and Shrinkage
(k) Dynamic Loads due to Vibrations
(l) Construction Loads

1.9 Design and Construction Review

Every building or structure designed shall have its design documents prepared in accordance with the provisions of Sec 1.9.1. The minimum requirements for design review and construction observation shall be those set forth under Sections 1.9.2 and 1.9.3 respectively.

1.9.1 Design Document

The design documents shall be prepared and signed by the Engineer responsible for the structural design of any building or structure intended for construction. The design documents shall include a design report, material specifications and a set of structural drawings, which shall be prepared in compliance with Sections 1.9.2 and 1.9.3 below for submittal to the concerned authority. For the purpose of this provision, the concerned authority shall be either persons from the government approval agency for the construction, or the owner of the building or the structure, or one of his representatives.

1.9.2 Design Report

The design report shall contain the description of the structural design with basic design information as provided below, so that any other structural design engineer will be able to independently verify the design parameters and the member sizes using this basic information. The design report shall include, but not be limited to the following:

1.9.3 Structural Drawings and Material Specifications

The structural drawings shall include, but not be limited to, the following:

1.9.4 Design Review

The design documents specified in Sec 1.9.1 shall be available for review when required by the concerned authority. Review shall be accomplished by an independent structural engineer qualified for this task and appointed by the concerned authority. Design review shall be performed through independent calculations, based on the information provided in the design documents prepared and signed by the original structural design engineer, to verify the design parameters including applied loads, methods of analysis and design, and final design dimensions and other details of the structural elements. The reviewing engineer shall also check the sufficiency and appropriateness of the supplied structural drawings for construction.

1.9.5 Construction Review

Construction observation shall be performed by a responsible person who will be a competent professional appointed by the owner of the building or the structure. Construction observation shall include, but not be limited to, the following:

(a) Specification of an appropriate testing and inspection schedule prepared and signed with date by the responsible person;

(b) Review of testing and inspection reports; and

(c) Regular site visit to verify the general compliance of the construction work with the structural drawings and specifications provided in Sec 1.9.3 above.

BNBC-2020 Part 6, Chapter 2
LOADS ON BUILDINGS AND STRUCTURES

2.1 INTRODUCTION

2.2 DEAD LOADS

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- 2.6.8 Loads on Helicopter Landing Areas (Specialized)
- 2.6.9 Erection and Construction Loads

2.1 Introduction

2.1.1 Scope

This Chapter specifies the minimum design forces including dead load, live load, wind and earthquake loads, miscellaneous loads and their various combinations. These loads shall be applicable for the design of buildings and structures in conformance with the general design requirements provided in Chapter 1

2.1 Introduction

2.1.2 Limitations

Provisions of this Chapter shall generally be applied to majority of buildings and other structures covered in this Code subject to normally expected loading conditions. For those buildings and structures having unusual geometrical shapes, response characteristics or site locations, or for those subject to special loading including tornadoes, special dynamic or hydrodynamic loads etc., site-specific or case-specific data or analysis may be required to determine the design loads on them. In such cases, and all other cases for which loads are not specified in this Chapter, loading information may be obtained from reliable references or specialist advice may be sought. However, such loads shall be applied in compliance with the provisions of other Parts or Sections of this Code.

2.1 Introduction

2.1.3 Terminology

2.1.4 Symbols and Notation

Design Load Combinations

- Allowable Stress Design (ASD) 2.7.2
- Strength Design (SD or LRFD) 2.7.3
- Load Combinations for Extraordinary Events 2.7.4
- Load Combinations for Serviceability 2.7.5

Basics

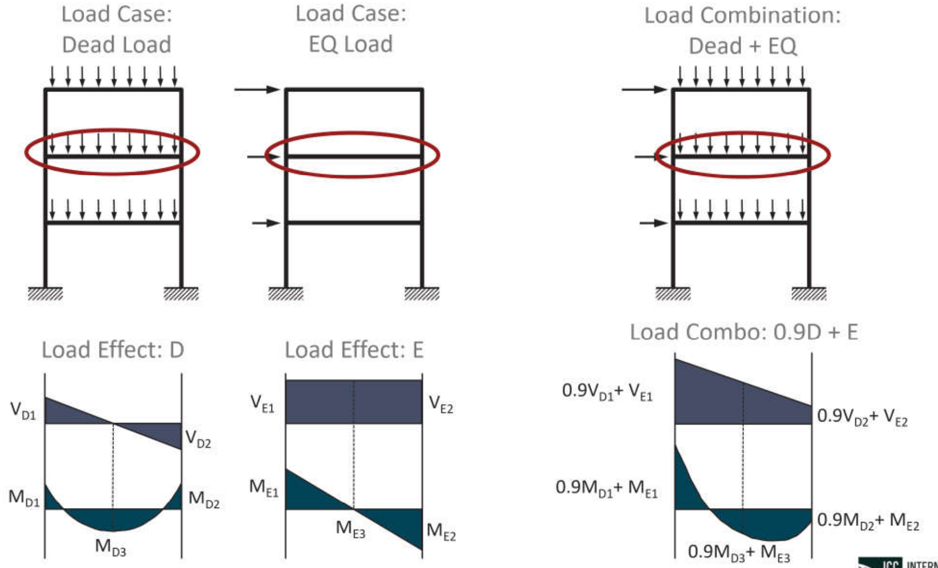
Combination of load effects or

Internal forces caused by external loads,

Such as bending moments, shear forces, axial forces,

Not load combinations.

2.7 Load Combinations using SD or LRFD



2.7.1 General

Buildings, foundations and structural members shall be investigated for adequate strength to resist the most unfavorable effect resulting from the various combinations of loads provided in this Section. The combination of loads may be selected using the provisions of either Sec 2.7.2 or Sec 2.7.3 whichever is applicable. However, once Sec 2.7.2 or Sec 2.7.3 is selected for a particular construction material, it must be used exclusively for proportioning elements of that material throughout the structure. In addition to the load combinations given in Sections 2.7.2 and 2.7.3 any other specific load combination provided elsewhere in this Code shall also be investigated to determine the most unfavorable effect.

2.7.1 General

The most unfavorable effect of loads may also occur when one or more of the contributing loads are absent, or act in the reverse direction. Loads such as *F*, *H* or *S* shall be considered in design when their effects are significant. Floor live loads shall not be considered where their inclusion results in lower stresses in the member under consideration. The most unfavourable effects from both wind and earthquake loads shall be considered where appropriate, but they need not be assumed to act simultaneously.

2.7.2 Allowable Stress Design Load Combinations

1. $D + F$
2. $D + H + F + L + T$
3. $D + H + F + (L_r \text{ or } R)$
4. $D + H + F + 0.75(L + T) + 0.75(L_r \text{ or } R)$
5. $D + H + F + (W \text{ or } 0.7E)$
6. $D + H + F + 0.75(W \text{ or } 0.7E) + 0.75L + 0.75(L_r \text{ or } R)$
7. $0.6D + W + H$
8. $0.6D + 0.7E + H$

2.7 Combinations of Loads

D = Dead loads, or related internal moments and forces. Dead load consists of: a) weight of the member itself, b) weight of all materials of construction incorporated into the building to be permanently supported by the member, including built-in partitions, c) weight of permanent equipment.

E = Total load effects of earthquake that include both horizontal and vertical, or related internal moments and forces. …

F = Loads due to weight and pressures of fluids with well-defined densities and controllable maximum heights or related internal moments and forces

2.7 Combinations of Loads

F_a = Loads due to flood or tidal surge or related internal moments and forces.

H = Loads due to weight and pressure of soil, water in soil, or other materials, or related internal moments and forces

L = Live loads due to intended use and occupancy, including loads due to movable objects and movable partitions and loads temporarily supported by the structure during maintenance, or related internal moments and forces, L includes any permissible reduction. If resistance to impact loads is taken into account in design, such effects shall be included with the live load L.

2.7 Combinations of Loads

L_r = Roof live loads, or related internal moments and forces.

R = Rain load, or related internal moments and forces.

T = Self-straining forces and cumulative effect of temperature, creep, shrinkage, differential settlement, and shrinkage-compensating concrete, or combinations thereof, or related internal moments and forces.

W = Wind load, or related internal moments and forces.

2.7.2 Allowable Stress Design Load Combinations

When a structure is located in a flood zone or in tidal surge zone, the following load combinations shall be considered:

1. In Coastal Zones vulnerable to tidal surges, $1.5F_a$ shall be added to other loads in combinations (5), (6); E shall be set equal to zero in (5) and (6).

2. In non-coastal Zones, $0.75F_a$ shall be added to combinations (5), (6) and (7); E shall be set equal to zero in (5) and (6).

2.7.2 Allowable Stress Design Load Combinations (without *F*, *H*, *T*)

1. D
2. $D + L$
3. $D + (L_r \text{ or } R)$
4. $D + 0.75L + 0.75(L_r \text{ or } R)$
5. $D + (W \text{ or } 0.7E)$
6. $D + 0.75(W \text{ or } 0.7E) + 0.75L + 0.75(L_r \text{ or } R)$
7. $0.6D + W$
8. $0.6D + 0.7E$

2.7.2 Allowable Stress Design Load Combinations

2.7.2.2 Stress increase

Unless permitted elsewhere in this Code, increases in allowable stress shall not be used with the loads or load combinations given in Sec 2.7.2.1.

2.7.3 Strength Design Load Combinations

1. $1.4(D + F)$
2. $1.2(D + F + T) + 1.6(L + H) + 0.5(L_r \text{ or } R)$
3. $1.2D + 1.6(L_r \text{ or } R) + (L \text{ or } 0.8W)$
4. $1.2D + 1.6W + L + 0.5(L_r \text{ or } R)$
5. $1.2D + 1.0E + 1.0L$
6. $0.9D + 1.6W + 1.6H$
7. $0.9D + 1.0E + 1.6H$

2.7.3 Strength Design Load Combinations (without *F*, *H*, *T*)

1. $1.4D$
2. $1.2D + 1.6L + 0.5(L_r \text{ or } R)$
3. $1.2D + 1.6(L_r \text{ or } R) + (L \text{ or } 0.8W)$
4. $1.2D + 1.6W + L + 0.5(L_r \text{ or } R)$
5. $1.2D + 1.0E + 1.0L$
6. $0.9D + 1.6W$
7. $0.9D + 1.0E$

2.7.3 Strength Design Load Combinations

Effects of one or more loads not acting shall be investigated. The most unfavorable effect from both wind and earthquake loads shall be investigated, where appropriate, but they need not be considered to act simultaneously.

Exceptions:

1. The load factor on live load *L* in combinations (3), (4), and (5) is permitted to be reduced to 0.5 for all occupancies in which minimum specified uniformly distributed live load is less than or equal to 5.0 kN/m^2, with the exception of garages or areas occupied as places of public assembly.

ACI 318-08 Ch. 9: Strength and Serviceability Requirements

R9.2.1(a) - Load factor modification of 9.2.1(a) is different from live load reduction based on loaded area typically allowed in general building code.

- The live load reduction adjusts the nominal load, L.
- The smaller load factor reflects the reduced probability of simultaneous occurrence of maximum values of multiple transient loads.
- Both may be used at the same time.

2.7.3 Strength Design Load Combinations

Exceptions:

2. The load factor on *H* shall be set equal to zero in combinations (6) and (7) if the structural action due to *H* counteracts that due to *W* or *E*. Where lateral earth pressure provides resistance to structural actions from other forces, it shall not be included in *H* but shall be included in the design resistance.

3. For structures designed in accordance with the provisions of Chapter 6, Part 6 of this Code (reinforced concrete structures), where wind load *W* has not been reduced by a directionality factor, it shall be permitted to use $1.3W$ in place of $1.6W$ in (4) and (6) above.

ASCE 7-05
6.5 (2.4.3) Analytical Procedure

- Directionality factor K_d introduced in ASCE 7-98
  - Added to equation for velocity pressure:
    - $q_z = 0.00256\ K_z\ K_{zt}\ K_d\ V^2\ I$ (Eq. 6.2.17)
  - Separate out effect of wind load factor
  - Requires adjustment to wind load factor (1.3 → 1.6) (2.7.3 Exception 3)
  - Table 6-4 (Table 6.2.12)

    Reason: Explicitly identify directionality effect in future editions.

ASCE 7-05 2.3.2 (2.7.3.1) Strength Design Load Combinations

Wind load factor:

- Old (ASCE 7-95, BNBC-2006): LF = 1.3 → included directionality effect
  0.85 (directionality) x 1.53 (LF w/o directionality) = 1.3
- Now: Identify directionality effect explicitly in K_d. Round load factor from 1.53 to 1.6.

2.7.3 Strength Design Load Combinations

When a structure is located in a flood zone or in tidal surge zone, the following load combinations shall be considered:

1. In Coastal Zones vulnerable to tidal surges, $1.6W$ shall be replaced by $1.6W+2.0F_a$ in combinations (4) and (6).

2. In Non-coastal Zones, $1.6W$ shall be replaced by $0.8W+1.0F_a$ in combinations (4) and (6).

2.7.4 Load Combinations for Extraordinary Events

Where required by the applicable Code, standard, or the authority having jurisdiction, strength and stability shall be checked to ensure that structures are capable of withstanding the effects of extraordinary (i.e., low-probability) events, such as fires, explosions, and vehicular impact.

2.7.5 Load Combinations for Serviceability

Serviceability limit states of buildings and structures shall be checked for the load combinations set forth in this Section as well as mentioned elsewhere in this Code. For serviceability limit states involving visually objectionable deformations, repairable cracking or other damage to interior finishes, and other short term effects, the suggested load combinations for checking vertical deflection due to gravity load is

1. $D + L$

2.7.5 Load Combinations for Serviceability

For serviceability limit states involving creep, settlement, or similar long-term or permanent effects, the suggested load combination is:

2. $D + 0.5L$

The dead load effect, *D*, used in applying combinations 1 and 2 above may be that portion of dead load that occurs following attachment of nonstructural elements. (Contd.)

2.7.5 Load Combinations for Serviceability

(Contd.) In applying combination 2 above to account for long term creep effect, the immediate (e.g. elastic) deflection may be multiplied by a creep factor ranging from 1.5 to 2.0. Serviceability against gravity loads (vertical deflections) shall be checked against the limits set forth in Sec 1.2.5 Chapter 1 of this Part as well as mentioned elsewhere in this Code.

1.2.5 Deflection Limits

Table 6.1.2: Deflection Limits[a, b, c, h] (Except earthquake load)

Construction	L	W^f	$D^g + L^d$
Roof members:[e]			
Supporting plaster ceiling	$l/360$	$l/360$	$l/240$
Supporting non-plaster ceiling	$l/240$	$l/240$	$l/180$
Not supporting ceiling	$l/180$	$l/180$	$l/120$
Floor members	$l/360$	-	$l/240$
Exterior walls and interior partitions			
With brittle finishes	-	$l/240$	
With flexible finishes	-	$l/120$	
Farm buildings	-		$l/180$
Greenhouses	-		$l/120$

Where, l, L, W and D stands for span of the member under consideration, live load, wind load and dead load respectively.

1.2.5 Deflection Limits

Notes:

a. For structural roofing and siding made of formed metal sheets, the total load deflection shall not exceed $l/60$. For secondary roof structural members supporting formed metal roofing, the live load deflection shall not exceed $l/150$. For secondary wall members supporting formed metal siding, the design wind load deflection shall not exceed $l/90$. For roofs, this exception only applies when the metal sheets have no roof covering.

b. Interior partitions not exceeding 2 m in height and flexible, folding and portable partitions are not governed by the provisions of this Section.

c. For cantilever members, l shall be taken as twice the length of the cantilever.

d. For wood structural members having a moisture content of less than 16% at time of installation and used under dry conditions, the deflection resulting from $L + 0.5D$ is permitted to be substituted for the deflection resulting from $L + D$.

e. The above deflections do not ensure against ponding. Roofs that do not have sufficient slope or camber to assure adequate drainage shall be investigated for ponding. See Sec 1.6.5 for rain and ponding requirements.

f. The wind load is permitted to be taken as 0.7 times the "component and cladding" loads for the purpose of determining deflection limits herein.

g. Deflection due to dead load shall include both instantaneous and long term effects.

h. For aluminum structural members or aluminum panels used in skylights and sloped glazing framing, roofs or walls of sunroom additions or patio covers, not supporting edge of glass or aluminum sandwich panels, the total load deflection shall not exceed $l/60$. For continuous aluminum structural members supporting edge of glass, the total load deflection shall not exceed $l/175$ for each glass lite or $l/60$ for the entire length of the member, whichever is more stringent. For aluminum sandwich panels used in roofs or walls of sunroom additions or patio covers, the total load deflection shall not exceed $l/120$.

2.7.5 Load Combinations for Serviceability

For serviceability limit state against lateral deflection of buildings and structures due to wind effect, the following combination shall be used:

3. $D + 0.5L + 0.7W$

Due to its transient nature, wind load need not be considered in analyzing the effects of creep or other long-term actions. Serviceability against wind load using load combination 3 above shall be checked in accordance with the limit set forth in Sec 1.5.6.2 Chapter 1 of this Part.

1.5.6.1 Story Drift Limitation

Story drift is the horizontal displacement of one level of a building or structure relative to the level above or below due to the design gravity (dead and live loads) or lateral forces (e.g. wind and earthquake loads). Calculated story drift shall include both translational and torsional deflections and conform to the following requirements:

1.5.6.1 Story Drift Limitation

(a) Story drift, Δ, for loads other than earthquake loads, shall be limited as follows:

$\Delta \leq 0.005h$ for T <0.7 second $\Delta \leq 0.004h$ for T ≥0.7 second $\Delta \leq 0.0025h$ for unreinforced masonry structures.

Where, h = height of floor ~~the building or structure~~ (Gazetted version). The period T used in this calculation shall be the same as that used for determining the base shear in Sec 2.5.7.2.

1.5.6.1 Story Drift Limitation

(b) The drift limits set out in (a) above may be exceeded where it can be demonstrated that greater drift can be tolerated by both structural and nonstructural elements without affecting life safety.

(c) For earthquake loads, the story drift, Δ shall be limited in accordance with the limits set forth in Sec 2.5.14.1

2.2 Dead Loads

2.2.2 Definition

Dead Load is the vertical load due to the weight of permanent structural and non-structural components and attachments of a building such as walls, floors, ceilings, permanent partitions and fixed service equipment etc.

2.2 Dead Loads

2.2.3 Assessment of Dead Load

Dead load for a structural member shall be assessed based on the forces due to:

- weight of the member itself,
- weight of all materials of construction incorporated into the building to be supported permanently by the member,
- weight of permanent partitions,
- weight of fixed service equipment, and
- net effect of prestressing.

2.2 Dead Loads

2.2.4 Weight of Materials of Construction

In estimating dead loads, the actual weights of materials and constructions shall be used, provided that in the absence of definite information, the weights given in Tables 6.2.1 and 6.2.2 shall be assumed for the purposes of design.

Table 6.2.1: Unit Weight of Basic Materials

Table 6.2.2: Weight of Construction Materials

2.2 Dead Loads

2.2.5 Weight of Permanent Partitions

When partition walls are indicated on the plans, their weight shall be considered as dead load acting as concentrated line loads in their actual positions on the floor. The loads due to anticipated partition walls, which are not indicated on the plans, shall be treated as live loads and determined in accordance with Sec 2.3.6.

2.2 Dead Loads

2.2.6 Weight of Fixed Service Equipment

Weights of fixed service equipment and other permanent machinery, such as electrical feeders and other machinery, heating, ventilating and air-conditioning systems, lifts and escalators, plumbing stacks and risers etc. shall be included as dead load whenever such equipment are supported by structural members.

2.2 Dead Loads

2.2.7 Additional Loads

In evaluating the final dead loads on a structural member for design purposes, allowances shall be made for additional loads resulting from the (i) difference between the prescribed and the actual weights of the members and construction materials; (ii) inclusion of future installations; (iii) changes in occupancy or use of buildings; and (iv) inclusion of structural and non-structural members not covered in Sections 2.2.2 and 2.2.3.

2.3 Live Loads

2.3.2 Definition

Live load is the load superimposed by the use or occupancy of the building not including the environmental loads such as wind load, rain load, earthquake load or dead load.

2.3 Live Loads

2.3.3 Minimum Floor Live Loads

The minimum floor live loads shall be the greatest actual imposed loads resulting from the intended use or occupancy of the floor, and shall not be less than the uniformly distributed load patterns specified in Sec 2.3.4 or the concentrated loads specified in Sec 2.3.5 whichever produces the most critical effect. The live loads shall be assumed to act vertically upon the area projected on a horizontal plane.

2.3 Live Loads

2.3.4 Uniformly Distributed Loads

The uniformly distributed live load shall not be less than the values listed in Table 6.2.3, reduced as may be specified in Sec 2.3.13, applied uniformly over the entire area of the floor, or any portion thereof to produce the most adverse effects in the member concerned.

Table 6.2.3: Minimum Uniformly Distributed and Concentrated Live Loads

2.3 Live Loads

2.3.5 Concentrated Loads

The concentrated load to be applied non-concurrently with the uniformly distributed load given in Sec 2.3.4, shall not be less than that listed in Table 6.2.3. Unless otherwise specified in Table 6.2.3 or in the following paragraph, the concentrated load shall be applied over an area of 300 mm x 300 mm and shall be located so as to produce the maximum stress conditions in the structural members.

In areas where vehicles are used or stored, such as car parking garages, ramps, repair shops etc., …

2.3 Live Loads

2.3.6 Provision for Partition Walls

When partitions, not indicated on the plans, are anticipated to be placed on the floors, their weight shall be included as an additional live load acting as concentrated line loads in an arrangement producing the most severe effect on the floor, unless it can be shown that a more favorable arrangement of the partitions shall prevail during the future use of the floor. (Contd.)

2.3 Live Loads

2.3.6 Provision for Partition Walls

(Contd.) In the case of light partitions, wherein the total weight per meter run is not greater than 5.5 kN, a uniformly distributed live load may be applied on the floor in lieu of the concentrated line loads specified above. Such uniform live load per square meter shall be at least 33% of the weight per meter run of the partitions, subject to a minimum of 1.2 kN/m^2 [25 psf; 15 psf in the IBC].

2.3 Live Loads

2.3.7 More than One Occupancy

Where an area of a floor is intended for two or more occupancies at different times, the value to be used from Table 6.2.3 shall be the greatest value for any of the occupancies concerned.

2.3.8 Minimum Roof Live Loads

Roof live loads shall be assumed to act vertically over the area projected by the roof or any portion of it upon a horizontal plane, and shall be determined as specified in Table 6.2.4.

Table 6.2.4: Minimum Roof Live Loads

2.3 Live Loads

2.3.9 Loads not Specified

Live loads, not specified for uses or occupancies in Sections 2.3.3, 2.3.4 and 2.3.5, shall be determined from loads resulting from:

(a) weight of the probable assembly of persons;

(b) weight of the probable accumulation of equipment and furniture, and

(c) weight of the probable storage of materials.

2.3 Live Loads

2.3.10 Partial Loading and Other Loading Arrangements

The full intensity of the appropriately reduced live load applied only to a portion of the length or area of a structure or member shall be considered, if it produces a more unfavorable effect than the same intensity applied over the full length or area of the structure or member.

Where uniformly distributed live loads are used in the design of continuous members and their supports, consideration shall be given to full dead load on all spans in combination with full live loads on adjacent spans and on alternate spans whichever produces a more unfavorable effect.

2.3 Live Loads

2.3.11 Other Live Loads

Live loads on miscellaneous structures and components, such as handrails and supporting members, parapets and balustrades, ceilings, skylights and supports, and the like, shall be determined from the analysis of the actual loads on them, but shall not be less than those given in Table 6.2.5.

Table 6.2.5: Miscellaneous Live Loads

2.3 Live Loads

2.3.12 Impact and Dynamic Loads

The live loads specified in Sec 2.3.3 shall be assumed to include allowances for impacts arising from normal uses only. However, forces imposed by unusual vibrations and impacts resulting from the operation of installed machinery and equipment shall be determined separately and treated as additional live loads. Live loads due to vibration or impact shall be determined by dynamic analysis of the supporting member or structure including foundations, or from the recommended values supplied by the manufacturer of the particular equipment or machinery. In absence of definite information, values listed in Table 6.2.6 for some common equipment, shall be used for design purposes.

2.3 Live Loads

Table 6.2.6: Minimum Live Loads on Supports and Connections of Equipment due to Impact[1]

Equipment or Machinery	Additional load due to impact as percentage of static load including self-weight: Vertical	Horizontal
1. Lifts, hoists and related operating machinery	100%	Not applicable
2. Light machinery (shaft or motor driven)	20%	Not applicable
3. Reciprocating machinery, or power driven units.	50%	Not applicable
4. Hangers supporting floors and balconies	33%	Not applicable
5. Cranes :		
(a) Electric overhead cranes	25% of maximum wheel load	(i) Transverse to the rail : 20% of the weight of trolley and lifted load only, applied one-half at the top of each rail (ii) Along the rail : 10% of maximum wheel load applied at the top of each rail
(b) Manually operated cranes	50% of the values in (a) above	50% of the values in (a) above
(c) Cab-operated travelling cranes	25%	Not applicable

[1] All these loads shall be increased if so recommended by the manufacturer. For machinery and equipment not listed, impact loads shall be those recommended by the manufacturers, or determined by dynamic analysis.

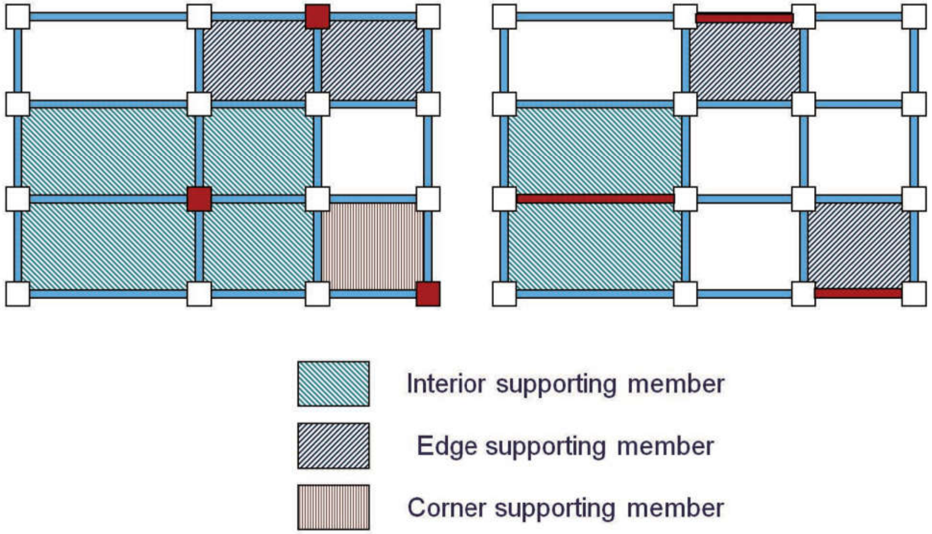
2.3.13 Reduction in Live Loads

ASCE 7-95:

$$L = L_0\left(0.25 + \frac{4.57}{\sqrt{A_I}}\right)$$

Reduced design live load shall be not less than 50% of L_0 for members supporting one floor nor less than 40% of L_0 for members supporting two or more floors

Influence Areas



2.3.13 Reduction in Live Loads

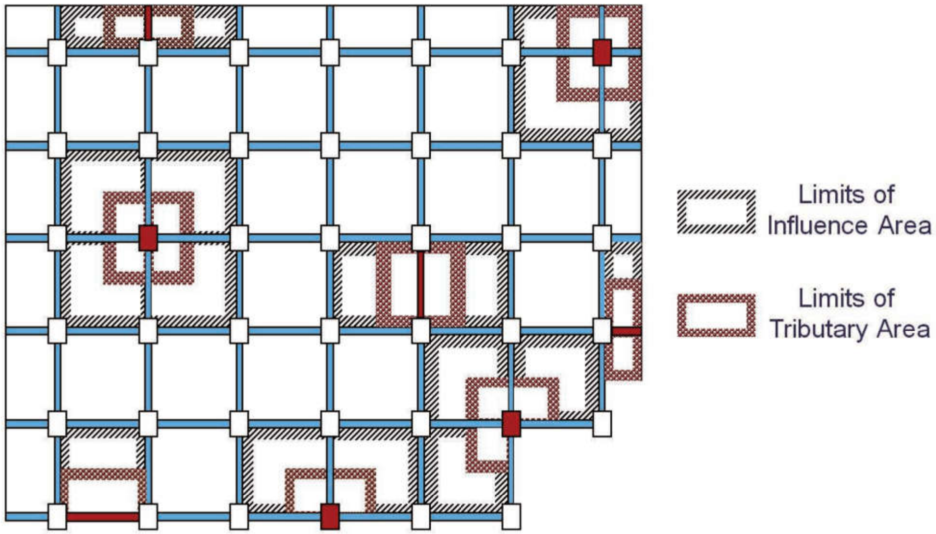
ASCE 7-98 through ASCE 7-05:

For $K_{LL} A_T > 37.16\ m^2$

$$L = L_0\left(0.25 + \frac{4.57}{\sqrt{K_{LL}A_T}}\right)$$

L shall not be less than $0.50L_0$ for members supporting one floor nor than $0.40L_0$ for members supporting two or more floors

Influence and Tributary Areas



2.3.13 Reduction in Live Loads

Table 6.2.7: Live Load Element Factor, K_{LL}

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

2.3.13 Limitations on Live Load Reduction

2.3.13.2 Heavy live loads

Live loads that exceed 4.80 kN/m^2 [100 psf] shall not be reduced.

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

2.3.13 Limitations on Live Load Reduction

2.3.13.3 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.

2.3.13 Limitations on Live Load Reduction

2.3.13.4 Special occupancies

(a) Live loads of 4.80 kN/m^2 or less shall not be reduced in public assembly occupancies.

(b) There shall be no reduction of live loads for cyclone shelters.

2.3.13 Limitations on Live Load Reduction

2.3.13.5 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.

Table 6.2.3 Roof Live Load

The minimum uniformly distributed roof live load, L_0, is now given in Tables 6.2.3 and 6.2.4.

Table 6.2.4 Roof Live Load

Table 6.2.4: Minimum Roof Live Loads(1)

	Type and Slope of Roof	Distributed Load, kN/m²	Concentrated Load, kN
I	Flat roof (slope = 0)	See Table 6.2.3	
II	(A) Pitched or sloped roof (0 < slope < 1/3) (B) Arched roof or dome (rise < 1/8 span)	1.0	0.9
III	(A) Pitched or sloped roof (1/3 ≤ slope < 1.0) (B) Arched roof or dome (1/8 ≤ rise < 3/8 span)	0.8	0.9
IV	(A) Pitched or sloped roof (slope ≥ 1.0) (B) Arched roof or dome (rise ≥ 3/8 span)	0.6	0.9
V	Greenhouse, and agriculture buildings	0.5	0.9
VI	Canopies and awnings, except those with cloth covers	Same as given in I to IV above based on the type and slope.	

Note: (1) Greater of this load and rain load as specified in Sec 2.6.2 shall be taken as the design live load for roof. The distributed load shall be applied over the area of the roof projected upon a horizontal plane and shall not be applied simultaneously with the concentrated load. The concentrated load shall be assumed to act upon a 300 mm x 300 mm area and need not be considered for roofs capable of laterally distributing the load, e.g. reinforced concrete slabs.

2.3.14 Reduction of Roof Live Loads

$L_r = L_0R_1R_2$ where $0.60 \le L_r \le 1.00$

$R_1 = 1$ for $A_t \le 18.58\ m^2$

$= 1.2 - 0.001A_t$ for $18.58\ m^2 < A_t < 55.74\ m^2$

$= 0.6$ for $A_t \ge 55.74\ m^2$

$R_2 = 1$ for $F \le 4$

$= 1.2 - 0.05F$ for $4 < F < 12$

$= 0.6$ for $F \ge 12$

where, for a pitched roof, F = 0.12 x slope, with slope expressed in percentage points and, for an arch or dome, F = rise-to-span ratio multiplied by 32

2.13.4 Reduction of Roof Live Loads

2.13.14.2 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 Sec 2.3.13.

Live Load Reduction - Example

Plan dimensions: (as shown)

Story height = 4 m

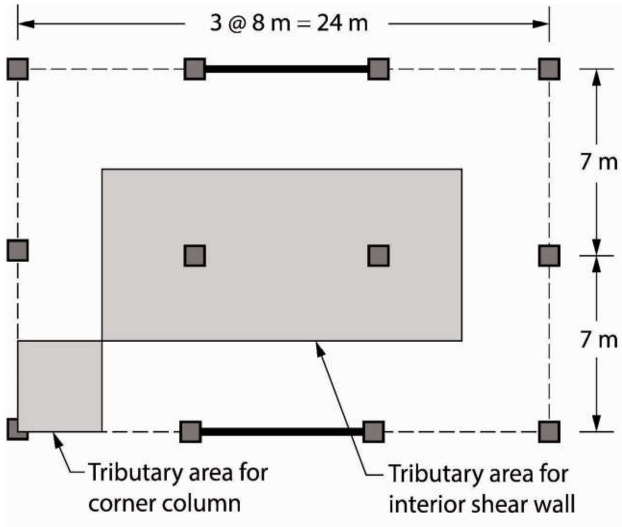
Live load: Floors = 2.4 kN/m^2

Roof = 1.0 kN/m^2 (assumed)

Dead load: Floors = 5.8 kN/m^2 (assumed)

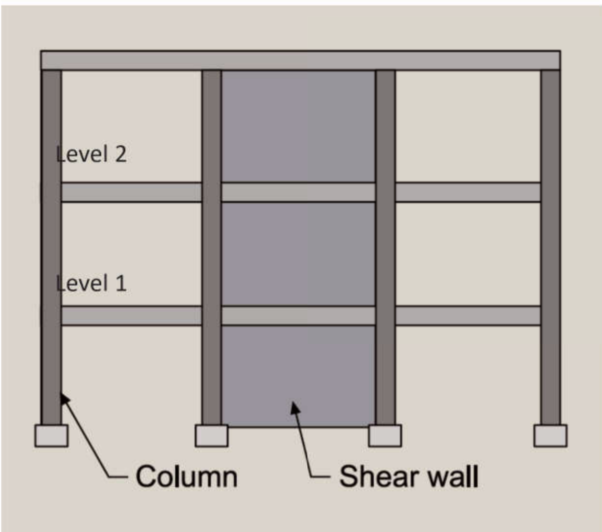
Roof = 4.3 kN/m^2 (assumed)

Live Load Reduction - Example



Plan

Live Load Reduction - Example



Elevation

Live Load Reduction - Example

Live Load Reduction for Corner Column

Level	A_T (m^2)	L_0	K_{LL}	$K_{LL} \times A_T$	R (%)	R (max) (%)	Reduction (%)	L (kN/m^2)
2	14	2.4	4	56	13.9	50	13.9	2.06
1	28	2.4	4	112	31.8	60	31.8	1.64
$R = 1 - L/L_0$								

Live Load Reduction - Example

Live Load Reduction for Interior Shear Wall

Level	A_T (m^2)	L_0	K_{LL}	$K_{LL} \times A_T$	R (%)	R (max) (%)	Reduction (%)	L (kN/m^2)
2	112	2.4	1	112	31.8	50	31.8	1.64
1	224	2.4	1	224	44.5	60	44.5	1.33
$R = 1 - L/L_0$								

Q: A: for Live Load Reduction

Q: Can partition loads be reduced since they are live loads?

A: Nowhere does BNBC-2020 say explicitly that partition loads cannot be reduced. However, it is believed that it cannot be reduced because it is not listed in Table 6.2.3.

2.6 Miscellaneous Loads

2.6.1 General

2.6.2 Rain Loads

2.6.3 Loads Due to Flood and Surge (Dhaka Metro area largely unaffected)

2.6.4 Temperature Effects

2.6.5 Soil and Hydrostatic Pressure

2.6.6 Loads due to Explosions (Specialized)

2.6.7 Vertical Forces on Air Raid Shelters (Specialized)

2.6.8 Loads on Helicopter Landing Areas (Specialized)

2.6.9 Erection and Construction Loads

2.6.2 Rain Loads

2.6.2 Rain Loads

Rain loads shall be determined in accordance with the following provisions.

2.6.2.1 Blocked drains

Each portion of a roof shall be designed to sustain the load from all rainwater that could be accumulated on it if the primary drainage system for that portion is undersized or blocked. Ponding instability shall be considered in this situation.

2.6.2 Rain Loads

2.6.2 Rain Loads

2.6.2.2 Controlled drainage

Roofs equipped with controlled drainage provisions shall be designed to sustain all rainwater loads on them to the elevation of the secondary drainage system plus 0.25 kN/m². Ponding instability shall be considered in this situation.

2.6.2 Rain Loads

ASCE 7-16

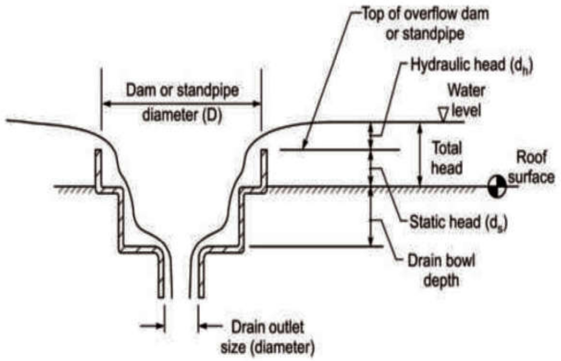
8.3 DESIGN RAIN LOADS

Each portion of a roof shall be designed to sustain the load of all rainwater that will accumulate on it if the primary drainage system for that portion is blocked plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow.

$$R = 0.0098(d_s + d_h) \qquad (8.3\text{-}1.si)$$

If the secondary drainage systems contain drain lines, such lines and their point of discharge shall be separate from the primary drain lines. Rain loads shall be based on the total head (static head [d_s] plus hydraulic head [d_h]) associated with the design flow rate for the specified secondary drains and drainage system. The total head corresponding to the design flow rate for the specified drains shall be based on hydraulic test data.

2.6.2 Rain Loads



Schematic Cross Section of Secondary (Overflow) Roof Drain and Total Head ($d_s + d_h$).

2.6.2 Rain Loads

The depth of water, d_h, above the inlet of the secondary drainage system (i.e., the hydraulic head) is a function of the rainfall intensity, i, at the site, the area of roof serviced by that drainage system, and the size of the drainage system. The flow rate through a single drainage system is as follows:

$$Q = (0.278 \times 10^{-6})Ai \qquad (m^3/s)$$

Tables C8.3.1 and C8.3.2 of ASCE 7-16 provides the value of hydraulic head, d_h corresponding to a range of flow rates for various drainage systems. The tables indicate that d_h can vary considerably depending on the type and size of each drainage system and the flow rate it must handle.

2.6.2 Rain Loads

A = tributary roof area plus one-half the wall area that diverts rainwater onto the roof (where applicable) serviced by a single drain outlet in the secondary drainage system (m^2)

i = design rainfall intensity (mm/hr)

2.6.2 Rain Loads

The usual design rain load uses a 60-min duration of a 100-year return period rainfall event for the design of the primary drainage system and the 15-min duration of a 100-year return period rainfall event for the secondary drainage system (assuming the primary drainage system is completely blocked or clogged).

For U.S. locations, the National Oceanic and Atmospheric Administration (NOAA's) National Weather Service Precipitation Frequency Data Server, Hydrometerorological Design Studies Center provides rainfall intensity data for various durations and various mean recurrence intervals (http://hdsc.nws.noaa.gov/hdsc/pfds/index.html).

2.6.3 Loads due to Flood and Surge

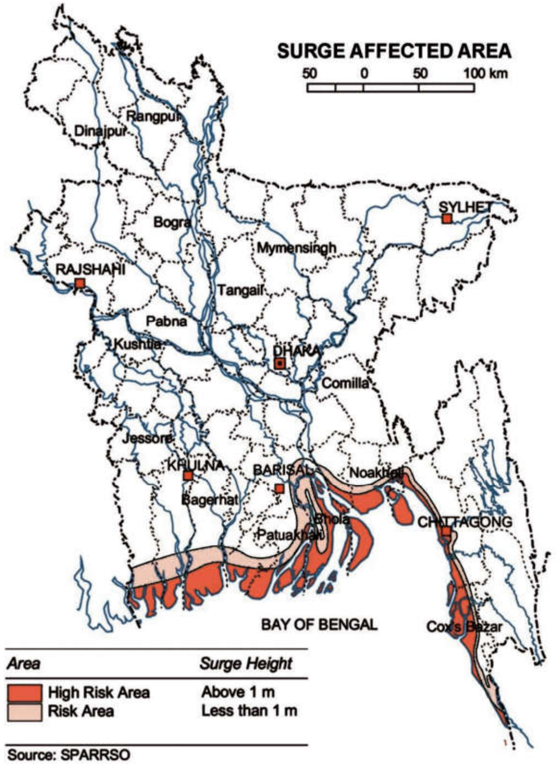
2.6.3.1 Flood loads on structures at inland areas

For structures sited at inland areas subject to flood, loads due to flood shall be determined considering hydrostatic effects which shall be calculated based on the flood elevation of 50-year return period. For river-side structures such as that under Exposure C specified in Sec 2.4.6.3 [wind] , hydrodynamic forces, arising due to approaching wind-generated waves shall also be determined in addition to the hydrostatic load on them. In this case, the amplitude of such wind-induced water waves shall be obtained from site-specific data.

2.6.3 Loads due to Flood and Surge

2.6.3.2 Flood and surge loads on structures at coastal areas

Coastal area of Bangladesh has been delineated as Risk Area (RA) and High Risk Area (HRA) based on the possible extent of the inland intrusion of the cyclone storm surge as shown in Figure 6.2.30. To be classified as coastal RISK AREA, the principal source of flooding must be sea tides, storm surge, and not riverine flood. The RA extends from the coast line to an inland limit up to which surge water can reach. The HRA includes a strip of land within the RA. It extends from the coast line up to the limit where the depth of storm surge inundation may exceed 1m. Entire area of the off-shore islands except the Maheshkhali area is included in the HRA. A part of Maheshkhali is covered by hills and therefore free from inundation. However, the western and northern parts of Maheshkhali are of low elevation and risk inundation.



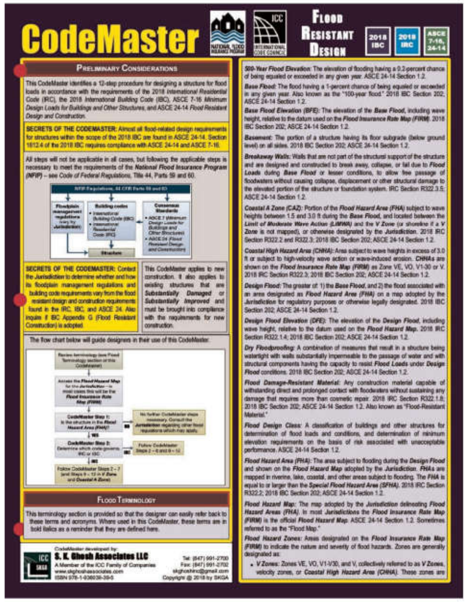
ASCE Flood Load Standard

5.5 CONSENSUS STANDARDS AND OTHER AFFILIATED CRITERIA

ASCE/SEI 24, *Flood Resistant Design and Construction,* American Society of Civil Engineers,

- Revised to 2014 Edition

SKGA Flood Load CodeMaster



2.6.4 Temperature Effects

Temperature effects, if significant, shall be considered in the design of structures or components thereof in accordance with the provision of this Section. In determining the temperature effects on a structure, the following provisions shall be considered:

(a) The temperatures indicated, shall be the air temperature in the shade. The range of the variation in temperature for a building site shall be taken into consideration.

2.6.4 Temperature Effects

(b) Effects of the variation of temperature within the material of a structural element shall be accounted for by one of the following methods.

(i) Relieve the stresses by providing adequate numbers of expansion or contraction joints,

(ii) Design the structural element to sustain additional stresses due to temperature effects.

2.6.4 Temperature Effects

(c) when the method b(ii) above is considered to be applicable, the structural analysis shall take into account the following :

(i) The variation in temperature within the material of the structural element, exposure condition of the element and the rate at which the material absorb or radiate heat.

(ii) The warping or any other distortion caused due to temperature changes and temperature gradient in the structural element.

2.6.4 Temperature Effects

(d) When it can be demonstrated by established principle of mechanics or by any other means that neglecting some or all of the effects of temperature, does not affect the safety and serviceability of the structure, the temperature effect can be considered insignificant and need not be considered in design.

2.6.5 Soil and Hydrostatic Pressure

For structures or portions thereof, lying below ground level, loads due to soil and hydrostatic pressure shall be determined in accordance with the provisions of this Section and applied in addition to all other applicable loads.

2.6.5.1 Pressure on basement wall:

In the design of basement walls and similar vertical or nearly vertical structures below grade, provision shall be made for the lateral pressure of adjacent soil. Allowance shall be made for possible surcharge due to fixed or moving loads. When a portion or the whole of the adjacent soil is below the surrounding water table, computations shall be based on the submerged unit weight of soil, plus full hydrostatic pressure.

2.6.5 Soil and Hydrostatic Pressure

2.6.5.2 Uplift on floors:

In the design of basement floors and similar horizontal or nearly horizontal construction below grade, the upward pressure of water, if any, shall be taken as the full hydrostatic pressure applied over the entire area. The hydrostatic head shall be measured from the underside of the construction.

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2.6.5 Soil and Hydrostatic Pressure

2018 IBC SECTION 1610

SOIL LOADS AND HYDROSTATIC PRESSURE

1610.1 Lateral pressures. Foundation walls and retaining walls shall be designed to resist lateral soil *loads* from adjacent soil. Soil *loads* specified in Table 1610.1 shall be used as the minimum design lateral soil *loads* unless determined otherwise by a geotechnical investigation in accordance with Section 1803. Foundation walls and other walls in which horizontal movement is restricted at the top shall be designed for at-rest pressure. Retaining walls free to move and rotate at the top shall be permitted to be designed for active pressure. Lateral pressure from surcharge *loads* shall be added to the lateral soil *load*. Lateral pressure shall be increased if expansive soils are present at the site. Foundation walls shall be designed to support the weight of the full hydrostatic pressure of undrained backfill unless a drainage system is installed in accordance with Sections 1805.4.2 and 1805.4.3.

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2.6.5 Soil and Hydrostatic Pressure

2018 IBC SECTION 1610

SOIL LOADS AND HYDROSTATIC PRESSURE

1610.1 Lateral pressures.

Exception: Foundation walls extending not more than 8 feet (2438 mm) below grade and laterally supported at the top by flexible *diaphragms* shall be permitted to be designed for active pressure.

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2.6.5 Soil and Hydrostatic Pressure

2021 IBC SECTION 1610

SOIL LOADS AND HYDROSTATIC PRESSURE

1610.2 Uplift loads on floor and foundations. Basement floors, slabs on ground, foundations, and similar approximately horizontal elements below grade shall be designed to resist uplift *loads* where applicable. The upward pressure of water shall be taken as the full hydrostatic pressure applied over the entire area. The hydrostatic *load* shall be measured from the underside of the element being evaluated. The design for upward *loads* caused by expansive soils shall comply with Section 1808.6.

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2.6.5 Soil and Hydrostatic Pressure

TABLE 1610.1
LATERAL SOIL LOAD

DESCRIPTION OF BACKFILL MATERIAL[c]	UNIFIED SOIL CLASSIFICATION	DESIGN LATERAL SOIL LOAD[a] (pound per square foot per foot of depth)	
		Active pressure	At-rest pressure
Well-graded, clean gravels; gravel-sand mixes	GW	30	60
Poorly graded clean gravels; gravel-sand mixes	GP	30	60
Silty gravels, poorly graded gravel-sand mixes	GM	40	60
Clayey gravels, poorly graded gravel-and-clay mixes	GC	45	60
Well-graded, clean sands; gravelly sand mixes	SW	30	60
Poorly graded clean sands; sand-gravel mixes	SP	30	60
Silty sands, poorly graded sand-silt mixes	SM	45	60
Sand-silt clay mix with plastic fines	SM-SC	45	100
Clayey sands, poorly graded sand-clay mixes	SC	60	100
Inorganic silts and clayey silts	ML	45	100
Mixture of inorganic silt and clay	ML-CL	60	100
Inorganic clays of low to medium plasticity	CL	60	100
Organic silts and silt clays, low plasticity	OL	Note b	Note b
Inorganic clayey silts, elastic silts	MH	Note b	Note b
Inorganic clays of high plasticity	CH	Note b	Note b
Organic clays and silty clays	OH	Note b	Note b

For SI: 1 pound per square foot per foot of depth = 0.157 kPa/m, 1 foot = 304.8 mm.
a. Design lateral soil loads are given for moist conditions for the specified soils at their optimum densities. Actual field conditions shall govern. Submerged or saturated soil pressures shall include the weight of the buoyant soil plus the hydrostatic loads.
b. Unsuitable as backfill material.
c. The definition and classification of soil materials shall be in accordance with ASTM D2487.

2.6 Miscellaneous Loads

- 2.6.1 General
- 2.6.2 Rain Loads
- 2.6.3 Loads Due to Flood and Surge (Dhaka Metro area largely unaffected)
- 2.6.4 Temperature Effects
- 2.6.5 Soil and Hydrostatic Pressure
- 2.6.6 Loads due to Explosions (Specialized)
- 2.6.7 Vertical Forces on Air Raid Shelters (Specialized)
- 2.6.8 Loads on Helicopter Landing Areas (Specialized)
- 2.6.9 Erection and Construction Loads

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2.6.9 Erection and Construction Loads

All loads required to be sustained by a structure or any portion thereof due to placing or storage of construction materials and erection equipment including those due to operation of such equipment shall be considered as erection loads. Provisions shall be made in design to account for all stresses due to such loads.

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Questions?

Thank you

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