Structural Loading Provisions in the Building Code: Past, Present and Future

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DiBlasi Associates, PC
Structural Engineers

Thomas A. DiBlasi, P.E., SECB
DiBlasi Associates, P.C.
500 Purdy Hill Road Monroe Connecticut
(203) 452-1331 FAX (203) 268-8103
TomD@DiBlasi-Engrs.com

Learning Objectives

- Better understand the evolution of the structural Building Code provisions
- Recognize the significance of structural design parameters that are required to be cited on the Construction Documents
- Get some insight into changes to the structural loading requirements that are forthcoming
- Understand what goes into a snow loading assessment of an existing building

Evolution of the Building Code

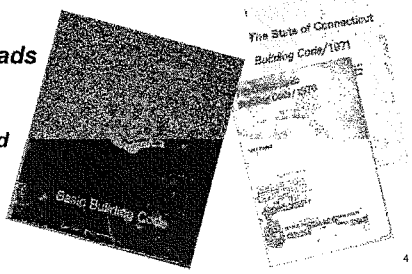
- First Connecticut State Building Code adopted in 1971
- Originally based on BOCA model building code
- Now based on IBC

Evolution of the Building Code

1971 State Building Code (eff. 9/1/71)

- Based on BOCA Basic Building Code / 1970

Structural Loads
- 13 pages
- All inclusive
- No referenced standards

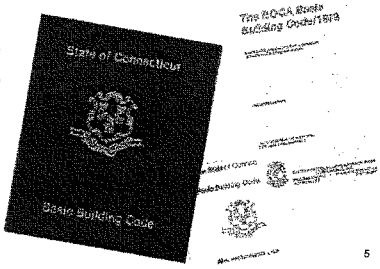


Evolution of the Building Code

1978 State Building Code (eff. 9/1/81)

- Based on BOCA Basic Building Code / 1978

Structural Loads
- 16 pages (including 4 page snow load appendix)
- All inclusive
- No referenced standards

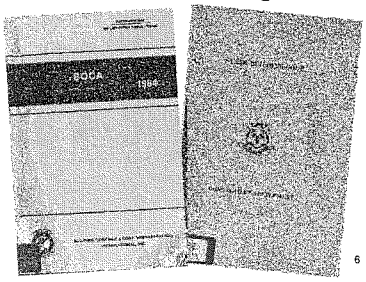


Evolution of the Building Code

1987 State Building Code (eff. 4/15/87)

- Based on BOCA Basic National Building Code / 1984

Structural Loads
- 31 pages
- All inclusive
- No referenced standards

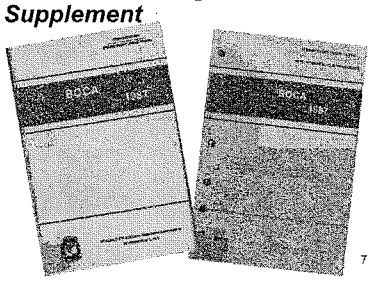


Evolution of the Building Code

1989 State Building Code

- Based on BOCA National Building Code/1987 and 1988 BOCA Supplement

Structural Loads
- 45 pages
- Referenced standard ANSI A58.1-1982 for some wind load calculations

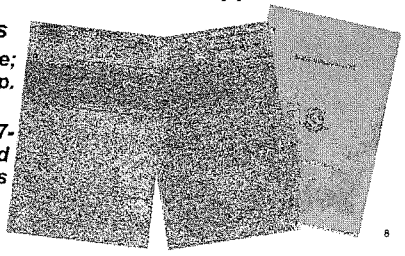


Evolution of the Building Code

1994 State Building Code (eff. 6/15/94)

- Based on BOCA National Building Code/1990 and 1992 BOCA Accumulative Supplement

Structural Loads
- 48 pages in Code; 38 pages in Supp.
- Referenced standard ASCE 7-88 for some wind load calculations



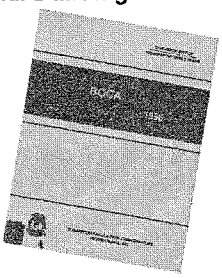
Evolution of the Building Code

1999 State Building Code

- *Based on BOCA National Building Code/1996*

Structural Loads

- *46 pages (8½"x11" page size)*
- *Largely inclusive*
- *Optional wind design using referenced standard ASCE 7-95*



Evolution of the Building Code

2005 State Building Code

- *Based on 2003 International Building Code*

Structural Loads

- *77 pages (8½"x11" page size)*
- *Referenced standard ASCE 7-02 required for derivation of virtually all snow, wind and seismic loads*

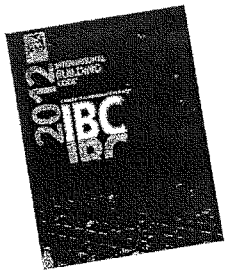
Evolution of the Building Code

2014 (?) State Building Code

- *Based on 2012 International Building Code*

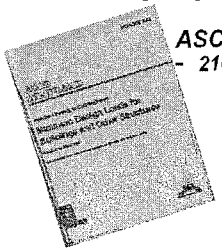
Structural Loads

- *46 pages (8½"x11" page size)*
- *Referenced standard ASCE/SEI 7-10 required for derivation of virtually all snow, wind and seismic loads*



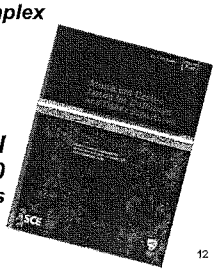
Evolution of the Building Code

- *Increased Complexity*
- *Increased Reliance on Referenced Standards*
  - *Getting Progressively More Complex*



ASCE 7-02
- *216 pages*

ASCE/SEI 7-10
- *358 pages*

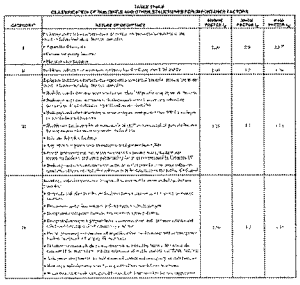


Construction Documents (§1603)

- *Live Loads*
- *Snow Design Data*
- *Wind Design Data*
- *Earthquake Design Data*
- *Flood Data*

Construction Documents

- *Importance Factor*
  - *Snow, Wind and Earthquake Loads*
  - *Reliability of Structure*
  - *Recurrence Interval of Event*
  - *Table 1604.5*



Construction Documents

- *Table 1604.5 - Categories of Buildings I-IV*
  - *Category II is Norm – I = 1.0*
  - *Importance Factor Can Amplify or Reduce*

Category	Snow Factor, I_s	Recurrence Interval
I	0.8	25 years
II	1.0	50 years
III	1.1	± 75 years
IV	1.2	100 years

Construction Documents

- *Wind Design Data - §1603.1.4*
  - *Basic Wind Speed*
  - *Wind Importance Factor*
  - *Wind Exposure*
  - *Internal Pressure Coefficient*
  - *Component & Cladding Wind Pressures*

Construction Documents

- Wind Design Data – Basic Wind Speed
  - Appendix of CT Building Code Supplement

(Add) APPENDIX K

Municipality	Ground Snow Load, P_g (psf)	Basic Wind Speed (3 sec. gust)	MCE Spectral Accelerations S_s	MCE Spectral Accelerations S_1
Andover	30	100	0.224	0.063
Ansonia	30	105	0.235	0.063
Ashford	35	100	0.239	0.063
Avon	35	95	0.241	0.064
Barkhamsted	40	90	0.239	0.063
Beacon Falls	30	100	0.253	0.064
Berlin	60	100	0.242	0.066

Construction Documents

- Wind Design Data – Basic Wind Speed
  - Wind Pressure in NOT directly proportional to wind speed.

$$q_z = 0.00256 K_z K_{zt} K_d V^2 I$$

Pressure due to a 100 mph wind is 23.5% higher than that due to a 90 mph wind !!!

Construction Documents

- Wind Design Data – Basic Wind Speed
  - Beware of changes to design methodologies
    - Current design based on wind speed of 3-second gust
    - 1999 State Building Code and earlier based on fastest mile
      - Conversion factors in Table 1609.3.1

TABLE 1609.3.1
EQUIVALENT BASIC WIND SPEEDS[a,b,c]

V_{3s}	85	90	100	105	110	120	125	130
V_{fm}	70	75	80	85	90	100	105	110

Construction Documents

- Wind Design Data – Basic Wind Speed
  - Allowable Stress Design vs. Strength Design
    - ASD loads provided through present Code
    - Relates to load combinations and material design requirements

ASD: $D + W$
$D + 0.75(W + L + S)$
$0.6D + W$

Construction Documents

- Wind Design Data – Basic Wind Speed
  - Strength Design

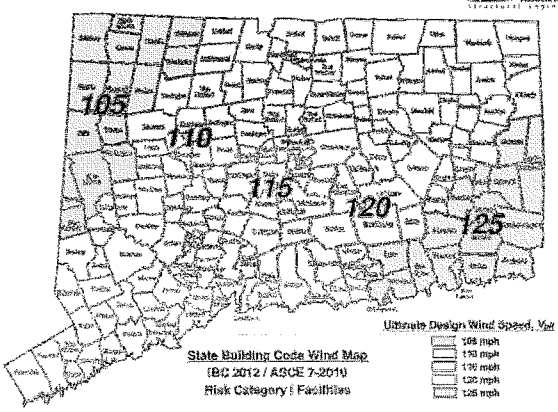
$1.2D + 1.6W + f_1L + 0.5S$
$0.9D + 1.6W$

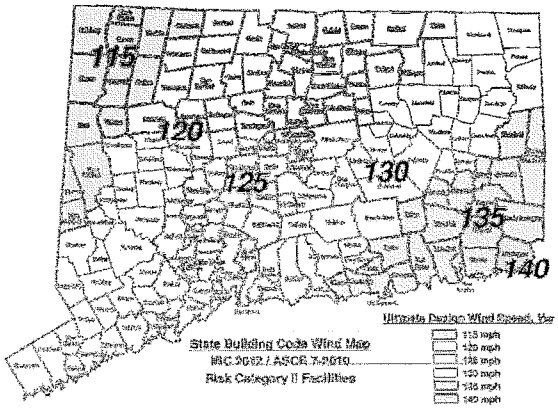
  - IBC 2012 / ASCE-SEI 2010 - Based on Ultimate Wind Loads, Not ASD Level Loads – Strength Design Load Cases to Change:

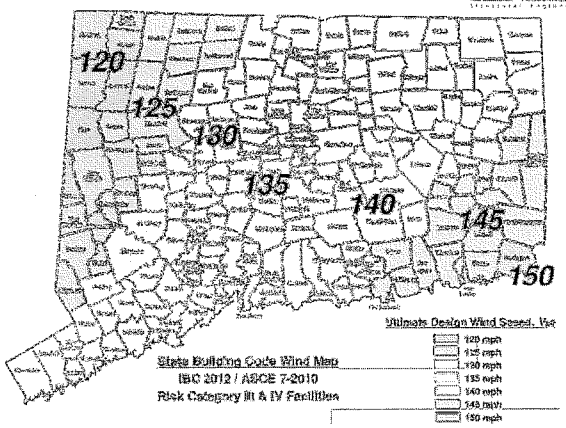
$1.2D + \underline{1.0}W + f_1L + 0.5S$
$0.9D + \underline{1.0}W$

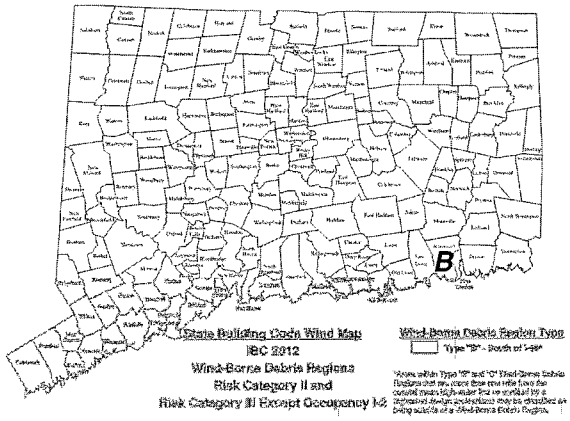
Construction Documents

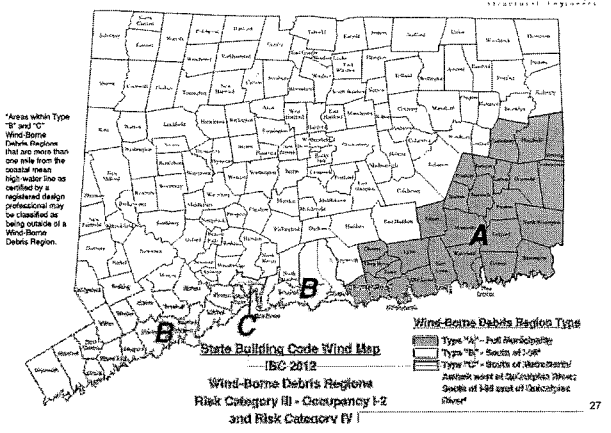
- Wind Design Data – Basic Wind Speed
  - IBC 2012 / ASCE-SEI 2010 – Importance Factor eliminated from wind pressure equation.
    - Incorporated into Wind Speed Maps
    - Formerly Category I = 0.87 and Categories III and IV = 1.15.
      - NOW 3 DIFFERENT MAPS !!!!











Construction Documents

- *Wind Design Data – Basic Wind Speed*
  - *Allowable (ASD) wind speeds will still be required by many other sections of the Building Code.*
    - *Conversion Equation:*

$$V_{asd} = V_{ult}\sqrt{0.6} \quad (0.775\ V_{ult})$$

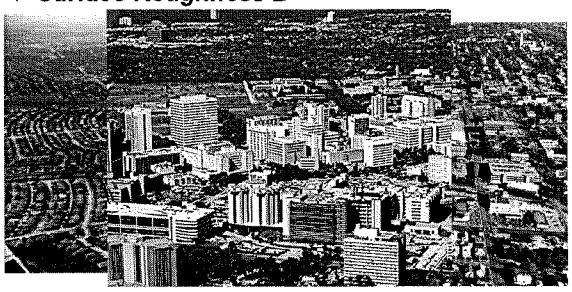
Construction Documents

- *Wind Design Data – Exposure Category*
  - *Categories B, C and D*
  - *Largely a function of the landscape – Surface Roughness Categories*
  - *Significant Effect on Wind Pressure*

Height above ground level, z		Exposure (Note 1)			
		B		C	D
ft	(m)	Case 1	Case 2	Cases 1 & 2	Cases 1 & 2
0-15	(0-4.6)	0.70	0.57	0.85	1.03
20	(6.1)	0.70	0.62	0.90	1.08
25	(7.6)	0.70	0.66	0.94	1.12
30	(9.1)	0.70	0.70	0.98	1.16
40	(12.2)	0.76	0.76	1.04	1.22
50	(15.2)	0.81	0.81	1.09	1.27

Construction Documents

- *Wind Design Data – Exposure Category*
  - *Surface Roughness B*



Construction Documents

- *Wind Design Data – Exposure Category*
  - *30' High Building*
    - *Category C wind loads are 40% greater than Category B*
    - *Category D wind loads are 66% greater than Category B and 18% greater than Category C*

Construction Documents

- *Wind Design Data – Exposure Category*
  - *Surface Roughness C*

Construction Documents

- *Wind Design Data – Exposure Category*
  - *Surface Roughness D*

Construction Documents

- *Wind Design Data – Exposure Category*
  - *IBC 2003 - Exposure Category B - Default*
    - *Urban and suburban areas, wooded areas or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. Exposure B shall be assumed unless the site meets the definition of another type of exposure.*

Construction Documents

- *Wind Design Data – Exposure Category*
  - *IBC 2003 - Exposure Category C*
    - *Open terrain with scattered obstructions, including surface undulations or other irregularities, having heights generally less than 30 feet extending more than 1,500 feet from the building site in any quadrant. This exposure shall also apply to any building located within Exposure B-type terrain where the building is directly adjacent to open areas of Exposure C-type terrain in any quadrant for a distance of more than 600 feet. This category includes flat open country, grasslands and shorelines in hurricane-prone regions.*

Construction Documents

- *Wind Design Data – Exposure Category*
  - *IBC 2003 - Exposure Category D*
    - *Flat, unobstructed areas exposed to wind flowing over open water (excluding shorelines in hurricane-prone regions) for a distance of at least 1 mile. Shorelines in Exposure D include inland waterways, the Great Lakes,…… This exposure shall apply only to those buildings and other structures exposed to the wind coming from over the water. Exposure D extends inland from the shoreline a distance of 1,500 feet or 10 times the height of the building or structure, whichever is greater.*

Construction Documents

- *Wind Design Data – Exposure Category*
  - *IBC 2012 – Major Changes*
    - *Default Exposure Category – C*
    - *Exposure Category D applicable in Hurricane-Prone Regions*

Construction Documents

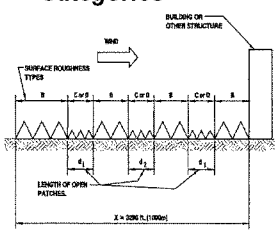
- *Wind Design Data – Exposure Category*
  - *IBC 2012 – Exposure Categories*
    - *Exposure D shall apply where the ground surface roughness, as defined by Surface Roughness D, prevails in the upwind direction for a distance of at least 5,000 feet or 20 times the height of the building, whichever is greater. Exposure D shall also apply where the ground surface roughness immediately upwind of the site is B or C, and the site is within a distance of 600 feet or 20 times the building height, whichever is greater, from an Exposure D condition as defined in the previous sentence.*

Construction Documents

- *Wind Design Data – Exposure Category*
  - *IBC 2012 – Exposure Categories*
    - *Exposure B shall apply where the ground surface roughness condition, as defined by Surface Roughness B, prevails in the upwind direction for a distance of at least 2,630 ft or 10 times the height of the building, whichever is greater.*
    - *Exposure C shall apply for all cases where exposures B or D do not apply.*

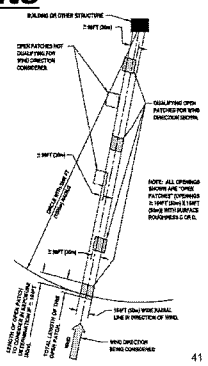
Construction Documents

- *Wind Design Data – Exposure Category*
  - *IBC 2012 – Exposure Categories*



If <20% Open Patches within 1,000m, then Exp. B

Min. patch dimension = 50m



BREAK

Construction Documents

- Snow Design Data – §1603.1.3
  - Ground Snow Load
  - Flat Roof Snow Load
  - Snow Exposure Factor
  - Snow Importance Factor
  - Thermal Factor

Construction Documents

- Snow Design Data – Ground Snow Load
  - Appendix of CT Building Code Supplement

(Add) APPENDIX K

Municipality	Ground Snow Load, P_g (psf)	Basic Wind Speed (3 sec. gust)	MCE Spectral Accelerations	
			S_s	S_1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Construction Documents

- Snow Design Data
  - Snow Exposure Factor, C_e - Table 1608.3.1

Terrain Category	Fully Exposed	Partially Exposed	Sheltered
B	0.9	1.0	1.2
C	0.9	1.0	1.1
D	0.8	0.9	1.0

See Footnotes!

Construction Documents

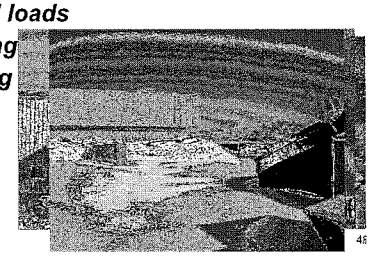
- Snow Design Data
  - Snow Thermal Factor, C_t - Table 1608.3.2

Thermal Condition	C_t
Typical Structures	1.0
Structures kept just above freezing; structures w/ cold, ventilated roofs	1.1
Unheated structures	1.2
Continuously heated greenhouses	0.85

See Footnotes!

Construction Documents

- Snow Design Data
  - ➢ What about non-uniform loading conditions???
    - Unbalanced loads
    - Snow drifting
    - Snow sliding



No requirement to specifically identify these special loads!

Construction Documents

- Snow Design Data
  - Flat Roof Snow Load, p_f – ASCE 7

$$p_f = 0.7C_eC_tIp_g \quad \text{(Eq. 7-1)}$$

For most common conditions, C_e, C_t and I = 1.0; using common ground snow load of 30 psf yields flat roof snow load of 21.0 psf.

30 psf minimum flat roof snow load per CT amendments!

Snow Load Design Evolution

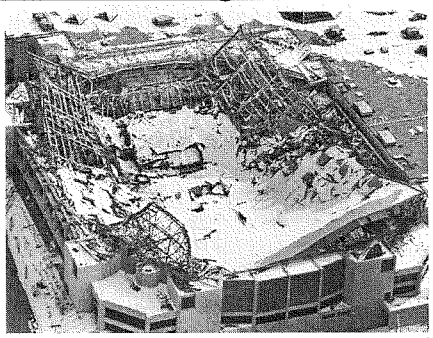
- Pre-1971
  - ➢ No State Building Code
  - ➢ Many cities had their own Building Codes
  - ➢ 30 psf design snow load not uncommon but definitely not uniform throughout the state
  - ➢ Where a Building Code was in effect, highly unlikely if there were any provisions to address non-uniform loading conditions

Snow Load Design Evolution

- 1971 State Building Code
  - Minimum roof live load of 30 psf in areas subject to snow
  - Non-Uniform Snow Loads?

    §712.1 – Shape of Roof: When the effect of the shape of the roof structure as determined by actual tests indicates lesser or greater snow retention than indicated in this article, the roof load shall be modified accordingly.

Snow Load Design Evolution



Hartford Civic Center - 18 January 1978

Snow Load Design Evolution

- 1978 State Building Code
  - Basic (ground) snow load of 40 psf
    - Snow load factor of 0.8
    - Yields flat roof snow load of 32 psf
  - Provisions for Non-Uniform Snow Loads Included
    - Appendix L
    - Some loading parameters amplified from model code (BOCA 1978)

Snow Load Design Evolution

- 1978 State Building Code
  - Unbalanced Snow Loads

Simple gable and hip roofs

Case I C_s

Case II C_s

For $\alpha \leq 20°$ use Case I only

For $\alpha > 20°$ use Cases I and II

Case I use data for simple flat and shed roofs (at left)

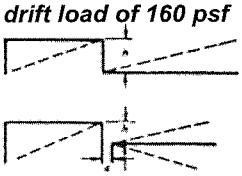
Case II $C_s = 1.25 \times$ Case I (above)

Gable roof with slope less than 30 degrees, design for uniform 32 psf over whole roof, but also evaluate for 40 psf on one half (other side unloaded)

Reductions permitted for slopes > 30°

Snow Load Design Evolution

- 1978 State Building Code
  - Snow Drifts at Low Roofs
    - Snow drift factor as high as 4.0 (roof steps 10'-0" high or greater)
    - Yields maximum snow drift load of 160 psf



$C_s = 16 \frac{h}{g}$

When $15 \frac{h}{g} < 0.8$ use $C_s = 0.8$

When $15 \frac{h}{g} > 4.0$ use $C_s = 4.0$

$w = 2h$

When $h < 5$ ft Use $W = 10$ ft
$h > 15$ ft Use $W = 30$ ft

h = Difference of roof heights in ft
g = Ground snow in psf
w = Width of drift from higher building in ft
a = Distance between buildings < 15 ft

Snow Load Design Evolution

- 1978 State Building Code
  - Snow Drifts at Projections
    - Parapets, RTU's
      - Snow drift factor as high as 2.0 (projections 8'-0" high greater)
      - Yields maximum snow drift load of 80 psf

$C_s = 10 \frac{h}{g}$

When $10 \frac{h}{g} < 0.8$ use $C_s = 0.8$

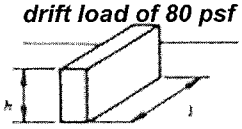
When $10 \frac{h}{g} > 2.0$ use $C_s = 2.0$

When $l < \frac{w}{2}$ use $C_s = 0.8$

$w = 2h$

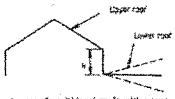
When $h < 5$ ft use $w = 10$ ft
When $h > 15$ ft use $w = 30$ ft

h = Height of projection in ft
g = Ground snow in psf
w = Width of snow drift in ft
l = Length of projection in ft



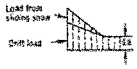
Snow Load Design Evolution

- 1978 State Building Code
  - Snow Sliding
    - "Design lower roof for loads applicable to multi-level roofs plus a portion of the sliding snow from the upper roof"



Lower of multi-level roofs with upper roof sloped towards lower roof

SNOW LOAD DISTRIBUTIONS



Design lower roof for loads applicable to multi-level roofs plus a portion of the sliding snow from the upper roof

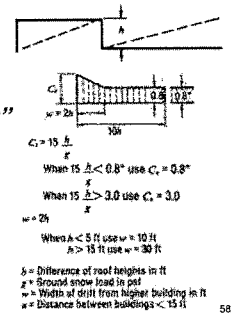
Design upper roof for loads applicable to single-level roofs

Snow Load Design Evolution

- 1987 State Building Code
  - Basic (ground) snow load of 40 psf
    - Snow load factor of 0.8 in sheltered areas and 0.6 in exposed areas
    - Yields flat roof snow load of 24 or <u>32 psf</u>
  - Provisions for Non-Uniform Snow Loads Included in Body of Building Code
    - Provisions for unbalanced snow, sliding snow and drifts at projections unchanged.

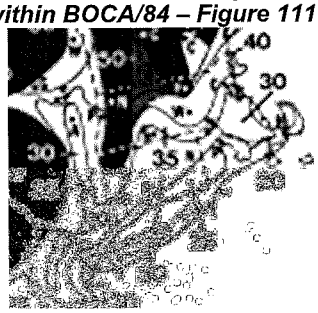
Snow Load Design Evolution

- 1987 State Building Code
  - Snow Drifts at Low Roofs
    - Maximum snow drift factor reduced from 4.0 to 3.0 (roof steps of 8'-0" or greater)
    - Yields maximum snow drift load of 120 psf



Snow Load Design Evolution

- 1989 State Building Code
  - Ground snow loads initially obtained from map within BOCA/84 – Figure 1111.2a



Snow Load Design Evolution

- 1989 State Building Code
  - Municipality Load Listing Issued by OSBI

Ground snow loads ranged from 25 to 45 psf

CONNECTICUT TOWN SNOW LOAD & WIND SPEED

TOWN	GROUND SNOW LOAD (PSF)	WIND SPEED (MPH)	WIND IMPORTANCE FACTORS — BUILDING CATEGORY I	II & III	IV
Andover	30	85	1.02	1.08	0.97
Ansonia	30	80	1.03	1.09	0.98
Ashford	30	85	1.02	1.08	0.97
Avon	30	80	1.02	1.08	0.97
Barkhamsted	35	75	1.01	1.07	0.96
Beacon Falls	30	80	1.03	1.09	0.98
Berlin	30	80	1.03	1.09	0.98
Bethany	30	80	1.03	1.09	0.98
Bethel	30	80	1.03	1.09	0.98
Bethlehem	35	80	1.02	1.08	0.97

Snow Load Design Evolution

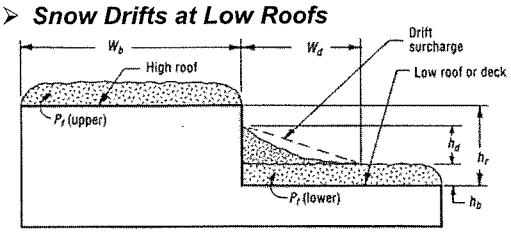
- 1989 State Building Code
  - No minimum flat-roof snow load indicated
  - From BOCA/87, §1111.4:

$$P_f = C_e I P_g$$

  - for a typical structure with a 30 psf ground snow load, the design flat-roof snow load would be only 21 psf !!!

Snow Load Design Evolution

- 1989 State Building Code
  - Snow Drifts at Low Roofs

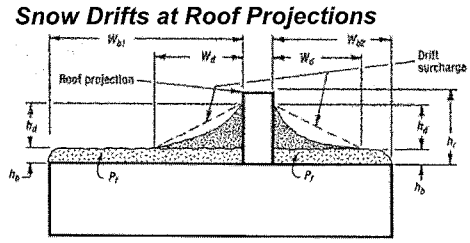


Density, $D = 0.13\,P_g + 14$ pcf [17.9 pcf for P_g = 30 psf]

Height of drift, $h_d = 0.43 \times \sqrt[3]{W_b} \times \sqrt[4]{P_g + 10} - 1.5$

Snow Load Design Evolution

- 1989 State Building Code
  - Snow Drifts at Roof Projections

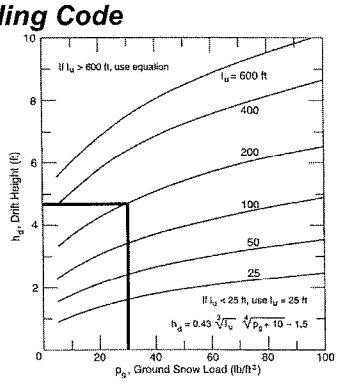


- Procedure similar to drifts at low roofs
- W_b = distance from projection to edge of roof or 50 feet, whichever is less.

Snow Load Design Evolution

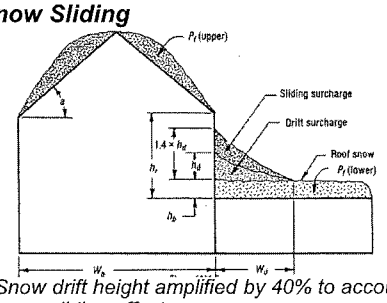
- 1989 State Building Code
  - Snow Drifts at Low Roofs

p_g = 30 psf
W_b = 200'
$h_d \approx$ 4'-9" (4.82')



Snow Load Design Evolution

- 1989 State Building Code
  - Snow Sliding



- Snow drift height amplified by 40% to account for snow sliding effects

Snow Load Design Evolution

- *1994 State Building Code*
  - *Ground snow loads tabulated in Connecticut Supplement*
  - *Minimum flat-roof snow load of 30 psf*
    - *Not applicable to non-uniform loading conditions*
  - *Non-Uniform Snow Loads*
    - *Provisions for unbalanced snow, snow drifting, and sliding snow unchanged.*
    - *For drifts at projections, maximum tributary roof width for calculating drift height (W_b) reduced from 50 feet to 25 feet.*

Snow Load Design Evolution

- *1999 State Building Code*
  - *Ground snow loads tabulated in Connecticut Supplement*
  - *Minimum flat-roof snow load of 30 psf*
    - *Not applicable to non-uniform loading conditions*
  - *Non-Uniform Snow Loads*
    - *Provisions for unbalanced snow, snow drifting, and sliding snow unchanged.*
    - *For drifts at projections, tributary roof width for calculating drift height (W_b) changed from maximum of 25 feet to minimum of 25'.*

Snow Load Design Evolution

- *1999 State Building Code*
  - *Drifts at Projections*

250' wide building
6'-0" high parapet on each end (W_b)
30 psf ground snow load, P_g

1994 State Building Code: W_b = lesser of building width or 25'
- Yields drift height (h_d) of only 1'-8"

1999 State Building Code: W_b = greater of building width or 25'
- Yields drift height (h_d) of 5'-4" *SIGNIFICANT DIFFERENCE!*

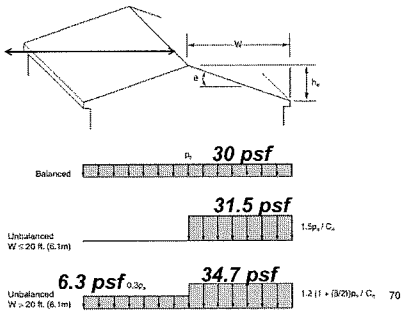
Snow Load Design Evolution

- *2005 State Building Code*
  - *Ground snow loads tabulated in Connecticut Supplement*
  - *Minimum flat-roof snow load of 30 psf*
    - *Not applicable to non-uniform loading conditions*
  - *Non-Uniform Snow Loads*
    - *For roof projections, minimum width of 25' eliminated; 75% of calculated drift height used for drift load calculation.*
    - *Many changes to other provisions!!!!*

Snow Load Design Evolution

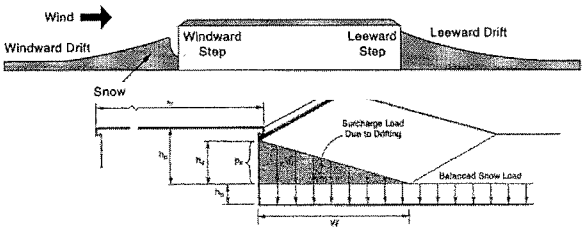
- *2005 State Building Code*
  - *Unbalanced Snow Loads*

Roof Slope = 20°
p_f = 21 psf
$p_{f\text{-}min}$ = 30 psf
C_e = 1.0
β = 1.5 – 0.025p_g
= 0.75



Snow Load Design Evolution

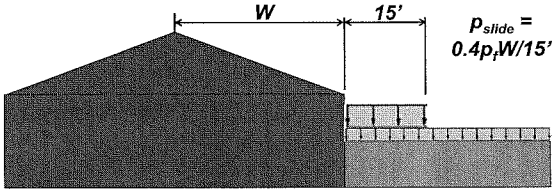
- *2005 State Building Code*
  - *Snow Drifting*
    - *Leeward Drifts vs. Windward Drifts*



Windward drift height = 75% of calculated h_d

Snow Load Design Evolution

- *2005 State Building Code*
  - *Snow Sliding*
    - *40% of snow from sloped roof above*



p_{slide} = 0.4p_fW/15'

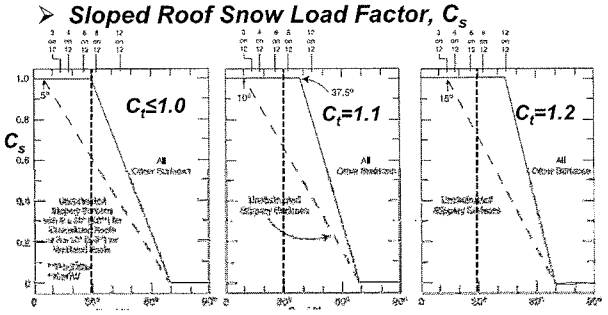
- *Applicable to slippery roofs ¼:12; other roofs 2:12*
- *Not additive to snow drift or unbalanced snow loads*

Snow Load Design Evolution

- *2005 State Building Code*
  - *Sloped Roof Snow Load Factor, C_s*
    - *Previously triggered at 30 degrees for all roofs*
    - *Roof thermal condition now taken into consideration*
    - *Roof surface taken into consideration*
      - *Unobstructed slippery surface vs. all other surfaces*

Snow Load Design Evolution

- 2005 State Building Code
  - Sloped Roof Snow Load Factor, C_s

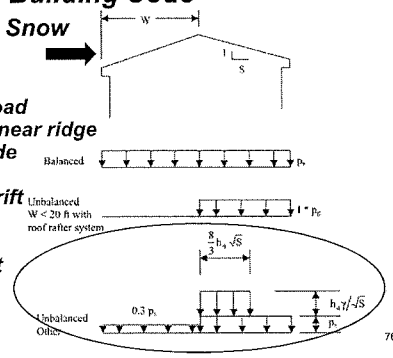


Snow Load Design Evolution

- 2014(?) State Building Code
  - Ground snow loads tabulated in Connecticut Supplement
  - Minimum flat-roof snow load of 30 psf
    - Not applicable to non-uniform loading conditions
  - Non-Uniform Snow Loads
    - Provisions for snow drifting and drifts at projections largely unchanged
    - Change to unbalanced snow loads

Snow Load Design Evolution

- 2014(?) State Building Code
  - Unbalanced Snow Loads
    - Unbalanced load concentrated near ridge on leeward side
    - Load based drift criteria
    - Length of drift increases as poof pitch decreases

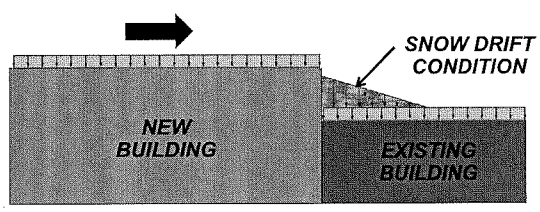


Snow Load Design Evolution

- 2014(?) State Building Code
  - Sloped Roof Snow Loads
    - CT Amendments: Sloped roof reduction factor for unobstructed slippery roofs shall not be used unless approved by the Building Official.

Snow Load Design Evolution

- Existing Buildings



Snow Load Design Evolution

- Existing Buildings

ASCE 7: Existing roofs shall be evaluated for increased snow loads caused by additions or alterations. Owners or agents for owners of an existing lower roof shall be advised of the potential for increased snow loads where a higher roof is constructed within 20 feet.

Not invoked anywhere in IBC.

Snow Load Design Evolution

- Existing Buildings

RI Building Code Amendments: When a new building is to be constructed or an existing building extended to a greater height than an existing adjoining building, a determination of structural integrity of the roof of the adjoining building shall be made regarding the snow loads in accordance with this Section. The person intending to cause the construction or building height extension shall deliver written notice of intent to the owner of the potentially affected building. The notice shall request license to enter the potentially affected building to inspect and determine the existing building's capacity to sustain additional imposed snow drift load. (cont.)

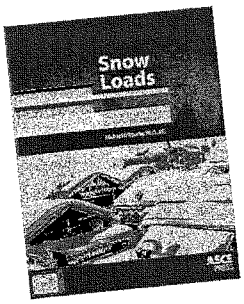
Snow Load Design Evolution

- Existing Buildings

.....The person causing such construction shall be liable and shall at their own expense preserve, protect and, if necessary, reconstruct those portions of the adjacent building affected by this construction. If the owner of the adjacent building refuses to allow inspection, protection or reconstruction as may be required, the person causing such new construction or building height extension shall notify, in writing, both the Building Official and the owner of the adjacent property. Such notification shall identify that the responsibility of providing inspection, protection or reconstruction to the adjacent building has become the exclusive responsibility of the owner of the adjacent property.

Snow Load Design Evolution

- *Additional Resources*



Guide to the Snow Load Provisions of ASCE 7-2010

Michael J. O'Rourke

ASCE Press

Snow Load Determination

Snow Load is a Function of:

- Snow Depth
- Snow Density
  - Unit weight of snow – pounds per cubic foot (pcf)
  - For Design Purposes, per ASCE 7:

    Density = [0.13 x Ground Snow Load] + 14 pcf

    For a 30 psf Ground Snow Load, Density = 17.9 pcf

    In reality, snow density varies considerably.

Snow Load Determination

Factors Effecting Snow Density

- Initial Snowfall Conditions
- Elapsed Duration & Weather Conditions Subsequent to Snowfall
- Exposure to Sunlight
- Heat Loss of Roof

3 to 10 February 2011
44 Snow Load Samples – Fairfield to Windsor Locks
14.8 pcf minimum – 30.0 pcf maximum
21.2 pcf median snow density

Snow Load Determination

Tools for Field Measurements

- Square-Edged Shovel
- Five-Gallon Bucket
- Postage Scale (50-pound capacity)
- Tape Measure
- Rigid Yard Stick (Steel or Aluminum)
- Calculator
- Note Pad and Pencil

Snow Load Determination

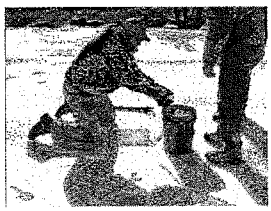
Procedure for Calculating In-Situ Snow Density

1. Zero the scale.
2. Weigh the five-gallon bucket.
3. Locate section(s) of roof deemed to represent typical snow depth condition.

Snow Load Determination

Procedure for Calculating In-Situ Snow Density

4. Using the square-edge shovel, dig a 1'-0" x 1'-0" hole down to the roof, and put all snow from hole into the five-gallon bucket.



Snow Load Determination

Procedure for Calculating In-Situ Snow Density

5. Weigh the bucket that has been filled with the snow from the 1'-0" x 1'-0" hole.
6. Measure the depth of the snow at the 1'-0" x 1'-0" hole (top of snow down to roof).

Snow Load Determination

Procedure for Calculating In-Situ Snow Density

7. Unit weight of snow at this location (psf) =

   Weight of filled bucket [Step 5]
   – weight of empty bucket [Step 2]

8. Density of snow at this location (pcf) =

   Unit weight of snow [Step 7]
   Depth of snow [Step 6]

Snow Load Determination

Procedure for Calculating Unit Snow Loads at Other Locations on Roof

1. Measure snow depth at various locations using rigid yard stick
2. Unit weight of snow at this location (psf) =

   Density of snow x
   Depth of snow

Unit Snow Loads (psf)

Snow Depth (inches)	Snow Density (pcf) 15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
10	12.5	13.3	14.2	15.0	15.8	16.7	17.5	18.3	19.2	20.0	20.8	21.7	22.5	23.3	24.2	25.0
11	13.8	14.7	15.6	16.5	17.4	18.3	19.3	20.2	21.1	22.0	22.9	23.8	24.8	25.7	26.6	27.5
12	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0
13	16.3	17.3	18.4	19.5	20.6	21.7	22.8	23.8	24.9	26.0	27.1	28.2	29.3	30.3	31.4	32.5
14	17.5	18.7	19.8	21.0	22.2	23.3	24.5	25.7	26.8	28.0	29.2	30.3	31.5	32.7	33.8	35.0
15	18.8	20.0	21.3	22.5	23.8	25.0	26.3	27.5	28.8	30.0	31.3	32.5	33.8	35.0	36.3	37.5
16	20.0	21.3	22.7	24.0	25.3	26.7	28.0	29.3	30.7	32.0	33.3	34.7	36.0	37.3	38.7	40.0
17	21.3	22.7	24.1	25.5	26.9	28.3	29.8	31.2	32.6	34.0	35.4	36.9	38.3	39.7	41.1	42.5
18	22.5	24.0	25.5	27.0	28.5	30.0	31.5	33.0	34.5	36.0	37.5	39.0	40.5	42.0	43.5	45.0
19	23.8	25.3	26.9	28.5	30.1	31.7	33.3	34.8	36.4	38.0	39.6	41.2	42.8	44.3	45.9	47.5
20	25.0	26.7	28.4	30.0	31.7	33.3	35.0	36.7	38.3	40.0	41.7	43.3	45.0	46.7	48.3	50.0
21	26.3	28.0	29.8	31.5	33.3	35.0	36.8	38.5	40.3	42.0	43.8	45.5	47.3	49.0	50.8	52.5
22	27.5	29.3	31.2	33.0	34.8	36.7	38.5	40.3	42.2	44.0	45.8	47.7	49.5	51.3	53.2	55.0
23	28.8	30.7	32.6	34.5	36.4	38.3	40.3	42.2	44.1	46.0	47.9	49.8	51.8	53.7	55.6	57.5
24	30.0	32.0	34.0	36.0	38.0	40.0	42.0	44.0	46.0	48.0	50.0	52.0	54.0	56.0	58.0	60.0
25	31.3	33.3	35.4	37.5	39.6	41.7	43.8	45.8	47.9	50.0	52.1	54.2	56.3	58.3	60.4	62.5
26	32.5	34.7	36.9	39.0	41.2	43.3	45.5	47.7	49.8	52.0	54.2	56.3	58.5	60.7	62.8	65.0
27	33.8	36.0	38.3	40.5	42.8	45.0	47.3	49.5	51.8	54.0	56.3	58.5	60.8	63.0	65.3	67.5
28	35.0	37.3	39.7	42.0	44.3	46.7	49.0	51.3	53.7	56.0	58.3	60.7	63.0	65.3	67.7	70.0
29	36.3	38.7	41.1	43.5	45.9	48.3	50.8	53.2	55.6	58.0	60.4	62.8	65.3	67.7	70.1	72.5
30	37.5	40.0	42.5	45.0	47.5	50.0	52.5	55.0	57.5	60.0	62.5	65.0	67.5	70.0	72.5	75.0

Snow Load Determination

Procedure for Calculating Unit Snow Loads at Other Locations on Roof

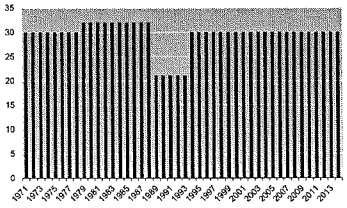
Consider additional density samples under certain conditions:

- Very large roofs
- Different roofing systems (variations in insulation)
- Variations in interior building environment
- Noticeable changes in snow
- Must use judgment!

Building Snow Load Evaluation

Building Reliability Assessment

- Are drawings available that indicate the design snow load?
- Was there a Building Code in effect at the time when then building was constructed? (State Building Code post-1971; local Building Code pre-1971)
  - If so, was there a minimum flat-roof snow load?

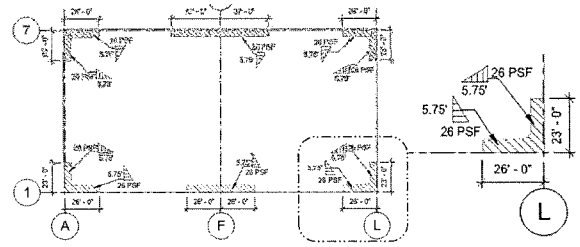


Building Snow Load Evaluation

Building Reliability Assessment

- Was a structural peer review performed? (requirement for Threshold Buildings since 1988)
- Was a Special Inspections program utilized (requirement since 1989 SBC)
- Was an effective structural plan review performed?
- Was the building properly maintained?
- Was the structural engineer from outside the state?
- What is the reputation of the engineer (or architect)?
- Would the structural system be expected to have any residual capacity? Has it performed well historically?

Building Snow Load Evaluation



ROOF SNOW DRIFT LOADING DIAGRAM
NO SCALE

NOTE:
SNOW DRIFT SURCHARGE IS TO BE APPLIED OVER THE 30 PSF FLAT ROOF SNOW LOAD

Building Snow Load Evaluation

Snow Drifting Assessment

- Was the building constructed before or after the adoption of the 1981 State Building Code?
- When in doubt, require removal of drifts.
- Structural drawings can be very helpful but oftentimes do not paint the complete picture.
- Amendment to next State Building Code for Roof Snow Load Data to be included in Construction Documents:
  - *Snow drift surcharge load(s)*
  - *Snow drift width(s)*

Building Snow Load Evaluation

Signs of Distress?

- Excessive deflection?

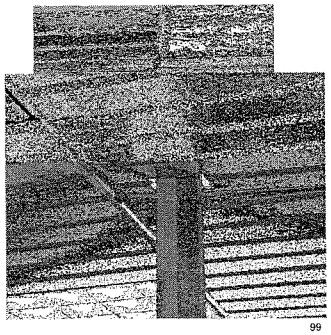
  Allowable deflection of a roof joist supporting an acoustical tile ceiling – 1/240 span under snow load

  - For a 50' span, this is 2½" !!!
- Cracking of wall and ceiling finishes

Building Snow Load Evaluation

Signs of Distress?

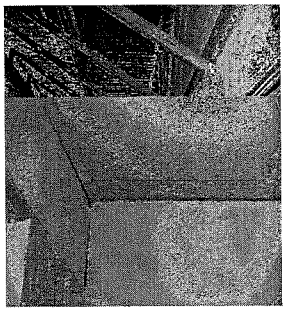
- Excessive deflection?
- Cracking of wall and ceiling finishes
- Differential deflection



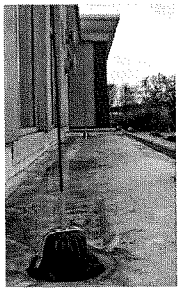
Building Snow Load Evaluation

Signs of Distress?

- Excessive deflection?
- Cracking of wall and ceiling finishes
- Differential deflection
- Bowing of walls



Building Snow Load Evaluation

Signs of Distress?

- Excessive deflection?
- Cracking of wall and ceiling finishes
- Differential deflection
- Bowing of walls
- Ponding of water – KEEP DRAINS CLEAR!
- Loud noises
- Err on the side of caution. Lives depend on it!