Supplemental Design Examples

for the

SNOW LOAD ANALYSIS FOR WASHINGTON

Second Edition

Using SEI/ASCE 7-05 criteria

Structural Engineers Association of Washington
www.seaw.org

SNOW LOAD MANUAL ATTACHMENT
USER NOTES

The design examples within this attachment are intended to supplement the previously published Snow Load Analysis for Washington, Second Edition, published by the Structural Engineers Association of Washington, Copyright 1995 (Snow Load Manual) and the previous supplemental design example problems based on SEI/ASCE 7-02. The examples within this attachment are not intended to change the original example design problem objectives or assumptions. The original design examples are on pages 33 to 44 within the Snow Load Manual, Part III.

The original design examples utilized the design criteria given within the 1994 Uniform Building Code (94 UBC), Appendix Chapter 16, STRUCTURAL FORCES, Division I – SNOW LOAD DESIGN. The changes within Appendix Chapter 16 from the 1994 to the 1997 editions of the uniform codes were trivial. Thus, the original design examples were relevant through the use of the 1997 Uniform Building Code (97 UBC).

The attached design examples (new examples) follow the original design examples with respect to example number, page number, location within the State, ground elevation, structure type and geometry. The new examples have been designed using the criteria set forth in Chapter 7, Snow Loads, of SEI/ASCE 7-05, the American Society of Civil Engineers Standard, Minimum Design Loads for Buildings and Other Structures. Please note that new examples that have changed from SEI/ASCE 7-02 to SEI/ASCE 7-05 are so noted in the new example Table of Contents. Also, note that the new examples refer to the Washington State Nonresidential Energy Code, or NREC. The current edition of the NREC is available on-line under wabo.org and following the leads.

There are some inequalities with respect to the change from the 94-97 UBC to the SEI/ASCE 7-02 and -05 documents. There are several and it is not the intent of this attachment to cover them all. Of note, however, are:

- There are no SEI/ASCE 7-02 / 05 companion code provisions to 94 UBC 1638.3.2 / 97 UBC 1641.3.2, Unbalanced Snow Loads, Gable Roofs with Nonparallel Ridge Lines or 94 UBC 1645 / 97 UBC 1648 Vertical Obstructions. The design professional should use his or her judgment with regard to application of these sections to a structure designed under SEI/ASCE 7-05 criteria.
- There were no 94 UBC / 97 UBC companion code provisions to SEI/ASCE 7-02 / 05 Section 7.3.2 Thermal Factors, Section 7.5.1 Partial Loading Continuous Beam Systems and Section 7.6.4 Unbalanced Snow Loads for Dome Roofs. Again, there are other differences but these are notable.
- There are many 94 UBC / 97 UBC to SEI/ASCE 7-02 / 05 companion code provisions that have changed in application limits, values and ranges. Many, but not all, of these changes will be demonstrated within the new examples.

With regard to the design items that are within the SEI/ASCE 7-02 / 05, Section 7.5 Partial Loading has no new example within this attachment. This section along with companion Figure 7-4, is left to the designer to apply to his or her specific project and specific conditions. The wording and intent of the application of this section is clear and straightforward. However, the results and issues that arise from the application of the section can be varied and often material specific. Some, but not all, of the issues that the designer should consider and investigate when applying SEI/ASCE 7-02 / 05 Section 7.5 were (most will be obvious):

- The impact of differing spans along the same beam line.
- The impact of differing tributary loading areas to the same beam line.
- The obvious impact of changing positive/negative moment locations along the beam line.
- The differing responses of pinned versus fixed beam/column and column/footing connections.
- The impact of differing eccentricities on slender columns.
- Any combination of the above and others not mentioned.

(Checked 10-25-08 J.A.T.C.E.)

The user of the Snow Load Manual should review the text on page 33 of the manual. The statements made with regard to methodology and purposes are valid for this attachment. Specific emphasis should be paid to the references made to locally established minimum design snow loads. Of specific interest in the State of Washington, the snow storms of the winter of 1996-97 have resulted in the establishment of some extremely variable snow load minimums within the same general geographic area. Please note that the local Building Officials ARE empowered to establish the design snow loads within their enforcement area under RCW 19.27. In any case, call the local jurisdiction.

DISCLAIMER

While considerable care has gone into reading and interpreting the data available from the **National Weather Service** and the **Soil Conservation Service**, the stations are widely spaced, and the period of data collection a specific stations varies from continuous records back into the 1890's to only a few years of data. Additionally, **NWS** data for the most part consists only of snow depth information which must be converted into snow load information by means of a snow depth-to-load conversion relationship. Extrapolations must then be made to infer, from these few points, a value for the snow load at every point in the State. These difficulties must be taken into account when using the values presented in this Snow Load Manual. Designers cannot rely solely on the data contained herein, but must also attempt to obtain local data for the site under consideration

The recommendations and information presented in the Snow Load Manual and this attachment are to be used only as a guide and design aid for the Building Officials and the experienced designer. Users of the Snow Load Manual and this attachment should be aware of the limitations of these design examples. They are primarily intended to illustrate the use of the SEI/ASCE 7-02/05 Chapter 7 Snow Loads design provisions and are not to be considered the best or only way to handle a particular type of snow loading. Again, RCW 19.27 empowers the local Building Official to establish the design snow loads for their jurisdictional area. Therefore, design snow loads to be used should be no less than those established by the local Building Official having jurisdiction over a given site.

While the **Snow Load Committee** has endeavored to present accurate guidelines for snow load design based on the data available, neither the **Snow Load Committee** nor the **Structural Engineers Association of Washington** will accept liability for the use of the information provided herein.

(Checked 10-25-08 J.A.T.C.E.)

SNOW LOAD MANUAL ATTACHMENT
TABLE OF CONTENTS

The design examples within this attachment are intended to supplement the previously published **Snow Load Analysis for Washington**, Second Edition, published by the Structural Engineers Association of Washington, Copyright 1995.

Relative to the original design examples on pages 33 to 44 of the Snow Load Manual, Design Example No. 1 and Design Example No. 2 have not been redone. Methods shown in these examples remain valid for this attachment.

Also relative to the original design examples, Design Example No. 11, referencing 94 UBC Appendix Section 1638.3.2 and 97 UBC Appendix Section 1641.3.2 Multiple Gable Roofs with Non-parallel Ridge Lines, has not been redone since there is no companion code provision within SEI/ASCE 7-02 / 05. As stated previously in the attachment user notes, the designer should use their best professional judgment with regard to application of this provision as well as 94 UBC Appendix Section 1645 and 97 UBC Appendix Section 1648 Vertical Obstructions to a structure designed under the provisions of SEI/ASCE 7-02 / 05.

Relative to the new design examples for the change from the 94 / 97 UBC to the SEI/ASCE 7-02 / 05, Design Example No. 7.2 is new and is meant to illustrate SEI/ASCE 7-02 / 05 Section 7.6.4 Unbalanced Snow Loads for Dome Roofs. Also new for the UBC to SEI/ASCE change, Design Example No. 12.1 is new and is meant to illustrate SEI/ASCE 7-02 / 05 Section 7.3.4 Minimum Values of Pf for Low-Slope Roofs and Section 7.10 Rain-on-Snow Surcharge Load.

Relative to the new design examples for the change from SEI/ASCE 7-02 to 7-05, Design Example No. 3.2 is new and is meant to illustrate the variability of the changed SEI/ASCE 7-05 Section 7.6.1 Unbalanced Snow Loads for Hip and Gable Roofs. Further, Design Examples 3.1, 9.1 and 10.1 have been reworked relative to changed SEI/ASCE 7-05 Section 7.6.1. Also, Design Example 12.1 is reworked relative to changed SEI/ASCE 7-05 Section 7.10 Rain on Snow Surcharge Load.

Please note that several editorial changes have been made to correct errata and clarify items on the previously published SEI/ASCE 7-02 Design Examples. These changes have not been "marked" and do not change the design examples with respect to procedures and results.

Also within the Design Examples following a statement or an equation, there are references made to the specific location within SEI/ASCE 7-02 / 05 justifying the statement or equation. These references are as follows: (E X-X) refers to equation X-X, (T X-X) refers to Table X-X, (F X-X) refers to Figure X-X and (S X.X.X) refers to Section X.X.X.

(Checked 10-25-08 J.A.T.C.E.)

Design Example No. 3.1

Location: Chewelah, Stevens County
Elevation: 1167'

Building Type: Industrial UBC I=1.0 (Original Problem Design Criteria)
Building Exposure: Sheltered UBC C_e =.9 (Original Problem Design Criteria)
Ground Snow Load: P_g =50.0 psf Reference Appendix A (SEAW 2[nd] "Snow Load Analysis")

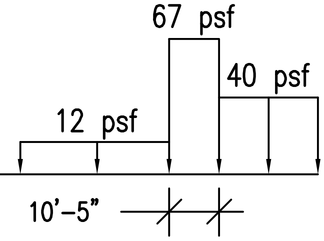
By SEI/ASCE 7-05
$P_f = 0.7 C_e C_t I P_g$ (E 7-1)
$C_e = 1.2$ Terrain Category B and Sheltered (T 7-2)
$C_t = 1.1$ Note: Minimum $C_t = 1.0$. Stevens County is in Washington State NREC Climate Zone 2. With gable shape shown, this would imply a "Roof over Attic" with a corresponding minimum R value of R-38. Thus $C_t = 1.1$. (T 7-3)
$I = 1.0$ Building Category II (T 7-4)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.2 x 1.1 x 1.0 x 50 psf = 46.2 psf

$P_s = C_s P_f$ (E 7-2)
$C_s = 0.86$ Reference F 7-2b for $C_t = 1.1$ and a 4:12 slope. A standing seam metal roof covering is assumed for this industrial application and thus, "unobstructed, slippery surface". (S 7.4.2)
$P_s = C_s P_f$ = 0.86 x 46.2 psf = 39.7 psf (Use 40.0 psf)

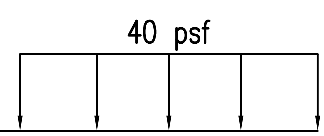
For Unbalanced Snow Load
Slope 4:12 = 18.4° < 70° (S 7.6.1)
AND
Slope 4:12 = 18.4° > 2.38° OR (70/W) + 0.5 = (70/31) + 0.5 = 2.76° (S 7.6.1)
Therefore, unbalanced snow load must be considered.
W = L_u = 31' > 20' (S 7.1 for definition of W & F 7-5 / S 7.6.1 for solution for W < 20')
Windward = 0.3 P_s = 0.3 x 40 psf = 12 psf (S 7.6.1)
$h_d = 0.43 \times \sqrt[3]{L_u} \times \sqrt[4]{P_g + 10} - 1.5 = 0.43 \times \sqrt[3]{31} \times \sqrt[4]{50 + 10} - 1.5 = 2.26'$ (F 7-9 & equation)
Density = $\gamma = 0.13 P_g + 14.0$ = (0.13 x 50 psf) + 14.0 = 20.5 pcf < 30 pcf (E 7-3)
Surcharge Width = $(8/3) \times h_d \times \sqrt{S} = (8/3) \times 2.26' \times \sqrt{3} = 10.4'$ (F 7-5 & S 7.6.1)
Surcharge Magnitude = $h_d \times \gamma / \sqrt{S}$ = 2.26' x 20.5 pcf / $\sqrt{3}$ = 27 psf (F 7-5 & S 7.6.1)

Unbalanced Snow Load

SEE SEI/ASCE 7-05
FIGURE 7-5 PAGE 89

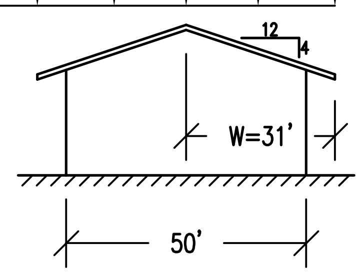


Balanced Snow Load



Note: S = roof slope run for a rise of one.

12/4 = 3/1 ⇒ S = 3



Note: $2P_f$ at overhangs not applicable because roof is not "warm roof" and under-insulated.

(CHECKED 10-25-08 J.A.T.C.E.)

Design Example No. 3.2

Location: Chewelah, Stevens County
Elevation: 1167'

Building Type: Industrial UBC I=1.0 (Original Problem Design Criteria)
Building Exposure: Sheltered UBC C_e =.9 (Original Problem Design Criteria)
Ground Snow Load: P_g =50.0 psf Reference Appendix A (SEAW 2[nd] "Snow Load Analysis")

By SEI/ASCE 7-05

$P_f = 0.7 C_e C_t I P_g$ (E 7-1)

$C_e = 1.2$ Terrain Category B and Sheltered (T 7-2)

$C_t = 1.1$ Note: Minimum $C_t = 1.0$. Stevens County is in Washington State NREC Climate Zone 2. With gable shape shown, this would imply a "Roof over Attic" with a corresponding minimum R value of R-38. Thus $C_t = 1.1$. (T 7-3)

$I = 1.0$ Building Category II (T 7-4)

$P_f = 0.7 C_e C_t I P_g = 0.7 \times 1.2 \times 1.1 \times 1.0 \times 50$ psf = 46.2 psf

$P_s = C_s P_f$ (E 7-2)

$C_s = 0.45$ Reference F 7-2b for $C_t = 1.1$ and a 12:12 slope. A standing seam metal roof covering is assumed for this industrial application and thus, "unobstructed, slippery surface". (S 7.4.2)

$P_s = C_s P_f = 0.45 \times 46.2$ psf = 20.8 psf (Use 21.0 psf)

For Unbalanced Snow Load

Slope 12:12 = 45° < 70° (S 7.6.1)

AND

Slope 12:12 = 45° > 2.38° OR (70/W) + 0.5 = (70/31) + 0.5 = 2.76° (S 7.6.1)

Therefore, unbalanced snow load must be considered.

$W = L_u = 31' > 20'$ (S 7.1 for definition of W & F 7-5 / S 7.6.1 for solution for W < 20')

Windward = $0.3\,P_s = 0.3 \times 20.8$ psf = 6 psf (S 7.6.1)

$h_d = 0.43 \times \sqrt[3]{L_u} \times \sqrt[4]{P_g + 10} - 1.5 = 0.43 \times \sqrt[3]{31} \times \sqrt[4]{50 + 10} - 1.5 = 2.26'$ (F 7-9 & equation)

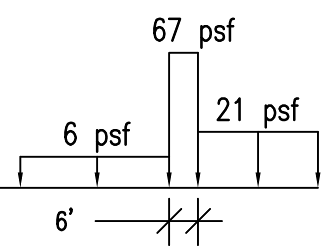
Density = $\gamma = 0.13 P_g + 14.0 = (0.13 \times 50 \text{ psf}) + 14.0 = 20.5$ pcf < 30 pcf (E 7-3)

Surcharge Width = $(8/3) \times h_d \times \sqrt{S} = (8/3) \times 2.26' \times \sqrt{1} = 6.0'$ (F 7-5 & S 7.6.1)

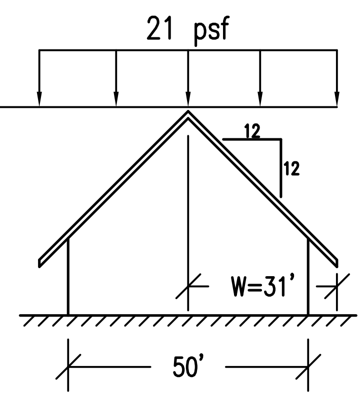
Surcharge Magnitude = $h_d \times \gamma / \sqrt{S} = 2.26' \times 20.5 \text{ pcf} / \sqrt{1} = 46$ psf (F 7-5 & S 7.6.1)

Unbalanced Snow Load

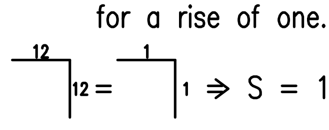
SEE SEI/ASCE 7-05
FIGURE 7-5 PAGE 89



Balanced Snow Load



Note: S = roof slope run for a rise of one.



Note: $2P_f$ at overhangs not applicable because roof is not "warm roof" and under-insulated.

(CHECKED 10-25-08 J.A.T.C.E.)

Design Example No. 4.1

Location: Medical Lake, Spokane County
Elevation: 2420'

Building Type: Office/Warehouse UBC I=1.0 (Original Problem Design Criteria)
Building Exposure: Open UBC C_e =.6 (Original Problem Design Criteria)
Ground Snow Load: P_g =36.0 psf Reference Appendix A (SEAW 2nd "Snow Load Analysis")

By SEI/ASCE 7-02 & 7-05
$P_f = 0.7 C_e C_t I P_g$ (E 7-1)
C_e =0.9 Terrain Category C and Fully Exposed (T 7-2)
C_t =1.0 (T 7-3)
I =1.0 Building Category II (T 7-4)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 0.9 x 1.0 x 1.0 x 36 psf = 22.7 psf (Use 23 psf)

For Snow Density and Uniform Snow Geometry
Density = γ = $0.13P_g$ + 14.0 = (0.13 x 36 psf) + 14.0 = 18.7 pcf < 30 pcf (E 7-3)
Uniform snow depth = h_b = P_f / γ = 22.7 psf/18.7 pcf = 1.21' (S 7.7.1 and F 7-8)
Parapet height = 4'
Available depth = h_c = Parapet height − h_b = 4' − 1.21' = 2.79' (S 7.7.1 and F 7-8)
h_c/h_b = 2.79'/1.21' = 2.31 > 0.2 (S 7.7.1)
Therefore, snow drift analysis is required.

Drifted Snow at East & West Parapet
L_u= 40' Total upwind building length to projection (S 7.8)
Roof projection/parapet drift = $0.75h_d$ (S 7.8)
Parapet h_d = $0.75[0.43 \times \sqrt[3]{L_u} \times \sqrt[4]{P_g + 10} - 1.5]$ (F 7-9 with given equation)
= $0.75[0.43 \times \sqrt[3]{40} \times \sqrt[4]{36 + 10} - 1.5]$ = 0.75[2.33'] = 1.75' (Use for h_d)
$h_d < h_c$ = 1.75' < 2.79' Use h_d for drift intensity and width.
Drift width = w = $4h_d$ = 4 x 1.75' = 7' (S 7.7.1 and F 7-8)
Drift intensity = P_d = $h_d \times \gamma$ = 1.75' x 18.7 pcf = 32.7 psf (Use 33 psf over P_f = 23 psf)

Drifted Snow at North & South Parapet
L_u= 100' Total upwind building length to projection (S 7.8)
Roof projection/parapet drift = $0.75h_d$ (S 7.8)
Parapet h_d = $0.75[0.43 \times \sqrt[3]{L_u} \times \sqrt[4]{P_g + 10} - 1.5]$ (F 7-9 with given equation)
= $0.75[0.43 \times \sqrt[3]{100} \times \sqrt[4]{36 + 10} - 1.5]$ = 0.75[3.70'] = 2.77' (Use for h_d)
$h_d < h_c$ = 2.77' < 2.79' Use h_d for drift intensity and width.
Drift width = w = $4h_d$ = 4 x 2.77' = 11.1' (S 7.7.1 and F 7-8)
Drift intensity = P_d = $h_d \times \gamma$ = 2.77' x 18.7 pcf = 51.8 psf (Use 52 psf over P_f = 23 psf)

Continued

(CHECKED 10-25-08 J.A.T.C.E.)

Design Example No. 4.1 Continued

Location: Medical Lake, Spokane County
Elevation: 2420'

Building Type: Office/Warehouse UBC I=1.0 (Original Problem Design Criteria)
Building Exposure: Open UBC C_e =.6 (Original Problem Design Criteria)
Ground Snow Load: P_g =36.0 psf Reference Appendix A (SEAW 2nd "Snow Load Analysis")

By SEI/ASCE 7-02 & 7-05

$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 0.9 x 1.0 x 1.0 x 36 psf = 22.7 psf (Use 23 psf)

Drifted Snow at East & West Parapet

Drift width = w = $4h_d$ = 4 x 1.75' = 7' (S 7.7.1 and F 7-8)

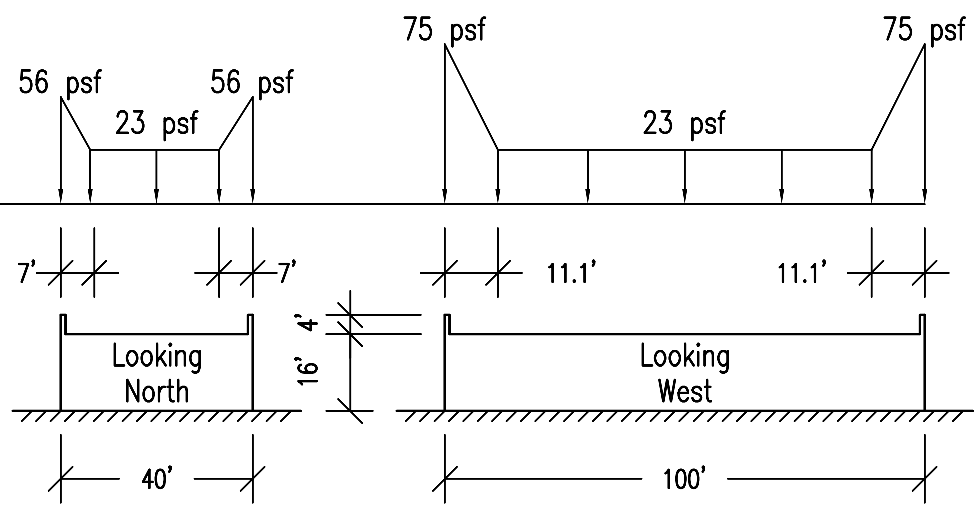
Drift intensity = P_d = h_d x γ = 1.75' x 18.7 pcf = 32.7 psf (Use 33 psf over P_f = 23 psf)

Drifted Snow at North & South Parapet

Drift width = w = $4h_d$ = 4 x 2.77' = 11.1' (S 7.7.1 and F 7-8)

Drift intensity = P_d = h_d x γ = 2.77' x 18.7 pcf = 51.8 psf (Use 52 psf over P_f = 23 psf)

Balanced Snow Load
with Drifted Snow



(CHECKED 10-25-08 J.A.T.C.E.)

Design Example No. 5.1

Location: Lake Cushman, Mason County
Elevation: 733'

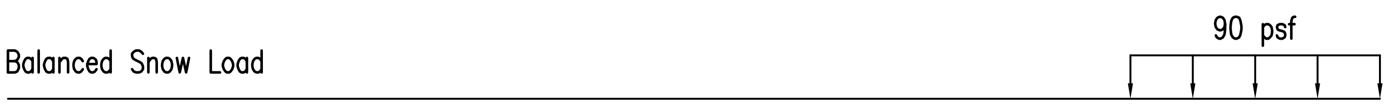
Building Type: Single family residence UBC I=1.0 (Original Problem Design Criteria)
Building Exposure: Heavy forest UBC C_e=.9 (Original Problem Design Criteria)
Roof Type: Metal roofing (Under–insulated assumed)
Ground Snow Load: P_g =114.0 psf Reference Appendix A (SEAW 2nd "Snow Load Analysis")

By SEI/ASCE 7–02 & 7–05

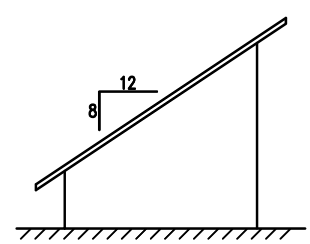
$P_f = 0.7 C_e C_t I P_g$ (E 7–1)
C_e =1.2 Terrain Category B and Sheltered (T 7–2)
C_t =1.0 Note: For this example, the roof is assumed to be unventilated with R–19 insulation with the text of Section 7.4.1 to be correct. Thus C_t taken as 1.0. (T 7–4)
I =1.0 Building Category II (T 7–3)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.2 x 1.0 x 1.0 x 114 psf = 95.8 psf

$P_s = C_s P_f$ (E 7–2)
C_s =0.94 Reference F 7–2a for C_t =1.0. The roof is assumed unventilated with R–19 insulation. Thus, the solid line of F 7–2a is used. (S 7.4.1)
$P_s = C_s P_f$ = 0.94 x 95.8 psf = 90.1 psf (Use 90.0 psf)

For Snow Load Along Eaves
Structure meets the "under–insulated" criteria of Section 7.4.5 and thus the special snow loads along the lower eaves must be considered (by code, other than lower eaves need not be considered).
Lower eave = $2P_f$ = 2 x 95.8 psf = 191.6 psf (Use 192.0 psf)
Upper and gable eaves = 0 psf



UNIFORM AND EAVE LOADS ARE NOT CONCURRENT



(CHECKED 10–25–08 J.A.T.C.E.)

Design Example No. 6.1

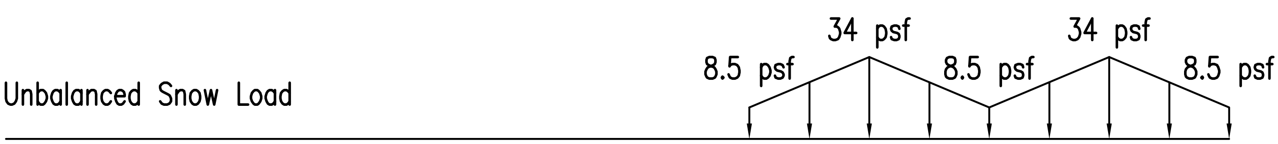
Location: Wenatchee, Chelan County
Elevation: 780'

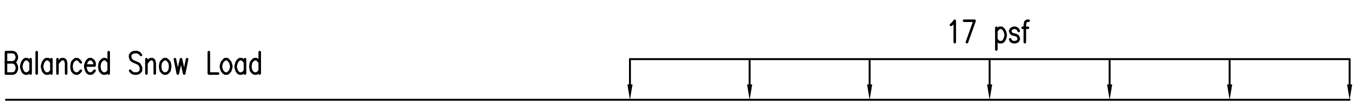
Building Type: Industrial UBC I=1.0 (Original Problem Design Criteria)
Building Exposure: City UBC C_e=.7 (Original Problem Design Criteria)
Ground Snow Load: P_g =22.0 psf Reference Appendix A (SEAW 2nd "Snow Load Analysis")

By SEI/ASCE 7–02 & 7–05
$P_f = 0.7 C_e C_t I P_g$ (E 7–1)
C_e =1.0 Terrain Category B and Partially Exposed (T 7–2)
C_t =1.1 Note: For this problem, assume these structures are cold storage or controlled atmosphere storage and thus kept just above freezing. (T 7–3)
I =1.0 Building Category II (T 7–4)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.0 x 1.1 x 1.0 x 22 psf = 16.9 psf (Use 17.0 psf)

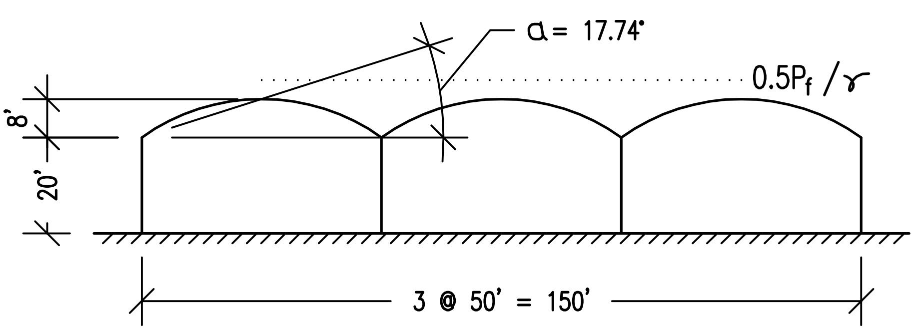
$P_s = C_s P_f$ (E 7–2)
C_s =1.0 For multiple folded plate, sawtooth and barrel vault roofs, C_s=1.0 regardless of roof slopes, roof coverings or warm/cold conditions present. (S 7.4.4)
$P_s = C_s P_f$ = 1.0 x 17.0 psf = 17 psf (Use 17 psf)

For Unbalanced Snow Load
$\alpha = \tan^{-1} 8/25 = 17.74^\circ > 3/8":12" = 1.79^\circ$ (S 7.6.3)
Therefore, unbalanced snow load must be considered.
Ridge or crown = $0.5P_f$ = 0.5 x 17 psf = 8.5 psf (S 7.6.3)
Valley = $2P_f / C_e$ = 2 x 17/1.0 = 34 psf (S 7.6.3)
Note: Valley snow depth does not exceed horizontal projection of snow depth at ridge or crown.





SEE DESIGN EXAMPLES 7.1 AND 7.2 FOR UNBALANCED LOADING AT OUTBOARD BARREL SECTIONS



(CHECKED 10–25–08 J.A.T.C.E.)

Design Example No. 7.1

Location: Republic, Ferry County
Elevation: 2600'

Building Type: Industrial UBC I=1.0 (Original Problem Design Criteria)
Building Exposure: Forested UBC C_e =.9 (Original Problem Design Criteria)
Roof Type: Bituminous mop down
Ground Snow Load: P_g =54.0 psf Reference Appendix A (SEAW 2[nd] "Snow Load Analysis")

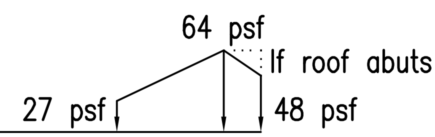
By SEI/ASCE 7-02 & 7-05

$P_f = 0.7 C_e C_t I P_g$ (E 7-1)
C_e =1.2 Terrain Category B and Sheltered (T 7-2)
C_t =1.2 Note: For this problem, assume this structure is un-heated dry storage. (T 7-3)
I =1.0 Building Category II (T 7-4)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.2 x 1.2 x 1.0 x 54 psf = 54.4 psf

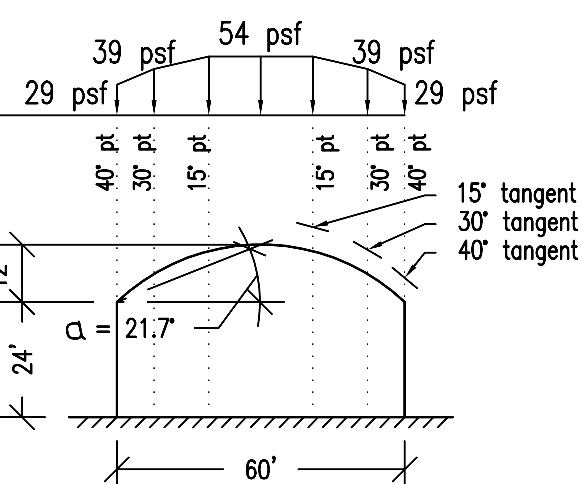
$P_s = C_s P_f$ (E 7-2)
C_s =Varies For un-heated structure with C_t =1.2, use figure 7-2c. With bituminous roof covering assumed, use dashed line for unobstructed slippery surfaces. C_s varies from 1.0 @ 15° to 0.0 @ 70°, linearly. Note break points @ 30° and eaves on balanced and unbalanced loading diagrams F 7-3, Case 2. (S 7.4 and 7.4.3)
$P_s = C_s P_f$ = 1.0 x 54.4 psf = 54.4 psf for 0° to 15° (Use 54 psf)
$P_s = C_s P_f$ = 0.71 x 54.4 psf = 38.6 psf @ 30° point (Use 39 psf)
$P_s = C_s P_f$ = 0.53 x 54.4 psf = 28.8 psf @ 40° point (Use 29 psf)

For Unbalanced Snow Load
$\alpha = \tan^{-1} 12/30 = 21.7° > 10°$
AND
$\alpha = \tan^{-1} 12/30 = 21.7° < 70°$ (S 7.6.2)
Therefore, unbalanced snow load must be considered.
Ridge or crown = $0.5P_f$ = 0.5 x 54.4 psf = 27.2 psf (Use 27 psf) (F 7-3 Case 2)
30° point = $2P_f C_s/C_e$ = 2 x 54.4 psf x 0.71/1.2 = 64.4 psf (Use 64 psf) (F 7-3 Case 2)
Eaves (40°) = $2P_f C_s/C_e$ = 2 x 54.4 psf x 0.53/1.2 = 48.1 psf (Use 48 psf) (F 7-3 Case 2)
If roof abuts, note horizontal dotted line @ 30° point. (F 7-3 Case 2 and Case 3)

Unbalanced Snow Load



Balanced Snow Load



(CHECKED 10-25-08 J.A.T.C.E.)

Design Example No. 7.2

Location: Republic, Ferry County
Elevation: 2600'

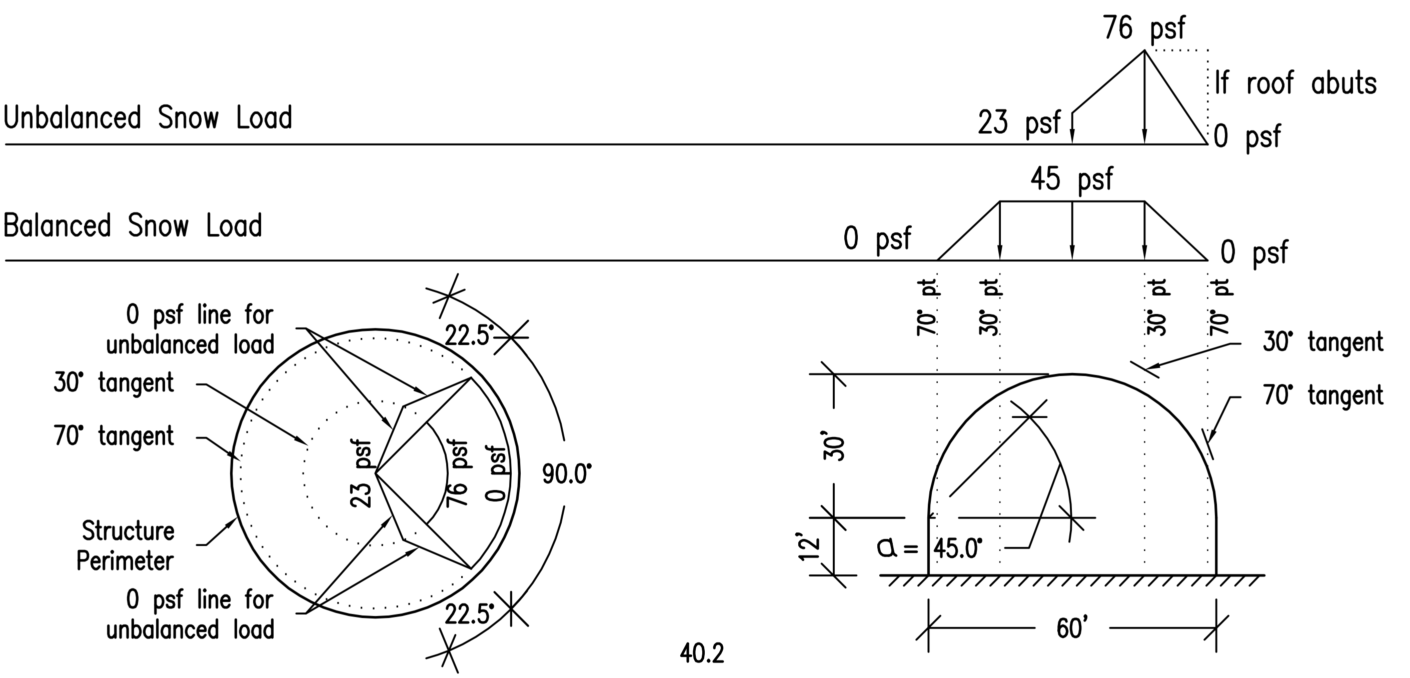
Building Type: Residence UBC I=1.0 (Original Problem Design Criteria)
Building Exposure: Forested UBC C_e=.9 (Original Problem Design Criteria)
Roof Type: Hemispherical dome with wood shake roof
Ground Snow Load: P_g =54.0 psf Reference Appendix A (SEAW 2nd "Snow Load Analysis")

<u>By SEI/ASCE 7-02 & 7-05</u>

$P_f = 0.7 C_e C_t I P_g$ (E 7-1)
C_e =1.2 Terrain Category B and Sheltered (T 7-2)
C_t =1.0 Unventilated roof with R>30 (S 7.4.1 and T 7-3)
I =1.0 Building Category II (T 7-4)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.2 x 1.0 x 1.0 x 54 psf = 45.4 psf

$P_s = C_s P_f$ (E 7-2)
C_s =Varies For unventilated roofs with R>30 and C_t=1.0, use figure 7-2a. With wood shake roof covering assumed, use solid line for All Other Roofs. C_s varies from 1.0 @ 30° to 0.0 @ 70°, linearly. Note break points @ 30° and 70° on balanced and unbalanced loading diagrams F 7-3, Case 3.
$P_s = C_s P_f$ = 1.0 x 45.4 psf = 45.4 psf for 0° to 30° (Use 45 psf)
$P_s = C_s P_f$ = 0.0 x 45.4 psf = 0.0 psf @ 70° point (Use 0 psf)
Portions of roof with slope > 70° shall be considered free of snow. (S7.6.2)

For Unbalanced Snow Load
$\alpha = \tan^{-1} 30/30 = 45° > 10°$
<u>AND</u>
$\alpha = \tan^{-1} 30/30 = 45° < 70°$ (S 7.6.2 and S 7.6.4)
Therefore, unbalanced snow load must be considered.
Ridge or crown = $0.5P_f$ = 0.5 x 45.4 psf = 22.7 psf (Use 23 psf) (F 7-3 Case 3)
30° point = $2P_f C_s/C_e$ = 2 x 45.4 psf x 1.0/1.2 = 75.7 psf (Use 76 psf) (F 7-3 Case 3)
70° point = 0 psf (Use 0 psf) (F 7-3 Case 3)
Reference S 7.6.4 for application area of unbalanced snow load on domed roof structures. (See plan below)



(CHECKED 10-25-08 J.A.T.C.E.)

Design Example No. 8.1

Location: Entiat, Chelan County
Elevation: 800'

Building Type: Commercial UBC I=1.0 (Original Problem Design Criteria)
Building Exposure: City UBC C_e =.7 (Original Problem Design Criteria)
Ground Snow Load: P_g =40.0 psf Reference Appendix A (SEAW 2nd "Snow Load Analysis")

By SEI/ASCE 7-02 & 7-05
$P_f = 0.7 C_e C_t I P_g$ (E 7-1)
$C_e = 1.0$ Terrain Category B and Partially Exposed (T 7-2)
$C_t = 1.0$ (T 7-3)
I =1.0 Building Category II (T 7-4)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.0 x 1.0 x 1.0 x 40 psf = 28.0 psf (Use 28 psf)

For Snow Density and Uniform Snow Geometry
Density = γ = $0.13 P_g$ + 14.0 = (0.13 x 40 psf) + 14.0 = 19.2 pcf < 30 pcf (E 7-3)
Uniform snow depth = h_b = P_f / γ = 28.0 psf/19.2 pcf = 1.46' (S 7.7.1 and F 7-8)
Difference in roof heights = 14'
Available depth = h_c = Roof difference − h_b = 14' − 1.46' = 12.54' (S 7.7.1 and F 7-8)
h_c / h_b = 12.54'/1.46' = 8.59 > 0.2 (S 7.7.1)
Therefore, snow drift analysis is required.

Drifted Snow to Lower Roof – Leeward Condition
L_u = 60' Total upwind building length to lower roof (S 7.7.1)
$h_d = 0.43 \times \sqrt[3]{L_u} \times \sqrt[4]{P_g + 10} - 1.5$ (F 7-9 with given equation)
$= 0.43 \times \sqrt[3]{60} \times \sqrt[4]{40 + 10} - 1.5 = 2.98'$ (Use 3' for application)
$h_d < h_c$ = 2.98' < 12.54' Use h_d for drift intensity and width.
Drift width = w = $4h_d$ = 4 x 3' = 12' (S 7.7.1 and F 7-8)
Drift intensity = P_d = $h_d \times \gamma$ = 3' x 19.2 pcf = 57.6 psf (Use 58 psf over P_f = 28 psf)

Drifted Snow to Lower Roof – Windward Condition
L_u = 30' Total upwind building length to lower roof (S 7.7.1)
$h_d = 0.43 \times \sqrt[3]{L_u} \times \sqrt[4]{P_g + 10} - 1.5$ (F 7-9 with given equation)
$= 0.43 \times \sqrt[3]{30} \times \sqrt[4]{40 + 10} - 1.5 = 2.06'$
Windward drift depth = $0.75h_d$ = 0.75 x 2.06' = 1.54' (S 7.7.1)
Windward drifting conditions do not govern lower roof snow load design.

Continued

(CHECKED 10-25-08 J.A.T.C.E.)

Design Example No. 8.1 Continued

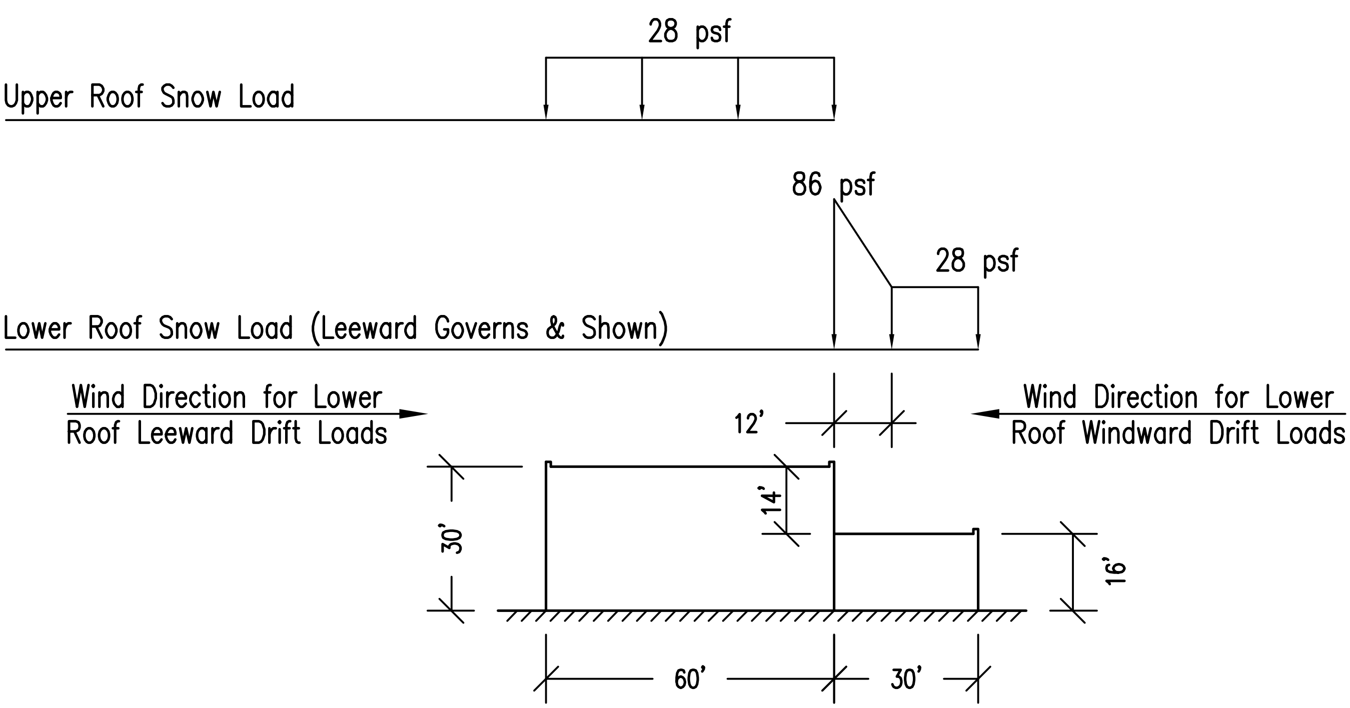
Location: Entiat, Chelan County
Elevation: 800'

Building Type: Commercial UBC I=1.0 (Original Problem Design Criteria)
Building Exposure: City UBC C =.7 (Original Problem Design Criteria)
Ground Snow Load: P_g =40.0 psf Reference Appendix A (SEAW 2nd "Snow Load Analysis")

By SEI/ASCE 7-02 & 7-05
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.0 x 1.0 x 1.0 x 40 psf = 28.0 psf (Use 28 psf)

Drifted Snow to Lower Roof – Leeward Condition
Drift width = w = $4h_d$ = 4 x 3' = 12' (S 7.7.1 and F 7-8)
Drift intensity = P_d = $h_d \times \gamma$ = 3' x 19.2 pcf = 57.6 psf (Use 58 psf over P_f = 28 psf)

Drifted Snow to Lower Roof – Windward Condition
Windward drifting conditions do not govern lower roof snow load design.



(CHECKED 10-25-08 J.A.T.C.E.)

Design Example No. 9.1

Location: Twisp, Okanogan County
Elevation: 1614'

Building Type: Commercial UBC I=1.0 (Both) (Original Problem Design Criteria)
Building Exposure: City UBC C_e =.7 (Both) (Original Problem Design Criteria)
Ground Snow Load: P_g =64.0 psf Reference Appendix A (SEAW 2nd "Snow Load Analysis")

By SEI/ASCE 7-05
For Upper Roof
$P_f = 0.7 C_e C_t I P_g$ (E 7-1)
C_e =1.0 Terrain Category B and Partially Exposed (T 7-2)
C_t =1.1 Washington State NREC Climate Zone 2 with R-38 in "Roof over attic" (T 7-3)
I =1.0 Building Category II (T 7-4)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.0 x 1.1 x 1.0 x 64 psf = 49.3 psf (Use 49 psf)

$P_s = C_s P_f$ (E 7-2)
C_s =1.0 Reference F 7-2b for C_t=1.1. Asphalt shingles assumed for this commercial application and thus, use solid line for "All Other Surfaces". (S 7.4 and 7.4.2)
$P_s = C_s P_f$ = 1.0 x 49.0 psf = 49.0 psf

For Unbalanced Snow Load
Slope 3:12 = 14.0° < 70° (S 7.6.1)
AND
Slope 3:12 = 14.0° > 2.38° OR (70/W) + 0.5 = (70/24) + 0.5 = 3.42° (S 7.6.1)
Therefore, unbalanced snow load must be considered.
W = L_u = 24' > 20' (S 7.1 for definition of W & F 7-5 / S 7.6.1 for solution for W < 20')
Windward = 0.3 P_s = 0.3 x 49 psf = 14.7 psf (Use 15 psf) (S 7.6.1)
$h_d = 0.43 \times \sqrt[3]{L_u} \times \sqrt[4]{P_g + 10} - 1.5 = 0.43 \times \sqrt[3]{24} \times \sqrt[4]{64 + 10} - 1.5 = 2.14'$ (F 7-9 & equation)
Density = γ = 0.13P_g + 14.0 = (0.13 x 64 psf) + 14.0 = 22.3 pcf < 30 pcf (E 7-3)
Surcharge Width = $(8/3) \times h_d \times \sqrt{S} = (8/3) \times 2.14' \times \sqrt{4} = 11.4'$ (F 7-5 & S 7.6.1)
Surcharge Magnitude = $h_d \times \gamma / \sqrt{S}$ = 2.14' x 22.3 pcf / $\sqrt{4}$ = 24 psf (F 7-5 & S 7.6.1)

For Lower Roof
$P_f = 0.7 C_e C_t I P_g$ (E 7-1)
C_e =1.0 Terrain Category B and Partially Exposed (T 7-2)
C_t =1.0 Washington State NREC Climate Zone 2 with R-30 in "Unventilated space" (S 7.4.1 and T 7-3)
I =1.0 Building Category II (T 7-4)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.0 x 1.0 x 1.0 x 64 psf = 44.8 psf (Use 45 psf)

For Snow Density and Uniform Snow Geometry
Density = γ = 0.13P_g + 14.0 = (0.13 x 64 psf) + 14.0 = 22.3 pcf < 30 pcf (E 7-3)
Uniform snow depth = h_b = P_f / γ = 44.8 psf/22.3 pcf = 2.01' (S 7.7.1 and F 7-8)
Difference in roof heights = 8'
Available depth = h_c = Roof difference − h_b = 8' − 2.01' = 5.99' (S 7.7.1 and F 7-8)
h_c/h_b = 5.99'/2.01' = 2.98 > 0.2 (S 7.7.1)
Therefore, snow drift analysis is required.

Continued

(CHECKED 10-25-08 J.A.T.C.E.)

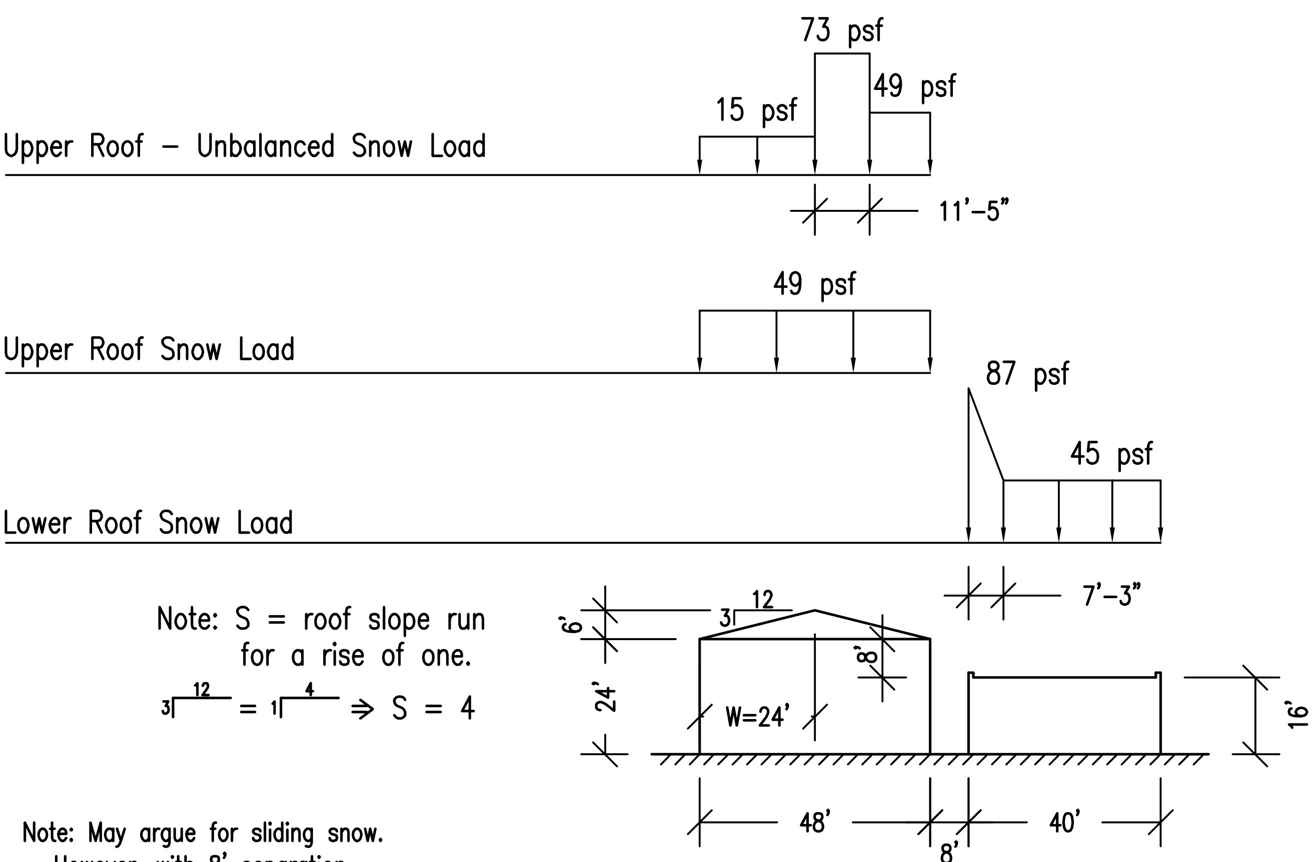
Design Example No. 9.1 Continued

Location: Twisp, Okanogan County
Elevation: 1614'

Building Type: Commercial UBC I=1.0 (Both) (Original Problem Design Criteria)
Building Exposure: City UBC C_e =.7 (Both) (Original Problem Design Criteria)
Ground Snow Load: P_g =64.0 psf Reference Appendix A (SEAW 2nd "Snow Load Analysis")

Drifted Snow to Lower Roof – Leeward Condition Not Considering Separation
L_u= 48' Total upwind building length to lower roof (S 7.7.1)
$h_d = 0.43 \times \sqrt[3]{L_u} \times \sqrt[4]{P_g + 10} - 1.5$ (F 7-9 with given equation)
$= 0.43 \times \sqrt[3]{48} \times \sqrt[4]{64 + 10} - 1.5 = 3.08'$ (Use 3' for application)
$h_d < h_c$ = 3.08' < 5.99' Use h_d for drift intensity and width.
Drift width = w = $4h_d$ = 4 x 3' = 12' (S 7.7.1 and F 7-8)
Drift intensity = $P_d = h_d \times \gamma$ = 3' x 22.3 pcf = 66.9 psf (Use 70 psf) (S 7.7.1)

Drifted Snow to Lower Roof – Separated Condition
Separation factor = (20–s)/20 = (20–8)/20 = 0.6 (S 7.7.2)
Therefore
Separated drift intensity = P_d = 0.6 x 70 psf = 42 psf (Use 42 psf over P_f = 45 psf)
Separated drift width = w = 0.6 x 12' = 7.2'



Note: S = roof slope run for a rise of one.
$3\ulcorner^{12} = 1\ulcorner^{4} \Rightarrow S = 4$

Note: May argue for sliding snow. However, with 8' separation, sliding snow seems unlikely.

(CHECKED 10-25-08 J.A.T.C.E.)

Design Example No. 10.1

Location: North Bend, King County
Elevation: 442'

Building Type: Fire Station UBC I=1.15 (Original Problem Design Criteria)
Building Exposure: City UBC C_e =.7 (Original Problem Design Criteria)
Ground Snow Load: P_g =33.0 psf Reference Appendix A (SEAW 2nd "Snow Load Analysis")

By SEI/ASCE 7-05
For Upper Roof
$P_f = 0.7 C_e C_t I P_g$ (E 7-1)
C_e =1.0 Terrain Category B and Partially Exposed (T 7-2)
C_t =1.1 Washington State NREC Climate Zone 1 with R-30 in "Roof over attic" (T 7-3)
I =1.2 Building Category IV (T 7-4)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.0 x 1.1 x 1.2 x 33 psf = 30.49 psf (Use 30 psf)

$P_s = C_s P_f$ (E 7-2)
C_s =1.0 Reference F 7-2b for C_t=1.1. Membrane with mineral granule surface assumed for this commercial application and thus, use solid line for "All Other Surfaces". (S 7.4 and 7.4.2)
$P_s = C_s P_f$ = 1.0 x 30.0 psf = 30.0 psf

For Unbalanced Snow Load
Slope 4:12 = 18.4° < 70° (S 7.6.1)
AND
Slope 4:12 = 18.4° > 2.38° OR (70/W) + 0.5 = (70/32.5) + 0.5 = 2.65° (S 7.6.1)
Therefore, unbalanced snow load must be considered.
W = L_u = 32.5' > 20' (S 7.1 for definition of W & F 7-5 / S 7.6.1 for solution for W < 20')
Windward = 0.3 P_s = 0.3 x 30 psf = 9 psf (S 7.6.1)
$h_d = 0.43 \times \sqrt[3]{L_u} \times \sqrt[4]{P_g + 10} - 1.5 = 0.43 \times \sqrt[3]{32} \times \sqrt[4]{33 + 10} - 1.5 = 2.00'$ (F 7-9 & equation)
Density = γ = 0.13 P_g + 14.0 = (0.13 x 33 psf) + 14.0 = 18.3 pcf < 30 pcf (E 7-3)
Surcharge Width = $(8/3) \times h_d \times \sqrt{S} = (8/3) \times 2.00' \times \sqrt{3} = 9.2'$ (F 7-5 & S 7.6.1)
Surcharge Magnitude = $h_d \times \gamma / \sqrt{S}$ = 2.00' x 18.3 pcf / $\sqrt{3}$ = 21 psf (F 7-5 & S 7.6.1)

For Lower Roof
$P_f = 0.7 C_e C_t I P_g$ (E 7.1)
C_e =1.0 Terrain Category B and Partially Exposed (T 7-2)
C_t =1.0 Washington State NREC Climate Zone 1 with R-21 in "Unventilated space" (S 7.4.1 and T 7-3)
I =1.2 Building Category IV (T 7-4)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.0 x 1.0 x 1.2 x 33 psf = 27.7 psf (Use 28 psf)

For Snow Density and Uniform Snow Geometry
Density = γ = 0.13P_g + 14.0 = (0.13 x 33 psf) + 14.0 = 18.3 pcf < 30 pcf (E 7-4)
Uniform snow depth = h_b = P_f /γ = 27.7 psf/18.3 pcf = 1.51' (S 7.7.1 and F 7-8)
Difference in roof heights = 8'
Available depth = h_c = Roof difference − h_b = 8' − 1.51' = 6.49' (S 7.7.1 and F 7-8)
h_c/h_b = 6.49'/1.51' = 4.30 > 0.2 (S 7.7.1)
Therefore, snow drift analysis is required.

Continued

(CHECKED 10-25-08 J.A.T.C.E.)

Design Example No. 10.1 Continued

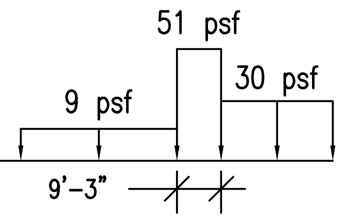
Location: North Bend, King County
Elevation: 442'

Building Type: Fire Station UBC I=1.15 (Original Problem Design Criteria)
Building Exposure: City UBC C_e =.7 (Original Problem Design Criteria)
Ground Snow Load: P_g =33.0 psf Reference Appendix A (SEAW 2nd "Snow Load Analysis")

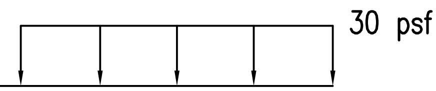
Drifted Snow to Lower Roof – Leeward Condition
L_u= 65' Total upwind building length to lower roof (S 7.7.1)
$h_d = 0.43 \times \sqrt[3]{L_u} \times \sqrt[4]{P_g + 10} - 1.5$ (F 7–9 with given equation)
$= 0.43 \times \sqrt[3]{65} \times \sqrt[4]{33 + 10} - 1.5 = 2.93'$ (Use 2.9' for application)
$h_d < h_c = 2.93' < 6.49'$ Use h_d for drift intensity and width.
Drift width = w = $4h_d$ = 4 x 2.9' = 11.6' (S 7.7.1 and F 7–8)
Drift intensity = $P_d = h_d \times \gamma$ = 2.9' x 18.3 pcf = 53.07 psf (Use 53 psf over P_f = 28 psf)

Sliding Snow to Lower Roof
Upper roof slope = 4:12 > 2:12 for "non–slippery" surfaces (S 7.9)
Therefore, sliding snow from upper roof to lower must be considered.
Sliding snow = $0.4P_f W$ = 0.4 x 30 psf x 32.5' = 390 plf of eave length (S 7.9)
Distributed distance = 15' (S 7.9)
Sliding snow intensity = $0.4P_f W/15'$ = 26 psf (Use 26 psf over P_f = 28 psf)
Note the use of P_f from upper roof, not P_s.

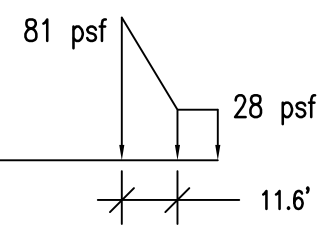
Upper Roof – Unbalanced Snow Load



Upper Roof Snow Load

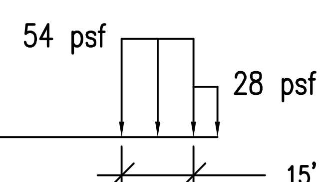


Lower Roof Snow Load – Drift and Uniform

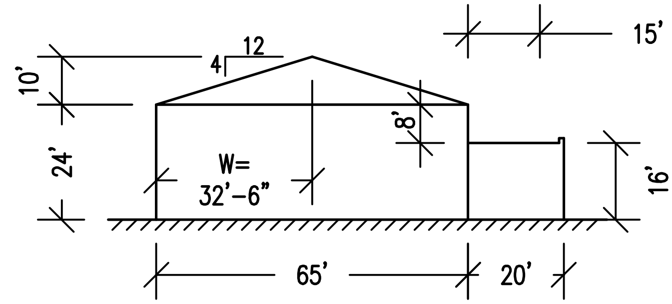


DRIFTING SNOW AND SLIDING SNOW DO NOT ACT CONCURRENTLY ON LOWER ROOF. SEE SECTION 7.9.

Lower Roof Snow Load – Sliding and Uniform



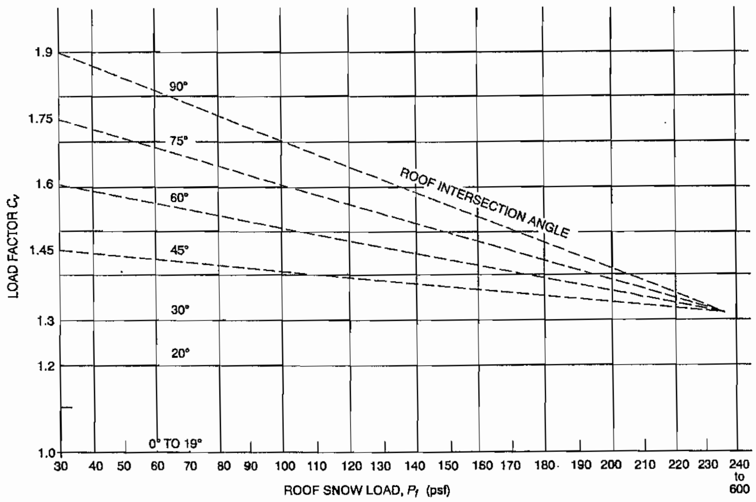
Note: S = roof slope run for a rise of one.
4:12 = 1:3 ⇒ S = 3



(CHECKED 10–25–08 J.A.T.C.E.)

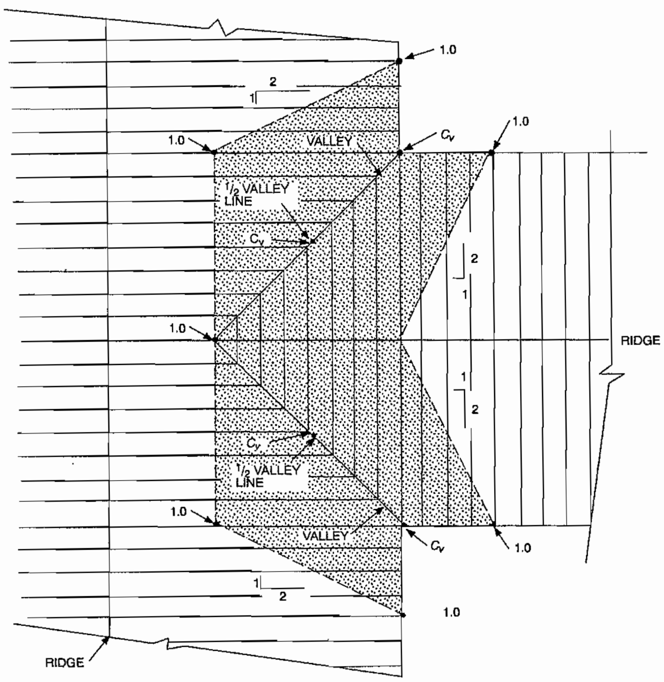
Design Example No. 11.1

1641.3.2 With nonparallel ridge lines. Structural members at roof valleys for multiple-gable roofs having intersecting ridge lines in areas where P_g is greater than 70 psf (3352 N/m^2) and where the slope is 3 units vertical in 12 units horizontal (16.7% slope) or greater shall be designed for P_f times C_v and the distribution of loads is as shown in Figures A-16-12 and A-16-13 where C_v shall be determined from Figure A-16-11.



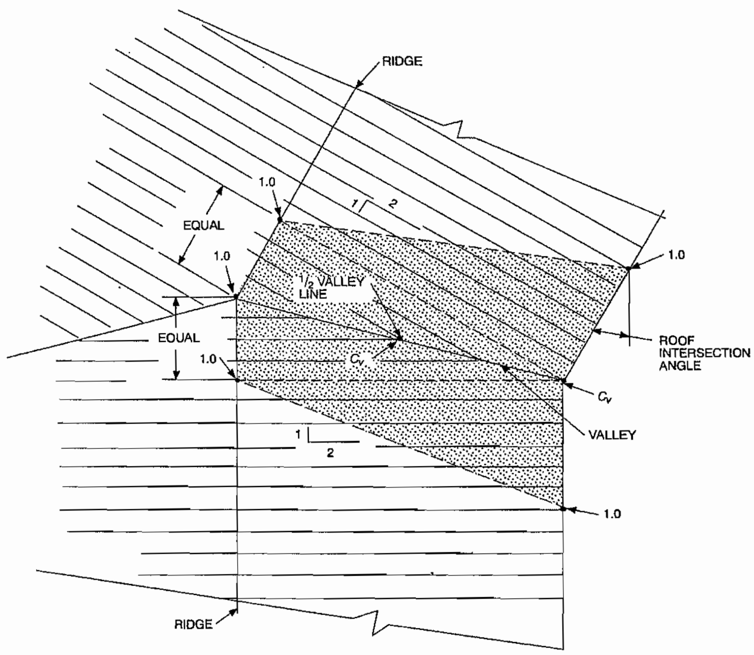
For SI: 1 psf = 47.8 N/m^2.

FIGURE A-16-11—VALLEY COEFFICIENT, C_v



DENOTES INCREASED LOAD AREA:
1. Load is constant on lines connecting points noted 1.0.
2. Load is constant on lines connecting points noted C_v.
3. Load varies linearly between 1.0 and C_v.

FIGURE A-16-12—VALLEY DESIGN COEFFICIENTS, C_v



DENOTES INCREASED LOAD AREA:
1. Load is constant on lines connecting points noted 1.0.
2. Load is constant on lines connecting points noted C_v.
3. Load varies linearly between 1.0 and C_v.

FIGURE A-16-13—VALLEY DESIGN COEFFICIENTS, C_v

RELEVANT 1997 UNIFORM BUILDING CODE SECTIONS REPRODUCED ABOVE. NEITHER SEI/ASCE 7–02 NOR 7–05 CONTAINS A COMPANION CODE SECTION FOR THIS CONDITION. NUMEROUS REPORTS OF THIS CONDITION OCCURRING AND CAUSING PROBLEMS IN BOTH HIGH SNOW LOAD AND LOW SNOW LOAD AREAS HAVE BEEN VOICED. THE DESIGNER SHOULD USE HIS/HER JUDGMENT AS TO THE USE OF THIS DESIGN CONDITION.

(CHECKED 10–25–08 J.A.T.C.E.)

Design Example No. 12.1

Location: Yakima, Yakima County
Elevation: 1066'

Building Type: Industrial UBC I=1.0 (Original Problem Design Criteria)
Building Exposure: City UBC C_e =.7 (Original Problem Design Criteria)
Ground Snow Load: P_g = (Elevation) x (Isobar) = 1066' x 0.018 = 19.2 psf
Reference SEAW 2nd "Snow Load Analysis"

By SEI/ASCE 7-05

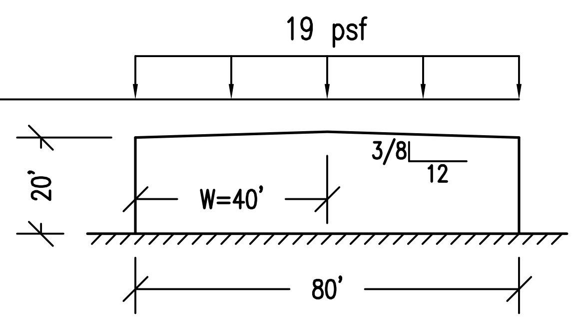
$P_f = 0.7 C_e C_t I P_g$ (E 7-1)
C_e =1.0 Terrain Category B and Partially Exposed (T 7-2)
C_t =1.0 Washington State NREC Climate Zone 1 with R-30 in "Unventilated Roof" (T 7-3)
I =1.0 Building Category II (T 7-4)
$P_f = 0.7 C_e C_t I P_g$ = 0.7 x 1.0 x 1.0 x 1.0 x 19.2 psf = 13.44 psf

For Minimum Values of P_f for Low-Slope Roofs
Slope 3/8:12 = 1.79° < (70/W) + 0.5 = (70/40) + 0.5 = 2.25° (S 7.3.4)
Therefore, minimum values for P_f shall apply. (S 7.3)
P_g < 20 psf
$P_f = I P_g$ = 1.0 x 19.2 psf = 19.2 psf (Use 19 psf) (S 7.3)

For Unbalanced Snow Load
Slope 3/8:12 = 1.79° < 70° (S 7.6.1)
BUT
Slope 3/8:12 = 1.79° < 2.38° OR (70/W) + 0.5 = (70/40) + 0.5 = 2.25° (S 7.6.1)
Therefore, unbalanced snow load need not be considered.

For Rain-on-Snow Surcharge Load
P_g = 19.2 psf < 20 psf (S 7.10)
BUT
Slope 3/8:12 = 1.79° > W/50 = 40/50 = 0.8° (S 7.10)
Therefore, 5 psf rain-on-snow surcharge need not be applied to established design snow loads. (S 7.10)

Balanced Snow Load



(CHECKED 10-25-08 J.A.T.C.E.)