AIRCRAFT HANGAR ROOF REPLACEMENT

Structural Calculations
Table of Contents

1. Project Overview

The project work consists of the construction of a new structural standing seam metal roof (SSSMR) system over the existing preformed metal roofing system on the AIDEA/FedEx Aircraft Maintenance Hangar at the Anchorage International Airport in Anchorage, Alaska. Work on this project will include but not necessarily be limited to the following:

1. Conducting roof system testing to verify that the proposed system complies with the performance requirements of Specification section 07416.

   The SSSMR system shall be tested for wind uplift resistance in accordance with ASTM E 1592; SSSMR systems previously tested and approved by the Corps Of Engineers' Standard Test Method For Structural Performance Of SSSMR By Uniform Static Air Pressure Difference may be acceptable if ultimate loads provide the factors of safety listed in the specifications.

2. Demolition of existing eave and rake flashings, ridge vents and other existing elements as necessary to accommodate the new roof system.

3. The SSSMR system will be installed directly over the existing roofing system.

4. The Contractor will design, fabricate and erect a subpurlin support system that will transfer loads from the new SSSMR system into the existing interstitial joist system. The subpurlin details shown in the drawings are schematic only and are included to communicate one possible schematic solution. The Contractor will submit his proposed subpurlin support solution for review and approval.

5. Construction of a new SSSMR system (including all associated details) with attachment to the subpurlin support system.

The contract documents for this project are in the form of performance criteria and design requirements that govern the design of a SSSMR system by the Contractor. Calculations for development of design criteria and for the conceptual design of the subpurlin support system are included herein.

Calculations and drawings for the design of the roofing system and the final design of the subpurlin support system will be developed and submitted by the Contractor's Design Engineer (deferred submittals per UBC-97, section 106.3.4.2). Submitted calculations and drawings will bear the Design Engineer's sealed certification which will be indicative that the Design Engineer acknowledges and accepts full design responsibility for the SSSMR system.

2. Summary of Design Criteria

2.1 Governing Building Codes And Standards

A. **General Building Code:** Uniform Building Code – 1997 Edition With Local Amendments As Adopted By The Municipality Of Anchorage (MOA).

B. **Wind Loads:** ASCE 7-93, Minimum Design Loads For Buildings And Other Structures, Published By The American Society Of Civil Engineers.

C. **Hot-Rolled Steel:** Specification For Structural Steel Buildings Allowable Stress Design And Plastic Design, June 1, 1989, Published By The American Institute Of Steel Construction.

D. **Cold-Formed Steel:** Specification For The Design Of Cold-Formed Steel Structural Members (Allowable Stress Design), 1996 Edition, Published By The American Iron And Steel Institute.

E. **Welding Of Hot-Rolled Steel:** ANSI/AWS D1.1-96, Structural Welding Code – Steel, 1996 Edition, Published By The American Welding Society.

F. **Welding Of Cold-Formed Steel:** ANSI/AWS D1.3-89, Structural Welding Code – Sheet Steel, 1989 Edition, Published By The American Welding Society.

2.2 Design Loads

A. **Dead Load:** .... Actual Weight Of Materials

B. **Roof Live Loads:** (Per 1997 UBC W/ MOA Amendments)
Uniform Load On Roof .... 20 PSF
Concentrated Load At Midspan Of A Roof Panel .... 300 Pounds

C. **Snow Loads:** (Per 1997 UBC W/ MOA Amendments)
Minimum Basic Ground Snow Load, Pg .... 57 PSF
Minimum Roof Snow Load, Pf .... 40 PSF

D. **Wind Loads:** (Per ASCE 7-93, except as noted)
Basic Wind Speed (Fastest Mile Speed), V .... 100 MPH
Wind Exposure Category C
Importance Factor, I 1.00
Mean Roof Height, H .... 78.5 Ft.
Positive Internal Pressure Coefficient, Gcpi+ 0.75
Negative Internal Pressure Coefficient, Gcpi- .... -0.25
Edge Zone Width, A .... 26.4 Ft.
Outward Pressure In Field Of Roof (Uplift) .... -67.3 PSF
Outward Pressure In Corner and Edge Zones (Uplift) .... -123.1 PSF
Inward Pressure On Entire Roof (Per UBC-97) .... 31.3 PSF

E. **<u>Seismic Criteria</u>:** (Per 1994 UBC, Division III – Earthquake Design, as modified by UBC 1996 Accumulative Supplement; Chapters 16 And 22 as allowed by MOA Amendments To UBC-97)
Seismic Zone 4
Seismic Zone Factor, Z 0.40
Soil Type S2
Site Coefficient 1.2
Seismic Importance Factor, I 1.00
Lateral Force-Resisting System Coefficient, Rw 6
Snow Load Included In Seismic Design .... 10 PSF

F. **<u>Thermal Load</u>: (Total Temperature Range)** .... ± 80 Degrees F.

2.3 Material Design Values

A. **<u>Hot-Rolled Steel</u>** (Minimum Yield Strength)
Hot-Rolled Subpurlins And All Other Shapes And Plates
Unless Noted Otherwise (ASTM A36) .... Fy = 36,000 PSI

B. **<u>Cold-Formed Steel</u>** (Minimum Yield Strength)
Steel Roof Panels Shall Conform To One Of The Following:
Zinc-Coated Steel (ASTM A 653, SS Grade 40) .... Fy = 40,000 PSI
Aluminum-Zinc Alloy Coated Steel (ASTM A 792,
AZ 55 Coating) .... Fy = 40,000 PSI
Aluminum-Coated Steel (ASTM A463, Type 2,
Coating Designation T2 65) .... Fy = 40,000 PSI
Cold-Formed Subpurlins (ASTM A653, SS Grade 50,
Coating Designation G90) .... Fy = 50,000 PSI

3. Wind Criteria

3.1 Governing Code for Wind Design

The governing building code for this project is the 1997 Uniform Building Code (UBC-97) with local amendments as adopted by the Municipality of Anchorage (MOA). Section 1615 of UBC-97 states that ". . any structure may be, designed in accordance with approved national standards." The national standard commonly used for the determination of wind pressures on buildings is ASCE 7 "Minimum Design Loads for Building and Other Structures", published by the American Society of Civil Engineers. ASCE 7 will be utilized for the determination of design wind pressures on the hangar roof.

3.2 Wind Speed Definitions

The minimum design wind speed required by UBC-97 is a "fastest mile speed" as defined in Section 1616 of UBC-97 (see Appendix A). The 1993 Edition of the ASCE 7 standard (ASCE 7-93) also uses "fastest mile speeds" for the determination of wind pressures and thus the minimum wind speeds required by UBC-97 (with MOA amendments) can be directly used with ASCE 7-93 (see Appendix B). The current edition of ASCE 7 (ASCE 7-95) represents the state-of-the-art for the determination of wind pressures on buildings. However, ASCE 7-95 utilizes "3 second gust speeds" rather than "fastest mile wind speeds" (see Appendix C). For a given wind storm, "3 second gust speeds" are inherently faster than "fastest mile speeds." Thus the UBC-97 wind speeds can not be used to calculate pressures using ASCE 7-95.

3.3 Minimum Design Wind Speeds

The MOA local amendments have historically required a minimum design wind speed ("fastest mile speed") of 100 mph for the entire Anchorage area. However, the recently adopted MOA amendments to UBC-97 have divided Anchorage into three minimum wind speed zones – 80, 90 and 100 mph. The latest amendments allow the use of a wind speed of 80 mph for buildings in and around Anchorage International Airport. An analysis of which "fastest mile wind speed" will result in design wind pressures closest to the state-of-the-art standard (ASCE 7-95) is discussed below.

3.4 Comparison of Design Wind Pressures from National Wind Standards

ASCE 7-95, the wind standard considered to be the state-of-the-art as regards the calculation of design wind pressures, was used to determine the order of magnitude of wind pressures expected on the hangar roof. There are no MOA amendments regarding "3 second gust speeds". Reference to the Basic Wind Speed Map (Figure 6-1) of ASCE 7-95 indicates tightly spaced wind contours in the vicinity of Anchorage. Close examination of this map indicates that Anchorage lies very close to but slightly above the 110 mph wind contour. As such, a "3 second gust speed" of 115 mph was used to determine the design wind pressures required by ASCE 7-95.

Negative Design Pressures (Roof Suction): ASCE 7-95 calculations using a "3 second gust speed" of 115 mph result in negative design pressures of 69.2 PSF in the field of the roof and 118.1 PSF in the corner and edge zones. These pressures were compared to the pressures calculated using UBC-97 and ASCE 7-93 for "fastest mile speeds" of 80, 90 and 100 mph. The resulting design pressures are summarized in Table 3-1. Review of the table indicates that the ASCE 7-95 negative pressures are most closely replicated by using a "fastest mile speed" of 100 mph with the ASCE 7-93 standard.

Positive Design Pressures (Roof Inward): ASCE 7-95 calculations using a "3 second gust speed" of 115 mph result in a positive design pressure of 32.6 PSF throughout the roof. For the 14.5° roof slope, the ASCE 7-93 provisions do not require any positive wind pressure on the roof and the UBC-97 provisions only require positive wind pressure in the field of the roof The resulting design pressures are summarized in Table 3-1. Review of the table indicates that the ASCE 7-95 positive pressures are most closely replicated by using a "fastest mile speed" of 100 mph with the UBC-97 code.

3.5 Conclusions of Comparative Analysis

Note that without local amendments, UBC-97, Figure 16-1 (see attached page A-8) or ASCE 7-93, Figure 1 (see attached page B-9) both show tightly spaced contours in the vicinity of Anchorage and appear to indicate a "fastest mile speed" of 80 mph for the city of Anchorage. Conversely, ASCE 7-95, Figure 6-1 (see attached pages C-9 and C-10) shows a similar arrangement of wind contours in this area but indicates a "3 second gust speed" of between 110 and 120 mph.

Reference to Table 3-1 indicates a dramatic difference between the Anchorage area wind pressures resulting from UBC-97 (w/ 80 mph "fastest mile speed") and ASCE-95 (w/ 115 mph "3 second gust speed"). It is our understanding that the ASCE 7-95 wind provisions are considered state-of-the-art and are based upon a significant amount of resent wind research including wind-tunnel testing. As such, in our professional opinion, it is prudent to utilize a "fast mile speed" of 100 mph with the ASCE 7-93 standard resulting in controlling negative pressures that are approximately equal to the most current national wind standard. Thus the wind performance criteria required for this project will be based upon a wind standard allowed by the governing code (ASCE 7-93) and a "fastest mile speed" in excess of the minimum required by the code (i.e., 100 mph in lieu of 80 mph).

3.6 Selected Design Wind Pressures

Based upon engineering judgement and the foregoing analysis, the wind pressure criteria required for this project is as follows:

Wind Standard: ASCE 7-93 (expect for positive pressure as noted below)
Minimum Wind Speed ("fastest mile speed"): 100 mph
Negative pressure in field of roof: -67.3 PSF
Negative pressure in edge zones: -123.1 PSF
Positive pressure on entire roof: 31.3 PSF (as required by UBC-97 for field of roof)

Table 3-1 Comparison of Hangar Roof Pressures Required by National Wind Standards

Negative Roof Pressures

Basic Wind Speed, mph		Negative Pressure in Field of Roof, PSF			Negative Pressure in Roof Edge Zone, PSF		
Fastest Mile Speed	3 Second Gust Speed	1997 UBC	ASCE 7-93	ASCE 7-95	1997 UBC	ASCE 7-93	ASCE 7-95
80		-40.1	-43.1		-65.2	-78.8	
90		-50.9	-54.5		-82.7	-99.7	
100		-62.7	***-67.3***		-101.8	***-123.1***	
	115			-69.2			-118.1

Positive Roof Pressures

Basic Wind Speed, mph		Positive Pressure in Field of Roof, PSF			Positive Pressure in Roof Edge Zone, PSF		
Fastest Mile Speed	3 Second Gust Speed	1997 UBC	ASCE 7-93	ASCE 7-95	1997 UBC	ASCE 7-93	ASCE 7-95
80		20.1	-		-	-	
90		25.5	-		-	-	
100		***31.3****	-		-	-	
	115			32.6			32.6

Notes: Selected design wind pressures are shown in bold italics.
* Positive wind pressure calculated for field shall be used for entire roof.

1997 UBC, V = 80 mph

Ref: Uniform Building Code, 1994 Edition, Sec. 1631

Date: 10-22-1998
By: RLF - Demonstration Disk

Same as 1997 UBC, Section 1615-1622

Job/Location AIDEA/FedEx Hangar Roof Replacement / Anchorage, Alaska
Detail......

ROOF
Building Height/Least Width. 79/ 264 ft
Basic Wind Speed.................. 80 mph
Envelope/Exposure/I .... PARTIALLY ENCLOSED / C / 1.00
Zone Width....................... 10.0 ft

Roof Slope....................... 3.000 on 12

..... Zone	Area ft2	Pressure psf
CENTER.............	10	+20.1/ -40.1
CENTER.............	25	+18.8/ -38.9
CENTER.............	50	+16.7/ -36.8
CENTER.............	100	+12.5/ -32.6
CENTER.............	300	+12.5/ -32.6
CENTER.............	500	+12.5/ -32.6
EAVES, RAKES, RIDGE	10	+0.0/ -65.2
EAVES, RAKES, RIDGE	25	+0.0/ -61.9
EAVES, RAKES, RIDGE	50	+0.0/ -56.3
EAVES, RAKES, RIDGE	100	+0.0/ -45.2
EAVES, RAKES, RIDGE	300	+0.0/ -45.2
EAVES, RAKES, RIDGE	500	+0.0/ -45.2
OVERHANGS..........	10	+0.0/ -65.2
OVERHANGS..........	25	+0.0/ -61.9
OVERHANGS..........	50	+0.0/ -56.3
OVERHANGS..........	100	+0.0/ -45.2
OVERHANGS..........	300	+0.0/ -45.2
OVERHANGS..........	500	+0.0/ -45.2

1997 UBC, V = 90 mph

Ref: Uniform Building Code, 1994 Edition, Sec. 1631 ?

Date: 10-22-1998 Same as 1997 UBC, Section 1615-1622
By: RLF - Demonstration Disk

Job/Location AIDEA/FedEx Hangar Roof Replacement / Anchorage, Alaska
Detail......

ROOF
Building Height/Least Width. 79/ 264 ft
Basic Wind Speed................. 90 mph
Envelope/Exposure/I .... PARTIALLY ENCLOSED / C / 1.00
Zone Width....................... 10.0 ft

Roof Slope...................... 3.000 on 12

..... Zone	Area ft2	Pressure psf
CENTER.............	10	+25.5/ -50.9
CENTER.............	25	+23.9/ -49.3
CENTER.............	50	+21.2/ -46.7
CENTER.............	100	+15.9/ -41.4
CENTER.............	300	+15.9/ -41.4
CENTER.............	500	+15.9/ -41.4
EAVES, RAKES, RIDGE	10	+0.0/ -82.7
EAVES, RAKES, RIDGE	25	+0.0/ -78.5
EAVES, RAKES, RIDGE	50	+0.0/ -71.4
EAVES, RAKES, RIDGE	100	+0.0/ -57.3
EAVES, RAKES, RIDGE	300	+0.0/ -57.3
EAVES, RAKES, RIDGE	500	+0.0/ -57.3
OVERHANGS..........	10	+0.0/ -82.7
OVERHANGS..........	25	+0.0/ -78.5
OVERHANGS..........	50	+0.0/ -71.4
OVERHANGS..........	100	+0.0/ -57.3
OVERHANGS..........	300	+0.0/ -57.3
OVERHANGS..........	500	+0.0/ -57.3

1997 UBC, V=100 mph

Ref: Uniform Building Code, 1994 Edition, Sec. 1631 ↴ Same as 1997 UBC, section 1615 - 1622

Date: 10-22-1998
By: RLF - Demonstration Disk

Job/Location AIDEA/FedEx Hangar Roof Replacement / Anchorage, Alaska
Detail......

ROOF
Building Height/Least Width. 79/ 264 ft
Basic Wind Speed................... 100 mph
Envelope/Exposure/I .... PARTIALLY ENCLOSED / C / 1.00
Zone Width........................ 10.0 ft

Roof Slope....................... 3.000 on 12

..... Zone	Area ft2	Pressure psf
CENTER.............	10	+31.3/ -62.7
CENTER.............	25	+29.4/ -60.7
CENTER.............	50	+26.1/ -57.4
CENTER.............	100	+19.6/ -50.9
CENTER.............	300	+19.6/ -50.9
CENTER.............	500	+19.6/ -50.9
EAVES, RAKES, RIDGE	10	+0.0/-101.8
EAVES, RAKES, RIDGE	25	+0.0/ -96.6
EAVES, RAKES, RIDGE	50	+0.0/ -87.9
EAVES, RAKES, RIDGE	100	+0.0/ -70.5
EAVES, RAKES, RIDGE	300	+0.0/ -70.5
EAVES, RAKES, RIDGE	500	+0.0/ -70.5
OVERHANGS..........	10	+0.0/-101.8
OVERHANGS..........	25	+0.0/ -96.6
OVERHANGS..........	50	+0.0/ -87.9
OVERHANGS..........	100	+0.0/ -70.5
OVERHANGS..........	300	+0.0/ -70.5
OVERHANGS..........	500	+0.0/ -70.5

ASCE 7-93
V = 80 mph

*********** SWD WIND PROGRAM (B1.1, 12/01/88) **********
DESIGN WIND PRESSURES PER ANSI A58.1-1982 AND TM 5-809-1
(Identical Wind Provisions in ASCE 7-93)
PROJECT: AIDEA/FedEx Hangar Roof Replacement

VELOCITY (MPH)	IMPORTANCE FACTOR	EXPOSURE
80	1.00	C

NS LENGTH (FT)	EW LENGTH (FT)	MEAN ROOF HEIGHT (FT)	ROOF SLOPE (IN/FT)	RIDGE DIRECTION
283	264	79	3.00	NS

****************** MAIN FRAMING PRESSURES (PSF) *****************

LOCATION	NS WIND GCPI=0	NS WIND -.25	NS WIND +.75	EW WIND GCPI=0	EW WIND -.25	EW WIND +.75
INTERNAL		-5.3	15.8		-5.3	15.8
WW WALL Z=79	19.9	25.1	4.1	19.9	25.1	4.1
WW WALL Z=70	19.2	24.5	3.4	19.2	24.5	3.4
WW WALL Z=60	18.4	23.7	2.7	18.4	23.7	2.7
WW WALL Z=50	17.5	22.8	1.7	17.5	22.8	1.7
WW WALL Z=40	16.4	21.7	0.7	16.4	21.7	0.7
WW WALL Z=30	15.2	20.4	-0.6	15.2	20.4	-0.6
WW WALL Z=25	14.4	19.7	-1.4	14.4	19.7	-1.4
WW WALL Z=20	13.5	18.7	-2.3	13.5	18.7	-2.3
WW WALL Z=15	12.4	17.6	-3.4	12.4	17.6	-3.4
LEE WALL	-12.1	-6.8	-27.8	-12.4	-7.2	-28.2
SIDE WALL	-17.4	-12.1	-33.1	-17.4	-12.1	-33.1
WW ROOF	-17.4	-12.1	-33.1	-22.3	-17.1	-38.1
WW ROOF*	0.0	0.0	0.0	5.0	10.2	-10.8
LEE ROOF	-17.4	-12.1	-33.1	-17.4	-12.1	-33.1

*************** COMPONENT/CLADDING PRESSURES (PSF) **************

TRIBUTARY AREA (SF)	ROOF ZONE 1	ROOF ZONE 2	ROOF ZONE 3	WALLS ZONE 4	WALLS ZONE 5	WALLS ZONE+4	WALLS ZONE+5
INTERNAL	15.8	15.8	15.8	15.8	15.8	-5.3	-5.3
10	-43.1	-78.8	-78.8	-47.3	-57.8	34.7	34.7
20	-41.8	-72.5	-72.5	-45.8	-54.4	33.2	33.2
50	-40.1	-64.1	-64.1	-43.9	-50.0	31.3	31.3
100	-38.9	-57.8	-57.8	-42.2	-46.6	29.6	29.6
200	-38.9	-57.8	-57.8	-40.8	-43.3	28.2	28.2
500	-38.9	-57.8	-57.8	-38.9	-38.9	26.3	26.3
EAVE**	-1.1	-1.1	-1.1				

ASCE 7-93

V= 90 mph

*********** SWD WIND PROGRAM (B1.1, 12/01/88) **********

DESIGN WIND PRESSURES PER ANSI A58.1-1982 AND TM 5-809-1

(Same as 7-93)

PROJECT: AIDEA/FedEx Hangar Roof Replacement

VELOCITY (MPH)	IMPORTANCE FACTOR	EXPOSURE
90	1.00	C

NS LENGTH (FT)	EW LENGTH (FT)	MEAN ROOF HEIGHT (FT)	ROOF SLOPE (IN/FT)	RIDGE DIRECTION
283	264	79	3.00	NS

****************** MAIN FRAMING PRESSURES (PSF) *****************

LOCATION	NS WIND GCPI=0	NS WIND -.25	NS WIND +.75	EW WIND GCPI=0	EW WIND -.25	EW WIND +.75
INTERNAL		-6.6	19.9		-6.6	19.9
WW WALL Z=79	25.1	31.8	5.2	25.1	31.8	5.2
WW WALL Z=70	24.3	31.0	4.4	24.3	31.0	4.4
WW WALL Z=60	23.3	30.0	3.4	23.3	30.0	3.4
WW WALL Z=50	22.1	28.8	2.2	22.1	28.8	2.2
WW WALL Z=40	20.8	27.4	0.8	20.8	27.4	0.8
WW WALL Z=30	19.2	25.9	-0.7	19.2	25.9	-0.7
WW WALL Z=25	18.2	24.9	-1.7	18.2	24.9	-1.7
WW WALL Z=20	17.1	23.7	-2.9	17.1	23.7	-2.9
WW WALL Z=15	15.7	22.3	-4.3	15.7	22.3	-4.3
LEE WALL	-15.3	-8.6	-35.2	-15.7	-9.1	-35.7
SIDE WALL	-22.0	-15.3	-41.9	-22.0	-15.3	-41.9
WW ROOF	-22.0	-15.3	-41.9	-28.3	-21.6	-48.2
WW ROOF*	0.0	0.0	0.0	6.3	12.9	-13.7
LEE ROOF	-22.0	-15.3	-41.9	-22.0	-15.3	-41.9

*************** COMPONENT/CLADDING PRESSURES (PSF) **************

TRIBUTARY AREA (SF)	ROOF ZONE 1	ROOF ZONE 2	ROOF ZONE 3	WALLS ZONE 4	WALLS ZONE 5	WALLS ZONE+4	WALLS ZONE+5
INTERNAL	19.9	19.9	19.9	19.9	19.9	-6.6	-6.6
10	-54.5	-99.7	-99.7	-59.8	-73.1	43.9	43.9
20	-52.9	-91.7	-91.7	-58.0	-68.9	42.0	42.0
50	-50.8	-81.1	-81.1	-55.6	-63.3	39.6	39.6
100	-49.2	-73.1	-73.1	-53.5	-59.0	37.5	37.5
200	-49.2	-73.1	-73.1	-51.6	-54.8	35.6	35.6
500	-49.2	-73.1	-73.1	-49.2	-49.2	33.2	33.2
EAVE**	-1.3	-1.3	-1.3				

ASCE 7-93
V= 100 mph

*********** SWD WIND PROGRAM (B1.1, 12/01/88) **********
DESIGN WIND PRESSURES PER ANSI A58.1-1982 AND TM 5-809-1
(same as 7-93)
PROJECT: AIDEA/FedEx Hangar Roof Replacement

VELOCITY (MPH)	IMPORTANCE FACTOR	EXPOSURE
100	1.00	C

NS LENGTH (FT)	EW LENGTH (FT)	MEAN ROOF HEIGHT (FT)	ROOF SLOPE (IN/FT)	RIDGE DIRECTION
283	264	79	3.00	NS

****************** MAIN FRAMING PRESSURES (PSF) *****************

LOCATION	NS WIND GCPI=0	NS WIND -.25	NS WIND +.75	EW WIND GCPI=0	EW WIND -.25	EW WIND +.75
INTERNAL		-8.2	24.6		-8.2	24.6
WW WALL Z=79	31.0	39.2	6.4	31.0	39.2	6.4
WW WALL Z=70	30.0	38.2	5.4	30.0	38.2	5.4
WW WALL Z=60	28.8	37.0	4.2	28.8	37.0	4.2
WW WALL Z=50	27.3	35.6	2.7	27.3	35.6	2.7
WW WALL Z=40	25.6	33.9	1.0	25.6	33.9	1.0
WW WALL Z=30	23.7	31.9	-0.9	23.7	31.9	-0.9
WW WALL Z=25	22.5	30.7	-2.1	22.5	30.7	-2.1
WW WALL Z=20	21.1	29.3	-3.6	21.1	29.3	-3.6
WW WALL Z=15	19.4	27.6	-5.3	19.4	27.6	-5.3
LEE WALL	-18.8	-10.6	-43.5	-19.4	-11.2	-44.0
SIDE WALL	-27.2	-18.9	-51.8	-27.2	-18.9	-51.8
WW ROOF	-27.2	-18.9	-51.8	-34.9	-26.7	-59.5
WW ROOF*	0.0	0.0	0.0	7.8	16.0	-16.9
LEE ROOF	-27.2	-18.9	-51.8	-27.2	-18.9	-51.8

*************** COMPONENT/CLADDING PRESSURES (PSF) **************

TRIBUTARY AREA (SF)	ROOF ZONE 1	ROOF ZONE 2	ROOF ZONE 3	WALLS ZONE 4	WALLS ZONE 5	WALLS ZONE+4	WALLS ZONE+5
INTERNAL	24.6	24.6	24.6	24.6	24.6	-8.2	-8.2
10	-67.3	-123.1	-123.1	-73.9	-90.3	54.2	54.2
20	-65.3	-113.3	-113.3	-71.6	-85.0	51.9	51.9
50	-62.7	-100.1	-100.1	-68.6	-78.1	48.9	48.9
100	-60.7	-90.3	-90.3	-66.0	-72.9	46.3	46.3
200	-60.7	-90.3	-90.3	-63.7	-67.6	44.0	44.0
500	-60.7	-90.3	-90.3	-60.7	-60.7	41.0	41.0
EAVE**	-1.6	-1.6	-1.6				

*********** NOTES ON WIND PRESSURE CALCULATIONS **********

PRESSURES ARE BASED ON THE FOLLOWING INTERPOLATIONS
THETA, H/L, L/B PER ANSI FIG 2, NOTE 4
KZ PER ANSI TABLE 6, NOTE 1
GZ AND GH PER ANSI TABLE 8, NOTE 2

POSITIVE PRESSURES ACT TOWARD SURFACES

INTERNAL PRESSURES HAVE BEEN INCLUDED IN ABOVE VALUES, ANSI RECOMMENDS INCLUDING INTERNAL PRESSURES FOR DESIGN OF 1 STORY FRAMES.

FOR H>60, COMPONENT/CLADDING PRESSURES ARE BASED ON EXPOSURE C AND QH PER ANSI TABLE 4, 4TH FOOTNOTE
THIS SIMPLIFICATION IS NOT MENTIONED IN TM 5-809-1

*WINDWARD ROOF PRESSURE HAS 2 VALUES PER ANSI FIG 2

COMPONENT/CLADDING PRESSURES ARE BASED ON EXPOSURE C PER ANSI PARAGRAPH 6.5.3.3.1.

ZONES +4 AND +5 REPRESENT THE LOWER LINE ON ANSI FIG 3A

ZONE DIMENSION: A=26.4 PER ANSI FIGURE 3, NOTE 6

**FOR ROOF OVERHANGS: ALGEBRAICALLY ADD EAVE PRESSURE TO PRESSURES ABOVE TO COMPLY WITH ANSI PARAGRAPH 6.7.2

General Wind Data

ASCE 7-95
V= 115 mph

Client: AIDEA
Project: FedEx Hangar Roof Replacement

Date: 10/22/98
Calculations Performed By: RLF

Input Variables	Value
Velocity, MPH	115.00
Importance Factor	1.00
Wind Exposure Category: A, B, C, or D	C
Mean Roof Height, ft.	78.5
Building Length, Parallel to Ridge, ft.	282.7
Building Length, Normal to Ridge, ft.	263.7
Wall Openings, SF:	
Wall 1 Parallel to Ridge:	200
Wall 2 Parallel to Ridge:	180
Wall 1 Normal to Ridge:	565
Wall 2 Normal to Ridge:	10,200
Roof Openings, SF	0
Roof Slope, Degrees	14.48
Positive Internal Pressure Coeff., Gcpi+	0.80
Negative Internal Pressure Coeff., Gcpi-	-0.30

Calculated Variables	Value
Power Law Coefficient	9.50
Gradient Height, ft.	900
Velocity Pressure Exp. Coeff., Kh	1.20
Gust Effect Factor, G	0.85
Velocity Pressure, qh, PSF	40.72
Minimum Building Plan Dimension, ft.	263.70
Percent of Wall Openings:	
Wall 1 Parallel to Ridge, %:	0.90
Wall 2 Parallel to Ridge, %:	0.81
Wall 1 Normal to Ridge, %:	2.73
Wall 2 Normal to Ridge, %:	49.27
Roof Opening, %	0.00
Edge Strip Dimension, a, ft.	26.37

Components and Cladding Figure 6-5B
(10 Degrees <Roof Slope< or = 30 Degrees)

ASCE 7-95
V = 115 mph

Client: AIDEA
Project: FedEx Hangar Roof Replacement

Date: 10/22/98
Calculations Performed By: RLF

Roof Component and Cladding Pressures by Area (PSF)												
Area	Inward without Overhang			Inward with Overhang			Outward without Overhang			Outward with Overhang		
SF	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
0 to 10	32.58	32.58	32.58	32.58	32.58	32.58	-69.22	-118.09	-118.09	-69.22	-122.16	-183.24
20	30.12	30.12	30.12	30.12	30.12	30.12	-68.00	-109.51	-109.51	-68.00	-122.16	-168.53
30	28.69	28.69	28.69	28.69	28.69	28.69	-67.28	-104.49	-104.49	-67.28	-122.16	-159.93
40	27.67	27.67	27.67	27.67	27.67	27.67	-66.77	-100.93	-100.93	-66.77	-122.16	-153.82
50	26.88	26.88	26.88	26.88	26.88	26.88	-66.38	-98.16	-98.16	-66.38	-122.16	-149.08
60	26.24	26.24	26.24	26.24	26.24	26.24	-66.06	-95.91	-95.91	-66.06	-122.16	-145.22
70	25.69	25.69	25.69	25.69	25.69	25.69	-65.78	-94.00	-94.00	-65.78	-122.16	-141.94
80	25.22	25.22	25.22	25.22	25.22	25.22	-65.55	-92.35	-92.35	-65.55	-122.16	-139.11
90	24.80	24.80	24.80	24.80	24.80	24.80	-65.34	-90.89	-90.89	-65.34	-122.16	-136.61
100	24.43	24.43	24.43	24.43	24.43	24.43	-65.15	-89.58	-89.58	-65.15	-122.16	-134.38

Footnotes:

1. Pressure, p = qh[(GCp)-(GCpi)]
2. Mean roof height, h ≤ to 60 ft. Mean roof height 60ft. < h < 90 ft. is acceptable provided the height-to-width ratio is less than or equal to 1 and Exposure "C" must be used as a minimum condition.
3. Per ASCE 7-95, Figure 6-5, note 10, and paragraph 6.5.3.3.1, a 0.85 reduction multiplier can be applied to pressures where a building is sited in Exposure "B" in all directions. This reduction has not been applied.
4. Gcpi is as indicated on the general wind information sheet. For this project, Gcpi+ = 0.8
   Gcpi- = -0.3
5. GCp is selected from Figure 6-5B, based on the following equations and area boundaries:

Positive with and without overhang: Zone 1, 2, 3

(GCp) = 0.5	for A ≤ 10 SF
(GCp) = 0.7000 - 0.2000 logA	for 10 < A ≤ 100 SF
(GCp) = 0.3	for A > 100 SF

Negative with and without overhang: Zone 1

(GCp) = -0.9	for A ≤ 10 SF
(GCp) = -1.0000 + 0.1000 logA	for 10 < A ≤ 100 SF
(GCp) = -0.8	for A > 100 SF

Negative without overhang: Zone 2, 3

(GCp) = -2.1	for A ≤ 10 SF
(GCp) = -2.8000 + 0.7000 logA	for 10 < A ≤ 100 SF
(GCp) = -1.4	for A > 100 SF

Negative with overhang: Zone 2

(GCp) = -2.2	for all A SF

Negative with overhang: Zone 3

(GCp) = -3.7	for A ≤ 10 SF
(GCp) = -4.9000 + 1.2000 logA	for 10 < A ≤ 100 SF
(GCp) = -2.5	for A > 100 SF

4. Snow Load Criteria

The minimum snow load requirements for this roof system are governed by the MOA amendments to UBC-97. These amendments are included herein as Appendix D. MOA amendment 23.15.1614, Snow Loads, requires the following:

- Snow loads shall be determined by using the provisions of Appendix Chapter 16 Division I.
- The minimum basic ground snow load Pg shall be 57 pounds per square foot.
- The minimum roof snow load Pf shall be 40 pounds per square foot.

UBC-97, Appendix Chapter 16, Division I, Section 1643 – Special Eave Requirements:

- Eave overhanging roof structures shall be designed to sustain a uniformly distributed load of 2.0 Pf, or as determined by the building official, to account for ice dams and snow accumulations as shown in Figure A-16-10.

The above provision applies to that portion of the roofing that cantilevers beyond the outermost structural support (i.e., edge joist).

5. Ventilation Criteria

The minimum ventilation requirements for this roof system are governed by the MOA amendments to UBC-97. These amendments are included herein as Appendix D. The MOA amendment includes the following applicable provisions:

- The opening area may be 1/300 of the area of the space ventilated provided 50 percent of the required opening area is provided by ventilation located in the upper portion of the space to be ventilated at a position at least 3 feet above the eave or cornice vents.
- The opening area may be 1/300 of the area of the space ventilated provided a vapor barrier not exceeding 1 perm is installed on the warm side of the attic insulation.

The roof for this project will comply with both of these provisions thus requiring a minimum ventilation open area equal to 1/300 of the area of the space ventilated.

Total Roof Area = 263.67/cos(14.48°) * 283.67 = 77,250 ft^2

Minimum Total Ventilation Area = 77,250 / 300 = 258 ft^2

Minimum Ventilation Area at Eaves = 258 / 4 = 64.5 ft^2

Minimum Ventilation Area at Ridge = 258 / 2 = 129.0 ft^2 (64.5 ft^2 on each side)

Average Clear Opening Area along Eaves
and Both Sides of Ridge = 64.5 ft^2 / 283.67 ft. = 0.23 ft^2 / ft

6. Minimum Subpurlin System

The SSSMR system will be installed directly over the existing roofing system. The Contractor will design and provide a subpurlin support system that will transfer loads from the new SSSMR system into the existing interstitial joist system. The subpurlin details shown in the drawings are minimum requirements. The adequacy of this minimum subpurlin system shall be verified by the Contractor's Design Engineer and increased in strength if necessary. The Design Engineer shall submit sealed calculations verifying or increasing the strength of the minimum subpurlin system indicated on the Contract Documents.

The calculations produced to develop the minimum subpurlin system shown in the Contract Documents are included herein.

CFS Version 2.21
Custon Section 1.5HU4x048
AIDEA/FedEx Roof Replacement
Frankfurt Short Bruza Associates, P.C.
5801 N. Broadway, Suite 500
Oklahoma City, OK 73118

Section: 15H4X048
Rev. Date 11-12-1998
Rev. Time 08:52:39
Rev. by Rick Forest
Phone (405) 840-2931
Fax (405) 842-7750

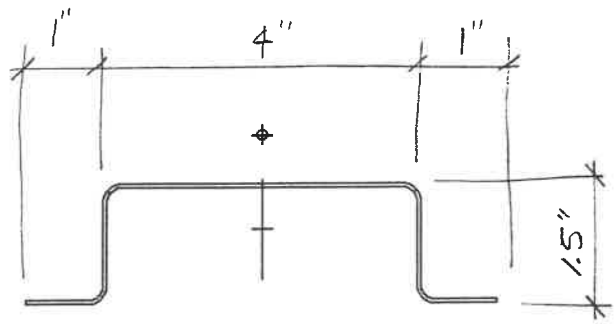
Section Input

Yield	(Fy)	50.000	Unit Weight		3.4000
Ultimate	(Fu)	60.000	One Inch =		1.0000
Modulus	(E)	29500.000	Cw Override		0.0000
			J Override		0.0000

Part 1 Thickness 0.0480 18 Gage X=0.000, Y=0.000

Length	Angle	Radius	Web	k	Hole	Distance
1.000	0.000	0.1875	Sgl	0.00	0.000	0.500
1.500	90.000	0.1875	Sgl	0.00	0.000	0.750
4.000	0.000	0.1875	Sgl	0.00	0.000	2.000
1.500	-90.000	0.1875	Sgl	0.00	0.000	0.750
1.000	0.000	0.1875	Sgl	0.00	0.000	0.500

Transverse Secondary
@ 2' o.c. in Edge Zone
@ 5'-1 5/8" in Field



Full Section Properties

Area	0.40535	Wt.	1.37821	Width	8.44489
Ix	0.15195	rx	0.61226	Ixy	0.00000
Sx(t)	0.26286	y(t)	0.57806	Alpha	90.0000
Sx(b)	0.16482	y(b)	0.92194		
Iy	1.29947	ry	1.79046	Xo	-0.00000
Sy(l)	0.44020	x(l)	2.95200	Yo	1.19164
Sy(r)	0.44020	x(r)	2.95200	jx	-0.00000
				jy	-2.86120
I1	1.29947	r1	1.79046		
I2	0.15195	r2	0.61226		
Ic	1.45142	rc	1.89225	Cw	0.22306
Io	2.02702	ro	2.23620	J	0.00031131

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Fully Braced Allowables

Compression		Positive Moment		Positive Moment	
Pao	7.0326	Maxo	4.6852	Mayo	11.2075
Ae	0.26958	Ixe	0.12583	Iye	1.15769
		Sxe(t)	0.18122	Sye(l)	0.41270
Tension		Sxe(b)	0.15617	Sye(r)	0.37358
Ta	12.4842				
		Negative Moment		**Negative Moment**	
		Maxo	4.2689	Mayo	11.2075
Shear		Ixe	0.13702	Iye	1.15769
Vay	1.9757	Sxe(t)	0.25514	Sye(l)	0.37358
Vax	3.5218	Sxe(b)	0.14230	Sye(r)	0.41270

CFS Version 2.21
Transverse Secondarys in Edge Zone @ 2ft
AIDEA/FedEx Roof Replacement
Frankfurt Short Bruza Associates, P.C.
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Analysis: EDGETRAN
Rev. Date 11-12-1998
Rev. Time 08:56:55
Rev. By Rick Forest
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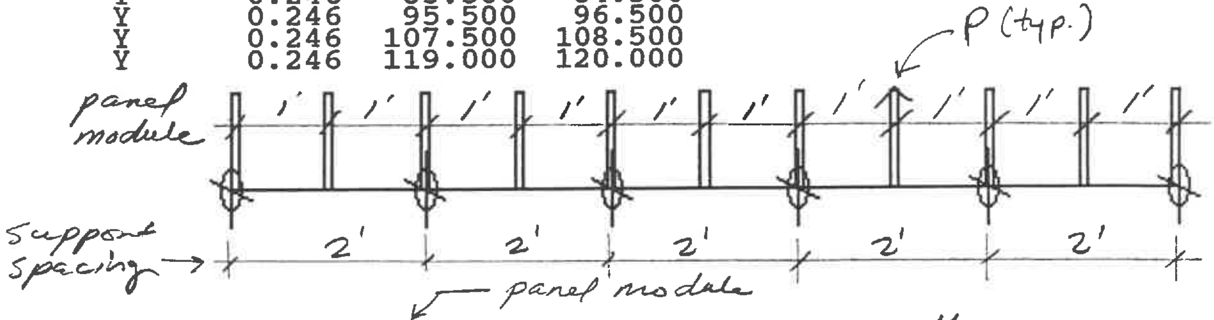
Analysis Input

Section	Start	End
15H4X048	0.000	120.000

Support	Location	Width	K
XYT	0.000	0.0000	1.00
XYT	24.000	0.0000	1.00
XYT	48.000	0.0000	1.00
XYT	72.000	0.0000	1.00
XYT	96.000	0.0000	1.00
XYT	120.000	0.0000	1.00

Loading 1
Multiplier 1.000

Dir	Magnitude	Start	End
Y	0.246	0.000	1.000
Y	0.246	11.500	12.500
Y	0.246	23.500	24.500
Y	0.246	35.500	36.500
Y	0.246	47.500	48.500
Y	0.246	59.500	60.500
Y	0.246	71.500	72.500
Y	0.246	83.500	84.500
Y	0.246	95.500	96.500
Y	0.246	107.500	108.500
Y	0.246	119.000	120.000



P = 2' (1') (123.1 psf) = 246# per clip

↑ spacing of transverse secondarys in edge zone

CFS Version 2.21
Transverse Secondarys in Edge Zone @ 2ft
~~AIDEA/FedEx Roof Replacement~~
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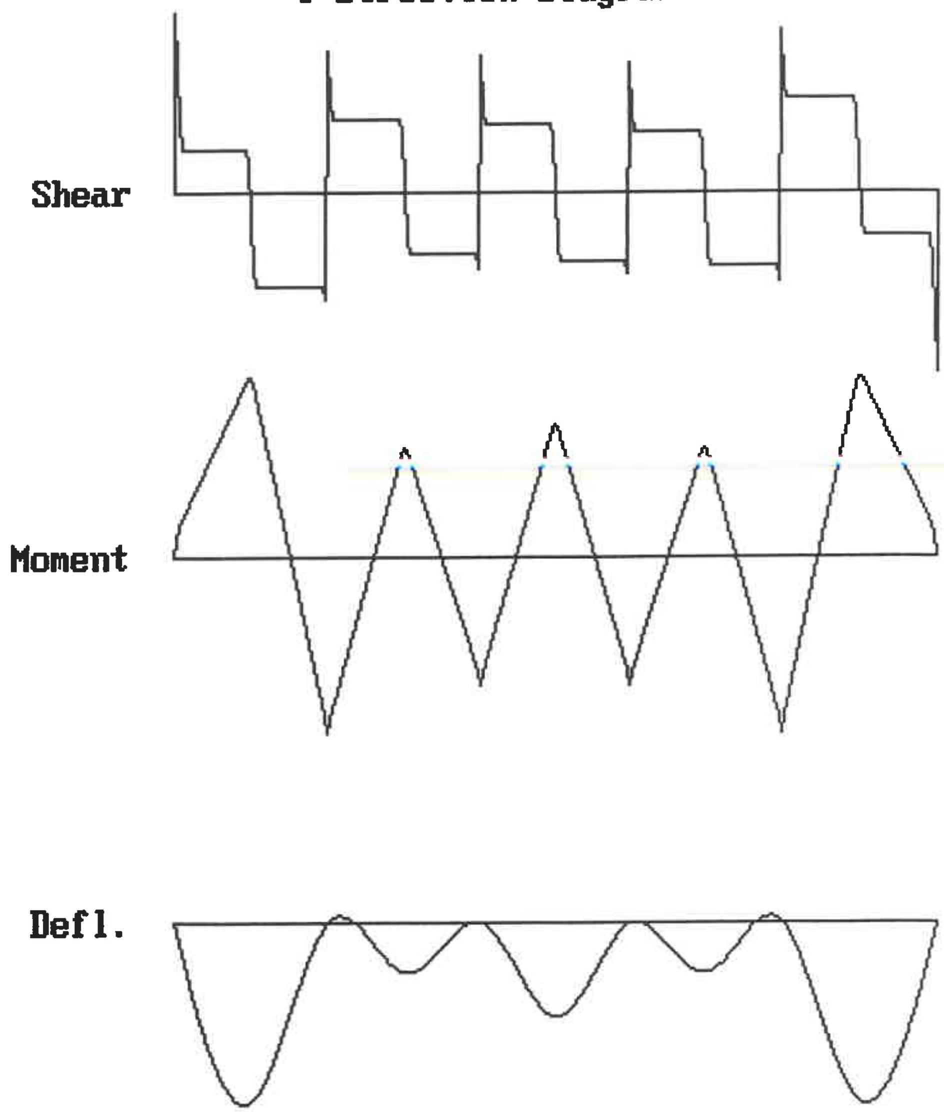
Section	Start	End	Rev. Date	Rev.Time	Rev. By
15H4X048	0.000	120.000	11-12-1998	08:52:39	Rick Forest

Y Direction Diagrams



6-5

CFS Version 2.21
Transverse Secondarys in Edge Zone @ 2ft
~~AIDEA/FedEx Roof Replacement~~
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Section	Start	End	Rev. Date	Rev.Time	Rev. By
15H4X048	0.000	120.000	11-12-1998	08:52:39	Rick Forest

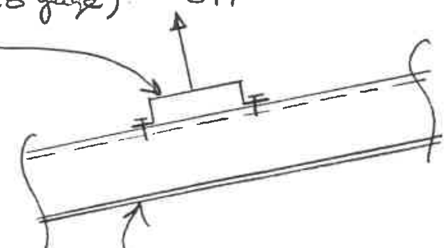
Y Direction Minima/Maxima

Location	Shear(l)	Shear(r)	Reaction
0.000	0.00000	0.32392	0.32392
1.000	0.07772	0.07772	
11.500	0.07772	0.07772	
12.500	-0.16828	-0.16828	
23.500	-0.16828	-0.16828	
24.000	-0.29127	0.25732	0.54859
24.500	0.13432	0.13432	
35.500	0.13432	0.13432	
36.500	-0.11168	-0.11168	
47.500	-0.11168	-0.11168	
48.000	-0.23468	0.24600	0.48068
48.500	0.12300	0.12300	
59.500	0.12300	0.12300	
60.500	-0.12300	-0.12300	
71.500	-0.12300	-0.12300	
72.000	-0.24600	0.23468	0.48068
72.500	0.11168	0.11168	
83.500	0.11168	0.11168	
84.500	-0.13432	-0.13432	
95.500	-0.13432	-0.13432	
96.000	-0.25732	0.29127	0.54859
96.500	0.16827	0.16827	
107.500	0.16827	0.16827	
108.500	-0.07773	-0.07773	
119.000	-0.07773	-0.07773	
120.000	-0.32373	0.00000	0.32373

Check screws & web crippling

Location	Moment	Location	Defl.
11.816	1.02922	10.924	0.00917
24.000	-0.99425	25.952	-0.00034
36.046	0.61782	36.444	0.00251
48.000	-0.72262	47.166	-0.00005
60.000	0.75337	60.000	0.00468
72.000	-0.72263	72.834	-0.00005
83.954	0.61783	83.556	0.00251
96.000	-0.99422	94.048	-0.00034
108.184	1.02918	109.076	0.00917

check bending



Maximum Uplift Reaction, P = 549#

Factor of Safety per AISI F1(b)(3)

$= \frac{2.50}{1.33} = 1.875$

Required Ultimate uplift capacity = 1.875(549) = 1,029#

Required Screw capacity = 1,029 / 2 = 515# per screw (ultimate)

Acceptable Fastener : CFI 1/4-14 TYPE AB Stainless Steel

Pullout Capacity = 568# > 515#
Pullover Capacity > 1,340# > 515#
} OK

CFS Version 2.21
~~Transverse Secondarys in Edge Zone @ 2ft~~
~~AIDEA/FedEx Roof Replacement~~

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Section	Start	End	Rev. Date	Rev.Time	Rev. By
15H4X048	0.000	120.000	11-12-1998	08:52:39	Rick Forest

~~Axial/Bending Check at 11.816~~

~~Kx =~~	~~1.000~~	~~Ky =~~	~~1.000~~	Kt =	1.000
Lx =	24.000	Ly =	24.000	Lt =	24.000
Cbx=	1.000	Cby=	1.000		
Cmx=	1.000	Cmy=	1.000		

Section 15H4X048 11-12-1998 08:52:39

Loads:	P	Mx	Vy	My	Vx
Total	0.0000	1.0292	-0.0000	0.0000	0.0000
Applied	0.0000	1.0292	-0.0000	0.0000	0.0000
Allowed	5.9163	4.6852	1.9757	10.6669	3.5218

Ae = 0.40535 | Ixe = 0.15195 | Iye = 1.29947
Sxe(t)= 0.26286 | Sye(l)= 0.44020
Sxe(b)= 0.16482 | Sye(r)= 0.44020

AISI Interaction Equations

```
C5-1 (P,Mx,My)  0.000 + 0.220 + 0.000 = 0.220 ✓
C5-2 (P,Mx,My)  0.000 + 0.220 + 0.000 = 0.220
C3.3-1 (Mx,Vy)          0.048 + 0.000 = 0.048
C3.3-1 (My,Vx)          0.000 + 0.000 = 0.000
```

~~Axial/Bending Check at 24.000, Right Side~~

~~Kx =~~	~~1.000~~	~~Ky =~~	~~1.000~~	~~Kt =~~	1.000
Lx =	24.000	Ly =	24.000	Lt =	24.000
Cbx=	1.145	Cby=	1.000		
Cmx=	1.000	Cmy=	1.000		

Section 15H4X048 11-12-1998 08:52:39

Loads:	P	Mx	Vy	My	Vx
Total	0.0000	-0.9942	0.2573	0.0000	0.0000
Applied	0.0000	-0.9942	0.2573	0.0000	0.0000
Allowed	5.9163	3.9491	1.9757	10.6669	3.5218

Ae = 0.40535 | Ixe = 0.15195 | Iye = 1.29947
Sxe(t)= 0.26286 | Sye(l)= 0.44020
Sxe(b)= 0.16482 | Sye(r)= 0.44020

AISI Interaction Equations

```
C5-1 (P,Mx,My)  0.000 + 0.252 + 0.000 = 0.252 ✓
C5-2 (P,Mx,My)  0.000 + 0.252 + 0.000 = 0.252
C3.3-1 (Mx,Vy)          0.054 + 0.017 = 0.071
C3.3-1 (My,Vx)          0.000 + 0.000 = 0.000
```

CFS Version 2.21
Transverse Secondarys in Edge Zone @ 2ft
AIDEA/FedEx Roof Replacement
Frankfurt Short Bruza Associates, P.C.
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Oklahoma City, OK 73118

Analysis: EDGETRAN
Rev. Date 11-12-1998
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Section	Start	End	Rev. Date	Rev.Time	Rev. By
15H4X048	0.000	120.000	11-12-1998	08:52:39	Rick Forest

Web-Crippling Check at 24.000
Bearing Width = 0.000

Section 15H4X048 11-12-1998 08:52:39

Part	Elem	Equation	Pa	Pay	Mx
1	2	C3.4-8	0.99882	0.99882	
1	4	C3.4-8	0.99882	0.99882	
Section Capacity				1.99764	4.26888
Section Load				0.54859	-0.99425

AISI Interaction Equations

C3.5-1 0.330 + 0.233 = 0.562 <=1.5 ✓
C3.5-2 0.302 + 0.233 = 0.535 <=1.5

CFS Version 2.21
Transverse Secondarys in Field @ 5'-2"
~~AIDEA/FedEx Roof Replacement~~

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Analysis: FIELDTRN
Rev. Date 11-12-1998
Rev. Time 10:06:47
Rev. By Rick Forest
Phone (405) 840-2931
Fax (405) 842-7750

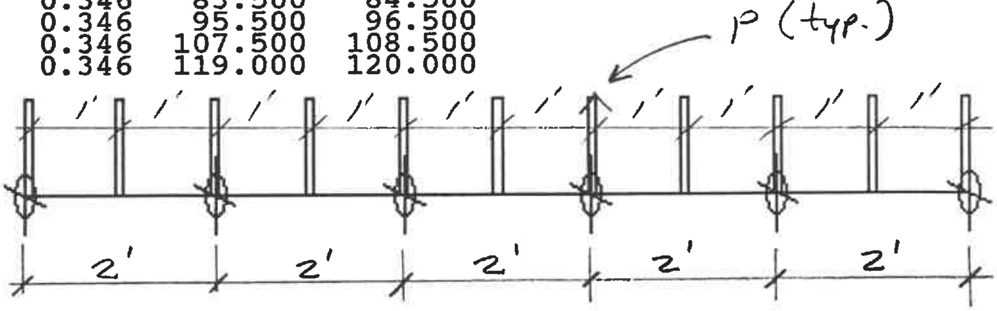
Analysis Input

Section	Start	End
15H4X048	0.000	120.000

Support	Location	Width	K
XYT	0.000	0.0000	1.00
XYT	24.000	0.0000	1.00
XYT	48.000	0.0000	1.00
XYT	72.000	0.0000	1.00
XYT	96.000	0.0000	1.00
XYT	120.000	0.0000	1.00

Loading 1
Multiplier 1.000

Dir	Magnitude	Start	End
Y	0.346	0.000	1.000
Y	0.346	11.500	12.500
Y	0.346	23.500	24.500
Y	0.346	35.500	36.500
Y	0.346	47.500	48.500
Y	0.346	59.500	60.500
Y	0.346	71.500	72.500
Y	0.346	83.500	84.500
Y	0.346	95.500	96.500
Y	0.346	107.500	108.500
Y	0.346	119.000	120.000



panel module

P = 5.135' (1') (67.3 psf) = 346# per clip

spacing of existing joists and new transverse secondarys in field

CFS Version 2.21
Transverse Secondarys in Field @ 5'-2"
AIDEA/FedEx Roof Replacement
Frankfurt Short Bruza Associates, P.C.
5801 N. Broadway, Suite 500
Oklahoma City, OK 73118

Analysis: FIELDTRN
Rev. Date 11-12-1998
Rev. Time 10:06:47
Rev. By Rick Forest
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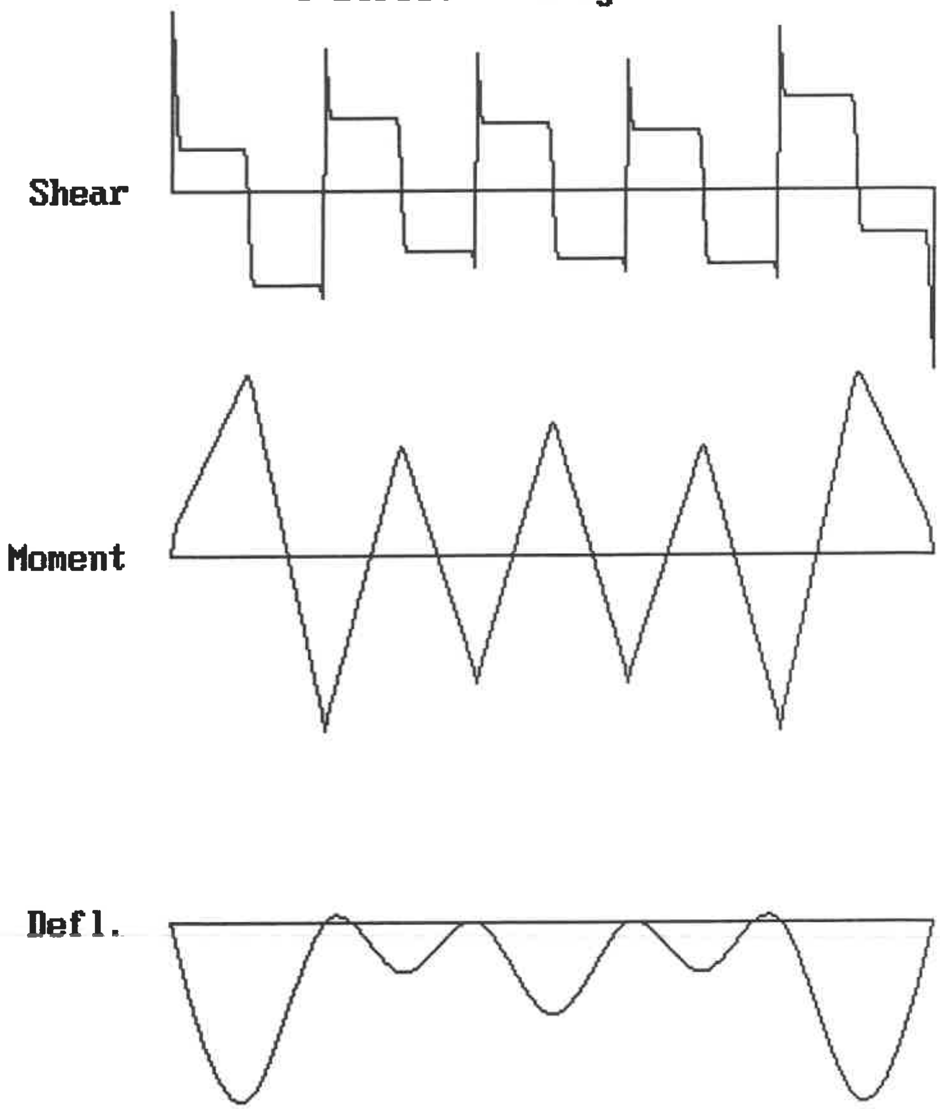
Section	Start	End	Rev. Date	Rev.Time	Rev. By
15H4X048	0.000	120.000	11-12-1998	08:52:39	Rick Forest

Y Direction Diagrams



CFS Version 2.21
Transverse Secondarys in Field @ 5'-2"
~~AIDEA/FedEx Roof Replacement~~
Frankfurt Short Bruza Associates, P.C.
5801 N. Broadway, Suite 500
Oklahoma City, OK 73118

Analysis: FIELDTRN
Rev. Date 11-12-1998
Rev. Time 10:06:47
Rev. By Rick Forest
Phone (405) 840-2931
Fax (405) 842-7750

Section	Start	End	Rev. Date	Rev.Time	Rev. By
15H4X048	0.000	120.000	11-12-1998	08:52:39	Rick Forest

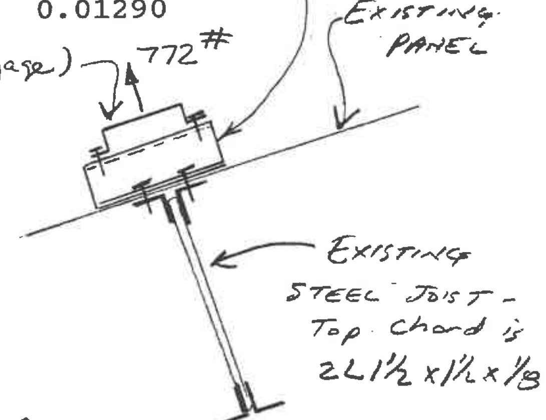
Y Direction Minima/Maxima

Location	Shear(l)	Shear(r)	Reaction
0.000	0.00000	0.45533	0.45533
1.000	0.10933	0.10933	
11.500	0.10933	0.10933	
12.500	-0.23667	-0.23667	
23.500	-0.23667	-0.23667	
24.000	-0.40967	0.36192	0.77159
24.500	0.18892	0.18892	
35.500	0.18892	0.18892	
36.500	-0.15708	-0.15708	
47.500	-0.15708	-0.15708	
48.000	-0.33008	0.34600	0.67608
48.500	0.17300	0.17300	
59.500	0.17300	0.17300	
60.500	-0.17300	-0.17300	
71.500	-0.17300	-0.17300	
72.000	-0.34600	0.33008	0.67608
72.500	0.15708	0.15708	
83.500	0.15708	0.15708	
84.500	-0.18892	-0.18892	
95.500	-0.18892	-0.18892	
96.000	-0.36192	0.40967	0.77159
96.500	0.23667	0.23667	
107.500	0.23667	0.23667	
108.500	-0.10933	-0.10933	
119.000	-0.10933	-0.10933	
120.000	-0.45533	0.00000	0.45533

check screws & web crippling

Location	Moment	Location	Defl.
11.816	1.44754	10.924	0.01290
24.000	-1.39838	25.951	-0.00047
36.046	0.86898	36.444	0.00353
48.000	-1.01638	47.166	-0.00007
60.000	1.05962	60.000	0.00658
72.000	-1.01638	72.834	-0.00007
83.954	0.86898	83.556	0.00353
96.000	-1.39838	94.049	-0.00047
108.184	1.44754	109.076	0.01290

check bending



Maximum Uplift Reaction = 772#

F.S. = 1.875 per AISI F1(5)(3)

Req'd. Ultimate Capacity = 1.875(772) = 1,448#

<u>Conx. of Transverse Member to Standoff Section</u>

Req'd. screw capacity = 1,448/2 = 724# per screw (ultimate)

Capacity of screws requires 16 gage standoff section

Acceptable Fastener: CFI 1/4-14 Type AB Stainless Steel
Pullout Capacity = 1,250#, Pullover Capacity > 1,340#

<u>Conx. of Standoff Section to Steel Joist</u>

CFS Version 2.21
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AIDEA/FedEx Roof Replacement
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Section	Start	End	Rev. Date	Rev.Time	Rev. By
15H4X048	0.000	120.000	11-12-1998	08:52:39	Rick Forest

Axial/Bending Check at 11.816

Kx =	1.000	Ky =	1.000	Kt =	1.000
Lx =	24.000	Ly =	24.000	Lt =	24.000
Cbx=	1.000	Cby=	1.000		
Cmx=	1.000	Cmy=	1.000		

Section 15H4X048 11-12-1998 08:52:39

Loads:	P	Mx	Vy	My	Vx
Total	0.0000	1.4475	-0.0000	0.0000	0.0000
Applied	0.0000	1.4475	-0.0000	0.0000	0.0000
Allowed	5.9163	4.6852	1.9757	10.6669	3.5218

Ae = 0.40535 Ixe = 0.15195 Iye = 1.29947
Sxe(t)= 0.26286 Sye(l)= 0.44020
Sxe(b)= 0.16482 Sye(r)= 0.44020

AISI Interaction Equations

C5-1 (P,Mx,My) 0.000 + 0.309 + 0.000 = 0.309 ✓
C5-2 (P,Mx,My) 0.000 + 0.309 + 0.000 = 0.309
C3.3-1 (Mx,Vy) 0.095 + 0.000 = 0.095
C3.3-1 (My,Vx) 0.000 + 0.000 = 0.000

Axial/Bending Check at 24.000, Right Side

Kx =	1.000	Ky =	1.000	Kt =	1.000
Lx =	24.000	Ly =	24.000	Lt =	24.000
Cbx=	1.145	Cby=	1.000		
Cmx=	1.000	Cmy=	1.000		

Section 15H4X048 11-12-1998 08:52:39

Loads:	P	Mx	Vy	My	Vx
Total	0.0000	-1.3983	0.3618	0.0000	0.0000
Applied	0.0000	-1.3983	0.3618	0.0000	0.0000
Allowed	5.9163	3.9491	1.9757	10.6669	3.5218

Ae = 0.40535 Ixe = 0.15195 Iye = 1.29947
Sxe(t)= 0.26286 Sye(l)= 0.44020
Sxe(b)= 0.16482 Sye(r)= 0.44020

AISI Interaction Equations

C5-1 (P,Mx,My) 0.000 + 0.354 + 0.000 = 0.354 ✓
C5-2 (P,Mx,My) 0.000 + 0.354 + 0.000 = 0.354
C3.3-1 (Mx,Vy) 0.107 + 0.034 = 0.141
C3.3-1 (My,Vx) 0.000 + 0.000 = 0.000

CFS Version 2.21
Transverse Secondarys in Field @ 5'-2"
AIDEA/FedEx Roof Replacement
Frankfurt Short Bruza Associates, P.C.
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Analysis: FIELDTRN
Rev. Date 11-12-1998
Rev. Time 10:06:47
Rev. By Rick Forest
Phone (405) 840-2931
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Section	Start	End	Rev. Date	Rev.Time	Rev. By
15H4X048	0.000	120.000	11-12-1998	08:52:39	Rick Forest

Web-Crippling Check at 24.000
Bearing Width = 0.000

Section 15H4X048 11-12-1998 08:52:39

Part	Elem	Equation	Pa	Pay	Mx
1	2	C3.4-8	0.99882	0.99882	
1	4	C3.4-8	0.99882	0.99882	
Section Capacity				1.99764	4.26888
Section Load				0.77159	-1.39838

AISI Interaction Equations

C3.5-1 0.463 + 0.328 = 0.791 <=1.5 ✓
C3.5-2 0.425 + 0.328 = 0.752 <=1.5

CFS Version 2.21
AISI Section 4HU2x048
AIDEA/FedEx Roof Replacement
Frankfurt Short Bruza Associates, P.C.
5801 N. Broadway, Suite 500
Oklahoma City, OK 73118

Section: 4HU2X048
Rev. Date 11-12-1998
Rev. Time 09:01:27
Rev. by Rick Forest
Phone (405) 840-2931
Fax (405) 842-7750

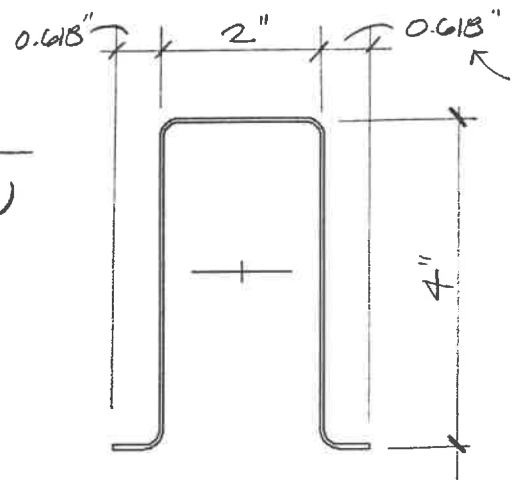
Section Input

Yield	(Fy)	50.000	Unit Weight	3.4000
Ultimate	(Fu)	60.000	One Inch =	1.0000
Modulus	(E)	29500.000	Cw Override	0.0000
			J Override	0.0000

Part 1 Thickness 0.0480 18 Gage X=0.000, Y=0.000

Length	Angle	Radius	Web	k	Hole	Distance
0.618	0.000	0.1875	Sgl	0.00	0.000	0.309
4.000	90.000	0.1875	Sgl	0.00	0.000	2.000
2.000	0.000	0.1875	Sgl	0.00	0.000	1.000
4.000	-90.000	0.1875	Sgl	0.00	0.000	2.000
0.618	0.000	0.1875	Sgl	0.00	0.000	0.309

Longitudinal Secondary
IN EDGE ZONE (@2'o.c.)



Full Section Properties

Area	0.51268	Wt.	1.74312	Width	10.68089
Ix	1.00180	rx	1.39787	Ixy	-0.00000
Sx(t)	0.53899	y(t)	1.85866	Alpha	0.0000
Sx(b)	0.46784	y(b)	2.14134		
Iy	0.46874	ry	0.95619	Xo	-0.00000
Sy(l)	0.29856	x(l)	1.57000	Yo	3.67459
Sy(r)	0.29856	x(r)	1.57000	jx	0.00000
				jy	-3.84359
I1	1.00180	r1	1.39787		
I2	0.46874	r2	0.95619		
Ic	1.47054	rc	1.69361	Cw	0.56406
Io	8.39311	ro	4.04610	J	0.00039374

CFS Version 2.21
AISI Section 4HU2x048
AIDEA/FedEx Roof Replacement
Frankfurt Short Bruza Associates, P.C.
5801 N. Broadway, Suite 500
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Section: 4HU2X048
Rev. Date 11-12-1998
Rev. Time 09:01:27
Rev. by Rick Forest
Phone (405) 840-2931
Fax (405) 842-7750

Fully Braced Allowables

Compression		Positive Moment		Positive Moment	
Pao	7.4946	Maxo	15.1382	Mayo	5.5915
Ae	0.28729	Ixe	1.00180	Iye	0.33744
		Sxe(t)	0.53899	Sye(l)	0.25380
Tension		Sxe(b)	0.46784	Sye(r)	0.18638
Ta	15.7041				
		Negative Moment		**Negative Moment**	
		Maxo	15.1382	Mayo	5.5915
Shear		Ixe	1.00180	Iye	0.33744
Vay	4.9143	Sxe(t)	0.53899	Sye(l)	0.18638
Vax	2.2022	Sxe(b)	0.46784	Sye(r)	0.25380

CFS Version 2.21
Longitudinal Secondarys in Edge Zone @2'
AIDEA/FedEx Roof Replacement
Frankfurt Short Bruza Associates, P.C.
5801 N. Broadway, Suite 500
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Analysis: EDGELONG
Rev. Date 11-12-1998
Rev. Time 09:15:27
Rev. By Rick Forest
Phone (405) 840-2931
Fax (405) 842-7750

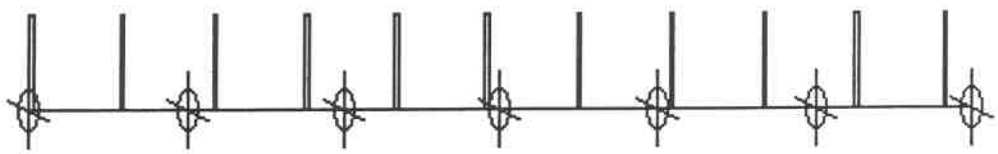
Analysis Input

Section	Start	End
4HU2X048	0.000	246.375

Support	Location	Width	K
XYT	0.000	0.0000	1.00
XYT	41.062	0.0000	1.00
XYT	82.125	0.0000	1.00
XYT	123.188	0.0000	1.00
XYT	164.250	0.0000	1.00
XYT	205.312	0.0000	1.00
XYT	246.375	0.0000	1.00

Loading 1
Multiplier 1.000

Dir	Magnitude	Start	End
Y	0.548	0.000	1.000
Y	0.548	23.500	24.500
Y	0.548	47.500	48.500
Y	0.548	71.500	72.500
Y	0.548	95.500	96.500
Y	0.548	119.500	120.500
Y	0.548	143.500	144.500
Y	0.548	167.500	168.500
Y	0.548	191.500	192.500
Y	0.548	215.500	216.500
Y	0.548	239.000	240.000



CFS Version 2.21
Longitudinal Secondarys in Edge Zone @2'
AIDEA/FedEx Roof Replacement
Frankfurt Short Bruza Associates, P.C.
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Oklahoma City, OK 73118

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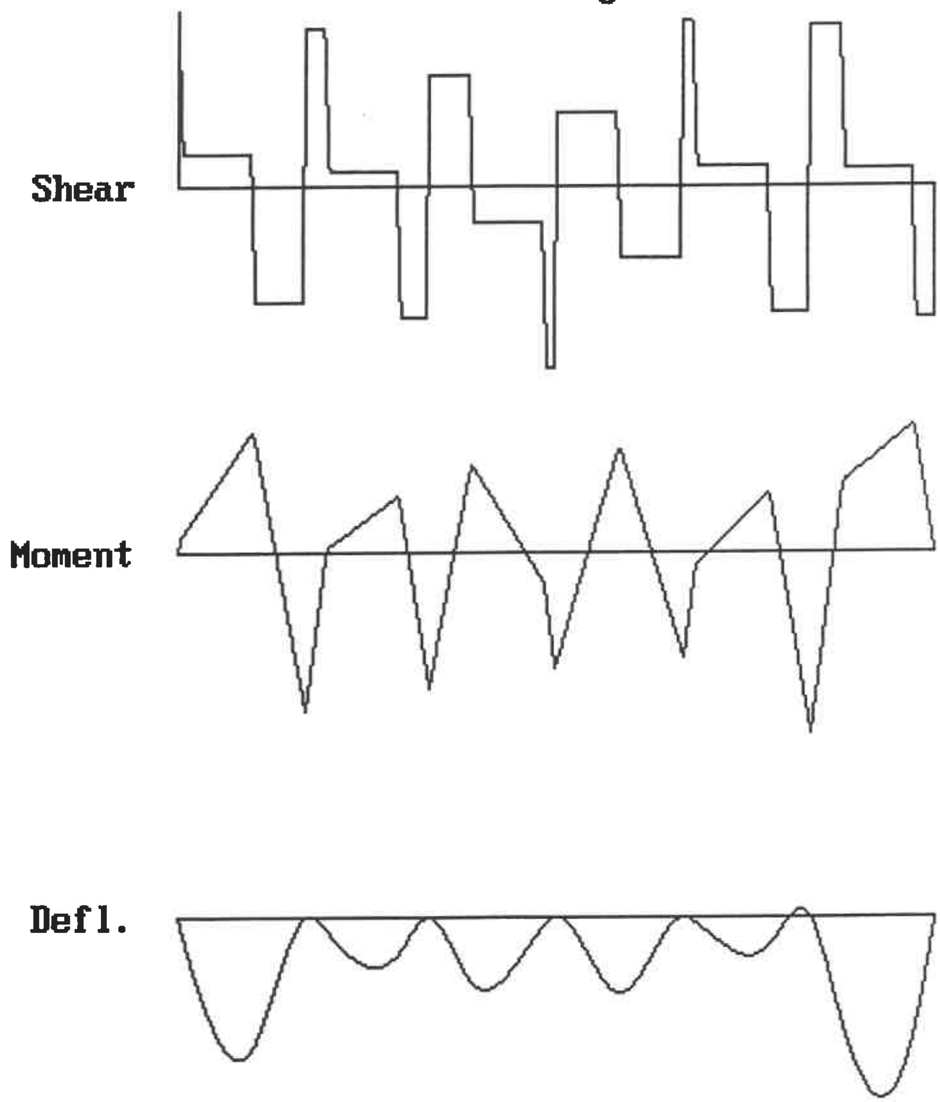
Section	Start	End	Rev. Date	Rev.Time	Rev. By
4HU2X048	0.000	246.375	11-12-1998	09:01:27	Rick Forest

Y Direction Diagrams



CFS Version 2.21
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Section	Start	End	Rev. Date	Rev.Time	Rev. By
4HU2X048	0.000	246.375	11-12-1998	09:01:27	Rick Forest

Y Direction Minima/Maxima

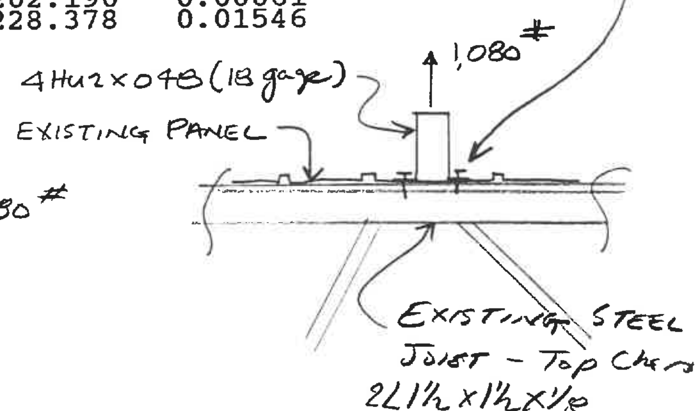
Location	Shear(l)	Shear(r)	Reaction
0.000	0.00000	0.66907	0.66907
1.000	0.12107	0.12107	
23.500	0.12107	0.12107	
24.500	-0.42693	-0.42693	
41.062	-0.42693	0.60518	1.03211
47.500	0.60518	0.60518	
48.500	0.05718	0.05718	
71.500	0.05718	0.05718	
72.500	-0.49082	-0.49082	
82.125	-0.49082	0.41762	0.90844
95.500	0.41762	0.41762	
96.500	-0.13038	-0.13038	
119.500	-0.13038	-0.13038	
120.500	-0.67838	-0.67838	
123.188	-0.67838	0.27718	0.95556
143.500	0.27718	0.27718	
144.500	-0.27082	-0.27082	
164.250	-0.27082	0.62746	0.89828
167.500	0.62746	0.62746	
168.500	0.07946	0.07946	
191.500	0.07946	0.07946	
192.500	-0.46854	-0.46854	
205.312	-0.46854	0.61144	1.07998
215.500	0.61144	0.61144	
216.500	0.06344	0.06344	
239.000	0.06344	0.06344	
240.000	-0.48456	-0.48456	
246.375	-0.48456	0.00000	0.48456

Check screws & web crippling

Location	Moment	Location	Defl.
23.721	3.13243	19.587	0.01204
41.062	-4.10496	42.396	-0.00011
71.604	1.44010	64.186	0.00419
82.125	-3.50389	81.942	-0.00000
96.262	2.24090	100.551	0.00608
123.188	-3.00122	123.950	-0.00003
144.006	2.69896	144.088	0.00635
164.250	-2.71665	164.349	-0.00000
191.645	1.50935	185.234	0.00319
205.312	-4.69415	202.190	-0.00061
239.116	3.30331	228.378	0.01546

check bending

Note: stagger screws to both joist angles



Maximum Uplift @ Transverse Secondary = 1,080#

Factor of Safety per AISI F1(b)(3)

$= \frac{2.50}{1.33} = 1.875$

Required ultimate uplift capacity = 1.875 (1,080) = 2,025#

Req'd. screw capacity = 2,025/2 = 1,013# per screw (ultimate)

↑ check pullout w/ ⅛" mat'l.
Check pullover w/ 18 gage mat'l.

Acceptable Fastener: CFI ¼-14 TYPE AB Stainless Steel

Pullout Capacity (12 gage, t = .105") = 2,310# > 1,013#
Pullover Capacity (20 gage) ≥ 1,340# > 1,013#
} ok

CFS Version 2.21
Longitudinal Secondarys in Edge Zone @2'
AIDEA/FedEx Roof Replacement
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Phone (405) 840-2931
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Section	Start	End	Rev. Date	Rev.Time	Rev. By
4HU2X048	0.000	246.375	11-12-1998	09:01:27	Rick Forest

Axial/Bending Check at 205.312, Left Side

Kx =	1.000	Ky =	1.000	Kt =	1.000
Lx =	41.062	Ly =	41.062	Lt =	41.062
Cbx=	1.243	Cby=	1.000		
Cmx=	1.000	Cmy=	1.000		

Section 4HU2X048 11-12-1998 09:01:27

Loads:	P	Mx	Vy	My	Vx
Total	0.0000	-4.6941	-0.4685	0.0000	0.0000
Applied	0.0000	-4.6941	-0.4685	0.0000	0.0000
Allowed	2.5764	9.0218	4.9143	5.4778	2.2022
Ae =	0.51268	Ixe =	1.00180	Iye =	0.46874
		Sxe(t)=	0.53899	Sye(l)=	0.29856
		Sxe(b)=	0.46784	Sye(r)=	0.29856

AISI Interaction Equations

C5-1 (P,Mx,My)	0.000 +	0.520 +	0.000 =	0.520	✓
C5-2 (P,Mx,My)	0.000 +	0.520 +	0.000 =	0.520	
C3.3-1 (Mx,Vy)		0.096 +	0.009 =	0.105	
C3.3-1 (My,Vx)		0.000 +	0.000 =	0.000	

Axial/Bending Check at 239.116

Kx =	1.000	Ky =	1.000	Kt =	1.000
Lx =	41.062	Ly =	41.062	Lt =	41.062
Cbx=	1.750	Cby=	1.000		
Cmx=	1.000	Cmy=	1.000		

Section 4HU2X048 11-12-1998 09:01:27

Loads:	P	Mx	Vy	My	Vx
Total	0.0000	3.3033	-0.0000	0.0000	0.0000
Applied	0.0000	3.3033	-0.0000	0.0000	0.0000
Allowed	2.5764	15.1382	4.9143	5.4778	2.2022
Ae =	0.51268	Ixe =	1.00180	Iye =	0.46874
		Sxe(t)=	0.53899	Sye(l)=	0.29856
		Sxe(b)=	0.46784	Sye(r)=	0.29856

AISI Interaction Equations

C5-1 (P,Mx,My)	0.000 +	0.218 +	0.000 =	0.218	✓
C5-2 (P,Mx,My)	0.000 +	0.218 +	0.000 =	0.218	
C3.3-1 (Mx,Vy)		0.048 +	0.000 =	0.048	
C3.3-1 (My,Vx)		0.000 +	0.000 =	0.000	

CFS Version 2.21
Longitudinal Secondarys in Edge Zone @2'
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Section	Start	End	Rev. Date	Rev.Time	Rev. By
4HU2X048	0.000	246.375	11-12-1998	09:01:27	Rick Forest

Web-Crippling Check at 205.312

~~Bearing Width = 0.000~~

Section 4HU2X048 11-12-1998 09:01:27

Part	Elem	Equation	Pa	Pay	Mx
1	2	C3.4-4	0.6685	0.6685	
1	4	C3.4-4	0.6685	0.6685	
Section Capacity				1.3370	15.1382
Section Load				1.0800	-4.6941

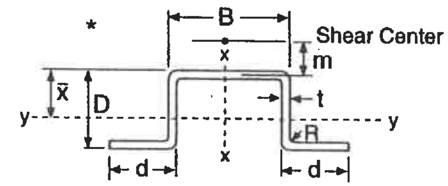
AISI Interaction Equations

C3.5-1 0.969 + 0.310 = 1.279 <=1.5 ✓
C3.5-2 0.889 + 0.310 = 1.199 <=1.5

Table I – 7

Gross Section Properties

Hat Sections Without Lips



ID	Dimensions							Properties of Full Section												
								Axis x–x			Axis y–y									
	D	B	t	d	R	Area	wt/ft	I_x	S_x	r_x	I_y	S_y	r_y	$\bar{x}$	m	J	C_w	j	r_o	x_o
	in.	in.	in.	in.	in.	in.^{2}	lb	in.^{4}	in.^{3}	in.	in.^{4}	in.^{3}	in.	in.	in.	in.^{4}	in.^{6}	in.	in.	in.
10HU5x075	10.000	5.000	0.075	1.050	0.1875	1.981	6.74	10.95	3.151	2.351	23.75	4.282	3.462	4.455	4.802	0.00371	98.4	9.70	10.12	–9.220
8HU12x135	8.000	12.000	0.135	1.670	0.1875	4.099	13.9	111.2	14.75	5.208	36.32	7.091	2.977	2.878	3.627	0.0249	762	9.06	8.80	–6.438
8HU12x105	8.000	12.000	0.105	1.340	0.1875	3.134	10.7	83.63	11.56	5.166	26.84	5.129	2.926	2.767	3.591	0.0115	597	8.93	8.66	–6.306
8HU8x105	8.000	8.000	0.105	1.340	0.1875	2.714	9.23	35.20	6.725	3.602	23.26	4.834	2.928	3.188	3.737	0.0100	222	8.17	8.29	–6.872
8HU8x075	8.000	8.000	0.075	0.980	0.1875	1.896	6.44	24.11	4.916	3.566	15.61	3.156	2.870	3.053	3.713	0.00355	161	8.05	8.14	–6.729
8HU4x075	8.000	4.000	0.075	0.980	0.1875	1.596	5.42	5.69	1.960	1.889	12.37	2.824	2.784	3.620	3.812	0.00299	31.9	7.77	8.12	–7.394
8HU4x060	8.000	4.000	0.060	0.840	0.1875	1.264	4.30	4.47	1.608	1.881	9.66	2.178	2.765	3.563	3.842	0.00152	25.8	7.76	8.10	–7.374
6HU9x135	6.000	9.000	0.135	1.670	0.1875	3.154	10.7	49.73	8.241	3.971	16.44	4.430	2.283	2.290	2.730	0.0192	177	6.97	6.75	–4.952
6HU9x105	6.000	9.000	0.105	1.340	0.1875	2.399	8.16	36.84	6.423	3.918	12.07	3.163	2.243	2.185	2.728	0.00882	140	6.85	6.63	–4.860
6HU6x105	6.000	6.000	0.105	1.340	0.1875	2.084	7.09	15.70	3.706	2.744	10.42	2.983	2.236	2.507	2.779	0.00766	51.6	6.21	6.32	–5.234
6HU6x075	6.000	6.000	0.075	0.915	0.1875	1.436	4.88	10.38	2.702	2.688	6.80	1.865	2.176	2.355	2.799	0.00269	37.7	6.11	6.18	–5.116
6HU3x075	6.000	3.000	0.075	0.915	0.1875	1.211	4.12	2.48	1.060	1.431	5.36	1.669	2.105	2.785	2.793	0.00227	7.55	5.81	6.10	–5.541
6HU3x060	6.000	3.000	0.060	0.760	0.1875	0.954	3.24	1.92	0.872	1.418	4.15	1.266	2.085	2.724	2.851	0.00115	6.04	5.83	6.09	–5.545
6HU3x048	6.000	3.000	0.048	0.660	0.1875	0.757	2.57	1.51	0.714	1.412	3.25	0.979	2.072	2.683	2.876	0.000581	4.88	5.83	6.08	–5.535
4HU6x135	4.000	6.000	0.135	1.670	0.1875	2.209	7.51	16.86	3.718	2.763	5.42	2.344	1.567	1.686	1.744	0.0134	22.6	4.81	4.63	–3.362
4HU6x105	4.000	6.000	0.105	1.340	0.1875	1.664	5.66	12.05	2.845	2.691	3.96	1.644	1.543	1.592	1.804	0.00612	17.9	4.74	4.56	–3.343
4HU4x105	4.000	4.000	0.105	1.340	0.1875	1.454	4.94	5.31	1.641	1.911	3.39	1.551	1.527	1.814	1.728	0.00534	6.89	4.17	4.26	–3.490
4HU4x075	4.000	4.000	0.075	0.915	0.1875	0.986	3.35	3.30	1.162	1.830	2.18	0.937	1.486	1.676	1.848	0.00185	4.83	4.15	4.21	–3.487
4HU2x075	4.000	2.000	0.075	0.915	0.1875	0.836	2.84	0.830	0.451	0.997	1.70	0.839	1.427	1.970	1.653	0.00157	1.15	3.74	3.99	–3.585
4HU2x060	4.000	2.000	0.060	0.750	0.1875	0.653	2.22	0.617	0.365	0.972	1.30	0.623	1.413	1.910	1.784	0.000784	0.830	3.83	4.04	–3.663
4HU2x048	4.000	2.000	0.048	0.618	0.1875	0.513	1.74	0.469	0.299	0.956	1.00	0.468	1.398	1.859	1.859	0.000394	0.640	3.88	4.06	–3.694
3HU4.5x135	3.000	4.500	0.135	1.670	0.1875	1.736	5.90	8.284	2.189	2.184	2.47	1.516	1.192	1.371	1.182	0.0105	5.66	3.69	3.52	–2.485
3HU4.5x105	3.000	4.500	0.105	1.340	0.1875	1.297	4.41	5.690	1.633	2.095	1.80	1.053	1.179	1.287	1.288	0.00477	4.20	3.64	3.48	–2.522
3HU3x105	3.000	3.000	0.105	1.340	0.1875	1.139	3.87	2.615	0.956	1.515	1.53	0.992	1.159	1.457	1.128	0.00419	1.89	3.08	3.17	–2.532
3HU3x075	3.000	3.000	0.075	0.915	0.1875	0.761	2.59	1.517	0.648	1.412	0.977	0.585	1.133	1.331	1.328	0.00143	1.14	3.13	3.19	–2.622

* Note vertical orientation of x–axis.

6–21

CONSTRUCTION FASTENERS, INC. 1-800-234-4533

STAINLESS STEEL TAPPING FASTENERS (304 STAINLESS) (TYPE AB & B)

304 Series Stainless Steel is an 18-8 stainless alloy with 18% chromium and 8% nickel. This alloy is not magnetic.

DIAMETER, THREAD & POINT... - 1/4-14 TYPE AB - 1/4-14 TYPE B

	Head Across Flats	Thread Major Dia.	Thread Minor Diameter	Nom. Tensile	Min. Torsional	Nom. Shear
#14-~~10~~ 14 Type AB	3/8"	.246-.240	.192-.185	3800 lbs.	142 ins.lbs.	2350 lbs.
1/4"-14 Type B	3/8"	.246-.240	.192-.185	3800 lbs.	142 ins.lbs.	2350 lbs.

APPLICATION...STEEL THICKNESS FROM 26 GAUGE (.022 NOMINAL) THRU 1/2"

Type B Material	Drill Size	Type AB Material	Drill Size
.065 - .085	#8 (.199)	.021 - .026	1/8" (.125)
.085 - .115	#7 (.201)	.027 - .050	5/32" (.156)
.115 - .375	#1 (.228)	.061 - .075	#8 (.199)
.378 - .500	.231 (.231)	.075 - .104	#7 (.201)

POTENTIAL STRENGTH IN APPLICATION (POUNDS ULTIMATE)

PULL OUT STRENGTH (LBS.)

Type B	Type AB
1/4" Plate: 3233*	12 Ga. (.105): 2310
12 Ga. (.105): 2260	14 Ga. (.075): 1394
14 Ga. (.075): 1458	16 Ga. (.060): 1250
16 Ga. (.060): 1260	18 Ga. (.052): 568

PULL OVER STRENGTH WITH ASSEMBLED STAINLESS STEEL BOND SEAL WASHER LBS

Type AB OR B

20 Ga. (.040) Galv.: 1340 24 Ga. (.028) Galv.: 790

22 Ga. (.034) Galv.: 1237 26 Ga. (.022) Galv.: 647

AVAILABLE SIZES (LENGTHS): Type A: 3/4" through 8" Type B: 3/4" Through 8" Type AB: 3/4" through 1-1/2"

LENGTH SELECTION...The fastener length selection should provide for 3/8" of fastener projecting through the material.

INSTALLATION AND APPLICATION CONSIDERATIONS - These are self tapping fasteners capable of tapping (threading) into steel. The part requires a pre-drilled hole. Hole size is a factor in fastener installation performance and pull o ut strength. These fasteners are manufactured from a special 304 Stainless Steel alloy for maximum installation performance. This alloy is a member of the non-magnetic 18-8 Stainless or 300 Series Stainless family. The 18-8 stainless alloy family includes various specific alloys with different corrosion resistance characteristics. The alloys used for fastener manufacture are 302 and 304 series. These alloys are considered to provide ultimate corrosion resistance . Drill size suggestions assumes 50-55,000 psi yield steel. Higher tensile steel may require adjustments in drill size to permit proper installation. Pull out strength (pounds ultimate) is based on 50,000 psi hot tolled st eel material. Pull over (pounds ultimate) is based on .035 thickness 15mm OD stainless steel Bond Seal washer. *Denotes tensile failure of fastener. Fastener failed in tension before pull out occurred. 300 Serie s Stainless Steel fasteners require a screw driver with 600 to 1000 RPM maximum for best installation performance.

Ultimate values listed are the result of laboratory testing. The specific job conditions should be considered and appropriate safety factors applied when specifying the proper fasteners.

Page WG49 CFI-PIC 6/15/98

ATLAS BOLT & SCREW COMPANY
1628 TROY ROAD
ASHLAND, OH 44805
(419)289-6171•(800)321-6977•FAX(419)289-2564

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NOTES/COMMENTS:

6-24

Drilling and Self-Tapping FASTENERS for Retrofit Applications

Specifications

Diameters: #12 & 1/4"
Lengths: 3/4" thru 8"
Points: Ultra-Z Drilling with TCP and Atlas Type B Self-Tapping
Material: Carbon Steel and 304 (HT3) Stainless Steel
Plating: Carbon Steel - .0005 min zinc with Oxyseal II
304 (HT3) - .0003 min cadmium

Strength Characteristics

for Drilling and Self-Tapping Fasteners

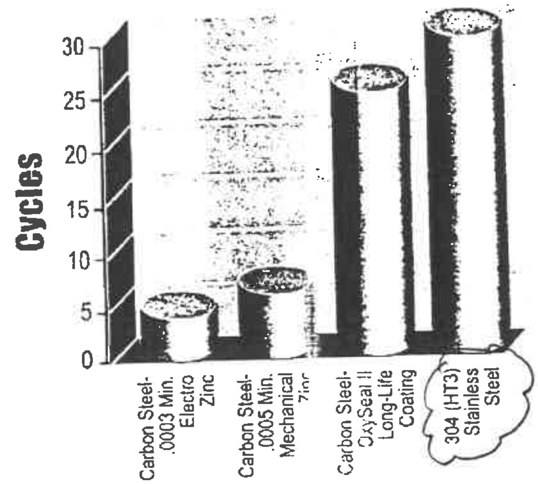
Fastener Size	Minimum Tensile (pounds)	Min. Fastener Torque Strength (inch-pounds)	Fastener Shear (pounds)
12-14	2800	92	2000
12-24	3250	100	2100
1/4 -14	3850	150	2600
1/4 -20	4275	168	2700
17-14	5200	175	3125
18-9	4550	170	2575

Ductility

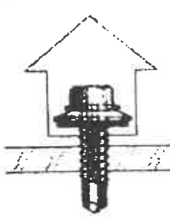
Carbon Steel ....15° Minimum bend
304 HT3 Stainless Steel ....180° Minimum bend

Kesternich Test Results

Tested to 50% red rust on head of fastener



Pull-Out Test Results for Ultra-Z Self-Drilling Fasteners



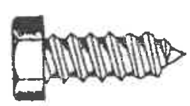
Fastener Diameter		Gauge 26	24	22	20	18	16	14	12	1/8	3/16	1/4
12-14	TCP3	145	214	292	344	554	760	1066	1634	2423	3001	/
12-24	TCP4	/	/	/	/	498	700	989	1535	2444	3488	3847
	TCP5	/	/	/	/	490	702	916	1530	2210	3704	4002
1/4-14	TCP3	144	234	296	349	613	883	1148	1861	2409	4553	5036
1/4-20	TCP3	143	228	274	366	559	784	1008	1681	2545	3557	/
1/4-14	TCP5	/	/	/	/	557	791	1119	1806	2553	4300	4592

Suggested Drill Size and Pull-Out Test Results for Self-Tapping Sheeting Fasteners

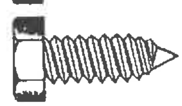
To determine the tension required to pull a properly applied screw out of a structural steel member

Steel Thickness	Point Type	Drill Size	Average Ultimate Pullout
26 Ga. (.018)	A, AB	1/8" (.125)	243 lbs.
24 Ga. (.024)	A, AB	5/32" (.156)	340 lbs.
22 Ga. (.030)	A, AB	5/32" (.156)	372 lbs.
20 Ga. (.036)	A, AB	5/32" (.156)	412 lbs.
18 Ga. (.048)	A, AB, BP	3/16" (.187)	518 lbs.
16 Ga. (.060)	A, AB, B, BP	3/16" (.187)	674 lbs.
14 Ga. (075)	AB, B, BP	#7 (.201)	831 lbs.
12 Ga. (.105)	AB, B, BP	#7 (.201)	1681 lbs.
1/8" (.125)	AB, B, BP	#2 (.221)	1780 lbs.
10 Ga. (.134)	AB, B, BP	#2 (.221)	1812 lbs.
3/16" (.187)	B, BP	#2 (.221)	2855 lbs.
1/4" (.250)	B, BP	#2 (.221)	3355 lbs.
3/8" (.375)	B, BP	#2 (.221)	3391 lbs.*
1/2" (.500)	B, BP	#1 (.228)	3500 lbs.*

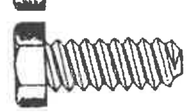
*Exceeds tensile strength of fastener.



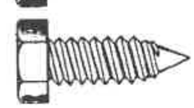
Type A:
For light gauge applications



Type AB:
For light & medium gauge applications



Type B:
For heavy gauge applications



Type BP
For heavy gauge applications & alignment

DISCLAIMER: All test results and recommendations are based on laboratory tests. **Specific job site conditions should be taken into consideration when specifying the proper fastener.** Because application conditions vary, we assume no liability for use of this information.

For free engineering, product & job site assistance, call Technical Services: 800-321-6977

6-25

7. *Existing Interstitial Joist and Primary Framing Systems*

The existing interstitial joist and primary framing systems were originally designed by American Buildings Company (ABC) to support similar loads to those currently required by the governing building codes. ABC's design commentary for their original building design is included as pages 7-2 through 7-10. The original building frame was designed to support a collateral dead load of 20 psf in addition to the dead load of the original building materials.

Added dead load of new roofing system:

Component Weights
22 gage roofing panel: 2.0 psf
1.5HUx048 Transverse Subpurlin: 3.4 plf
4HU2x048 Longitudinal Subpurlin (edge zone): 3.4 plf
4HU2x060 Standoff Clip (field zone): 2.83 lbs. Each

Average Uniformly Distributed Load
Edge Zone: 2.0 psf + 3.4 plf / 2.0 ft + 3.4 plf / 2.0 ft = 5.4 psf
Field Zone: 2.0 psf + 3.4 plf / 5.14 ft + 2.83 / (2x5.14) = 2.94 psf

Due to the inclusion of the 20 psf collateral load, the building frame has the reserve capacity to support the additional dead load of the new roofing system.

III. Loads

The following loads are applied to the building. These loads are defined by the Specifications, Drawings, referenced codes and standards, Project meetings and communications, and as determined by American Buildings Company (ABC).

Dead load	
Roof cladding	1.4 psf
Bar joists	3.0 psf
Decking	1.7 psf
Purlins	1.0 psf
Draft curtain	0.4 psf
Bracing	2.0 psf
Wall cladding	2.5 psf (wall area)
Girts	1.0 psf do
Bracing	1.0 psf do
Firewall gyp board	4.0 psf do
Liner panel	2.7 psf do
Truss frames	Selfweight
Header system	88.6 kips total
Air Handling Units (4)	5.0 kips each
Support frame	2.8 kips each
Collateral dead load	20.0 psf
Roof snow load	40.0 psf (no trib area reduction)
Unbalanced	
	40.0 psf to one slope
	20.0 psf to opposite slope
In combination with seismic	
Roof snow load	10.0 psf

Crane loads

Column lines 5 thru 11, B thru N

Single concentrated load at any point - dead plus live

Dead load	10.0 kips
Live load	40.0 kips including impact
Total load to frame	50 kips

Column lines 2 thru 5, F thru J

Single concentrated load at any point - dead plus live

Dead load	10.0 kips
Live load	40.0 kips including impact
Total load to frame	50 kips

Both loads are to be applied to Column line 5

DESIGN COMMENTARY

Wind load - ASCE7-88

Velocity	100 mph
Exposure	C
I	1.0
Partially Enclosed	

Main Wind-Force Resisting System
- Main frames
- Endwall columns
- Longitudinal bracing
- Other members supporting tributary areas) 700 sf

Building Components and Cladding

Numbered zones per FSB Drawing 07.01

	Zone	Inward	Outward
Roof cladding	1	40.0 psf	-62.3 psf
	2	40.0 psf	-100.0 psf
	3	40.0 psf	-100.0 psf
Fasteners	1	40.0 psf	-67.2 psf
	2	40.0 psf	-122.9 psf
	3	40.0 psf	-122.9 psf
Joist purlins	1	40.0 psf	-60.6 psf
	2	40.0 psf	-93.4 psf
	3	40.0 psf	-93.4 psf
Decking, purlins	1	40.0 psf	-40.0 psf
	2	40.0 psf	-40.0 psf
	3	40.0 psf	-40.0 psf
Wall girts	5	35.9 psf	-60.6 psf
	6	37.8 psf	-83.6 psf
	7	39.7 psf	-106.5 psf

Seismic - SEAOC, 1990

Zone	4
I	1.0
Site coefficient	1.2

Temperature

Temperature differential of ±80 deg Farenheit

Megadoor loads

Detail loads are in accordance with Megadoor drawing A2-12401, Rev. B, dated 920207.

Gross load for main frame design

Open position dead load	100.4 kips	(doors and mullions)
Closed position dead load	87.8 kips	do

Pipe Racks

See Design Commentary pages 25-32 for detail

West side -6.7" [illegible]

East side -9.0" [illegible]

[illegible] side -6.7" [illegible]

IV. Load Combinations

A. Definitions - independent loads

Loading nomenclature for STAAD runs

Dead — D
Collateral dead — C
Roof snow - balanced — Sb
Roof snow - unbalanced left — Sul (40 psf left slope, 20 psf right slope)
Roof snow - unbalanced right — Sur (40 psf right slope, 20 psf left slope)
Wind -> external suction windward roof
internal pressure — W>ps
internal suction — W>ss
Wind -> external pressure windward roof
internal pressure — W>pp
internal suction — W>sp
Wind parallel to ridge
internal pressure — W|p
internal suction — W|s
Temperature — T
Seismic ->
Dead + collateral W — Ed>
Snow W — Es>
Crane W — Ec>
Seismic parallel to ridge
Compression chord (*)
Dead + collateral W — Edc|
Snow W — Esc|
Tension chord (*)
Dead + collateral W — Edt|
Snow W — Est|
Future crane
Single point load at one of twelve locations on the half frame, 10' oc. — Cri (i = 1 to 12)
See sketch at end of Commentary, page 18
Tail crane
Single point load at four locations on the half frame — Crti (i = 9 to 12)
See sketch at end of Commentary, page 18

(*) Note: 'Compression' and 'Tension' chord here always refer to the top chord of the frame trusses. The primary bracing system is located within the plane of the top chord in every other bay. Bottom chord seismic dead loads are carried to the frame top chord by vertical sway bracing. As one views the top chord bracing from above, longitudinal seismic loads will create compression in the top chord of one frame, and tension in the top chord of the adjacent frame. These are the 'Compression' and 'Tension' chords referred to here. See sketch at end of Commentary, p 28.

B. Combinations

No wind or seismic 1/3 stress increase is used for any load combination.

Main truss frames are designed for the following load combinations, using allowable stress design procedures and a value of K = 1.0 (K is a multiplier for the seismic loads) for the seismic load conditions. STAAD-III, Version 17.0 is used for the analysis and stress checking.

After all members in a particular frame are determined the frame is checked using a value of K = 3(Rw/8) = 2.25 for the seismic combinations. SEAOC paragraph 4G4, 'Low Buildings', is used to check the 'Strength' of the members. 'Strength' is defined in SEAOC paragraph 4C2 as follows:

Axial Compression   Psc = 1.7FaA
Axial Tension   Pst = FyA

STAAD-III checks the members using allowable stresses. Psc is 1.7 times the allowable, while Pst is 1.667 times the allowable. Thus, if the overstress in STAAD-III is less than 1.667 for any member it meets the 'Strength' criteria of paragraph 4G4.

Some question does arise with regard to what loading condition should be checked for the 'Strength' criteria. We have a 'Braced Frame Where Bracing Carries Gravity Loads'. In order to ensure that the frames meet the intent of paragraph 4G4, both the Specification defined load combinations, as well as seismic forces by themselves (no gravity loads, including dead) are checked.

K = 3*Rw/8 for seismic forces (SEAOC Paragraph 4G4)
Rw = 6 -> K = 2.25 for truss frames

Below is the Load Combinations used for frame analysis. Where a particular load combination does not occur on a particular frame (such as all cranes on frames 12 thru 14), the Load Combination is excluded from the analysis.

Dependent Load Group 1

FSB combination DL + LL + SL

Frames 6 thru 15

60	D + C + Sb	
61	D + C + Sul	
62 - 73	D + C + Cri + Sb	i = 1 to 12
74 - 85	D + C + Cri + Sul	do

Frames 2 thru 4

70 - 73	D + C + Crti + Sb	i = 9 to 12
82 - 85	D + C + Crti + Sul	do

DESIGN COMMENTARY

```
     Frame 5
62 - 73   D + C + Cri + Crt12 + Sb       i = 1 to 12
74 - 85   D + C + Cri + Crt12 + Sul          do

FSB combination DL + ELi
   86   D + C + KEd>
   87   D + C + KEd<
   88   D + C + KEdcl
   89   D + C + KEdtl

FSB combination DL + WLi
   91   D     + W>ps        Max uplift
   92   D     + W>ss
   93   D     + W<ps        Max uplift
   94   D     + W<ss
   95   D + C + W>pp
   96   D + C + W>sp        Max inward
   97   D + C + W<pp
   98   D + C + W<sp        Max inward
   99   D     + Wlp         Max uplift
  100   D +C  + Wls         Max inward

FSB combination DL + TL
  101   D + C + T

FSB combination DL - TL
  102   D + C - T

FSB combination 0.8DL + 1.0ELi
  103   0.8(D + C) + KEd>
  104   0.8(D + C) + KEd<
  105   0.8(D + C) + KEdcl
  106   0.8(D + C) + KEdtl

FSB combination 0.8DL + 1.0WLi
  107   0.8D       + W>ps        Max uplift
  108   0.8(D + C) + W>sp        Max inward
  109   0.8D       + W<ps        Max uplift
  110   0.8(D + C) + W<sp        Max inward
  111   0.8D       + Wlp         Max uplift
  112   0.8(D + C) + Wls         Max inward

FSB combination 0.8DL + 1.0TL
  113   0.8(D + C) + T

FSB combination 0.8DL - 1.0TL
  114   0.8(D + C) - T
```

1997

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VOLUME 2

STRUCTURAL ENGINEERING DESIGN PROVISIONS

INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS · 1922 ·
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A-2

Division III—WIND DESIGN

SECTION 1615 — GENERAL

Every building or structure and every portion thereof shall be designed and constructed to resist the wind effects determined in accordance with the requirements of this division. Wind shall be assumed to come from any horizontal direction. No reduction in wind pressure shall be taken for the shielding effect of adjacent structures.

Structures sensitive to dynamic effects, such as buildings with a height-to-width ratio greater than five, structures sensitive to wind-excited oscillations, such as vortex shedding or icing, and buildings over 400 feet (121.9 m) in height, shall be, and any structure may be, designed in accordance with approved national standards.

The provisions of this section do not apply to building and foundation systems in those areas subject to scour and water pressure by wind and wave action. Buildings and foundations subject to such loads shall be designed in accordance with approved national standards.

Allows use of ASCE 7-93

SECTION 1616 — DEFINITIONS

The following definitions apply only to this division:

BASIC WIND SPEED is the fastest-mile wind speed associated with an annual probability of 0.02 measured at a point 33 feet (10 000 mm) above the ground for an area having exposure category C.

EXPOSURE B has terrain with buildings, forest or surface irregularities, covering at least 20 percent of the ground level area extending 1 mile (1.61 km) or more from the site.

EXPOSURE C has terrain that is flat and generally open, extending $^1/_2$ mile (0.81 km) or more from the site in any full quadrant.

EXPOSURE D represents the most severe exposure in areas with basic wind speeds of 80 miles per hour (mph) (129 km/h) or greater and has terrain that is flat and unobstructed facing large bodies of water over 1 mile (1.61 km) or more in width relative to any quadrant of the building site. Exposure D extends inland from the shoreline $^1/_4$ mile (0.40 km) or 10 times the building height, whichever is greater.

FASTEST-MILE WIND SPEED is the wind speed obtained from wind velocity maps prepared by the National Oceanographic and Atmospheric Administration and is the highest sustained average wind speed based on the time required for a mile-long sample of air to pass a fixed point.

OPENINGS are apertures or holes in the exterior wall boundary of the structure. All windows or doors or other openings shall be considered as openings unless such openings and their frames are specifically detailed and designed to resist the loads on elements and components in accordance with the provisions of this section.

PARTIALLY ENCLOSED STRUCTURE OR STORY is a structure or story that has more than 15 percent of any windward projected area open and the area of opening on all other projected areas is less than half of that on the windward projection.

SPECIAL WIND REGION is an area where local records and terrain features indicate 50-year fastest-mile basic wind speed is higher than shown in Figure 16-1.

UNENCLOSED STRUCTURE OR STORY is a structure that has 85 percent or more openings on all sides.

SECTION 1617 — SYMBOLS AND NOTATIONS

The following symbols and notations apply to the provisions of this division.

C_e = combined height, exposure and gust factor coefficient as given in Table 16-G.

C_q = pressure coefficient for the structure or portion of structure under consideration as given in Table 16-H.

I_W = importance factor as set forth in Table 16-K.

P = design wind pressure.

q_s = wind stagnation pressure at the standard height of 33 feet (10 000 mm) as set forth in Table 16-F.

SECTION 1618 — BASIC WIND SPEED

The minimum basic wind speed at any site shall not be less than that shown in Figure 16-1. For those areas designated in Figure 16-1 as special wind regions and other areas where local records or terrain indicate higher 50-year (mean recurrence interval) fastest-mile wind speeds, these higher values shall be the minimum basic wind speeds.

SECTION 1619 — EXPOSURE

An exposure shall be assigned at each site for which a building or structure is to be designed.

SECTION 1620 — DESIGN WIND PRESSURES

Design wind pressures for buildings and structures and elements therein shall be determined for any height in accordance with the following formula:

$$P = C_e\, C_q\, q_s\, I_w \qquad (20\text{-}1)$$

SECTION 1621 — PRIMARY FRAMES AND SYSTEMS

1621.1 General. The primary frames or load-resisting system of every structure shall be designed for the pressures calculated using Formula (20-1) and the pressure coefficients, C_q, of either Method 1 or Method 2. In addition, design of the overall structure and its primary load-resisting system shall conform to Section 1605.

The base overturning moment for the entire structure, or for any one of its individual primary lateral-resisting elements, shall not exceed two thirds of the dead-load-resisting moment. For an entire structure with a height-to-width ratio of 0.5 or less in the wind direction and a maximum height of 60 feet (18 290 mm), the combination of the effects of uplift and overturning may be reduced by one third. The weight of earth superimposed over footings may be used to calculate the dead-load-resisting moment.

1621.2 Method 1 (Normal Force Method). Method 1 shall be used for the design of gabled rigid frames and may be used for any structure. In the Normal Force Method, the wind pressures shall be assumed to act simultaneously normal to all exterior surfaces. For pressures on roofs and leeward walls, C_e shall be evaluated at the mean roof height.

1621.3 Method 2 (Projected Area Method). Method 2 may be used for any structure less than 200 feet (60 960 mm) in height except those using gabled rigid frames. This method may be used in stability determinations for any structure less than 200 feet (60 960 mm) high. In the Projected Area Method, horizontal pressures shall be assumed to act upon the full vertical projected area of the structure, and the vertical pressures shall be assumed to act simultaneously upon the full horizontal projected area.

SECTION 1622 — ELEMENTS AND COMPONENTS OF STRUCTURES

Design wind pressures for each element or component of a structure shall be determined from Formula (20-1) and C_q values from Table 16-H, and shall be applied perpendicular to the surface. For outward acting forces the value of C_e shall be obtained from Table 16-G based on the mean roof height and applied for the entire height of the structure. Each element or component shall be designed for the more severe of the following loadings:

1. The pressures determined using C_q values for elements and components acting over the entire tributary area of the element.

2. The pressures determined using C_q values for local areas at discontinuities such as corners, ridges and eaves. These local pressures shall be applied over a distance from a discontinuity of 10 feet (3048 mm) or 0.1 times the least width of the structure, whichever is less.

The wind pressures from Sections 1621 and 1622 need not be combined.

SECTION 1623 — OPEN-FRAME TOWERS

Radio towers and other towers of trussed construction shall be designed and constructed to withstand wind pressures specified in this section, multiplied by the shape factors set forth in Table 16-H.

SECTION 1624 — MISCELLANEOUS STRUCTURES

Greenhouses, lath houses, agricultural buildings or fences 12 feet (3658 mm) or less in height shall be designed in accordance with Chapter 16, Division III. However, three fourths of q_s, but not less than 10 psf (0.48 kN/m^2), may be substituted for q_s in Formula (20-1). Pressures on local areas at discontinuities need not be considered.

SECTION 1625 — OCCUPANCY CATEGORIES

For the purpose of wind-resistant design, each structure shall be placed in one of the occupancy categories listed in Table 16-K. Table 16-K lists importance factors, I_w, for each category.

TABLE 16-F—WIND STAGNATION PRESSURE (q_s) AT STANDARD HEIGHT OF 33 FEET (10 058 mm)

Basic wind speed (mph)[1] (× 1.61 for km/h)	70	80	90	100	110	120	130
Pressure q_s (psf) (× 0.0479 for kN/m^2)	12.6	16.4	20.8	25.6	31.0	36.9	43.3

[1]Wind speed from Section 1618.

TABLE 16-G—COMBINED HEIGHT, EXPOSURE AND GUST FACTOR COEFFICIENT (C_e)[1]

HEIGHT ABOVE AVERAGE LEVEL OF ADJOINING GROUND (feet) × 304.8 for mm	EXPOSURE D	EXPOSURE C	EXPOSURE B
0-15	1.39	1.06	0.62
20	1.45	1.13	0.67
25	1.50	1.19	0.72
30	1.54	1.23	0.76
40	1.62	1.31	0.84
60	1.73	1.43	0.95
80	1.81	1.53	1.04
100	1.88	1.61	1.13
120	1.93	1.67	1.20
160	2.02	1.79	1.31
200	2.10	1.87	1.42
300	2.23	2.05	1.63
400	2.34	2.19	1.80

[1]Values for intermediate heights above 15 feet (4572 mm) may be interpolated.

At mean roof ht., h = 78.5 ft.

$C_e \cong 1.52$

TABLE 16-H—PRESSURE COEFFICIENTS (C_q)

STRUCTURE OR PART THEREOF	DESCRIPTION	C_q FACTOR
1. Primary frames and systems	**Method 1** (Normal force method)	
	Walls:	
	Windward wall	0.8 inward
	Leeward wall	0.5 outward
	Roofs[1]:	
	Wind perpendicular to ridge	
	Leeward roof or flat roof	0.7 outward
	Windward roof	
	less than 2:12 (16.7%)	0.7 outward
	Slope 2:12 (16.7%) to less than 9:12 (75%)	0.9 outward or 0.3 inward
	Slope 9:12 (75%) to 12:12 (100%)	0.4 inward
	Slope > 12:12 (100%)	0.7 inward
	Wind parallel to ridge and flat roofs	0.7 outward
	Method 2 (Projected area method)	
	On vertical projected area	
	Structures 40 feet (12 192 mm) or less in height	1.3 horizontal any direction
	Structures over 40 feet (12 192 mm) in height	1.4 horizontal any direction
	On horizontal projected area[1]	0.7 upward
2. Elements and components not in areas of discontinuity[2]	Wall elements	
	All structures	1.2 inward
	Enclosed and unenclosed structures	1.2 outward
	Partially enclosed structures	1.6 outward
	Parapets walls	1.3 inward or outward
	Roof elements[3]	
	Enclosed and unenclosed structures	
	Slope < 7:12 (58.3%)	1.3 outward
	Slope 7:12 (58.3%) to 12:12 (100%)	1.3 outward or inward
	Partially enclosed structures	
	Slope < 2:12 (16.7%)	1.7 outward
	Slope 2:12 (16.7%) to 7:12 (58.3%)	1.6 outward or 0.8 inward
	Slope > 7:12 (58.3%) to 12:12 (100%)	1.7 outward or inward
3. Elements and components in areas of discontinuities[2,4,5]	Wall corners[6]	1.5 outward or 1.2 inward
	Roof eaves, rakes or ridges without overhangs[6]	
	Slope < 2:12 (16.7%)	2.3 upward
	Slope 2:12 (16.7%) to 7:12 (58.3%)	2.6 outward
	Slope > 7:12 (58.3%) to 12:12 (100%)	1.6 outward
	For slopes less than 2:12 (16.7%)	
	Overhangs at roof eaves, rakes or ridges, and canopies	0.5 added to values above
4. Chimneys, tanks and solid towers	Square or rectangular	1.4 any direction
	Hexagonal or octagonal	1.1 any direction
	Round or elliptical	0.8 any direction
5. Open-frame towers[7,8]	Square and rectangular	
	Diagonal	4.0
	Normal	3.6
	Triangular	3.2
6. Tower accessories (such as ladders, conduit, lights and elevators)	Cylindrical members	
	2 inches (51 mm) or less in diameter	1.0
	Over 2 inches (51 mm) in diameter	0.8
	Flat or angular members	1.3
7. Signs, flagpoles, lightpoles, minor structures[8]		1.4 any direction

[1]For one story or the top story of multistory partially enclosed structures, an additional value of 0.5 shall be added to the outward C_q. The most critical combination shall be used for design. For definition of partially enclosed structures, see Section 1616.

[2]C_q values listed are for 10-square-foot (0.93 m^2) tributary areas. For tributary areas of 100 square feet (9.29 m^2), the value of 0.3 may be subtracted from C_q, except for areas at discontinuities with slopes less than 7 units vertical in 12 units horizontal (58.3% slope) where the value of 0.8 may be subtracted from C_q. Interpolation may be used for tributary areas between 10 and 100 square feet (0.93 m^2 and 9.29 m^2). For tributary areas greater than 1,000 square feet (92.9 m^2), use primary frame values.

[3]For slopes greater than 12 units vertical in 12 units horizontal (100% slope), use wall element values.

[4]Local pressures shall apply over a distance from the discontinuity of 10 feet (3048 mm) or 0.1 times the least width of the structure, whichever is smaller.

[5]Discontinuities at wall corners or roof ridges are defined as discontinuous breaks in the surface where the included interior angle measures 170 degrees or less.

[6]Load is to be applied on either side of discontinuity but not simultaneously on both sides.

[7]Wind pressures shall be applied to the total normal projected area of all elements on one face. The forces shall be assumed to act parallel to the wind direction.

[8]Factors for cylindrical elements are two thirds of those for flat or angular elements.

TABLE 16-I—SEISMIC ZONE FACTOR Z

ZONE	1	2A	2B	3	4
Z	0.075	0.15	0.20	0.30	0.40

NOTE: The zone shall be determined from the seismic zone map in Figure 16-2.

TABLE 16-J—SOIL PROFILE TYPES

SOIL PROFILE TYPE	SOIL PROFILE NAME/GENERIC DESCRIPTION	AVERAGE SOIL PROPERTIES FOR TOP 100 FEET (30 480 mm) OF SOIL PROFILE		
		Shear Wave Velocity, $\bar{v}_s$ feet/second (m/s)	Standard Penetration Test, $\bar{N}$ [or $\bar{N}_{CH}$ for cohesionless soil layers] (blows/foot)	Undrained Shear Strength, $\bar{s}_u$ psf (kPa)
S_A	Hard Rock	> 5,000 (1,500)	—	—
S_B	Rock	2,500 to 5,000 (760 to 1,500)		
S_C	Very Dense Soil and Soft Rock	1,200 to 2,500 (360 to 760)	> 50	> 2,000 (100)
S_D	Stiff Soil Profile	600 to 1,200 (180 to 360)	15 to 50	1,000 to 2,000 (50 to 100)
S_E[1]	Soft Soil Profile	< 600 (180)	< 15	< 1,000 (50)
S_F	Soil Requiring Site-specific Evaluation. See Section 1629.3.1.			

[1]Soil Profile Type S_E also includes any soil profile with more than 10 feet (3048 mm) of soft clay defined as a soil with a plasticity index, $PI > 20$, $w_{mc} \geq 40$ percent and $s_u < 500$ psf (24 kPa). The Plasticity Index, PI, and the moisture content, w_{mc}, shall be determined in accordance with approved national standards.

TABLE 16-K—OCCUPANCY CATEGORY

OCCUPANCY CATEGORY	OCCUPANCY OR FUNCTIONS OF STRUCTURE	SEISMIC IMPORTANCE FACTOR, I	SEISMIC IMPORTANCE[1] FACTOR, I_p	WIND IMPORTANCE FACTOR, I_w
1. Essential facilities[2]	Group I, Division 1 Occupancies having surgery and emergency treatment areas Fire and police stations Garages and shelters for emergency vehicles and emergency aircraft Structures and shelters in emergency-preparedness centers Aviation control towers Structures and equipment in government communication centers and other facilities required for emergency response Standby power-generating equipment for Category 1 facilities Tanks or other structures containing housing or supporting water or other fire-suppression material or equipment required for the protection of Category 1, 2 or 3 structures	1.25	1.50	1.15
2. Hazardous facilities	Group H, Divisions 1, 2, 6 and 7 Occupancies and structures therein housing or supporting toxic or explosive chemicals or substances Nonbuilding structures housing, supporting or containing quantities of toxic or explosive substances that, if contained within a building, would cause that building to be classified as a Group H, Division 1, 2 or 7 Occupancy	1.25	1.50	1.15
3. Special occupancy structures[3]	Group A, Divisions 1, 2 and 2.1 Occupancies Buildings housing Group E, Divisions 1 and 3 Occupancies with a capacity greater than 300 students Buildings housing Group B Occupancies used for college or adult education with a capacity greater than 500 students Group I, Divisions 1 and 2 Occupancies with 50 or more resident incapacitated patients, but not included in Category 1 Group I, Division 3 Occupancies All structures with an occupancy greater than 5,000 persons Structures and equipment in power-generating stations, and other public utility facilities not included in Category 1 or Category 2 above, and required for continued operation	1.00	1.00	1.00
4. Standard occupancy structures[3]	All structures housing occupancies or having functions not listed in Category 1, 2 or 3 and Group U Occupancy towers	1.00	1.00	1.00
5. Miscellaneous structures	Group U Occupancies except for towers	1.00	1.00	1.00

[1]The limitation of I_p for panel connections in Section 1633.2.4 shall be 1.0 for the entire connector.
[2]Structural observation requirements are given in Section 1702.
[3]For anchorage of machinery and equipment required for life-safety systems, the value of I_p shall be taken as 1.5.

A-7

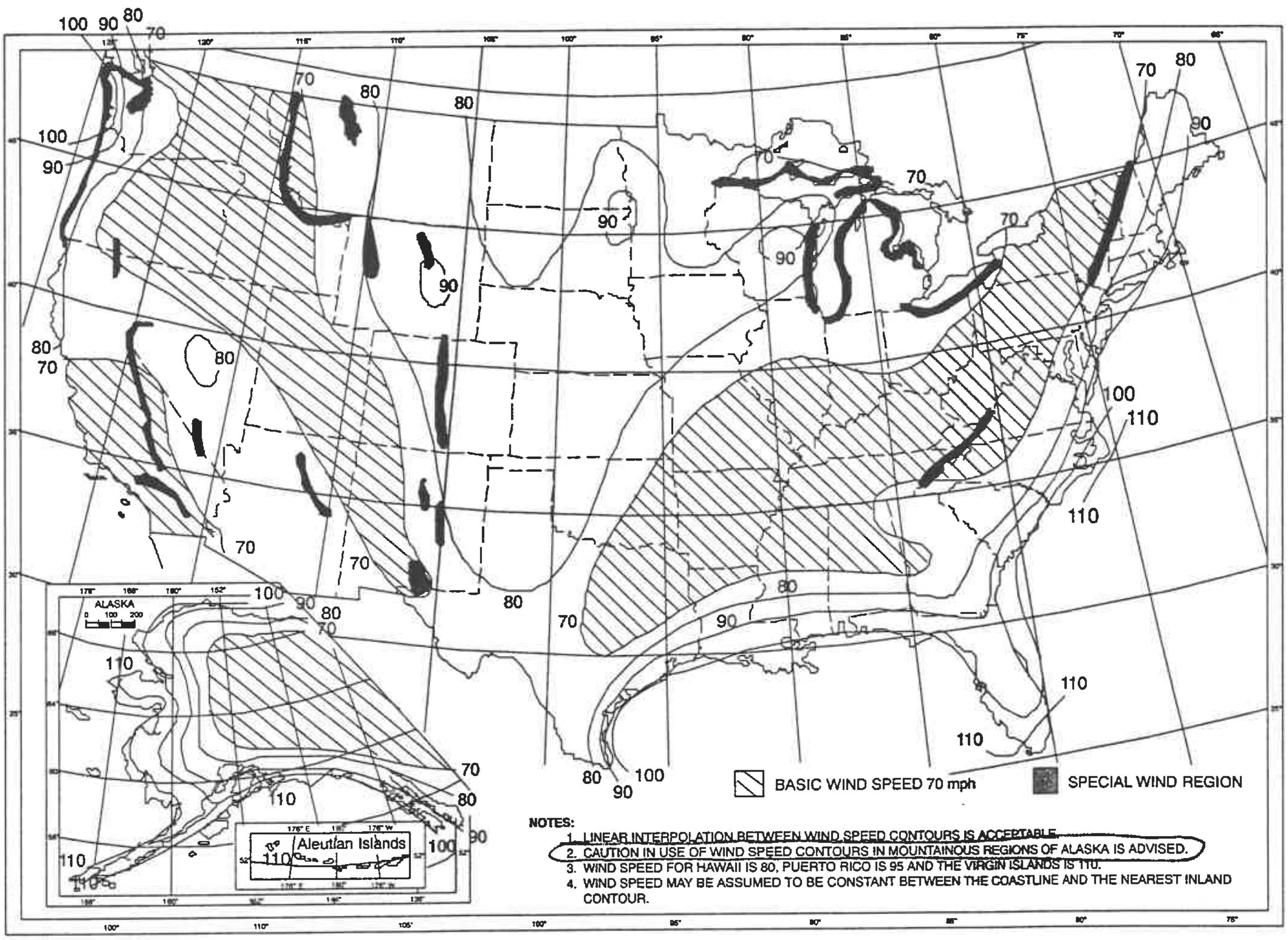

FIGURE 16-1—MINIMUM BASIC WIND SPEEDS IN MILES PER HOUR (× 1.61 for km/h)

Anchorage Amendments to 1997 UBC require a basic wind speed of 80, 90, or 100 mph depending on location within Anchorage.

Appendix B – Wind Provisions of ASCE 7-93

ASCE 7-93

American Society of Civil Engineers

Minimum Design Loads for Buildings and Other Structures

Revision of
ANSI/ASCE 7-88

Note: This revision of the ASCE 7-88 standard includes a major revision of Section 9, Earthquake Loads and corresponding revisions to Section 2, Combination of Loads. All other sections of the ASCE 7-88 standard are unchanged.

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$$L_r = 20R_1R_2 \geq 12 \qquad \text{(Eq. 2)}$$

where L_r = roof load per square foot of horizontal projection, in pounds per square foot.

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

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

where A_t = tributary area in square feet for any structural member and

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

where, for a pitched roof, F = number of inches of rise per foot and, for an arch or dome, F = rise-to-span ratio multiplied by 32.

4.11.2 Special-Purpose Roofs. Roofs used for promenade purposes shall be designed for a minimum live load of 60 lb/ft^2. Roofs used for roof gardens or assembly purposes shall be designed for a minimum live load of 100 lb/ft^2. Roofs used for other special purposes shall be designed for appropriate loads, as directed or approved by the authority having jurisdiction.

4.12 References

The following standards are referred to in this section:

1. American National Standard Practice for the Inspection of Elevators, Escalators, and Moving Walks (Inspectors' Manual), ANSI A17.2-1985.

2. American National Standard Safety Code for Elevators and Escalators, ANSI/ASME A17.1-1984.

3. American National Standard for Assembly Seating, Tents, and Air-Supported Structures, ANSI/-NFPA 102-1986.

5. Soil and Hydrostatic Pressure

5.1 Pressure on Basement Walls

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

5.2 Uplift on Floors

In the design of basement floors and similar approximately 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. Any other upward loads shall be considered.

6. Wind Loads

6.1 General

Provisions for the determination of wind loads on buildings and other structures are described in the following subsections. These provisions apply to the calculation of wind loads for main wind-force resisting systems and for individual structural components and cladding of buildings and other structures. Specific guidelines are given for using wind-tunnel investigations to determine wind loading and structural response for buildings or structures having irregular geometric shapes, response characteristics, or site locations with shielding or channeling effects that warrant special consideration, or for cases in which more accurate wind loading is desired.

6.1.1 Wind Loads During Erection and Construction Phases. Adequate temporary bracing shall be provided to resist wind loading on structural components and structural assemblages during the erection and construction phases.

6.1.2 Overturning and Sliding. The overturning moment due to wind load shall not exceed two-thirds of the dead load stabilizing moment unless the building or structure is anchored so as to resist the excess moment. When the total resisting force due to friction is insufficient to prevent sliding, anchorage shall be provided to resist the excess sliding force.

6.2 Definitions

The following definitions apply only to the provisions of Section 6:

Basic wind speed, V: fastest-mile wind speed at 33 feet (10 meters) above the ground of terrain Exposure C (see 6.5.3.1) and associated with an annual probability of occurrence of 0.02.

Buildings: structures that enclose a space.

Components and cladding: structural elements that are either directly loaded by the wind or receive wind loads originating at relatively close locations and that transfer those loads to the main wind-force resisting system. Examples include curtain walls, exterior glass windows and panels, roof sheathing, purlins, girts, studs, and roof trusses.

Design Force, F: equivalent static force to be used in the determination of wind loads for unenclosed buildings and structures (called *other structures* herein). The force is assumed to act on the gross structure or components and cladding thereof in a direction parallel to the wind (not necessarily normal to the surface area) and shall be considered to vary with respect to height in accordance with the velocity pressure q_z evaluated at height z.

Design pressure, p: equivalent static pressure to be used in the determination of wind loads for *buildings*. The pressure shall be assumed to act in a direction normal to the surface considered and is denoted as:

p_z = pressure that varies with height in accordance with the velocity pressure q_z evaluated at height z, or

p_h = pressure that is uniform with respect to height as determined by the velocity pressure q_h evaluated at mean roof height h.

Flexible buildings and structures: slender *buildings* and *other structures* having a height exceeding five times the least horizontal dimension or a fundamental natural frequency less than 1 Hz. For those cases in which the horizontal dimensions vary with height, the least horizontal dimension at midheight shall be used.

Importance factor, I: a factor that accounts for the degree of hazard to human life and damage to property (see Commentary, 1.4).

Main wind-force resisting system: an assemblage of major structural elements assigned to provide support for secondary members and cladding. The system primarily receives wind loading from relatively remote locations. Examples include rigid and braced frames, space trusses, roof and floor diaphragms, shear walls, and rod-braced frames.

Other structures: unenclosed buildings and structures.

Tributary area, A: that portion of the surface area receiving wind loads assigned to be supported by the structural element considered. For a rectangular tributary area, the width of the area need not be less than one-third the length of the area.

6.3 Symbols and Notation

The following symbols and notation apply only to the provisions of Section 6:

A = tributary area, in square feet;
a = width of pressure coefficient zone, in feet;
A_f = area of other structures or components and cladding thereof projected on a plane normal to wind direction, in square feet;
B = horizontal dimension of buildings or other structures measured normal to wind direction, in feet;
C_D = force coefficient for horizontal component of wind force on tower guy;
C_f = force coefficient to be used in determination of wind loads for other structures;
C_L = force coefficient for lift component of wind force on tower guy;
C_p = external pressure coefficient to be used in determination of wind loads for buildings;
C_{pi} = internal pressure coefficient to be used in determination of wind loads for buildings;
D = diameter of a circular structure or member, in feet;
D' = depth of protruding elements (ribs or spoilers), in feet;
F = design wind force, in pounds;
f = fundamental frequency of vibration, in Hz;
G = gust response factor;
$\overline{G}$ = gust response factor for main wind-force resisting systems of flexible buildings and structures;
G_h = gust response factor for main wind-force resisting systems evaluated at height $z = h$;
G_z = gust response factor for components and cladding evaluated at height z above ground;

GC_p = product of external pressure coefficient and gust response factor to be used in determination of wind loads for buildings;

GC_{pi} = product of internal pressure coefficient and gust response factor to be used in determination of wind loads for buildings;

h = mean roof height of a building or height of other structure, except that eave height may be used for roof slope of less than 10 degrees, in feet;

I = importance factor;

K_z = velocity pressure exposure coefficient evaluated at height z;

L = horizontal dimension of a building or other structure measured parallel to wind direction, in feet;

M = larger dimension of sign, in feet;

N = smaller dimension of sign, in feet;

p = design pressure to be used in determination of wind loads for buildings, in pounds per square foot;

p_h = design pressure evaluated at height $z = h$, in pounds per square foot;

p_z = design pressure evaluated at height z above ground, in pounds per square foot;

q = velocity pressure, in pounds per square foot;

q_h = velocity pressure evaluated at height $z = h$, in pounds per square foot;

q_z = velocity pressure evaluated at height z above ground, in pounds per square foot;

r = rise-to-span ratio for arched roofs;

V = basic wind speed obtained from Fig. 1 and Table 7, in miles per hour;

X = distance to center of pressure from windward edge, in feet;

z = height above ground level, in feet;

ϵ = ratio of solid area to gross area for open sign, face of a trussed tower, or lattice structure;

θ = angle of plane of roof from horizontal, in degrees;

ν = height-to-width ratio for sign; and

ϕ = angle between wind direction and chord of tower guy, in degrees.

6.4 Calculation of Wind Loads

6.4.1 General. The design wind loads for buildings and other structures as a whole or for individual components and cladding thereof shall be determined using one of the following procedures: (1) analytical procedure in accordance with 6.4.2 or (2) wind-tunnel procedure in accordance with 6.4.3.

6.4.2 Analytical Procedure. Design wind pressures for buildings and design wind forces for other structures shall be determined in accordance with the appropriate equations given in Table 4 using the following procedure:

1. A velocity pressure q (q_z or q_h) is determined in accordance with the provisions of 6.5.
2. A gust response factor G is determined in accordance with the provisions of 6.6.
3. Appropriate pressure or force coefficients are selected from the provisions of 6.7.

The equations given in Table 4 are for determination of: (1) wind loading on main wind-force resisting systems, and (2) wind loading on individual components and cladding.

6.4.2.1 Minimum Design Wind Loading. The wind load used in the design of the main wind-force resisting system for buildings and other structures shall be not less than 10 lb/ft^2 multiplied by the area of the building or structure projected on a vertical plane that is normal to the wind direction.

In the calculation of design wind loads for components and cladding for buildings, the pressure difference between opposite faces shall be taken into consideration. The combined design pressure shall be not less than 10 lb/ft^2 acting in either direction normal to the surface.

The wind load used in the design of components and cladding for other structures shall be not less than 10 lb/ft^2 multiplied by the projected area A_f.

6.4.2.2 Limitations of Analytical Procedure. The provisions given under 6.4.2 apply to the majority of buildings and other structures, but the designer is cautioned that judgment is required for those buildings and structures having unusual geometric shapes, response characteristics, or site locations for which channeling effects or buffeting in the wake of upwind obstructions may warrant special consideration. For such situations, the designer should refer to recognized literature for documentation pertaining to wind-load effects or use the wind-tunnel procedure of 6.4.3.

6.4.2.2.1 Buildings. An example of a building with an unusual geometric shape for which the provisions of 6.4.2 may not be applicable is a dome.

6.4.2.2.2 Other Structures. Examples of other structures for which the provisions of 6.4.2 may not be applicable include bridges and cranes.

6.4.2.2.3 Flexible Buildings and Structures. The provisions of 6.4.2 take into consideration the load magnification effect caused by gusts in resonance with alongwind vibrations of the structure but do not include allowances for crosswind or torsional loading, vortex shedding, or instability due to galloping or flutter.

Table 4
Design Wind Pressures, *p*, and Forces, *F*

Design wind loading	Buildings		Other structures	Flexible Buildings and Structures (Height/Least Horizontal Dimension > 5 or f < 1 Hz) Buildings	Flexible Buildings and Structures (Height/Least Horizontal Dimension > 5 or f < 1 Hz) Other structures
Main wind-force resisting systems	$p = qG_hC_p - q_h(GC_{pi})$ # ** q: q_z for windward wall evaluated at height z above ground q_h for leeward wall, side walls, and roof evaluated at mean roof height G_h: given in Table 8 C_p: given in Fig. 2 (Table 10 for arched roofs) GC_{pi}: given in Table 9		$F = q_zG_hC_fA_f$ q_z: evaluated at height z above ground G_h: given in Table 8 C_f: given in Tables 11-16 A_f: projected area normal to wind†	$p = q\bar{G}C_p$ # q: q_z for windward wall evaluated at height z above ground q_h for leeward wall evaluated at mean roof height $\bar{G}$: obtained by rational analysis C_p: given in Fig. 2	$F = q_z\bar{G}C_fA_f$ q_z: evaluated at height z above ground $\bar{G}$: obtained by rational analysis C_f: given in Tables 11-16 A_f: projected area normal to wind†
	$h \leq 60$ ft	$h > 60$ ft			
Components and cladding‡	$p = q_h[(GC_p) - (GC_{pi})]$** q_h: evaluated at mean roof height using Exposure C (see 6.5.3) for all terrains GC_p: given in Figs. 3a and 3b GC_{pi}: given in Table 9	$p = q[(GC_p) - (GC_{pi})]$** q: q_z for positive pressure evaluated at height z above ground q_h for negative pressure evaluated at mean roof height GC_p: Given in Fig. 4§ GC_{pi}: Given in Table 9	$F = q_z G_zC_fA_f$ q_z: evaluated at height z above ground G_z: given in Table 8 C_f: given in Tables 11-16 A_f: projected area normal to wind†	$p = q[(GC_p) - (GC_{pi})]$** q: q_z for positive pressure evaluated at height z above ground q_h for negative pressure evaluated at mean roof height GC_p: Given in Fig. 4 GC_{pi}: Given in Table 9	$F = q_zG_zC_fA_f$ q_z: evaluated at height z above ground G_z: given in Table 8 C_f: given in Tables 11-16 A_f: projected area normal to wind†

**Positive pressure acts toward surface and negative pressure acts away from surface; values of external and internal pressures shall be combined algebraically to ascertain most critical load.

#Pressure shall be applied simultaneously on windward and leeward walls and on roof surfaces as shown in Fig. 2.

†A_f is the projected area normal to the wind except where C_f is given for the surface area.

‡Major structural components supporting tributary areas greater than 700 ft^2 in extent may be designed using the provisions for main wind-force resisting systems.

§In the design of components and cladding for buildings having a mean roof height h, 60 ft $< h <$ 90 ft, GC_p values of Fig. 3 may be used provided q is taken as q_h and Exposure C (see 6.5.3) is used for all terrains.

NOTE: Pressures are in pounds per square foot; forces are in pounds.

B-6

6.4.3 Wind-Tunnel Procedure. Properly conducted wind-tunnel tests or similar tests employing fluids other than air may be used for the determination of design wind loads in lieu of the provisions of 6.4.2. This procedure is recommended for those buildings or structures having unusual geometric shapes, response characteristics, or site locations for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration, and for which no reliable documentation pertaining to wind effects is available in the literature. The procedure is also recommended for those buildings or structures for which more accurate wind-loading information is desired.

Tests for the determination of mean and fluctuating forces and pressures shall be considered to be properly conducted only if: (1) the natural wind has been modeled to account for the variation of wind speed with height; (2) the natural wind has been modeled to account for the intensity of the longitudinal component of turbulence; (3) the geometric scale of the structural model is not more than three times the geometric scale of the longitudinal component of turbulence; (4) the response characteristics of the wind-tunnel instrumentation are consistent with the measurements to be made; and (5) due regard is given to the dependence of forces and pressures on the Reynolds number.

Tests for the purpose of determining the dynamic response of a structure shall be considered to be properly conducted only if requirements (1) through (5) are satisfied and the structural model is scaled with due regard to length, mass distribution, stiffness, and damping.

6.5 Velocity Pressure

6.5.1 Procedure for Calculating Velocity Pressure. The velocity pressure q_z at height z shall be calculated from the formula:

$$q_z = 0.00256K_z(IV)^2 \quad \text{(Eq.3)}$$

where the basic wind speed V is selected in accordance with the provisions of 6.5.2, the importance factor I is set forth in Table 5, and the velocity pressure exposure coefficient K_z is given in Table 6 in accordance with the provisions of 6.5.3. The numerical coefficient 0.00256 shall be used except where sufficient climatic data are available to justify the selection of a different value of this factor for a specific design application.

6.5.2 Selection of Basic Wind Speed. The basic wind speed V used in the determination of design wind loads on buildings and other structures shall be as given in Fig. 1 for the contiguous United States and Alaska and in Table 7 for Hawaii and Puerto Rico except as provided in 6.5.2.1 and 6.5.2.2. The basic wind speed used shall be at least 70 mph.

6.5.2.1 Special Wind Regions. Special consideration shall be given to those regions for which records or experience indicates that the wind speeds are higher than those reflected in Fig. 1 and Table 7. Some special regions are indicated in Fig. 1; however, all mountainous terrain, gorges, and ocean promontories shall be examined for unusual wind conditions and the authority having jurisdiction shall, if necessary, adjust the values given in Fig. 1 and Table 7 to account for higher local winds. Where necessary, such adjustment shall be based on meteorological advice and an estimate of the basic wind

Table 5
Importance Factor, *I* (Wind Loads)

Category*	*I*: 100 miles from hurricane oceanline and in other areas	*I*: At hurricane oceanline
I	1.00	1.05
II	1.07	1.11
III	1.07	1.11
IV	0.95	1.00

*See 1.4 and Table 1.

NOTES:
(1) The building and structure classification categories are listed in Table 1.
(2) For regions between the hurricane oceanline and 100 miles inland the importance factor I shall be determined by linear interpolation.
(3) Hurricane oceanlines are the Atlantic and Gulf of Mexico coastal areas.

⟹ I = 1.00

Table 6
Velocity Pressure Exposure Coefficient, K_z

Height above ground level, z (feet)	K_z Exposure A	Exposure B	Exposure C	Exposure D
0 - 15	0.12	0.37	0.80	1.20
20	0.15	0.42	0.87	1.27
25	0.17	0.46	0.93	1.32
30	0.19	0.50	0.98	1.37
40	0.23	0.57	1.06	1.46
50	0.27	0.63	1.13	1.52
60	0.30	0.68	1.19	1.58
70	0.33	0.73	1.24	1.63
80	0.37	0.77	1.29	1.67
90	0.40	0.82	1.34	1.71
100	0.42	0.86	1.38	1.75
120	0.48	0.93	1.45	1.81
140	0.53	0.99	1.52	1.87
160	0.58	1.05	1.58	1.92
180	0.63	1.11	1.63	1.97
200	0.67	1.16	1.68	2.01
250	0.78	1.28	1.79	2.10
300	0.88	1.39	1.88	2.18
350	0.98	1.49	1.97	2.25
400	1.07	1.58	2.05	2.31
450	1.16	1.67	2.12	2.36
500	1.24	1.75	2.18	2.41

NOTES:
(1) Linear interpolation for intermediate values of height z is acceptable.
(2) For values of height z greater than 500 feet, K_z may be calculated from Eq. C3 in the Commentary.
(3) Exposure categories are defined in 6.5.3.

Table 7
Basic Wind Speed, V

Location	V (mph)
Hawaii	80
Puerto Rico	95

NOTE: The unique topographical features common to the islands of Hawaii and Puerto Rico suggest that it may be advisable to adjust the values given in Table 7 to account for locally higher winds for structures sited near mountainous terrain, gorges, and ocean promontories.

speed obtained in accordance with the provisions of 6.5.2.2.

6.5.2.2 Estimation of Basic Wind Speeds from Climatic Data. Regional climatic data may be used in lieu of the basic wind speeds given in Fig. 1 and Table 7 provided: (1) acceptable extreme-value statistical-analysis procedures have been employed in reducing the data; (2) due regard is given to the length of record, averaging time, anemometer height, data quality, and terrain exposure; and (3) the basic wind speed used is not less than 70 mph.

6.5.2.3 Limitation. Tornadoes have not been considered in developing the basic wind-speed distributions. For those structures or buildings that must be designed to resist tornadic winds the designer is referred to the references in the Commentary (see C6.5.2.3) on tornado-resistant design.

6.5.3 Exposure Categories.

6.5.3.1 General. An exposure category that adequately reflects the characteristics of ground surface irregularities shall be determined for the site at which the building or structure is to be constructed.

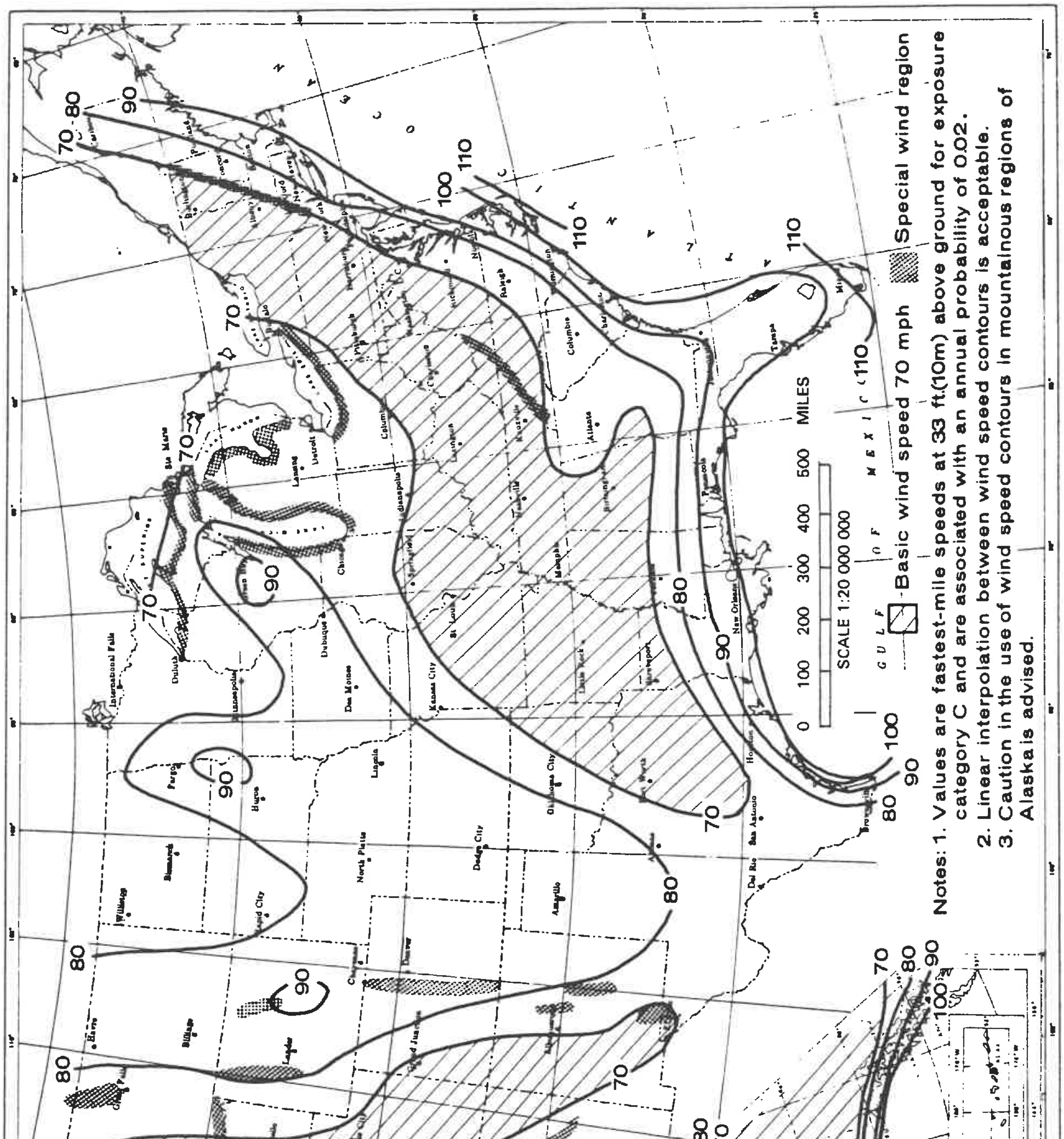


Fig. 1. Basic Wind Speed (mph)

B-9

Account shall be taken of large variations in ground surface roughness that arise from natural topography and vegetation as well as from constructed features. The exposure in which a specific building or structure is sited shall be assessed as being one of the following categories:

1. *Exposure A*. Large city centers with at least 50% of the buildings having a height in excess of 70 feet. Use of this exposure category shall be limited to those areas for which terrain representative of Exposure A prevails in the upwind direction for a distance of at least one-half mile or 10 times the height of the building or structure, whichever is greater. Possible channeling effects or increased velocity pressures due to the building or structure being located in the wake of adjacent buildings shall be taken into account.

2. *Exposure B*. Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. Use of this exposure category shall be limited to those areas for which terrain representative of Exposure B prevails in the upwind direction for a distance of at least 1500 feet or 10 times the height of the building or structure, whichever is greater.

3. *Exposure C*. Open terrain with scattered obstructions having heights generally less than 30 feet. This category includes flat open country and grasslands.

4. *Exposure D*. Flat, unobstructed areas exposed to wind flowing over large bodies of water. 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 1500 feet or 10 times the height of the building or structure, whichever is greater.

6.5.3.2 Exposure Category for Design of Main Wind-Force Resisting Systems. Wind loads for the design of the main wind-force resisting system in buildings and other structures shall be based on the exposure categories defined in 6.5.3.1.

6.5.3.3 Exposure Category for Design of Components and Cladding. 6.5.3.3.1 Buildings with Height h Less than or Equal to 60 Feet. Components and cladding for buildings with a mean roof height of 60 feet or less shall be designed on the basis of Exposure C.

6.5.3.3.2 Buildings with Height h Greater than 60 Feet and Other Structures. Components and cladding for buildings with a mean roof height in excess of 60 feet and for other structures shall be designed on the basis of the exposure categories defined in 6.5.3.1, except that Exposure B shall be assumed for buildings and other structures sited in terrain representative of Exposure A.

6.5.4 Shielding. Reductions in velocity pressures due to apparent direct shielding afforded by buildings and structures or terrain features shall not be permitted.

6.6 Gust Response Factors

Gust response factors are employed to account for the fluctuating nature of wind and its interaction with buildings and other structures. In certain cases gust response factors are combined with pressure coefficients to yield values of GC_p and GC_{pi}; in these cases gust response factors shall not be determined separately.

For main wind-force resisting systems the value of the gust response factor G_h shall be determined from Table 8 evaluated at the building or structure height h. For components and cladding the value of the gust response factor G_z shall be determined from Table 8 evaluated at the height above ground z at which the component or cladding under consideration is located on the structure.

Gust response factors $\overline{G}$ for main wind-force resisting systems of flexible buildings and structures shall be calculated by a rational analysis that incorporates the dynamic properties of the main wind-force resisting system.

NOTE: One such procedure for determining $\overline{G}$ is described in the Commentary (see 6.6.1).

6.7 Pressure and Force Coefficients

6.7.1 General. Pressure and force coefficients for buildings and structures and their components and cladding are given in Figs. 2, 3, and 4 and Tables 9 through 16. The values of the coefficients for buildings in Figs. 3 and 4 and Table 9 include the gust response factors; in these cases the pressure coefficient values and gust response factors shall not be separated.

6.7.2 Roof Overhangs.

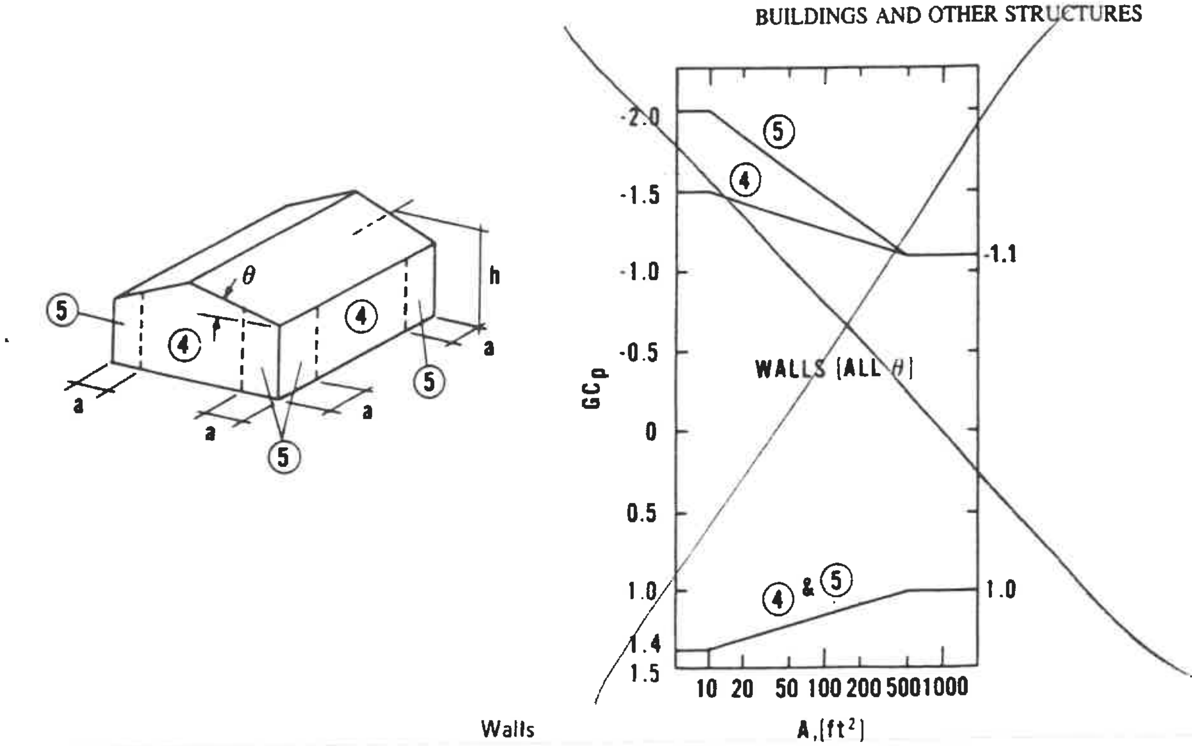
6.7.2.1 Main Wind-Force Resisting System. A positive pressure on the bottom surface of roof overhangs corresponding to $C_p = 0.8$ shall be applied in combination with pressures indicated in Fig. 2.

6.7.2.2 Components and Cladding. Roof overhangs shall be designed for pressures given in Figs. 3 and 4.

Table 8
Gust Response Factors, G_h and G_z

Height above ground level, z (feet)	G_h and G_z			
	Exposure A	Exposure B	Exposure C	Exposure D
0 - 15	2.36	1.65	1.32	1.15
20	2.20	1.59	1.29	1.14
25	2.09	1.54	1.27	1.13
30	2.01	1.51	1.26	1.12
40	1.88	1.46	1.23	1.11
50	1.79	1.42	1.21	1.10
60	1.73	1.39	1.20	1.09
70	1.67	1.36	1.19	1.08
80	1.63	1.34	1.18	1.08
90	1.59	1.32	1.17	1.07
100	1.56	1.31	1.16	1.07
120	1.50	1.28	1.15	1.06
140	1.46	1.26	1.14	1.05
160	1.43	1.24	1.13	1.05
180	1.40	1.23	1.12	1.04
200	1.37	1.21	1.11	1.04
250	1.32	1.19	1.10	1.03
300	1.28	1.16	1.09	1.02
350	1.25	1.15	1.08	1.02
400	1.22	1.13	1.07	1.01
450	1.20	1.12	1.06	1.01
500	1.18	1.11	1.06	1.00

NOTES:
(1) For main wind-force resisting systems, use building or structure height $h = z$.
(2) Linear interpolation is acceptable for intermediate values of z.
(3) For height above ground of more than 500 feet, Eq. C5 of the Commentary may be used.
(4) Value of gust response factor shall be not less than 1.0.

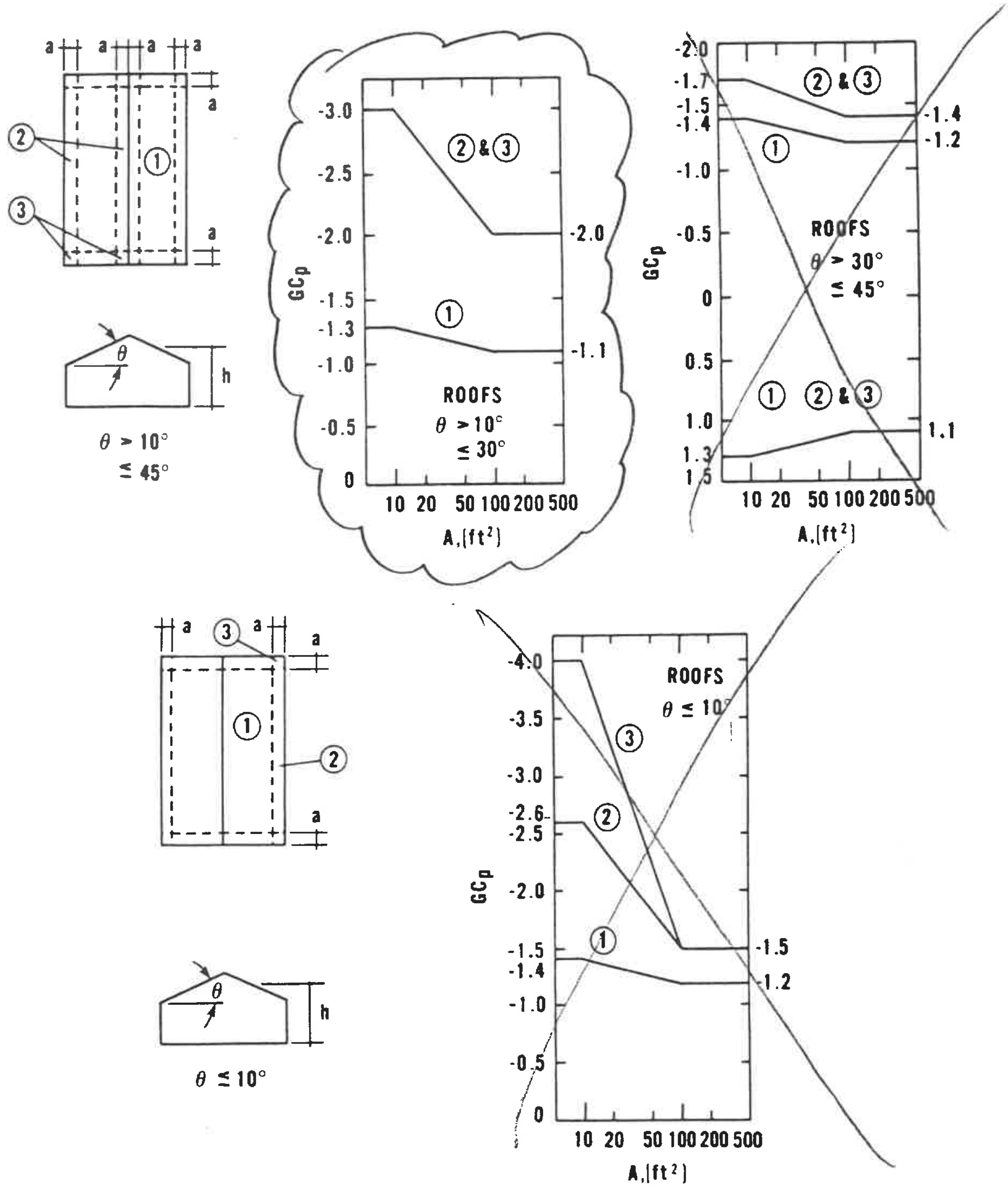


Walls
(a)

NOTES:

(1) The vertical scale denotes GC_p to be used with q_h based on Exposure C.
(2) The horizontal scale denotes the tributary area A, in square feet.
(3) External pressure coefficients for walls may be reduced by 10% when $\theta \leq 10$ degrees.
(4) If a parapet equal to or higher than 3 ft is provided around the perimeter of roof with $\theta \leq 10$ degrees, zone 3 may be treated as zone 2.
(5) Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
(6) Each component shall be designed for maximum positive and negative pressures.
(7) Notation: a: 10% of minimum width or $0.4h$, whichever is smaller, but not less than either 4% of minimum width or 3 feet; h: mean roof height, in feet, except that eave height may be used when $\theta \leq 10$ degrees; and θ: roof slope from horizontal, in degrees.

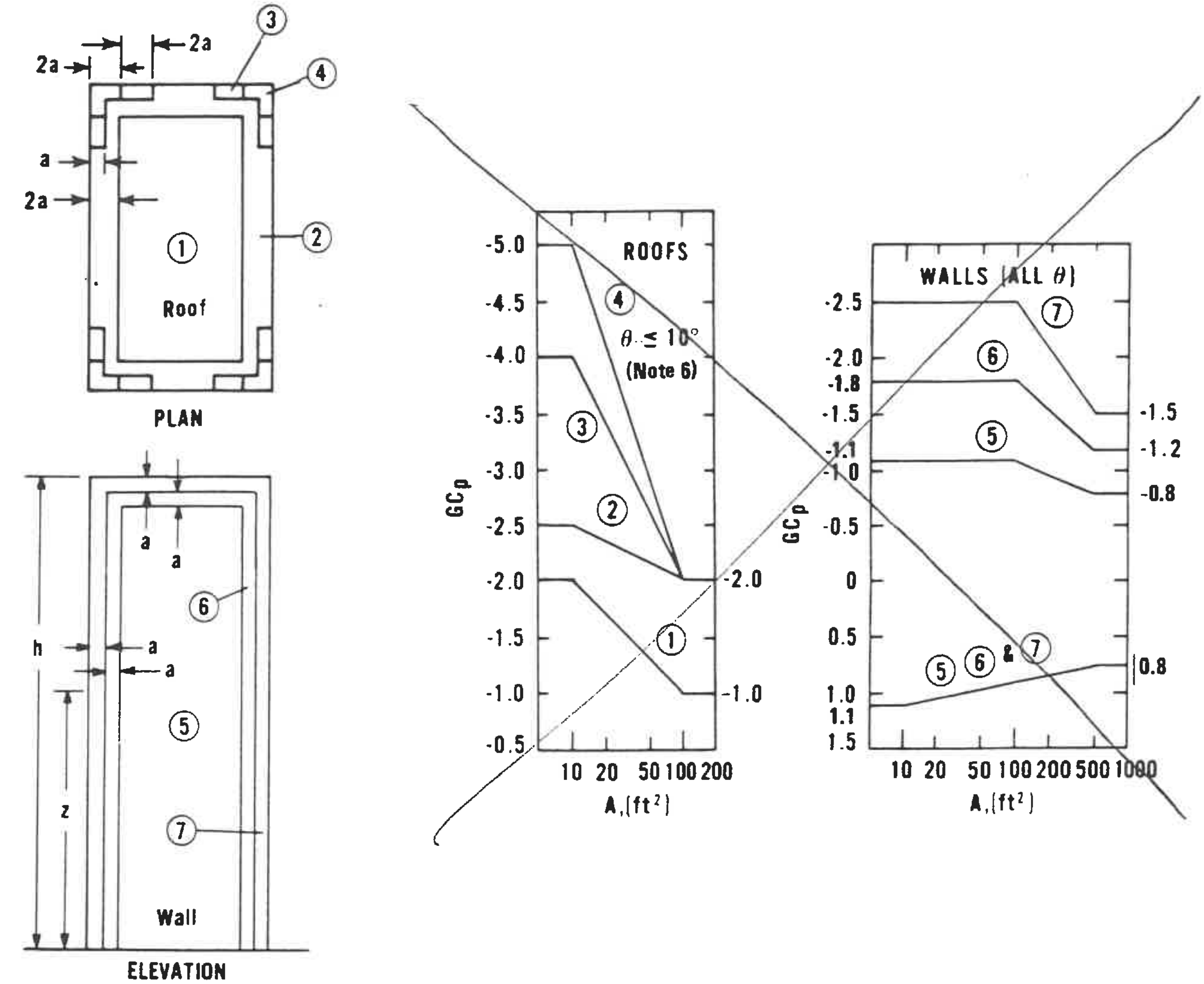
Fig. 3. External Pressure Coefficients, GC_p, for Loads on Building Components and Cladding for Buildings with Mean Roof Height h Less than or Equal to 60 Feet



Roofs
(b)

Fig. 3.–*Continued*

B-13



NOTES:

(1) Vertical scale denotes GC_p to be used with appropriate q_z or q_h.
(2) Horizontal scale denotes tributary area A, in square feet.
(3) Use q_h with negative values of GC_p and q_z with positive values of GC_p.
(4) Each component shall be designed for maximum positive and negative pressures.
(5) If a parapet equal to or higher than 3 ft is provided around the roof perimeter, Zones 3 and 4 may be treated as Zone 2.
(6) For roofs with slope of more than 10 degrees, use GC_p from Fig. 3b and attendant q_h based on Exposure C.
(7) Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
(8) Notation: a: 5% of minimum width or $0.5h$, whichever is smaller; h: mean roof height, in feet; and z: height above ground, in feet.

Fig. 4. External Pressure Coefficients, GC_p, for Loads on Building Components and Cladding for Buildings with Mean Roof Height h Greater than 60 Feet

Table 9
Internal Pressure Coefficients for Buildings, GC_{pi}

	Condition	GC_{pi}
Condition I	All conditions except as noted under condition II.	+0.25 −0.25
Condition II	Buildings in which both of the following are met: 1. Percentage of openings in one wall exceeds the sum of the percentages of openings in the remaining walls and roof surfaces by 5% or more, and 2. Percentage of openings in any one of the remaining walls or roof do not exceed 20%.	+0.75 −0.25

NOTES:
(1) Values are to be used with q_z or q_h as specified in Table 4.
(2) Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
(3) To ascertain the critical load requirements for the appropriate condition, two cases shall be considered: a positive value of GC_{pi} applied simultaneously to all surfaces, and a negative value of GC_{pi} applied to all surfaces
(4) Percentage of openings in a wall or roof surface is given by ratio of area of openings to gross area for the wall or roof surface considered.

Table 10
External Pressure Coefficients for Arched Roofs, C_p

Condition	Rise-to-span ratio, r	C_p Windward quarter	C_p Center half	C_p Leeward quarter
Roof on elevated structure	$0 < r < 0.2$	−0.9	$-0.7 - r$	−0.5
	$0.2 \leqslant r < 0.3$*	$1.5r - 0.3$	$-0.7 - r$	−0.5
	$0.3 \leqslant r \leqslant 0.6$	$2.75r - 0.7$	$-0.7 - r$	−0.5
Roof springing from ground level	$0 < r \leqslant 0.6$	$1.4r$	$-0.7 - r$	−0.5

*When the rise-to-span ratio is $0.2 \leqslant r \leqslant 0.3$, alternate coefficients given by $6r - 2.1$ shall also be used for the windward quarter.

NOTES:
(1) Values listed are for the determination of average loads on main windforce resisting system.
(2) Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
(3) For components and cladding: (a) at roof perimeter, use the external pressure coefficients in Fig. 3b with θ based on spring-line slope and q_h based on Exposure C (b) and for remaining roof areas, use external pressure coefficients of this table multiplied by 1.2 and q_h based on Exposure C.

Appendix C – Wind Provisions of ASCE 7-95

ASCE 7-95

American Society of Civil Engineers

Minimum Design Loads for Buildings and Other Structures

Revision of ANSI/ASCE 7-93

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New York, New York 10017-2398

C-2

structure is watertight. Walls and floors below an elevation one foot (0.30 m) above the base flood elevation shall be substantially impermeable to the passage of water. Openings below the base flood elevation shall be provided with watertight closures and shall have adequate structural capacity to resist all applicable loads.

5.3.4.4 Enclosures below Base Flood Elevation. Enclosed spaces below the base flood elevation shall not be used for any purpose other than parking of vehicles, building access or storage. Enclosed spaces which do not meet the requirements of Section 5.3.4.3 shall be provided with vents, valves, or other openings which will automatically equalize the hydrostatic forces on exterior and interior walls by allowing for the entry and exit of flood waters.

To provide for equalization of hydrostatic forces a minimum of two openings having a total net area of not less than one square inch for every square foot (0.007 m^2 for every square meter) of enclosed area subject to flooding shall be provided. The bottom of all openings shall not be higher than 12 in. (0.30 m) above grade. Openings shall not be equipped with screens, louvers, valves, or other coverings or devices unless they permit the automatic entry and exit of floodwaters.

5.3.4.5 Scour. The effects of scour shall be included in the design of the foundations of buildings or other structures in special flood hazard areas—*A* Zones.

Foundation embedment shall be below the depth of potential scour.

***5.3.5 Coastal High Hazard Areas—V Zones.** Loadings in *V* Zones are more severe than loadings in *A* Zones, and the design shall take into account the following: elevation above the base flood elevation, foundation type, obstructions below the base flood elevation, and the effects of erosion and scour.

**5.3.5.1 Elevation.* Buildings or structures erected within a coastal high hazard area shall be elevated so that the lowest portion of the lowest horizontal structural members supporting the lowest floor with the exception of footings, mat or raft foundations, piles, pile caps, columns, grade beams, and bracing shall be located at or above the base flood elevation.

Buildings or structures erected in coastal high hazard areas shall be supported on piles or columns. The piles or columns and their foundation and structure attached thereto shall be anchored to resist floatation, collapse and permanent lateral movement due to the effects of wind, water, and impact loads acting simultaneously on all building components.

All structural components subject to wind loads, hydrostatic and hydrodynamic loads and impact loads from water-borne objects during the occurrence of flooding to the base flood elevation shall be capable of resisting such forces, including the effects of buoyancy.

5.3.5.2 Space below Base Flood Elevation. Spaces below the base flood elevation shall be free of obstruction.

Exceptions:

1. Footings, mat or raft foundations, piles, pile caps, columns, grade beams, and bracing that provide structural support for the building.
2. Structural systems of entrances and required exits.
3. Incidental storage of portable or mobile items that are readily moveable in the event of a storm.
4. Walls or partitions shall not be used to enclose all or part of the space, unless they are not part of the structural support of the building and are designed to breakaway or collapse without causing collapse, displacement or other damage to the structural system of the building in accordance with Section 5.3.2.2. Insect screening, open wood lattice, and similar screening, which allow the passage of water, shall not be used unless these systems comply with Section 5.3.2.2.

**5.3.5.3 Erosion and Scour.* The effects of long-term erosion, storm-induced erosion and local scour shall be included in the design of foundations of buildings or other structures in coastal high-hazard areas. Foundation embedment shall be below the depth of potential scour.

6. Wind Loads

6.1 General

Provisions for the determination of wind loads on buildings and other structures are described in the following subsections. These provisions apply to the calculation of wind loads for main wind-force resisting systems and for individual structural components and cladding of buildings and other structures. Specific requirements are given

C-3

for using wind-tunnel investigations to determine wind loading and structural response for buildings or other structures having irregular geometric shapes, response characteristics, or site locations with shielding or channeling effects that warrant specific investigation, or to establish more accurate wind loading.

6.2 Definitions

The following definitions apply only to the provisions of Section 6:

***Basic wind speed, V:** 3-second gust speed at 33 ft (10 m) above the ground in Exposure C (see 6.5.3.1) and associated with an annual probability of 0.02 of being equaled or exceeded (50-year mean recurrence interval).

Building, enclosed: a building that does not comply with the requirements for open or partially enclosed buildings.

Building, open: a structure having all walls at least 80% open.

Building, partially enclosed: a building that complies with both of the following conditions:

1. the total area of openings in a wall that receives positive external pressure exceeds the sum of the areas of openings in the balance of the building envelope (walls and roof) by more than 10%; and
2. the total area of openings in a wall that receives positive external pressure exceeds 4 sq ft (0.37 m²) or 1% of the area of that wall, whichever is smaller, and the percentage of openings in the balance of the building envelope does not exceed 20%

These conditions are expressed by the following equations:

1. $A_o > 1.10A_{oi}$
2. $A_o > 4$ sq ft (0.37 m²) or $> 0.01A_g$, whichever is smaller, and $A_{oi}/A_{gi} \leq 0.20$ where:

A_o = the total area of openings in a wall that receives positive external pressure, in sq ft (m²);

A_g = the gross area of that wall in which A_o is identified, in sq ft (m²);

A_{oi} = the sum of the areas of openings in the building envelope (walls and roof) not including A_o, in sq ft (m²);

A_{gi} = the sum of the gross surface areas of the building envelope (walls and roof) not including A_g, in sq ft (m²).

Building, low-rise: enclosed or partially enclosed buildings which comply with the following conditions:

1. mean roof height h less than or equal to 60 ft (18 m);
2. mean roof height h does not exceed least horizontal dimension.

***Components and cladding:** elements that do not qualify as part of the main wind-force resisting system.

Design force, *F:* equivalent static force to be used in the determination of wind loads for open buildings and other structures.

Design pressure, *p:* equivalent static pressure to be used in the determination of wind loads for buildings. The pressure is denoted as:

p_z = pressure that varies with height in accordance with the velocity pressure q_z evaluated at height z, or

p_h = pressure that is uniform with respect to height as determined by the velocity pressure q_h evaluated at mean roof height h.

***Effective wind area:** the area used to determine GC_p. For components and cladding panels, the effective wind area in Figs. 6-5 through 6-8 is the span length multiplied by an effective width that need not be less than one-third the span length. For cladding fasteners, the effective wind area shall not be greater than the area that is tributary to an individual fastener.

***Flexible buildings and other structures:** Slender buildings and other structures that have a fundamental natural frequency less than 1 Hz. Included are buildings and other structures that have a height h exceeding four times the least horizontal dimension.

***Importance factor,** *I:* a factor that accounts for the degree of hazard to human life and damage to property.

***Main wind-force resisting system:** an assemblage of structural elements assigned to provide support and stability for the overall structure. The system generally receives wind loading from more than one surface.

Recognized literature: published research findings and technical papers that are approved by the authority having jurisdiction.

6.3 Symbols and Notation

The following symbols and notation apply only to the provisions of Section 6:

A = effective wind area, in square feet (sq meters).
a = width of pressure coefficient zone, in feet (meters).
A_f = area of open buildings and other structures either normal to the surface or projected on a plane normal to the wind direction, in square feet (sq meters).
B = horizontal dimension of a building measured normal to wind direction, in feet (meters).
C_f = force coefficient to be used in the determination of wind loads for other structures.
C_p = external pressure coefficient to be used in the determination of wind loads for buildings.
D = diameter of a circular structure or member, in feet (meters).
D' = depth of protruding elements such as ribs and spoilers, in feet (meters).
G = gust effect factor.
G_f = gust effect factor for main wind-force resisting systems of flexible buildings and other structures.
GC_p = product of external pressure coefficient and gust effect factor to be used in the determination of wind loads for buildings.
GC_{pf} = product of the equivalent external pressure coefficient and gust effect factor to be used in the determination of wind loads for main wind-force resisting system of low-rise buildings.
GC_{pi} = product of internal pressure coefficient and gust effect factor to be used in the determination of wind loads for buildings.
H = height of hill or escarpment in Fig. 6-2, in feet (meters).
h = mean roof height of a building or height of other structure, except that eave height shall be used for roof angle θ of less than or equal to 10°, in feet (meters).
I = importance factor.
K_1, K_2, K_3 = multipliers in Fig. 6-2 to obtain K_{zt}.
K_h = velocity pressure exposure coefficient evaluated at height $z = h$.
K_z = velocity pressure exposure coefficient evaluated at height z.
K_{zt} = topographic factor.
L = horizontal dimension of a building measured parallel to the wind direction, in feet (meters).
L_h = distance upwind of crest of hill or escarpment in Fig. 6-2 to where the difference in ground elevation is half the height of hill or escarpment, in feet (meters).
M = larger dimension of sign, in feet (meters).
N = smaller dimension of sign, in feet (meters).
p = design pressure to be used in the determination of wind loads for buildings, in pounds per square foot (N/m^2).
p_h = design pressure evaluated at height $z = h$, in pounds per square foot (N/m^2).
p_L = wind pressure acting on leeward face in Fig. 6-9.
p_W = wind pressure acting on windward face in Fig. 6-9.
p_z = design pressure evaluated at height z above ground, in pounds per square foot (N/m^2).
q = velocity pressure, in pounds per square foot (N/m^2).
q_h = velocity pressure evaluated at height $z = h$, in pounds per square foot (N/m^2).
q_z = velocity pressure evaluated at height z above ground, in pounds per square foot (N/m^2).
r = rise-to-span ratio for arched roofs.
*V = basic wind speed obtained from Fig. 6-1, in miles per hour (meters per second). The basic wind speed corresponds to a 3-sec. gust speed at 33 ft (10 m) above ground in exposure category C and is associated with an annual probability of 0.02 of being equaled or exceeded (50-year mean recurrence interval).
W = width of building in Figs. 6-5C and 6-7A and width of span in Figs. 6-6 and 6-7B, in feet (meters).
X = distance to center of pressure from windward edge in Table 6-6, in feet (meters).
x = distance upwind or downwind of crest in Fig. 6-2, in feet (meters).
z = height above ground level, in feet (meters).

ϵ = ratio of solid area to gross area for open sign, face of a trussed tower, or lattice structure.

θ = angle of plane of roof from horizontal, in degrees.

ν = height-to-width ratio for solid sign.

6.4 Calculation of Wind Loads

6.4.1 General

6.4.1.1 Allowed procedures. The design wind loads for buildings and other structures as a whole or for individual components and cladding thereof shall be determined using one of the following procedures: (1) Analytical procedure in accordance with 6.4.2; or (2) wind-tunnel procedure in accordance with 6.4.3.

6.4.1.2 Minimum design wind loading. The wind load used in the design of the main wind-force resisting system shall be not less than 10 lb/sq ft (0.48 kN/m²) multiplied by the area of the building or structure projected on a vertical plane normal to the wind direction. In the calculation of design wind loads for components and cladding for buildings, the algebraic sum of the pressures acting on opposite faces shall be taken into account. The design pressure for components and cladding of buildings shall be not less than 10 lb/sq ft (0.48 kN/m²) acting in either direction normal to the surface. The design force for open buildings and other structures shall be not less than 10 lb/sq ft (0.48 kN/m²) multiplied by the area A_f.

***6.4.2 Analytical Procedure.** Design wind pressures and design wind forces shall be determined in accordance with the appropriate equations given in Table 6-1 using the following procedure:

1. A velocity pressure q (q_z or q_h) is determined in accordance with the provisions of 6.5.
2. A gust effect factor G is determined in accordance with the provisions of 6.6.
3. Appropriate pressure or force coefficients are selected from the provisions of 6.7.

The equations given in Table 6-1 are for determination of: (1) Wind loading on main wind-force resisting systems; and (2) wind loading on individual components and cladding.

**6.4.2.1 Limitations of analytical procedure.* The provisions of 6.4.2 take into consideration the load magnification effect caused by gusts in resonance with along-wind vibrations of flexible buildings and other structures but do not include allowances for across-wind loading, vortex shedding, or instability due to galloping or flutter. The designer shall refer to recognized literature for documentation pertaining to wind load effects, or use the wind-tunnel procedure of 6.4.3, for site locations for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration, or for those buildings and other structures having unusual geometric shapes or response characteristics.

**6.4.2.2 Air-permeable cladding.* Design pressures determined from Section 6.4.2 shall be used, unless approved test data or recognized literature demonstrate lower loads for the type of air-permeable cladding being considered.

6.4.2.3 Application of pressures and forces. Design pressures, p, shall be assumed to act in a direction normal to the surface considered. Design forces, F, shall be assumed to act on the gross structure or components and cladding in accordance with Tables 6-6 through 6-10 and shall be considered to vary with respect to height in accordance with the velocity pressure q_z.

***6.4.3 Wind-Tunnel Procedure.** Wind-tunnel tests or similar tests employing fluids other than air shall be used for the determination of design wind loads in accordance with 6.4.3.1.

6.4.3.1 Test conditions. Tests for the determination of mean and fluctuating forces and pressures shall be considered to be properly conducted only if all of the following conditions are satisfied:

1. the natural atmospheric boundary layer has been modeled to account for the variation of wind speed with height;
2. the relevant macro (integral) length and micro length scales of the longitudinal component of atmospheric turbulence are modeled to approximately the same scale as that used to model the building or other structure;
3. the modeled building or other structure and surrounding structures and topography are geometrically similar to their full-scale counterparts;
4. the projected area of the modeled building or other structure and surroundings is less than 8% of the test section cross-sectional area unless correction is made for blockage;
5. the longitudinal pressure gradient in the wind tunnel test section is accounted for;
6. Reynolds number effects on pressures and forces are minimized; and
7. response characteristics of the wind tunnel instrumentation are consistent with the required measurements.

TABLE 6-1
Design Wind Pressure, *p* (psf) (N/m²), and Forces, *F* (lb) (N)

Design wind loading	Low-rise buildings	Buildings of all heights	Open buildings and other structures
Main wind-force resisting systems	$p = q_h[(GC_{pf}) - (GC_{pi})]$ *#§ q_h: at mean roof height using *Exposure C for all terrain* GC_{pf}: given in Fig. 6-4 GC_{pi}: given in Table 6-4	$p = qGC_p - q_h(GC_{pi})$ *# q: q_z for windward wall at height *z above ground* q_h for leeward wall, side walls and roof at mean roof height G: given in 6.6.1 C_p: given in Fig. 6-3 GC_{pi}: given in Table 6-4	$F = q_zGC_fA_f$ q_z: at height *z* above ground G: given in 6.6.1 C_f: given in Tables 6-6 through 6-10 A_f: projected area normal to wind†
	Buildings and Low-Rise Buildings		
	h ≤ 60 ft (18 m)	h > 60 ft (18 m)	
Components and cladding‡	$p = q_h[(GC_p) - (GC_{pi})]$* q_h: at mean roof height using Exposure C for all terrain GC_p: given in Figs. 6-5, 6-6 and 6-7 GC_{pi}: given in Table 6-4	$p = q[(GC_p) - (GC_{pi})]$ *§§ q: q_z for positive pressure at height *z* above ground q_h for negative pressure at mean roof height GC_p: given in Fig. 6-8 GC_{pi}: given in Table 6-4	$F = q_zGC_fA_f$ q_z: at height *z* above ground G: given in 6.6.1 C_f: given in Tables 6-6 through 6-10 A_f: projected area normal to wind†

Flexible Buildings and Other Structures ($f < 1$ Hz. Includes buildings and structures with height/least horizontal dimension > 4)

Design wind loading	Buildings	Other Structures
Main wind-force resisting systems	$p = qG_fC_p$ *# q: q_z for windward wall at height *z* above ground q_h for leeward wall at mean roof height G_f: obtained by rational analysis C_p: given in Fig. 6-3	$F = q_zG_fC_fA_f$ q_z: at height *z* above ground G_f: obtained by rational analysis C_f: given in Tables 6-6 through 6-10 A_f: projected area normal to wind†
Components and cladding‡	$p = q[(GC_p) - (GC_{pi})]$* q: q_z for positive pressure at height *z* above ground q_h for negative pressure at mean roof height GC_p: given in Fig. 6-8 GC_{pi}: given in Table 6-4	$F = q_zGC_fA_f$ q_z: at height *z* above ground G: given in 6.6.1 C_f: given in Tables 6-6 through 6-10 A_f: projected area normal to wind†

*Positive pressure acts toward surface and negative pressure acts away from surface; values of external and internal pressures shall be combined algebraically to determine most critical load.

#Pressure shall be applied simultaneously on windward and leeward walls and on roof surfaces as shown in Figs. 6-3 and 6-4.

†A_f is the projected area normal to the wind except where C_f is given for the surface area.

‡Major structural components supporting tributary areas greater than 700 sq ft (65 m²) shall be permitted to be designed using the provisions for main wind-force resisting systems.

§Low-rise buildings shall be permitted to be designed in accordance with the provisions for buildings in 6.5.3.2.2.

§§In the design of components and cladding for buildings having a mean roof height h, 60 ft (18 m) < h < 90 ft (27 m), GC_p values of Figs. 6-5, 6-6, and 6-7 shall be used only if the height-to-width ratio is 1 or less and q is taken as q_h and Exposure C (see 6.5.3.3.1) is used for all terrain.

6.4.3.2 Dynamic response. Tests for the purpose of determining the dynamic response of a building or other structure shall be in accordance with 6.4.3.1. The structural model and associated analysis shall account for mass distribution, stiffness, and damping.

6.5 Velocity Pressure

***6.5.1 Procedure for Calculating Velocity Pressure.** The velocity pressure q_z shall be calculated from the formula.

$$q_z = 0.00256 K_z K_{zt} V^2 I \text{ (lb/sq ft)}$$
$$[\text{In SI: } q_z = 0.613 K_z K_{zt} V^2 I \text{ (N/m}^2\text{)}] \qquad \text{(Eq. 6-1)}$$

where the basic wind speed V is selected in accordance with the provisions of 6.5.2, the importance factor I is set forth in Table 6-2, and the velocity pressure exposure coefficient K_z is given in Table 6-3 in accordance with the provisions of 6.5.3. Provisions of 6.5.5 shall be used to determine K_{zt} where applicable, but K_{zt} shall not be less than 1.0. The numerical coefficient 0.00256 (or 0.613 in SI) shall be used except where sufficient climatic data are available to justify the selection of a different value of this factor for a specific design application.

***6.5.2 Selection of Basic Wind Speed.** The basic wind speed V used in the determination of design wind loads on buildings and other structures shall be as given in Fig. 6-1 except as provided in 6.5.2.1 and 6.5.2.2.

**6.5.2.1 Special wind regions.* The basic wind speed shall be increased where records or experience indicate that the wind speeds are higher than those reflected in Fig. 6-1. Mountainous terrain, gorges and special regions shown in Fig. 6-1 shall be examined for unusual wind conditions. The authority having jurisdiction shall, if necessary, adjust the values given in Fig. 6-1 to account for higher local wind speeds. Such adjustment shall be based on meteorological information and an estimate of the basic wind speed obtained in accordance with the provisions of 6.5.2.2.

TABLE 6-2
Importance Factor, *I* (Wind Loads)

Category	I
I	0.87
II	1.00
III	1.15
IV	1.15

NOTE:
1. The building and structure classification categories are listed in Table 1-1.

TABLE 6-3
Velocity Pressure Exposure Coefficients, K_h and K_z

Height above ground level, z ft	(m)	A	B	C	D
0-15	(0-4.6)	0.32	0.57	0.85	1.03
20	(6.1)	0.36	0.62	0.90	1.08
25	(7.6)	0.39	0.66	0.94	1.12
30	(9.1)	0.42	0.70	0.98	1.16
40	(12.2)	0.47	0.76	1.04	1.22
50	(15.2)	0.52	0.81	1.09	1.27
60	(18)	0.55	0.85	1.13	1.31
70	(21.3)	0.59	0.89	1.17	1.34
80	(24.4)	0.62	0.93	1.21	1.38
90	(27.4)	0.65	0.96	1.24	1.40
100	(30.5)	0.68	0.99	1.26	1.43
120	(36.6)	0.73	1.04	1.31	1.48
140	(42.7)	0.78	1.09	1.36	1.52
160	(48.8)	0.82	1.13	1.39	1.55
180	(54.9)	0.86	1.17	1.43	1.58
200	(61.0)	0.90	1.20	1.46	1.61
250	(76.2)	0.98	1.28	1.53	1.68
300	(91.4)	1.05	1.35	1.59	1.73
350	(106.7)	1.12	1.41	1.64	1.78
400	(121.9)	1.18	1.47	1.69	1.82
450	(137.2)	1.24	1.52	1.73	1.86
500	(152.4)	1.29	1.56	1.77	1.89

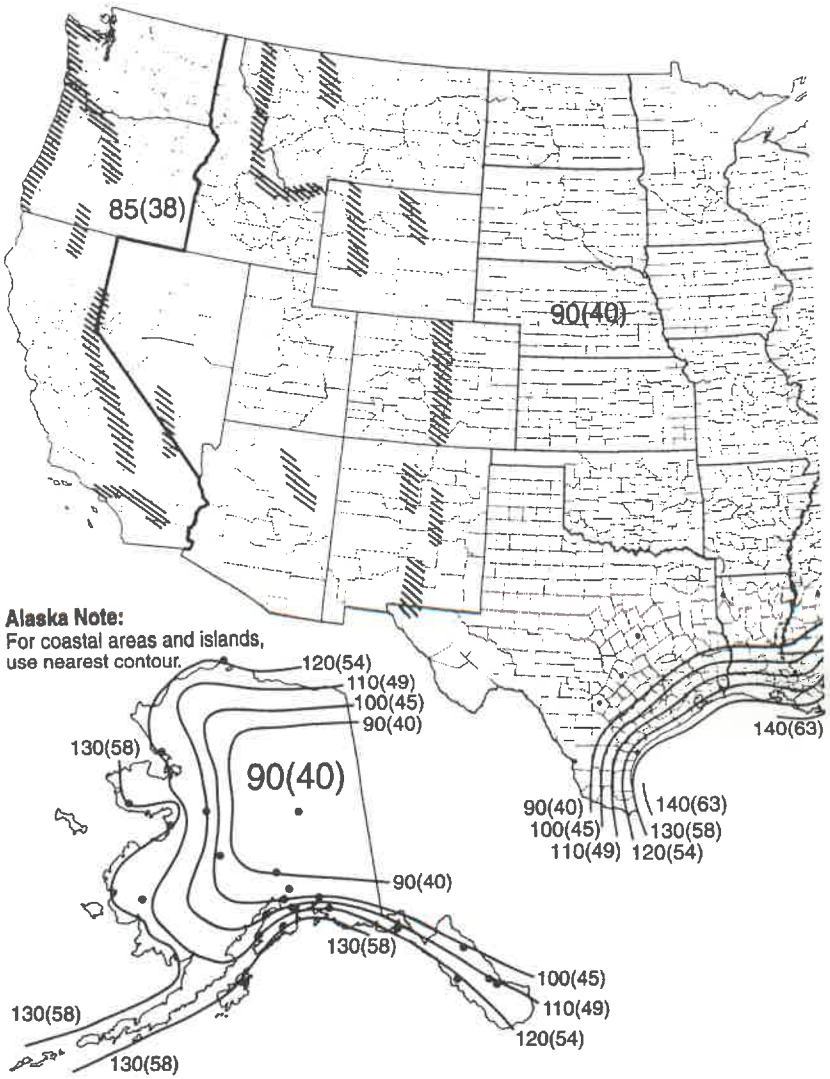
NOTES:
1. Linear interpolation for intermediate values of height z is acceptable.
2. For values of height z greater than 500 ft (152.4 m), K_z shall be calculated from Eq. (C3).
3. Exposure categories are defined in 6.5.3.

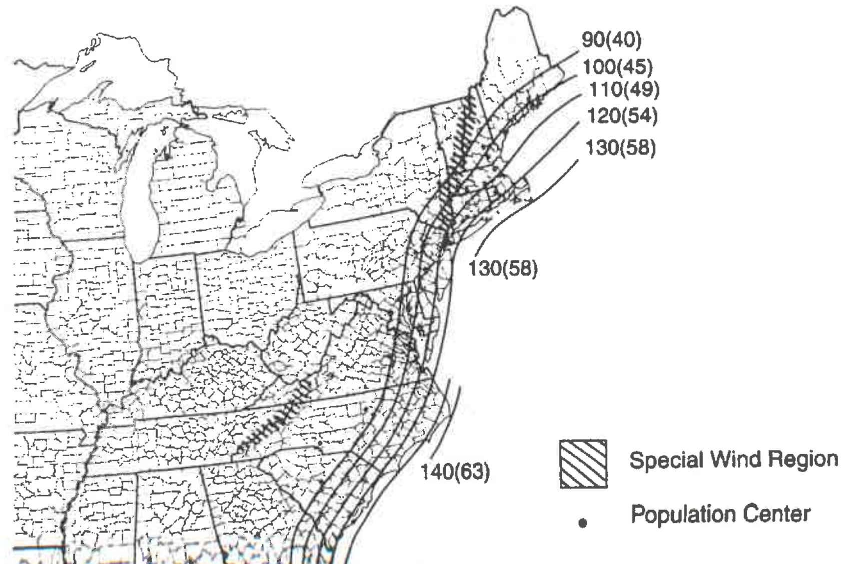
**6.5.2.2 Estimation of basic wind speeds from regional climatic data.* Regional climatic data shall only be used in lieu of the basic wind speeds given in Fig. 6-1 when: (1) Approved extreme-value statistical-analysis procedures have been employed in reducing the data; (2) and the length of record, sampling errror, averaging time, anemometer height, data quality, and terrain exposure have been taken into account.

**6.5.2.3 Limitation.* Tornadoes have not been considered in developing the basic wind-speed distributions.

***6.5.3 Exposure Categories**

6.5.3.1 General. An exposure category that adequately reflects the characteristics of ground surface irregularities shall be determined for the site at which the building or structure is to be constructed. Account shall be taken of variations in ground surface roughness that arise from natural topography and vegetation as well as from





Location	V mph	(m/s)
Hawaii	105	(47)
Puerto Rico	125	(56)
Guam	170	(76)
Virgin Islands	125	(56)
American Samoa	125	(56)

Notes:

1. Values are 3-second gust speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category and are associated with an annual probability of 0.02.
2. Linear interpolation between wind speed contours is permitted.
3. Islands and coastal areas shall use wind speed contour of coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

FIG. 6-1. Basic Wind Speed

C-9

ASCE 7-95 Figure 6-1

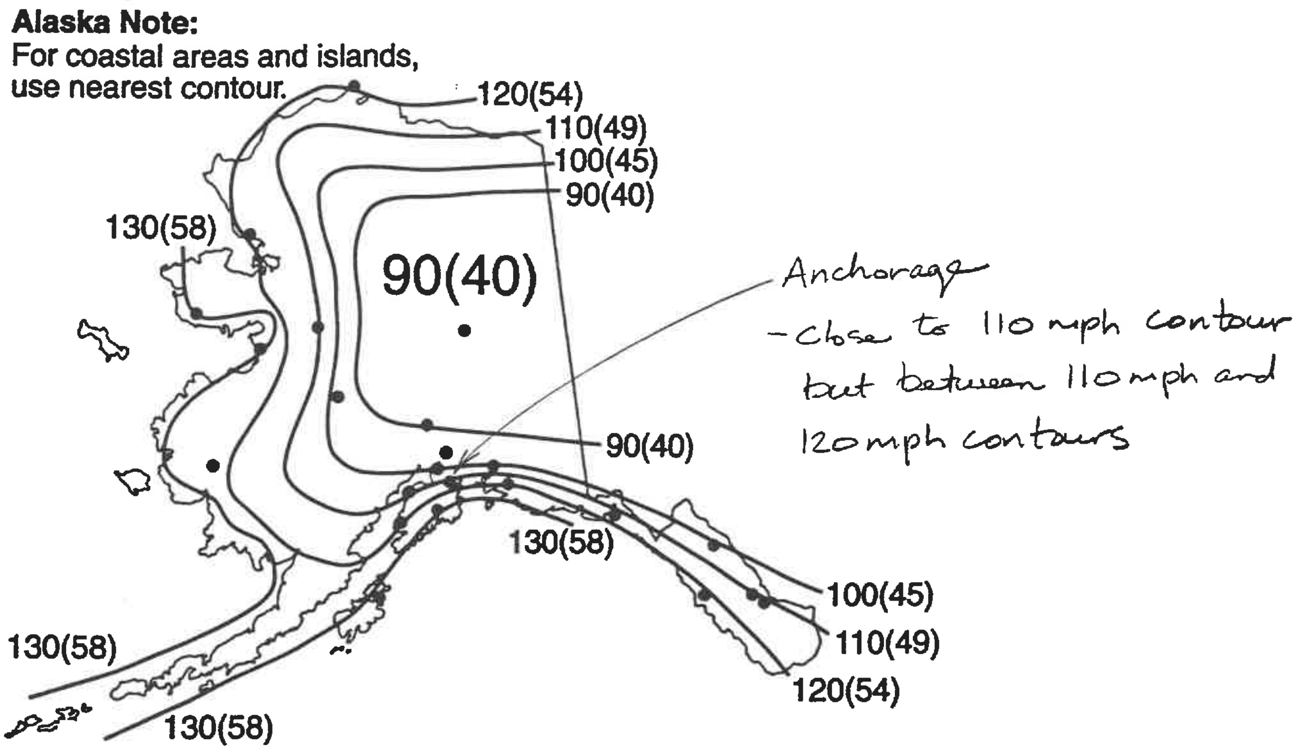
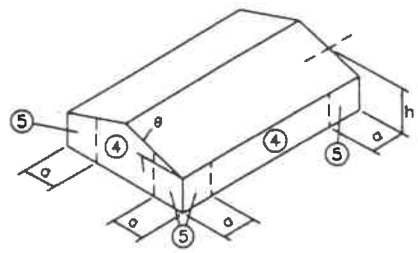


FIG. 6-1. Basic Wind Speed

Notes:
1. Values are 3-second gust speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category and are associated with an annual probability of 0.02.
2. Linear interpolation between wind speed contours is permitted.
3. Islands and coastal areas shall use wind speed contour of coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.



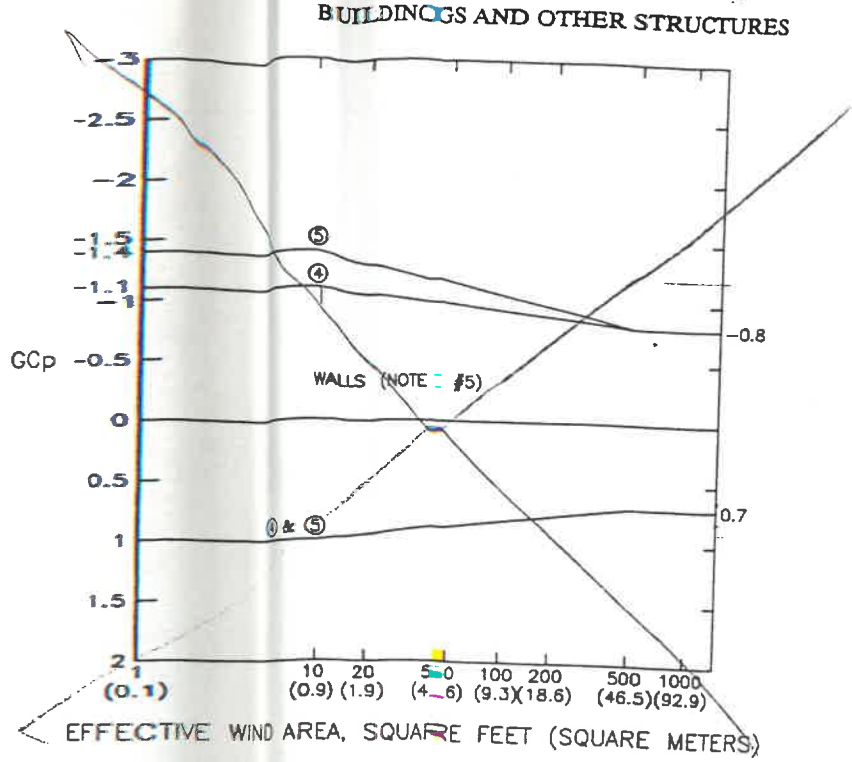


FIG. 6-5A Walls

NOTES:

1. Vertical scale denotes GC_p to be used with q_h based on Exposure C.
2. Horizontal scale denotes effective wind area, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. Values of GC_p for walls shall be reduced by 10% when $\theta \leq 10°$.
6. If a parapet equal to or higher than 3 ft (1 m) is provided around the perimeter of the roof with $\theta \leq 10°$, Zone 3 shall be treated as Zone 2.
7. Values of GC_p for roof overhangs include pressure contributions from both upper and lower surfaces.
8. For hipped roofs with $10 < \theta \leq 30°$, edge/ridge strips and pressure coefficients for ridges of gabled roofs shall apply on each hip.
9. On the lower level of flat, stepped roofs shown in Fig. 6-5C, the zone designations and pressure coefficients shown in Fig. 6-5B ($\theta \leq 10°$) shall apply, except that at the roof-upper wall intersection(s), Zone 3 shall be treated as Zone 2 and Zone 2 shall be treated as Zone 1. Positive values of GC_p equal to those for walls in Fig. 6-5A shall apply on the cross-hatched areas shown in Fig. 6-5C.
10. For buildings sited within Exposure B, calculated pressures shall be multiplied by 0.85.
11. Notation:

    a: 10 percent of least horizontal dimension or $0.4h$, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (1 m).
    b: $1.5h_1$ in Fig. 6-5C, but not greater than 100 ft (30.5 m).
    h: Mean roof height, in feet (meters), except that eave height shall be used for $\theta \leq 0°$.
    h_i: h_1 or h_2 in Fig. 6-5C; $h = h_1 + h_2$; $h_1 \geq 10$ ft (3.1 m); $h_i/h = 0.3$ to 0.7.
    W: Building width in Fig. 6-5C.
    W_i: W_1 or W_2 or W_3 in Fig. 6-5C. $W = W_1 + W_2$ or $W_1 + W_2 + W_3$; $W_i/W = 0.25$ to 0.75.
    θ: Angle of plane of roof from horizontal, in degrees.

***FIG. 6-5. External Pressure Coefficients, GC_p, for Loads on Building Components and Cladding for Enclosed or Partially Enclosed Buildings with Mean Roof Height h Less than or Equal to 60 ft (18 m)**

C-11

THIS HAS TO BE ② & ③, SINCE ① IS DEFINED LEC 11-15-97

See Errata dated 4/12/96

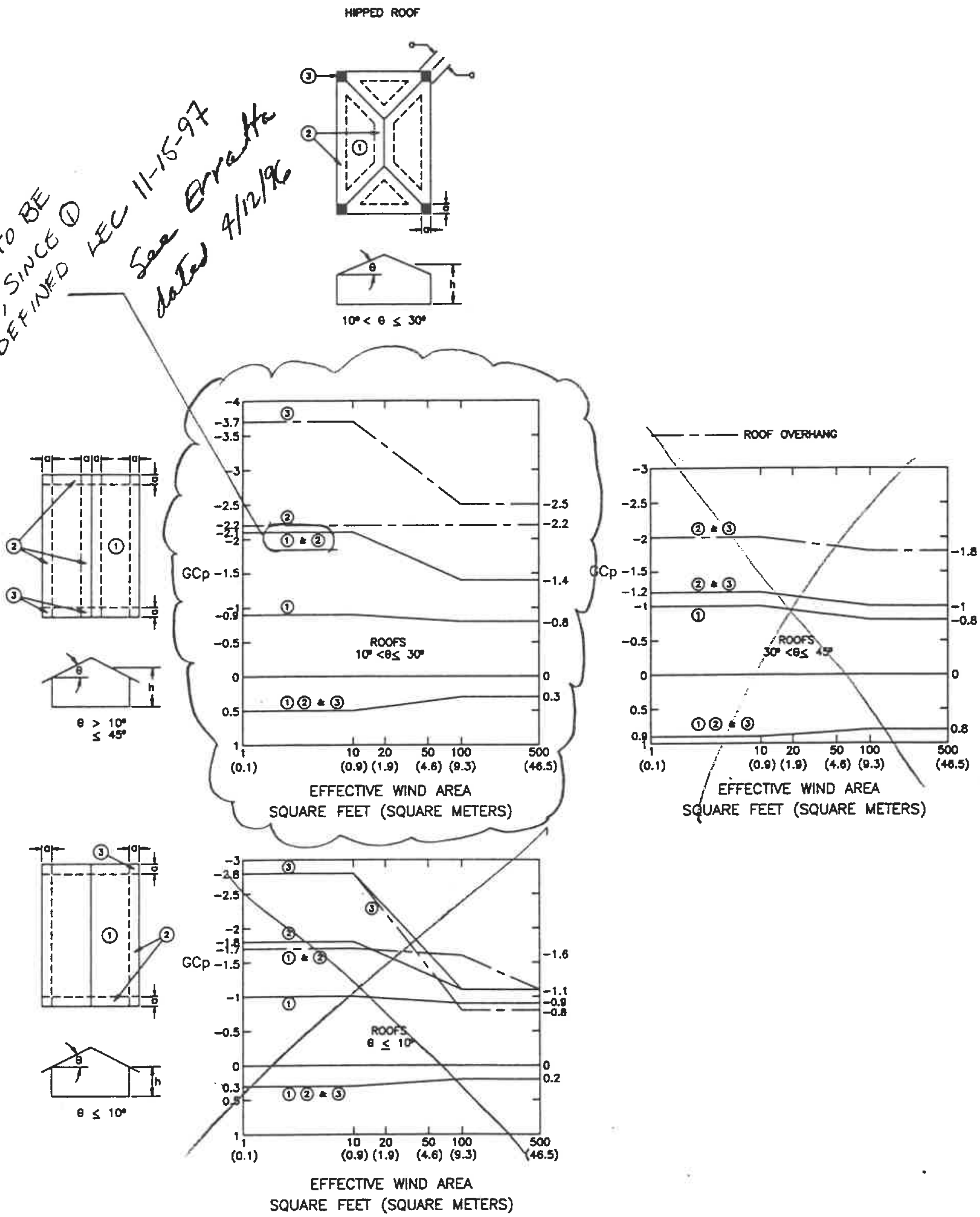
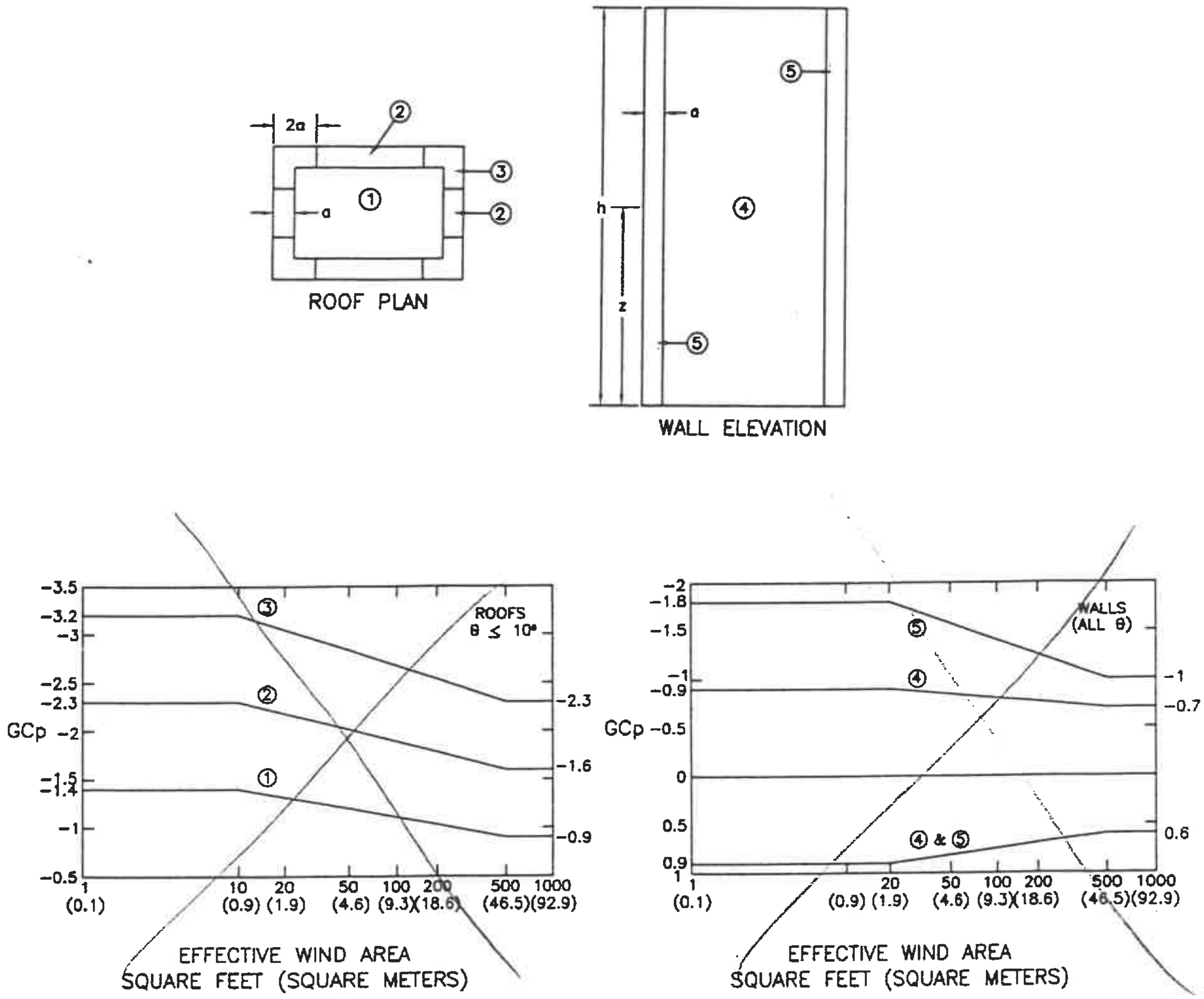


FIG. 6-5B. Gabled and Hipped Roofs (Refer to Notes on Fig. 6-5)



NOTES:

1. Vertical scale denotes GC_p to be used with appropriate q_z or q_h.
2. Horizontal scale denotes effective wind area A, in square feet (square meters).
3. Plus and minus signs signify pressures acting toward and away from the surface, respectively.
4. Use q_z with positive values of GC_p and q_h with negative values of GC_p.
5. Each component shall be designed for maximum positive and negative pressures.
6. Coefficients are for roofs with angle $\theta \leq 10°$. For other roof angles and geometry, use GC_p values from Fig. 6-5B and attendant q_h based on Exposure C.
7. If a parapet equal to or higher than 3 ft (1 m) is provided around the perimeter of the roof, Zone 3 shall be treated as Zone 2.
8. Notation:
   - a: 10% of least horizontal dimension, but not less than 3 ft (1 m).
   - h: mean roof height, in feet (meters).
   - z: height above ground, in feet (meters).
   - θ: Angle of plane of roof from horizontal, in degrees.

***FIG. 6-8. External Pressure Coefficients, GC_p, for Loads on Building Components and Cladding for Enclosed or Partially Enclosed Buildings with Mean Roof Height h Greater than 60 ft (18 m)**

C-13

TABLE 6-4
Internal Pressure Coefficients for Buildings, GC_{pi}

Condition	GC_{pi}
Open buildings	0.00
Partially enclosed buildings	+0.80 −0.30
Buildings satisfying the following conditions:	+0.80 −0.30
(1) sited in hurricane-prone regions having a basic wind speed greater than or equal to 110 mph (49 m/s) or in Hawaii, and	
(2) having glazed openings in the lower 60 ft (18 m) which are not designed to resist wind-borne debris or are not specifically protected from wind-borne debris impact	
All buildings except those listed above	+0.18 −0.18

NOTES:
1. Plus and minus signs signify pressures acting toward and away from the internal surfaces.
2. Values of GC_{pi} shall be used with q_z or q_h as specified in Table 6-1.
3. Two cases shall be considered to determine the critical load requirements for the appropriate condition: a positive value of GC_{pi} applied to all internal surfaces, and a negative value of GC_{pi} applied to all internal surfaces.
4. For buildings with mean roof height $h \leq 60$ ft (18 m) and sited within Exposure B, calculated internal pressures shall be multiplied by 0.85.
5. Hurricane-prone regions include areas vulnerable to hurricanes, such as the U.S. Atlantic and Gulf Coasts, Hawaii, Puerto Rico, Guam, Virgin Islands, and American Samoa.
6. If a building by definition complies with both the "Open" and "Partially Enclosed" definitions, it shall be treated as an "Open" building.

constructed features. The exposure in which a specific building or other structure is sited shall be assessed as being one of the following categories:

1. **Exposure A.** Large city centers with at least 50% of the buildings having a height in excess of 70 ft (21.3 m). Use of this exposure category shall be limited to those areas for which terrain representative of Exposure A prevails in the upwind direction for a distance of at least 0.5 mi (0.8 km) or 10 times the height of the building or other structure, whichever is greater. Possible channeling effects or increased velocity pressures due to the building or structure being located in the wake of adjacent buildings shall be taken into account.
2. **Exposure B.** Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. Use of this exposure category shall be limited to those areas for which terrain representative of Exposure B prevails in the upwind direction for a distance of at least 1,500 ft (460 m) or 10 times the height of the building or other structure, whichever is greater.
3. **Exposure C.** Open terrain with scattered obstructions having heights generally less than 30 ft (9.1 m). This category includes flat open country and grasslands.
4. **Exposure D.** Flat, unobstructed areas exposed to wind flowing over open water for a distance of at least 1 mi (1.61 km). 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

TABLE 6-5
External Pressure Coefficients for Arched Roofs, C_p

		C_p		
Condition	Rise-to-span ratio, r	Windward quarter	Center half	Leeward quarter
Roof on elevated structure	$0 < r < 0.2$	−0.9	$-0.7 - r$	−0.5
	$0.2 \leq r < 0.3$*	$1.5r - 0.3$	$-0.7 - r$	−0.5
	$0.3 \leq r \leq 0.6$	$2.75r - 0.7$	$-0.7 - r$	−0.5
Roof springing from ground level	$0 < r \leq 0.6$	$1.4r$	$-0.7 - r$	−0.5

*When the rise-to-span ratio is $0.2 \leq r \leq 0.3$, alternate coefficients given by $6r - 2.1$ shall also be used for the windward quarter.

NOTES:
1. Values listed are for the determination of average loads on main windforce resisting systems.
2. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
3. For wind directed parallel to the axis of the arch, use pressure coefficients from Fig. 6-3 with wind directed parallel to ridge.
4. For components and cladding: (1) At roof perimeter, use the external pressure coefficients in Fig. 6-5B with θ based on spring-line slope and q_h based on Exposure C; and (2) for remaining roof areas, use external pressure coefficients of this table multiplied by 0.87 and q_h based on Exposure C.

Appendix D – MOA Amendments to UBC-97

Municipality of Anchorage

Rick Mystrom, Mayor

Department of Public Works

Building Safety Division

P.O. Box 196650 • 3500 East Tudor Road
Anchorage, Alaska 99519-6650
(907) 343-8301

UBC

These local amendments were adopted by the Anchorage Municipal Assembly on December 15, 1998, under Ordinance 98-178, and are an integral addition to and part of the basic code. A code book is not complete without the legally adopted local amendments. These amendments resulted from the input of representatives from the various trades, organizations, professions, and code enforcement agencies. They are updated periodically by Assembly action.

The accessibility requirements are now located within the Uniform Building Code under Chapter 11, and are part of the Uniform Building Code amendments. However, the accessibility amendments are published as a separate set of amendments. This copy of the building code amendments does not include the accessibility amendments. If you are interested in the accessibility requirements, you will need to purchase that document separately. There are illustrations attached to that document as an appendix.

After adoption, the Municipality of Anchorage is legally required to enforce this code and local amendments. If you have any questions about these amendments or the basic code, do not hesitate to call Building Safety.

Ron Watts

Ron Watts
Chief Building Official

23.15.1402.6 Vapor Retarders

Add a new subsection as follows:

All exterior wall, ceiling, roof and floor assemblies which enclose heated spaced and which are exposed to outdoor ambient temperatures shall be protected against water vapor transmission. Assemblies not otherwise of impermeable construction shall have installed, on the heated side of the insulation or air spaces, vapor retarders having a perm rating of 0.06 minimum (equivalent to 6 mil polyethylene).

23.15.1402.7 Wall Insulation

Add a new subsection 1402.7 as follows:

Wall insulation:

1. Basement walls below grade shall be insulated to provide a minimum thermal resistance of R=10.

2. Foundation walls or crawlspace walls shall be insulated to provide a minimum thermal resistance of R = 8.

23.15.1501 Roof And Roof Structures

Revise Section 1501.1 by adding the following sentence at the end of the section:

For protection of exits from falling ice and snow refer to Appendix Chapter 16, Section ~~1640~~ 1643 (Volume 2) "Special eave requirements".

23.15.1505.1 Attic Access

Add a fourth paragraph as follows:

Attic access shall not be located in a room containing bathing facilities.

23.15.1505.3 Ventilation

Replace entire Section with revised section, to read:

Enclosed attics and enclosed roof framing spaces formed where ceilings are applied directly to the underside of roof framing members shall have cross ventilation for each separate space by providing ventilation openings protected against the entrance of rain or snow. Where eave or cornice vents are installed, insulation shall not block the free flow of air and shall be held back from the face of the roof sheathing to provide an air space a minimum of 1 ½ inches (37.5 mm) in depth between the insulation and the roof sheathing. The net free ventilation area shall not be less than 1/150 of the area of the space ventilated at a position at least 3 feet (914.4 mm) above the eave of cornice.

EXCEPTIONS:

1. The opening area may be 1/300 of the area of the space ventila ed provided 50 percent of the required opening area is provided by ventilation located in the upper portion of the space to be ventilated at a position at least 3 feet (914.4 nm) above the eave or cornice vents.

2. The opening area may be 1/300 of the area of the space ventilat d provided a vapor barrier not exceeding 1 perm (5.7×10^{-11} kg ($Pa.s.m^2$) is installe l on the warm side of the attic insulation.

Openings for ventilation shall be covered with corrosion resistant meta mesh with a mesh opening of ¼ inch (6.4 mm) in dimension.

Smoke and heat venting shall be in accordance with Section 906.

23.15.1506.3 Overflow Drains And Scuppers

Amend the second paragraph by eliminating the words:

...and shall not be connected to the roof drain lines.

23.15.1507 Roof Covering Materials And Application

Add after first paragraph:

Eave underlayment of self-sealing modified bitumen shall be installed f om the eaves to a line 36 inches inside the exterior wall line. Install one layer of 15 lb fe t with 18 inch (457 mm) lap over eave underlayment with subsequent laps at 2 inches horizontally and 4 inches vertically continuing to the ridge. This applies also to Tables 15-3-2, 15-D-1, and 154-D-2.

23.15.1507.1 Roof Covering Materials

Add after first paragraph:

Eave underlayment consisting of self-sealing modified bitumen shall be i 1stalled from the eaves to a line 36 inches inside the exterior wall line. Install one laye of 15 lb felt with 18 inch (457 mm) lap over eave underlayment with subsequent laps at 2 inches horizontally and 4 inches vertically continuing to the ridge. This applies ılso to Tables 15-B-2, 15-D-1, 15-D-2. See Table B-1 for Asphalt Shingle Application.

23.15.1507.5 Asphalt Shingles

Add after existing sentence:

Asphalt shingles shall be applied not less than 235 pounds per square.

23.15.Table 15-D-1 Roofing Tile Application For All Tiles

Delete column titled "2-1/2:12 to less than 3:12" in its entirety.

23.15.1607.5 Reduction Of Live Loads

Amend the first paragraph by deleting the words "and Table 16-C.....Roofs".

23.15.1614 Snow Loads

Delete the first sentence of the first paragraph and add the following:

> Snow loads shall be determined by using the provisions of Appendix Chapter Division I. The minimum basic ground snow load Pg shall be 57 pounds per square foot (2739 Pa). The minimum roof snow load Pf shall be 40 pounds per square foot. (GAC 14.04.300- 2305(c) and GAAB 22.10.010-2305(c)) (1915 Pa).

23.15.1616 Definitions

Add the following to the definition of "EXPOSURE D":

> The SHORELINE shall be defined as the high tide line (as indicated by the edge of vegetation on the most recent Municipality of Anchorage base aerial photograph set). UNOBSTRUCTED shall be defined as any site not sheltered from the shore line by vegetation or other impediments at least 4 feet high and covering at least 60 percent of an area extending at least 30 feet perpendicular to a line connecting the building to any point of the shoreline.

23.15.1618 Basic Wind Speed

Delete the first sentence and substitute the following:

> The minimum basic wind speed shall be 80 miles per hour in the area west and/or north of the boundary line defined from south to north by the New Seward Highway, Ingra Street, East 1st Avenue, N Post Road, Post Road and the Alaska Railroad Main Track through Elmendorf AFB and Fort Richardson. The minimum basic wind speed shall be 100 miles per hour in the area east and/or south of the boundary line defined from south to north, starting at the New Seward Highway, by Rabbit Creek Road, Hillside Drive, O'Malley Road, Hillside Drive, a straight line between the intersections of Hillside Road at Abbott Road and Tudor Road at Patterson Street, Patterson Street, Tagalak, Paxson Drive, Patterson Street, and the Glenn Highway. The minimum basic wind speed shall be 90 miles per hour in the area between these two boundary lines. (Refer to Figures 1618A and 1618B.)

3.15.1626.2 Minimum Seismic Design

Add the following Exception:

EXCEPTION: The seismic design of any structure with a permit application dated on or before December 31, 1999 may be based on 1994 UBC, Division III -- Earthquake Design, as modified by UBC 1996 Accumulative Supplement; Chapters 16 and 22.

23.15.1629.4.2 Seismic Zone 4 Near-Source Factor

Delete paragraph in its entirety and substitute the following:

The value of N_a from Table 16-S and N_v from Table 16-T shall be 1.0.

23.15.1630.1.1.3 Minimum Design Lateral Forces And Related Effects

Delete subsection 3 in its entirety and substitute the following:

3. A minimum of 25 percent of the design, balanced roof snow load shall be included.

23.15.1701.1 General

In the first sentence, replace "Section 108" with "Section 305, Inspections, of the Administrative Code".

Add the following:

EXCEPTION #2: For one, two and three family, wood framed construction no Special inspection will be required under this chapter unless specifically required by the Engineer of Record.

23.15.1701.2 Special Inspector

Add the following:

Provided the Engineer of Record is a registered professional engineer in the State of Alaska, the Engineer of Record shall be deemed qualified to perform special inspections required under this chapter without further statements of qualifications or resumes to the Building Official.

23.15.1701.3 Duties And Responsibilities Of The Special Inspector

In the Second Paragraph, delete the second sentence and replace with the following:

All discrepancies shall be brought to the immediate attention of the contractor for correction, and shall be documented in a Special Inspection Report. If action is not taken immediately or within an agreed time frame to correct the nonconformance, the Special Inspector shall promptly inform the Engineer of Record and the Building Official, verbally and in writing through a Special Inspection Report. Discrepancies discovered by