Structural Calculations - Rev

for

Lees Summit Joint Operations Center
Lees Summit, MO

Prepared by:

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2/13/2025

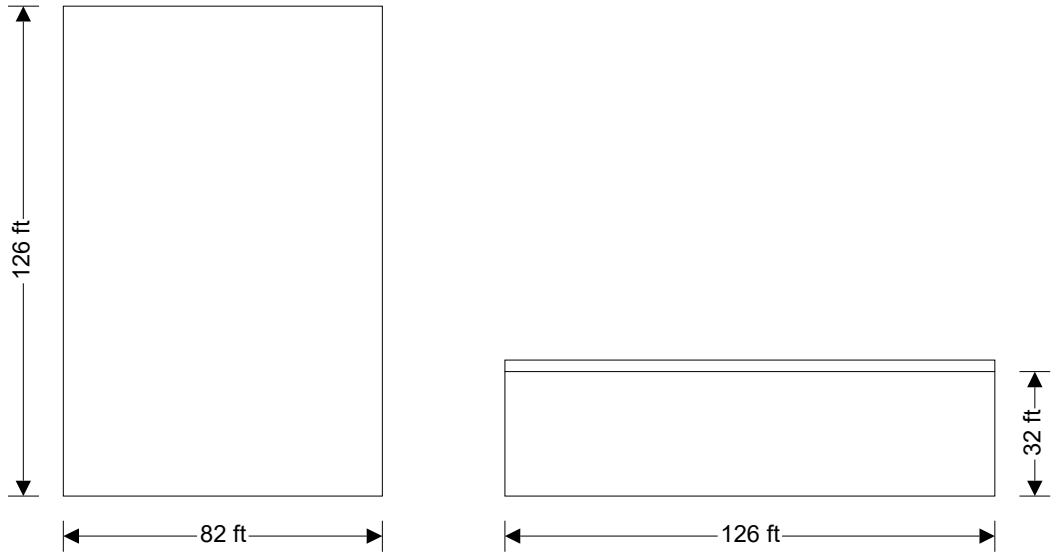
WIND LOADING (ASCE7)

WIND LOADING

In accordance with ASCE7-10

Using the components and cladding design method

Tedds calculation version 2.1.14



Building data

Type of roof	Flat
Length of building	b = **82.00** ft
Width of building	d = **126.00** ft
Height to eaves	H = **32.00** ft
Height of parapet	h_p = **3.00** ft
Mean height	h = **32.00** ft
End zone width	a = max(min(0.1×min(b, d), 0.4×h), 0.04×min(b, d), 3ft) = **8.20** ft

General wind load requirements

Basic wind speed	V = **250.0** mph
Risk category	IV
Velocity pressure exponent coef (Table 26.6-1)	K_d = **1.00**
Exposure category (cl 26.7.3)	C
Enclosure classification (cl.26.10)	Partially enclosed buildings
Internal pressure coef +ve (Table 26.11-1)	GC_{pi_p} = **0.55**
Internal pressure coef –ve (Table 26.11-1)	GC_{pi_n} = **-0.55**
Parapet internal pressure coef +ve (Table 26.11-1)	GC_{pi_pp} = **0.55**
Parapet internal pressure coef –ve (Table 26.11-1)	GC_{pi_np} = **-0.55**
Gust effect factor	G_f = **0.85**

Topography

Topography factor not significant $K_{zt} = 1.0$

Velocity pressure

Velocity pressure coefficient (T.30.3-1) $K_z =$ **0.99**

Velocity pressure $q_h = 0.00256 \times K_z \times K_{zt} \times K_d \times V^2 \times 1psf/mph^2 =$ **158.7** psf

Velocity pressure at parapet

Velocity pressure coefficient (T.30.3-1) $K_z =$ **1.01**

Velocity pressure $q_p = 0.00256 \times K_z \times K_{zt} \times K_d \times V^2 \times 1psf/mph^2 =$ **161.6** psf

Peak velocity pressure for internal pressure

Peak velocity pressure – internal (as roof press.) $q_i =$ **158.72** psf

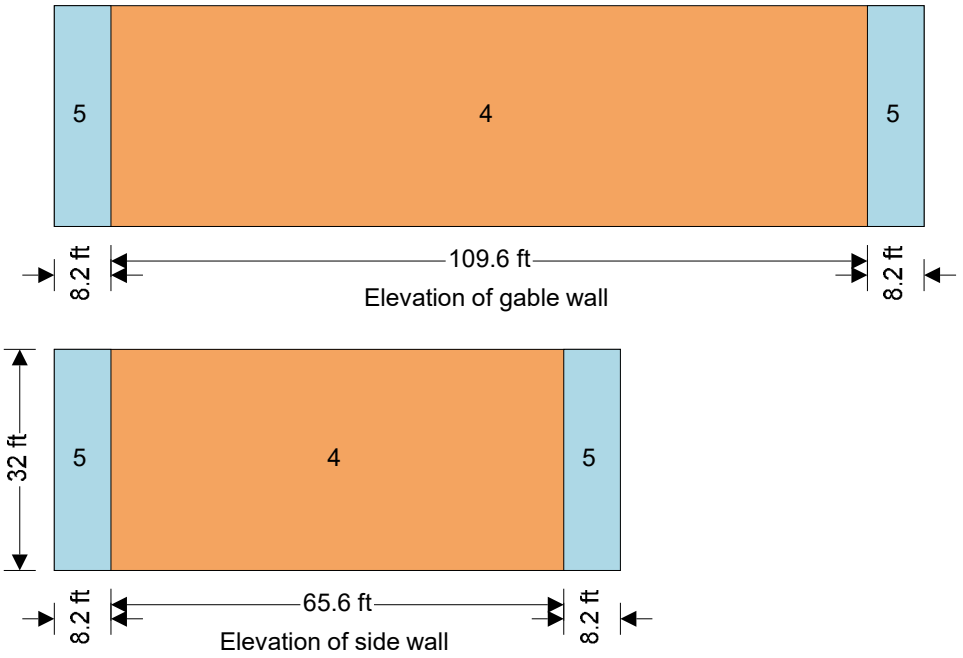
Equations used in tables

Net pressure $p = q_h \times [GC_p - GC_{pi}]$

Parapet net pressure $p = q_p \times [GC_p - GC_{pi\_p}]$

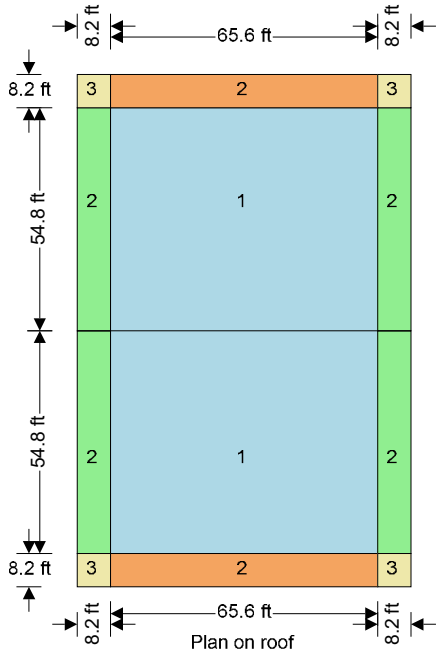
Components and cladding pressures - Wall (Table 30.4-1 and Figure 30.4-2A)

Component	Zone	Length (ft)	Width (ft)	Eff. area (ft^2)	$+GC_p$	$-GC_p$	Pres (+ve) (psf)	Pres (-ve) (psf)
<=10 sf	4	-	-	10.0	0.90	-0.99	230.1	-244.4
50 sf	4	-	-	50.0	0.79	-0.88	212.5	-226.8
200 sf	4	-	-	200.0	0.69	-0.78	197.3	-211.6
>500 sf	4	-	-	500.1	0.63	-0.72	187.3	-201.6
<=10 sf	5	-	-	10.0	0.90	-1.26	230.1	-287.3
50 sf	5	-	-	50.0	0.79	-1.04	212.5	-252.0
200 sf	5	-	-	200.0	0.69	-0.85	197.3	-221.6
>500 sf	5	-	-	500.1	0.63	-0.72	187.3	-201.6
>500 sf	5	-	-	500.1	0.63	-0.72	187.3	-201.6



Components and cladding pressures - Roof (Figure 30.4-2A)

Component	Zone	Length (ft)	Width (ft)	Eff. area (ft^2)	$+GC_p$	$-GC_p$	Pres (+ve) (psf)	Pres (-ve) (psf)
<=10 sf	1	-	-	10.0	0.30	-1.00	134.9	-246.0
25 sf	1	-	-	25.0	0.26	-0.96	128.6	-239.7
50 sf	1	-	-	50.0	0.23	-0.93	123.8	-234.9
>100 sf	1	-	-	100.1	0.20	-0.90	119.0	-230.1
<=10 sf	2	-	-	10.0	0.90	-1.80	230.1	-373.0
25 sf	2	-	-	25.0	0.84	-1.52	220.1	-328.8
50 sf	2	-	-	50.0	0.79	-1.31	212.5	-295.3
>100 sf	2	-	-	100.1	0.74	-1.10	204.9	-261.9
<=10 sf	3	-	-	10.0	0.90	-1.80	230.1	-373.0
25 sf	3	-	-	25.0	0.84	-1.52	220.1	-328.8
50 sf	3	-	-	50.0	0.79	-1.31	212.5	-295.3
>100 sf	3	-	-	100.1	0.74	-1.10	204.9	-261.9



WIND LOADING (ASCE7)

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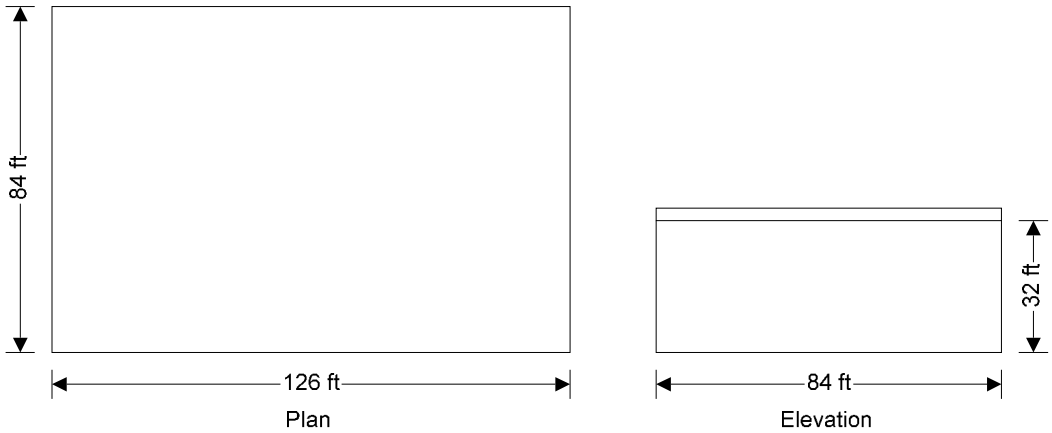
In accordance with ASCE7-10

Using the directional design method

Tedds calculation version 2.1.14



Building data

Type of roof	Flat
Length of building	b = **126.00** ft
Width of building	d = **84.00** ft
Height to eaves	H = **32.00** ft
Height of parapet	h_p = **3.00** ft

Mean height — h = **32.00** ft

General wind load requirements

Basic wind speed	V = **250.0** mph
Risk category	IV
Velocity pressure exponent coef (Table 26.6-1)	K_d = **1.00**
Exposure category (cl 26.7.3)	C
Enclosure classification (cl.26.10)	Partially enclosed buildings
Internal pressure coef +ve (Table 26.11-1)	GC_{pi_p} = **0.55**
Internal pressure coef –ve (Table 26.11-1)	GC_{pi_n} = **-0.55**
Gust effect factor	G_f = **0.85**
Minimum design wind loading (cl.27.1.5)	p_{min_r} = **8** lb/ft^2

Topography

Topography factor not significant	K_{zt} = 1.0
Velocity pressure equation	$q = 0.00256 \times K_z \times K_{zt} \times K_d \times V^2 \times 1psf/mph^2$

Velocity pressures table

z (ft)	K_z (Table 27.3-1)	q_z (psf)
15.00	0.85	136.00
20.00	0.90	144.00
32.00	0.99	158.72
35.00	1.01	161.60

Peak velocity pressure for internal pressure

Peak velocity pressure – internal (as roof press.) — q_i = **158.72** psf

Parapet pressures and forces

Velocity pressure at top of parapet	q_p = **161.6** psf
Combined net pressure coefficient, leeward	GC_{pnl} = **-1.0**
Combined net parapet pressure, leeward	$p_{pl} = q_p \times GC_{pnl}$ = **-161.6** psf
Combined net pressure coefficient, windward	GC_{pnw} = **1.5**
Combined net parapet pressure, windward	$p_{pw} = q_p \times GC_{pnw}$ = **242.4** psf
Wind direction 0 deg:	
Leeward parapet force	$F_{w,wpl\_0} = p_{pl} \times h_p \times b$ = **-61.1** kips
Windward parapet force	$F_{w,wpw\_0} = p_{pw} \times h_p \times b$ = **91.6** kips
Wind direction 90 deg:	
Leeward parapet force	$F_{w,wpl\_90} = p_{pl} \times h_p \times d$ = **-40.7** kips
Windward parapet force	$F_{w,wpw\_90} = p_{pw} \times h_p \times d$ = **61.1** kips

Pressures and forces

Net pressure	$p = q \times G_f \times C_{pe} - q_i \times GC_{pi}$
Net force	$F_w = p \times A_{ref}$

Roof load case 1 - Wind 0, GC_{pi} 0.55, $-c_{pe}$

Zone	Ref. height (ft)	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p (psf)	Net pressure p (psf)	Area A_{ref} (ft^2)	Net force F_w (kips)
A (-ve)	32.00	-0.90	158.72	-208.72	2016.00	-420.77

Zone	Ref. height (ft)	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p (psf)	Net pressure p (psf)	Area A_{ref} (ft^2)	Net force F_w (kips)
B (-ve)	32.00	-0.90	158.72	-208.72	2016.00	-420.77
C (-ve)	32.00	-0.50	158.72	-154.75	4032.00	-623.96
D (-ve)	32.00	-0.30	158.72	-127.77	2520.00	-321.98

Total vertical net force $F_{w,v}$ = **-1787.49** kips

Total horizontal net force $F_{w,h}$ = **0.00** kips

Walls load case 1 - Wind 0, GC_{pi} 0.55, -c_{pe}

Zone	Ref. height (ft)	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p (psf)	Net pressure p (psf)	Area A_{ref} (ft^2)	Net force F_w (kips)
A_1	15.00	0.80	136.00	5.18	1890.00	9.80
A_2	20.00	0.80	144.00	10.62	630.00	6.69
A_3	32.00	0.80	158.72	20.63	1512.00	31.20
B	32.00	-0.50	158.72	-154.75	4032.00	-623.96
C	32.00	-0.70	158.72	-181.73	2688.00	-488.50
D	32.00	-0.70	158.72	-181.73	2688.00	-488.50

Overall loading

Projected vertical plan area of wall $A_{vert\_w\_0} = b \times (H + h_p)$ = **4410.00** ft^2

Projected vertical area of roof $A_{vert\_r\_0}$ = **0.00** ft^2

Minimum overall horizontal loading $F_{w,total\_min} = p_{min\_w} \times A_{vert\_w\_0} + p_{min\_r} \times A_{vert\_r\_0}$ = **70.56** kips

Leeward net force $F_l = F_{w,wB} + F_{w,wpl\_0}$ = **-685.0** kips

Windward net force $F_w = F_{w,wA\_1} + F_{w,wA\_2} + F_{w,wA\_3} + F_{w,wpw\_0}$ = **139.3** kips

Overall horizontal loading $F_{w,total} = \max(F_w - F_l + F_{w,h}, F_{w,total\_min})$ = **824.4** kips

Roof load case 2 - Wind 0, GC_{pi} -0.55, -0c_{pe}

Zone	Ref. height (ft)	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p (psf)	Net pressure p (psf)	Area A_{ref} (ft^2)	Net force F_w (kips)
A (+ve)	32.00	-0.18	158.72	63.01	2016.00	127.03
B (+ve)	32.00	-0.18	158.72	63.01	2016.00	127.03
C (+ve)	32.00	-0.18	158.72	63.01	4032.00	254.06
D (+ve)	32.00	-0.18	158.72	63.01	2520.00	158.79

Total vertical net force $F_{w,v}$ = **666.92** kips

Total horizontal net force $F_{w,h}$ = **0.00** kips

Walls load case 2 - Wind 0, GC_{pi} -0.55, -0c_{pe}

Zone	Ref. height (ft)	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p (psf)	Net pressure p (psf)	Area A_{ref} (ft^2)	Net force F_w (kips)
A_1	15.00	0.80	136.00	179.78	1890.00	339.78
A_2	20.00	0.80	144.00	185.22	630.00	116.69

Zone	Ref. height (ft)	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p (psf)	Net pressure p (psf)	Area A_{ref} (ft^2)	Net force F_w (kips)
A_3	32.00	0.80	158.72	195.23	1512.00	295.18
B	32.00	-0.50	158.72	19.84	4032.00	79.99
C	32.00	-0.70	158.72	-7.14	2688.00	-19.20
D	32.00	-0.70	158.72	-7.14	2688.00	-19.20

Overall loading

Projected vertical plan area of wall $A_{vert\_w\_0} = b \times (H + h_p) =$ **4410.00** ft^2

Projected vertical area of roof $A_{vert\_r\_0} =$ **0.00** ft^2

Minimum overall horizontal loading $F_{w,total\_min} = p_{min\_w} \times A_{vert\_w\_0} + p_{min\_r} \times A_{vert\_r\_0} =$ **70.56** kips

Leeward net force $F_l = F_{w,wB} + F_{w,wpl\_0} =$ **18.9** kips

Windward net force $F_w = F_{w,wA\_1} + F_{w,wA\_2} + F_{w,wA\_3} + F_{w,wpw\_0} =$ **843.3** kips

Overall horizontal loading $F_{w,total} = \max(F_w - F_l + F_{w,h}, F_{w,total\_min}) =$ **824.4** kips

Roof load case 3 - Wind 90, GC_{pi} 0.55, $-c_{pe}$

Zone	Ref. height (ft)	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p (psf)	Net pressure p (psf)	Area A_{ref} (ft^2)	Net force F_w (kips)
A (-ve)	32.00	-0.90	158.72	-208.72	1344.00	-280.52
B (-ve)	32.00	-0.90	158.72	-208.72	1344.00	-280.52
C (-ve)	32.00	-0.50	158.72	-154.75	2688.00	-415.97
D (-ve)	32.00	-0.30	158.72	-127.77	5208.00	-665.42

Total vertical net force $F_{w,v} =$ **-1642.43** kips

Total horizontal net force $F_{w,h} =$ **0.00** kips

Walls load case 3 - Wind 90, GC_{pi} 0.55, $-c_{pe}$

Zone	Ref. height (ft)	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p (psf)	Net pressure p (psf)	Area A_{ref} (ft^2)	Net force F_w (kips)
A_1	15.00	0.80	136.00	5.18	1260.00	6.53
A_2	20.00	0.80	144.00	10.62	420.00	4.46
A_3	32.00	0.80	158.72	20.63	1008.00	20.80
B	32.00	-0.40	158.72	-141.26	2688.00	-379.71
C	32.00	-0.70	158.72	-181.73	4032.00	-732.75
D	32.00	-0.70	158.72	-181.73	4032.00	-732.75

Overall loading

Projected vertical plan area of wall $A_{vert\_w\_90} = d \times (H + h_p) =$ **2940.00** ft^2

Projected vertical area of roof $A_{vert\_r\_90} =$ **0.00** ft^2

Minimum overall horizontal loading $F_{w,total\_min} = p_{min\_w} \times A_{vert\_w\_90} + p_{min\_r} \times A_{vert\_r\_90} =$ **47.04** kips

Leeward net force $F_l = F_{w,wB} + F_{w,wpl\_90} =$ **-420.4** kips

Windward net force $F_w = F_{w,wA\_1} + F_{w,wA\_2} + F_{w,wA\_3} + F_{w,wpw\_90} =$ **92.9** kips

Overall horizontal loading $F_{w,total} = \max(F_w - F_l + F_{w,h}, F_{w,total\_min}) =$ **513.3** kips

Roof load case 4 - Wind 90, GC_{pi} -0.55, $+c_{pe}$

Zone	Ref. height (ft)	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p (psf)	Net pressure p (psf)	Area A_{ref} (ft^2)	Net force F_w (kips)
A (+ve)	32.00	-0.18	158.72	63.01	1344.00	84.69
B (+ve)	32.00	-0.18	158.72	63.01	1344.00	84.69
C (+ve)	32.00	-0.18	158.72	63.01	2688.00	169.38
D (+ve)	32.00	-0.18	158.72	63.01	5208.00	328.17

Total vertical net force $F_{w,v}$ = **666.92** kips

Total horizontal net force $F_{w,h}$ = **0.00** kips

Walls load case 4 - Wind 90, GC_{pi} -0.55, $+c_{pe}$

Zone	Ref. height (ft)	Ext pressure coefficient c_{pe}	Peak velocity pressure q_p (psf)	Net pressure p (psf)	Area A_{ref} (ft^2)	Net force F_w (kips)
A_1	15.00	0.80	136.00	179.78	1260.00	226.52
A_2	20.00	0.80	144.00	185.22	420.00	77.79
A_3	32.00	0.80	158.72	195.23	1008.00	196.79
B	32.00	-0.40	158.72	33.33	2688.00	89.59
C	32.00	-0.70	158.72	-7.14	4032.00	-28.80
D	32.00	-0.70	158.72	-7.14	4032.00	-28.80

Overall loading

Projected vertical plan area of wall $A_{vert\_w\_90} = d \times (H + h_p)$ = **2940.00** ft^2

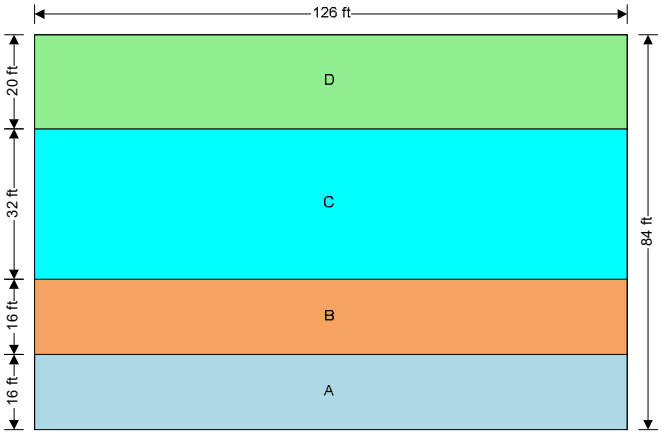
Projected vertical area of roof $A_{vert\_r\_90}$ = **0.00** ft^2

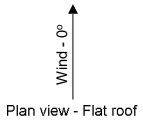
Minimum overall horizontal loading $F_{w,total\_min} = p_{min\_w} \times A_{vert\_w\_90} + p_{min\_r} \times A_{vert\_r\_90}$ = **47.04** kips

Leeward net force $F_l = F_{w,wB} + F_{w,wpl\_90}$ = **48.9** kips

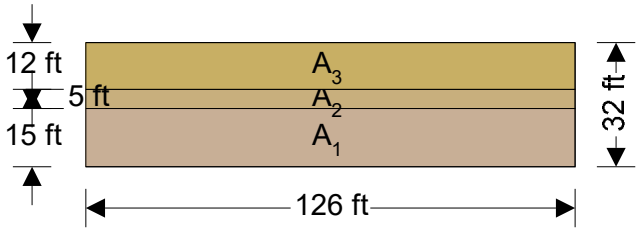
Windward net force $F_w = F_{w,wA\_1} + F_{w,wA\_2} + F_{w,wA\_3} + F_{w,wpw\_90}$ = **562.2** kips

Overall horizontal loading $F_{w,total} = \max(F_w - F_l + F_{w,h}, F_{w,total\_min})$ = **513.3** kips

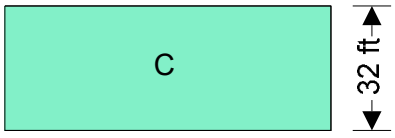




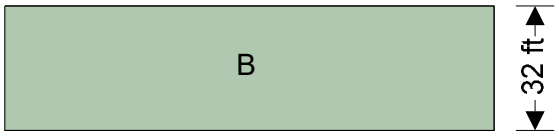
Plan view - Flat roof



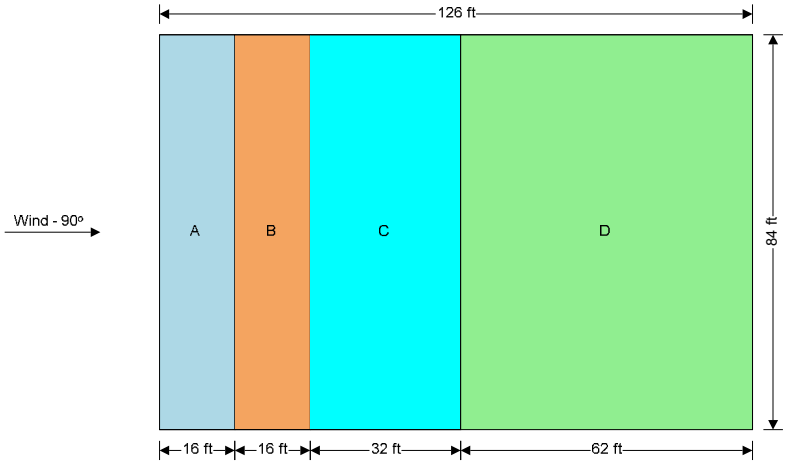
Windward face



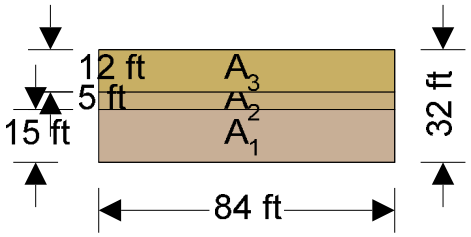
Side face



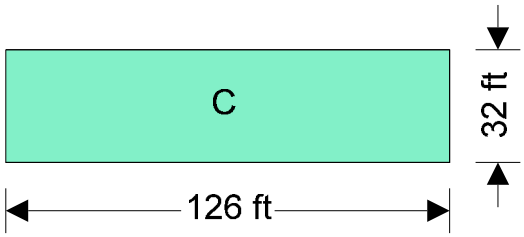
Leeward face



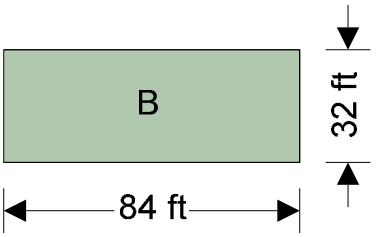
Plan view - Flat roof



Windward face



Side face



Leeward face

CHAPTER 3

STRUCTURAL DESIGN AND TESTING CRITERIA

SECTION 301
GENERAL

301.1 Scope. The requirements of this chapter shall govern the structural design and testing criteria of *storm shelters*.

301.2 General design requirements. *Storm shelters* shall be designed to resist the loads and load combinations as prescribed by this chapter in addition to the loads and load combinations prescribed in the *applicable code*.

301.3 General testing requirements. Where the capacity of *storm shelter envelope* components cannot be determined by engineering calculations in accordance with Section 301.2, it shall be determined through testing in accordance with Section 306.

SECTION 302
LOAD COMBINATIONS

302.1 General. The *storm shelter* shall be designed to resist the load combinations specified in Section 302.2 or 302.3. *Storm shelters* that are designed as combination tornado and *hurricane shelters* shall comply with requirements for both sets of load combinations using either Section 302.2 or 302.3.

302.2 Strength design. Where strength design or load and resistance factor design (LRFD) is used, *storm shelters* and portions thereof shall be designed to resist the most critical effects resulting from the following combinations of factored loads. Each load combination shall also be investigated with one or more of the variable loads set to zero.

For *tornado shelters*:

$1.4D$ **(Equation 3-1)**

$1.2D + 1.6L_T + 0.5L_{rT}$ **(Equation 3-2)**

$1.2D + 1.6L_{rT} + (L_T \text{ or } 0.5W_T)$ **(Equation 3-3)**

$1.2D + 1.0W_T + L_T + 0.5L_{rT}$ **(Equation 3-4)**

$0.9D + 1.0W_T$ **(Equation 3-5)**

For *hurricane shelters*:

$1.4D$ **(Equation 3-6)**

$1.2D + 1.6L + 0.5(L_{rH} \text{ or } R_H)$ **(Equation 3-7)**

$1.2D + 1.6(L_{rH} \text{ or } R_H) + (L \text{ or } 0.5W_H)$ **(Equation 3-8)**

$1.2D + 1.0W_H + L + 0.5(L_{rH} \text{ or } R_H)$ **(Equation 3-9)**

$0.9D + 1.0W_H$ **(Equation 3-10)**

In addition, for *hurricane shelters* subject to the requirements of Section 402.1 and located in:

Coastal high-hazard area or a *Coastal A Zone:*

$1.2D + 1.0W_H + 2.0F_{aH} + L + 0.5(L_{rH} \text{ or } R_H)$ **(Equation 3-11)**

$0.9D + 1.0W_H + 2.0F_{aH}$ **(Equation 3-12)**

All other locations:

$1.2D + 0.5W_H + 1.0F_{aH} + L + 0.5(L_{rH} \text{ or } R_H)$ **(Equation 3-13)**

$0.9D + 0.5W_H + 1.0F_{aH}$ **(Equation 3-14)**

302.3 Allowable stress design. Where allowable stress design (ASD, working stress design) is used, *storm shelters* and portions thereof shall be designed to resist the most critical effects resulting from the following combinations of loads. Each load combination shall also be investigated with one or more of the variable loads set to zero.

For *tornado shelters*:

$D + L_T$ **(Equation 3-15)**

$D + L_{rT}$ **(Equation 3-16)**

$D + 0.75L_T + 0.75L_{rT}$ **(Equation 3-17)**

$D + 0.6W_T$ **(Equation 3-18)**

$D + 0.75L_T + 0.75(0.6W_T) + 0.75L_{rT}$ **(Equation 3-19)**

$0.6D + 0.6W_T$ **(Equation 3-20)**

For *hurricane shelters*:

$D + L$ **(Equation 3-21)**

$D + (L_{rH} \text{ or } R_H)$ **(Equation 3-22)**

$D + 0.75L + 0.75(L_{rH} \text{ or } R_H)$ **(Equation 3-23)**

$D + 0.6W_H$ **(Equation 3-24)**

$D + 0.75L + 0.75(0.6W_H) + 0.75(L_{rH} \text{ or } R_H)$ **(Equation 3-25)**

$0.6D + 0.6W_H$ **(Equation 3-26)**

In addition, for *hurricane shelters* subject to the requirements of Section 402.1 and located in:

Coastal high-hazard area or a *Coastal A Zone:*

$D + 0.6W_H + 1.5F_{aH}$ **(Equation 3-27)**

$D + 0.75L + 0.75(0.6W_H) + 0.75(L_{rH} \text{ or } R_H) + 1.5F_{aH}$ **(Equation 3-28)**

$0.6D + 0.6W_H + 1.5F_{aH}$ **(Equation 3-29)**

All other locations:

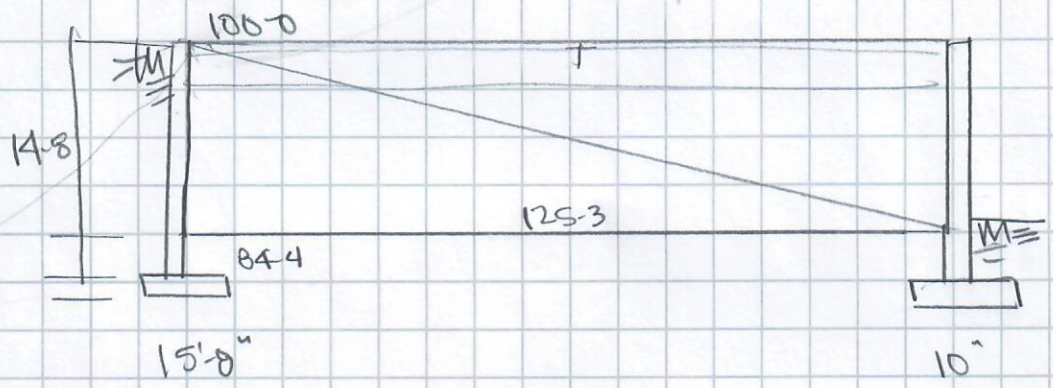
$D + 0.75L + 0.75(0.6W_H) + 0.75(L_{rH} \text{ or } R_H) + 0.75F_{aH}$ **(Equation 3-30)**

$0.6D + 0.6W_H + 0.75F_{aH}$ **(Equation 3-31)**

SECTION 303
LOADS

303.1 Rain loads. Rain loads shall be determined in accordance with the *applicable code*.

J&S STRUCTURAL ENGINEERS Overland Park, KS 66223 P:913.549.4701	PROJECT NAME: LS. VOC			PROJECT NUMBER:
	SUBJECT: Boyancy Calc			SHEET NUMBER:
	CALC BY: KM	DATE: 2/6/25	CHECKED BY:	DATE:



WT of Water Displaced: .83(125.25) + 14.83(125.25)(1/2) = 1032.7 ft²/FT

1032.7 ft²(81') = 83,649 ft³

83649 ft³ (62.5 lbs) = 5,228,063 lbs

NONBRG: WT OF STRUCTURE:

WT OF ROOF: ~~536 plf~~

WALL Panels: 200 psf (2)(37) = 14800 lb/ft

FLOOR: 65 psf (2') = ~~+301 lb/ft~~

FTG: 2.67(1.33)(150)(2) = 1065 lb/ft

15865 lb/ft (81')

= 1,285,065 kips

~~WT POST: 65 psf (40.5 ft)(18.75) = 49360 lbs~~

BRG WALL:

WT OF ROOF = 1072/10 (81')(125.25) = 1088k

WALL: 14800 lb/ft (125.25 ft)(2) = 3707k

WT OF FLOOR: 65(81')(125.25) = 659k

FTG: 2.67(1.33)(150)(2)(125.25) = 133k

TOTAL STRUCTURE WT: 1285 + 1088 + 3707 + 659 + 133 = 6872 K

SOIL WT: .110 KCF (1.17)(15.67')(81') = 163 — 7035k

FS = 6872 / 5228 = 1.31