



SOLAR-ROOF-CHECK

THE RLA THE RIGOROUS LOAD ANALYSIS

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SRC JOB ID: 637
JOB REPORT DATE: 2014-12-02/Rev F
JOB NUMBER: 103
JOB NAME: 103-zep
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Date: 2014.12.02 12:16:10 -0800

Program Version: 2014-12-01:7

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LOAD COMBINATIONS: ASCE 7-05, IBC 2009 (NOT APPLICABLE IN CA)

- LOADING COMB. #1: WIND UPLIFT - 0.6DL SOLAR AT STANDOFF ($C_D=1.6$) ZONE 2
- LOADING COMB. #2: DL RF + DL SOLAR + RF LL ($C_D=1.25$).
- LOADING COMB. #3: DL RF + DL SOLAR + WIND DOWN ($C_D=1.6$). ZONE 1
- LOADING COMB. #4: DL RF + DL SOLAR + SNOW ($C_D=1.15$).
- LOADING COMB. #5: DL RF + DL SOLAR +.75WIND +.75SNOW ($C_D=1.6$) ZONE 1
- LOADING COMB. #6: CHECK SEISMIC FOR SECT. 3404.4 ALTERATIONS.
- LOADING COMB. #7: (0.6)(DL RF + DL SOLAR) + WIND UP ($C_D=1.6$). ZONE 1

LOAD COMBINATIONS: ASCE 7-10, IBC 2012 CALIFORNIA, CBC 2013

- LOADING COMB. #1: (0.6)WIND UPLIFT - 0.6DL SOLAR AT STANDOFF ($C_D=1.6$) ZONE 2
- LOADING COMB. #2: DL RF + DL SOLAR + RF LL ($C_D=1.25$).
- LOADING COMB. #3: DL RF + DL SOLAR + (0.6)WIND DOWN ($C_D=1.6$) ZONE 1
- LOADING COMB. #4: DL RF + DL SOLAR + SNOW ($C_D=1.15$)
- LOADING COMB. #5: DL RF + DL SOLAR +.75(0.6)WIND +.75SNOW ($C_D=1.6$) ZONE 1
- LOADING COMB. #6: CHECK SEISMIC FOR SECT. 3404.4 ALTERATIONS
- LOADING COMB. #7: (0.6)WIND UP-0.6(DL RF + DL SOLAR) ($C_D=1.6$) ZONE 1

REFERENCES: NJ, NDS LATEST EDITION

Duration Factors	Section Modules		Size Form Factor	
$C_{d_{Wind}} := 1.6$	$S_{2X2} := 0.563$	$S_{4X4} := 7.150$	$C_{f_{2x2}} := 1.5$	$C_{f_{4x4}} := 1.5$
$C_{d_{Snow}} := 1.15$	$S_{2X4} := 3.063$	$S_{4X6} := 17.650$	$C_{f_{2x4}} := 1.5$	$C_{f_{4x6}} := 1.3$
$C_{d_{DL}} := 0.9$	$S_{2X6} := 7.563$	$S_{4X8} := 30.660$	$C_{f_{2x6}} := 1.3$	$C_{f_{4x8}} := 1.3$
$C_{d_{LL}} := 1.25$	$S_{2X8} := 13.14$	$S_{4X10} := 49.900$	$C_{f_{2x8}} := 1.2$	$C_{f_{4x10}} := 1.2$
	$S_{2X10} := 21.39$	$S_{4X12} := 73.800$	$C_{f_{2x10}} := 1.1$	$C_{f_{4x12}} := 1.1$
$F_b := 1000.00 \text{ psi}$	$S_{2X12} := 31.64$		$C_{f_{2x12}} := 1.0$	

USER INPUT:

1. Ceiling Type:	None
2. Collar Tie Space:	0
3. Coverage %:	20
4. Frame Size:	2x8@16
5. Ground Snow (psf):	30
6. Sloped Roof Snow Load (psf):	30
7. Lag Screw Diameter (in):	3/8
8. Lag Screw Embedment (in):	2
9. Overall Span (ft):	7
10. PV Weight (psf):	4
11. Rafter Sloped Span (ft):	7
12. Roofing Type:	Asphalt Shingles
13. Roof Mean Height (ft):	20
14. Roof Slope (degrees):	20
15. Roof Type:	Truss
16. Sloped Ceiling?:	Yes
17. Standoff Max. Horz. Space (ft):	4
18. Standoff Max. Vert. Space (ft):	4
19. Standoff Staggered?:	Yes
20. Wind Exposure:	B
21. Wind Speed (mph):	110
22. w_r = Weight of RoofType (psf):	2.00
23. w_{ra} = Weight of Rafter (psf):	1.95
24. w_c = Weight of CeilingType:	0
25. w_{cj} = Weight of Ceiling Joists (psf):	0.65
26. s = Rafter spacing (ft.):	1.33
27. PV Orientation:	Portrait

NOTE: θ = 14. Roof Slope (degrees)

SLOPED/VAULTED CEILING - CARRIED BY THE TOP CHORD/RAFTER:

DL_{tc} := Deadload Top Chord (Rafter)
 DL_{bc} := Deadload Bottom Chord (Ceiling)

FLAT CEILING - CARRIED BY THE CEILING JOISTS:

DL_{tc} := Deadload Top Chord (Rafter)
 DL_{bc} := Deadload Bottom Chord (Ceiling)
 wDL_{tc} := $DL_{tc} \times s$ (plf) 9.27
 wDL_{bc} := $DL_{bc} \times s$ (plf) 0
TA = Horizontal spacing x Vertical spacing (sf) 16.00
Topographic Factor
Assume Roof is not on top of a hill, bluff, or mountain ridge. 1.0
Sect. 6.5.7.2, pg. 26
 C_{LS} 1.00

COMPONENTS AND CLADDING:**ASCE 7-05:**

Zone 1: Net Wind Pressure - See Figure 6-3, pg. 42 NA
Zone 2: Net Wind Pressure - See Figure 6-3, pg 42 NA
Adjustment Factor for Height and Exposure - See Figure 6-3, pg. 44 NA

ASCE 7-10:

Zone 1: Net Wind Pressure - See Figure 30.5-1 19.40
Zone 2: Net Wind Pressure - See Figure 30.5-1, : 31.90
Adjustment Factor for Height and Exposure - See Figure 30.5-1, 1.00
 $p_{Zone1\ up}$ = Net Wind Pressure x Adj. Factor (psf) = 19.40
 $p_{Zone2\ up}$ = Net Wind Pressure x Adj. Factor (psf) = 31.90
 $p_{Zone1\ dn}$ = Net Wind Pressure x Adj. Factor (psf) = 16.00

Note: For ASCE 7-10 the wind forces have been multiplied by 0.6

LOADING COMBINATION #1: WIND UPLIFT CONNECTION TO RAFTER - ZONE 2

$$P_1 := TA \times (P_{up} - 6 \times DL_{Solar} \times \cos(\theta)) \text{ uplift} \quad 270.16$$

$$d = \text{Diam.lag screws} \text{ User Input} \quad 3/8$$

$$t = \text{lb/inch Withdrawal NDS 2012 - Tab. 11.2A, pg 75} \quad 269.00$$

$$e = \text{Threaded embedment into wood User Input} \quad 2.00$$

W = Total withdrawal capacity

$$W := C_d W_{wind} \times t \times e \quad 860.80$$

$$\% := \frac{W \times 100}{P_1} \quad 318.63$$

<< If equal to or more than 100% Code Compliant, OK!

Table 3 represents the maximum Moment ($M = PL/a$) resulting from point loads (standoffs), for any spans (L) listed.

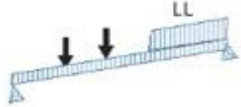
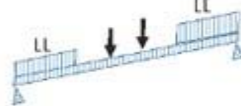
$$a = 4.50$$

Table 3 (The Moment Factor "a" for a 2 Rail system)

Table 3 (The Moment Factor "a" for Zep or similar system)

Length	Staggered		Unstaggered		Length	Staggered		Unstaggered	
	Portrait	Landscape	Portrait	Landscape		Portrait	Landscape	Portrait	Landscape
L = 4'	4.00	4.00	4.00	2.91	L = 4'	5.00	5.00	5.00	5.00
L = 5'	4.00	3.50	3.72	2.50	L = 5'	5.00	5.00	5.00	5.00
L = 6'	4.00	3.00	3.43	2.09	L = 6'	5.00	5.00	5.00	5.00
L = 7'	3.60	2.84	2.95	1.83	L = 7'	4.50	4.50	4.50	4.19
L = 8'	3.20	2.67	2.46	1.56	L = 8'	4.00	4.00	4.00	3.37
L = 9'	3.03	2.59	2.34	1.44	L = 9'	4.00	4.00	4.00	3.12
L = 10'	2.86	2.50	2.22	1.31	L = 10'	4.00	4.00	4.00	2.86
L = 11'	2.77	2.25	2.04	1.19	L = 11'	4.00	4.00	3.70	2.48
L = 12'	2.67	2.00	1.85	1.07	L = 12'	4.00	4.00	3.39	2.09
L = 13'	2.61	1.88	1.74	0.90	L = 13'	4.00	3.87	3.35	1.98
L = 14'	2.55	1.75	1.62	0.92	L = 14'	4.00	3.73	3.30	1.87
L = 15'	2.51	1.68	1.50	0.86	L = 15'	4.00	3.32	2.88	1.78
L = 16'	2.46	1.60	1.38	0.81	L = 16'	4.00	2.90	2.46	1.68
L = 17'	2.43	1.45	1.31	0.76	L = 17'	4.00	2.74	2.36	1.57
L = 18'	2.40	1.29	1.23	0.72	L = 18'	4.00	2.57	2.25	1.45
L = 19'	2.38	1.24	1.17	0.68	L = 19'	4.00	2.46	2.18	1.38
L = 20'	2.35	1.18	1.11	0.65	L = 20'	4.00	2.35	2.11	1.30
L = 21'	2.22	1.14	1.06	0.62	L = 21'	4.00	2.28	2.06	1.25
L = 22'	2.09	1.10	1.00	0.59	L = 22'	4.00	2.20	2.00	1.20

Note: For ASCE 7-10 the wind forces have been multiplied by 0.6

COMBINATION #2:		DL Rf + DL SOLAR + Rf LL (Cd=1.25) with LL= 19.63 psf	
$w := LL \times s \text{ plf}$	(plf) := 26.18	$P := TA \times DL_{\text{Solar}}$	64.00
$c := \frac{(L - 5.5)}{2}$	(ft) := NA	$M_{DL} := \left(wDL_{tc} \times \frac{L^2}{8} + P_{sp} \times \frac{L}{a} \right) \times \cos(\theta)$	146.89
For Spans < 10.0 ft		$M_{LL} := \frac{\left[\left(w \times \frac{3}{2 \times L} \right) \times (2 \times L - 3) \right]^2 \times \cos(\theta)}{2 \times w}$	68.33
For Spans =>10.0 ft		$M_{LL} := \frac{\left[\frac{w \times c \times (2 \times L - c) + w \times c^2}{2 \times L} \right]^2 \times \cos(\theta)}{2 \times w}$	NA
$M := M_{DL} + M_{LL}$	(lb-ft) := 215.22	$S_r := M \times \frac{12}{Fb \times Cd_{LL} \times Cf_x \times C_r \times C_{LS}}$	1.50
$\% := \frac{S_x}{S_r} \times 100$	<< IF EQUAL TO OR MORE THAN 100% CODE COMPLIANT, OK!		877.64
COMBINATION #3: ZONE 1		DL Rf + DL SOLAR + WIND DOWN (Cd=1.6)	
$P_3 := TA \times (p_{dn} + DL_{\text{Solar}} \times \cos(\theta))$			213.74
$M_3 := \left(wDL_{tc} \times \frac{L^2}{8} \right) \times \cos(\theta \times \text{deg}) + P_3 \times \frac{L}{a}$			385.82
$S_r := M_3 \times \frac{12}{Fb \times Cd_{\text{Wind}} \times Cf_x \times C_r \times C_{LS}}$			2.10
$\% := \frac{S_x \times 100}{S_r}$	<< IF EQUAL TO OR MORE THAN 100% CODE COMPLIANT, OK!		626.65
COMBINATION #4:		DL Rf + DL SOLAR + SNOW (Cd=1.15)	
$S = \text{Sloped Roof Snow Load (psf)}$			30.00
$P_4 := TA \times (S + DL_{\text{Solar}})$			544.00
$M_4 := \left(wDL_{tc} \times \frac{L^2}{8} + P_4 \times \frac{L}{a} \right) \times \cos(\theta)$			848.52
$S_r := M_4 \times \frac{12}{Fb \times Cd_{\text{Snow}} \times Cf_x \times C_r \times C_{LS}}$			6.42
$\% := \frac{S_x \times 100}{S_r}$	<< IF EQUAL TO OR MORE THAN 100% CODE COMPLIANT, OK!		204.80

Note: For ASCE 7-10 the wind forces have been multiplied by 0.6

LOADING COMBINATION #5: ZONE 1 DL_{Rf} + DL_{Solar} +.75WIND +.75SNOW (C_D=1.6)	
S = Sloped Roof Snow Load (psf)	30.00
$P_5 := TA \times (.75 \times S + DL_{Solar}) \times \cos(\theta) + (TA \times .75 \times P_{dn})$	513.63
$M_5 := \left(wDL_{tc} \times \frac{L^2}{8} + P_5 \times \frac{L}{a} \right) \times \cos(\theta)$	852.31
$S_r := M_5 \times \frac{12}{F_b \times C_{dWind} \times C_{f_x} \times C_r \times C_{LS}}$	4.63
$\% := \frac{S_x \times 100}{S_r} \ll \text{IF EQUAL TO OR MORE THAN 100\% CODE COMPLIANT, OK!}$	283.67

LOADING COMBINATION #6: CHECK SEISMIC LOADING!	
ExistingDL := DL _{Rf} + Walls Walls := 5.5 psf	12.45
ProposedDL := ExistingDL + DL _{Solar} × C	13.25
SeismicIncrease := $100 \times \left(\frac{\text{ProposedDL}}{\text{ExistingDL}} \right) - 100$	6.43
<< IF EQUAL TO OR LESS THAN 10% CODE COMPLIANT, OK!	

SEISMIC SUMMARY

Sect. 3404.3 Alterations (See Exception):

The addition of the Solar Panels, meets the following:

- The design strength of existing elements required to resist seismic forces is not reduced.
- The seismic force to required existing structural elements is not substantially increased.
- No new structural elements are being added.
- New nonstructural elements are being connected to existing structure per Chapter 16.
- Alterations do not create structural irregularities.

Note: For ASCE 7-10 the wind forces have been multiplied by 0.6

LOADING COMBINATION #7:	ZONE 1	(0.6)(DL_{Rf} + DL_{SOLAR}) + WIND UP	(C_D=1.6)
$P_7 := TA \times (P_{up} - 0.6 \times DL_{Solar} \times \cos(\theta))$			150.16
$M_7 := \left(P_7 \times \frac{L}{a} \right) - wDL_{tc} \times \frac{L^2}{8} \times \cos(\theta)$			201.57
$S_r := M_7 \times \frac{12}{F_b \times C_{dWind} \times C_{f_x} \times C_r \times C_{LS}}$			1.10
$\% := \frac{S_x \times 100}{S_r}$	<< IF EQUAL TO OR MORE THAN 100% CODE COMPLIANT, OK!		1199.44

LIMITS OF SCOPE OF WORK AND LIABILITY

Existing deficiencies which may be readily observable, and conditions which may not be code compliant, or may be in need of repair, or are concealed in any way that is not observable at the time of any inspections, are not included in this scope of work. There is no implication that any visual inspections, by the Solar Company or the Engineer of Record, are intended to be technically exhaustive, or that such inspections indicate that every aspect of every component was analyzed, or that every conceivable deficiency was reported. The calculations do not include an analysis of the overall structural stability, and code compliance of an existing building, nor prediction of satisfactory performance or life expectancy of any existing building.