Force Transfer Around Opening; Case Study: Las Ventanas, Long Beach, CA

Las Ventanas: The Windows

Affordable Housing Complex

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VP of Productions, Core Structure, Inc.

CORE
From The Ground Up

Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.

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Project Descriptions

- William Hezmalhalch Architects (WHA)
- Core Structure, Inc.
- AMCAL General Contractors

- $28 M Budget
- 102 units; ~4000 S.F. retail space, semi-subterranean podium parking garage, 4-story Light Frame Construction
- > 1 acre off the Pacific Coast Highway in Long Beach.

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Why FTAO?

To Avoid This!

Constructability

To Achieve This!

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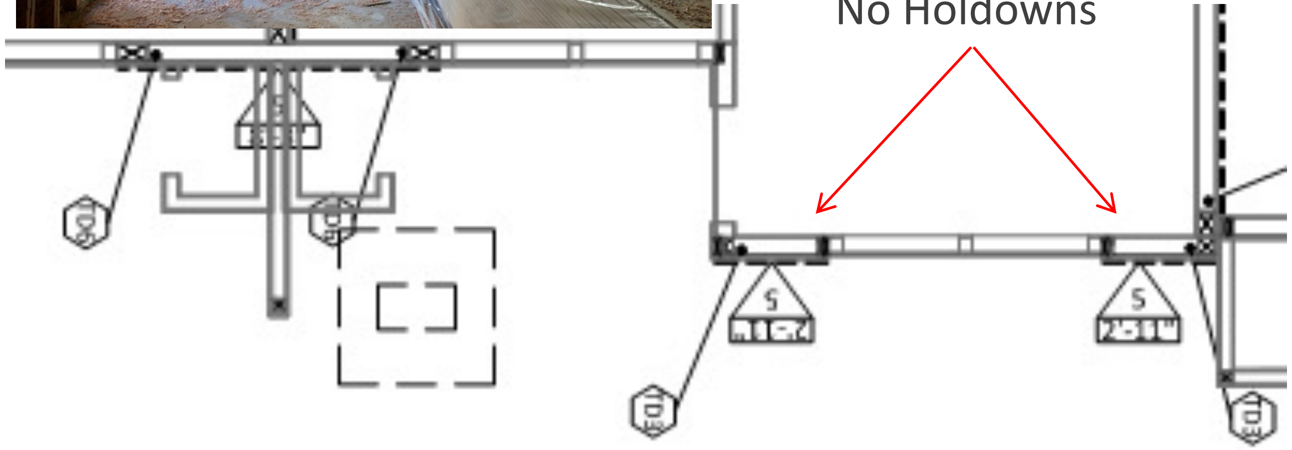

Advantages:

- Reduce the Number of Holdowns (30-40%)

- BUT THAT S NOT THE ONLY SAVINGS!

Las Ventanas , Photo Courtesy of WHA

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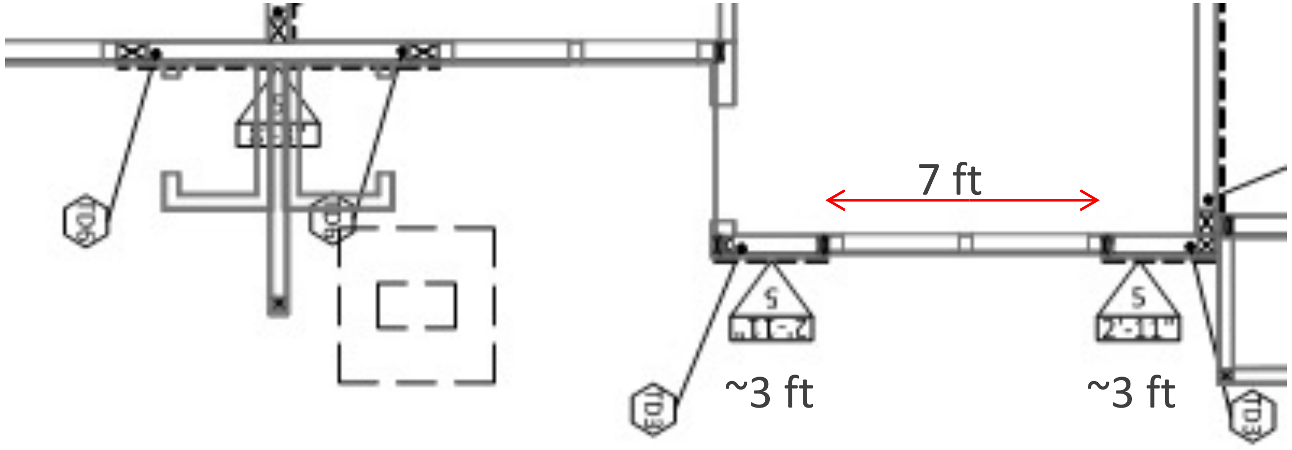
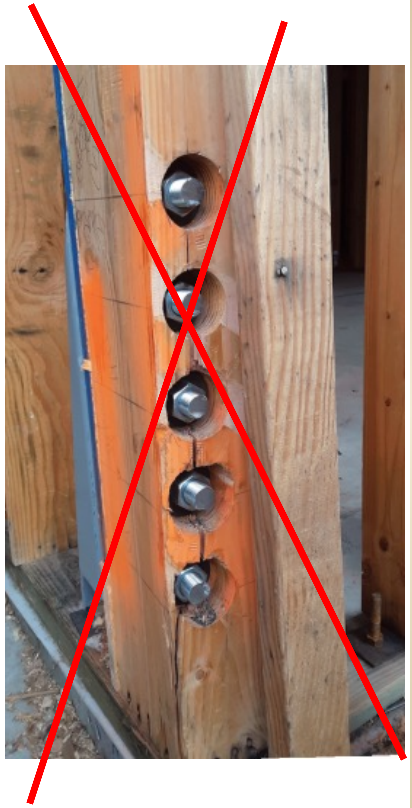


Advantages:

- Use Smaller Holdowns

W/O FTAO: 8700#
W/FTAO: 4015#



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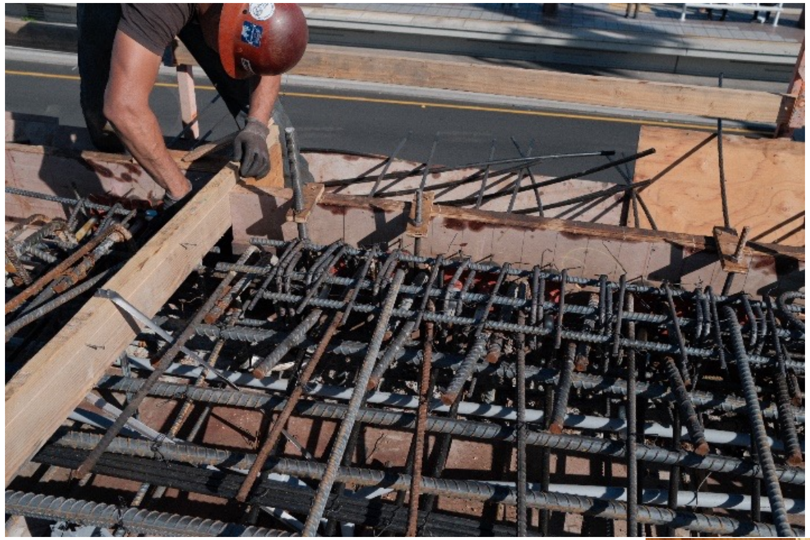

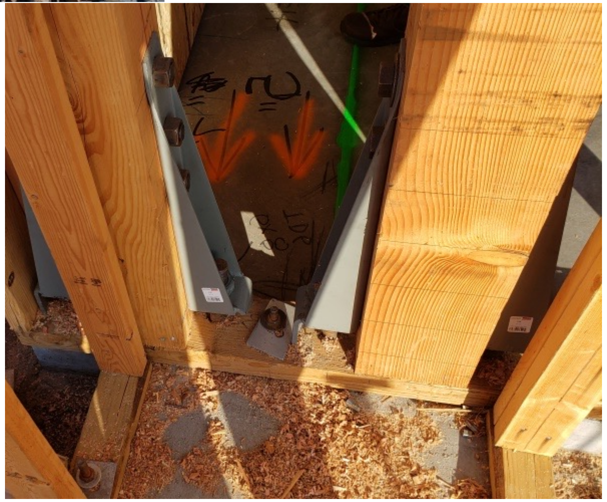

Advantages:

- Able to use Narrow Piers as shear walls
- Able to use one sided shear walls
- No Steel Moment Frame, No Pre-Fabricated Shear walls(panels)
- Reduce Required Reinforcement and Alleviate Congestion at Podium Slab
- **ALL MEANS REDUCED COST**

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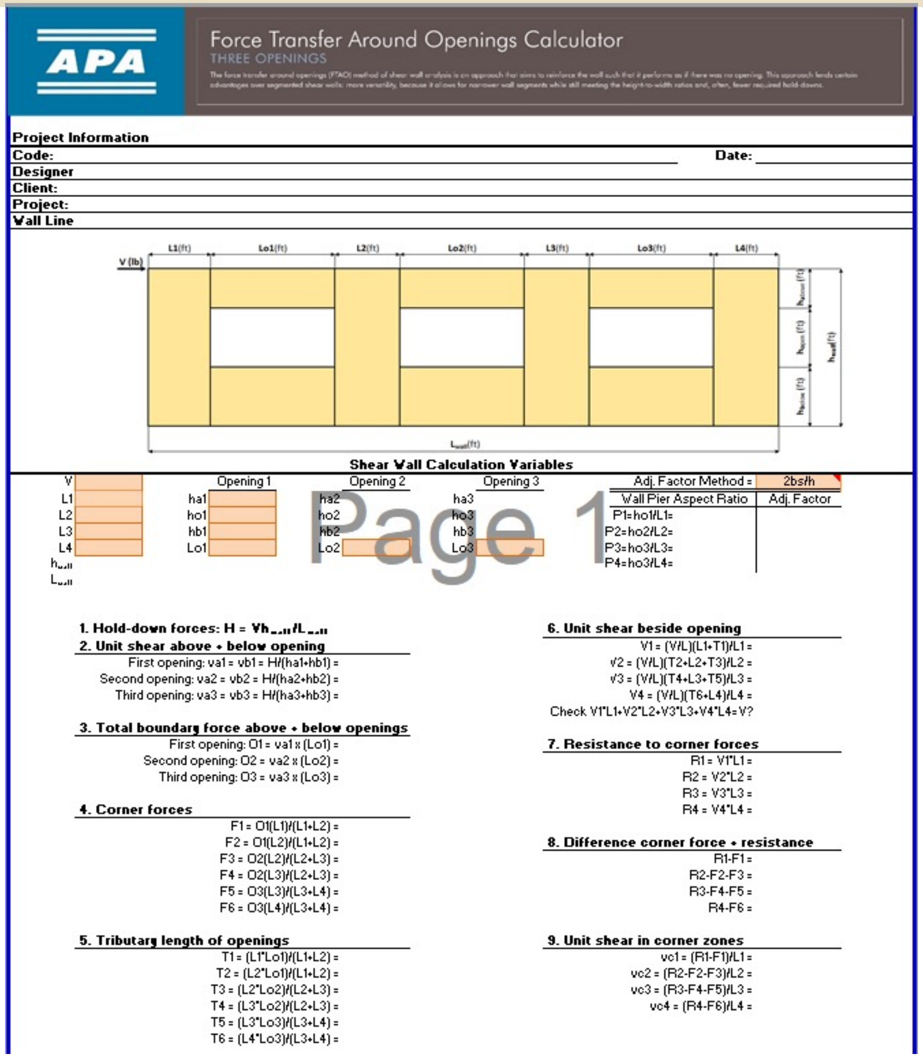
Easy to Incorporate



APA | Force Transfer Around Openings Calculator
THREE OPENINGS

Project Information
Code: Date:
Designer
Client:
Project:
Wall Line

Shear Wall Calculation Variables

V, L1, L2, L3, L4 | Opening 1: ha1, ho1, hb1, Lo1 | Opening 2: ha2, ho2, hb2, Lo2 | Opening 3: ha3, ho3, hb3, Lo3 | Adj. Factor Method = 2bs/h

Wall Pier Aspect Ratio | Adj. Factor
P1=ho1/L1=
P2=ho2/L2=
P3=ho3/L3=
P4=ho3/L4=

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1. Hold-down forces: H = Vh/L
2. Unit shear above + below opening
First opening: va1 = vb1 = H/(ha1+hb1) =
Second opening: va2 = vb2 = H/(ha2+hb2) =
Third opening: va3 = vb3 = H/(ha3+hb3) =

3. Total boundary force above + below openings
First opening: O1 = va1 x (Lo1) =
Second opening: O2 = va2 x (Lo2) =
Third opening: O3 = va3 x (Lo3) =

4. Corner forces
F1 = O1(L1)/(L1+L2) =
F2 = O1(L2)/(L1+L2) =
F3 = O2(L2)/(L2+L3) =
F4 = O2(L3)/(L2+L3) =
F5 = O3(L3)/(L3+L4) =
F6 = O3(L4)/(L3+L4) =

5. Tributary length of openings
T1 = (L1*Lo1)/(L1+L2) =
T2 = (L2*Lo1)/(L1+L2) =
T3 = (L2*Lo2)/(L2+L3) =
T4 = (L3*Lo2)/(L2+L3) =
T5 = (L3*Lo3)/(L3+L4) =
T6 = (L4*Lo3)/(L3+L4) =

6. Unit shear beside opening
V1 = (V/L)(L1+T1)/L1 =
V2 = (V/L)(T2+L2+T3)/L2 =
V3 = (V/L)(T4+L3+T5)/L3 =
V4 = (V/L)(T6+L4)/L4 =
Check V1*L1+V2*L2+V3*L3+V4*L4=V?

7. Resistance to corner forces
R1 = V1*L1 =
R2 = V2*L2 =
R3 = V3*L3 =
R4 = V4*L4 =

8. Difference corner force + resistance
R1-F1 =
R2-F2-F3 =
R3-F4-F5 =
R4-F6 =

9. Unit shear in corner zones
vc1 = (R1-F1)/L1 =
vc2 = (R2-F2-F3)/L2 =
vc3 = (R3-F4-F5)/L3 =
vc4 = (R4-F6)/L4 =

Wall and Opening Segment Lengths				Window location and Height				Tota;l Shear in Walls		
	L1=	4	ft		H1=	4	ft			
	L2=	6	ft		H2=	2.67	ft	V=	3750	lb
	L3=	4	ft		H3=	1.33	ft			
	L4=	2	ft	Wall Height=	H=	8				
	L5=	3.5	ft							
	L6=		ft							
	L7=		ft							
	Sum=	19.5								

1-- Calculate Hold-Down Forces:

T=C= 1538 lb

2- Calculate shear stress above and below openings:

va=vb= 289 plf

3- Find Inflection point of assumed beam segments above and below openings:

a1=	3.00	a2=	1.07	a3=	0.00	ft
b1=	3.00	b2=	0.93	b3=	0.00	ft

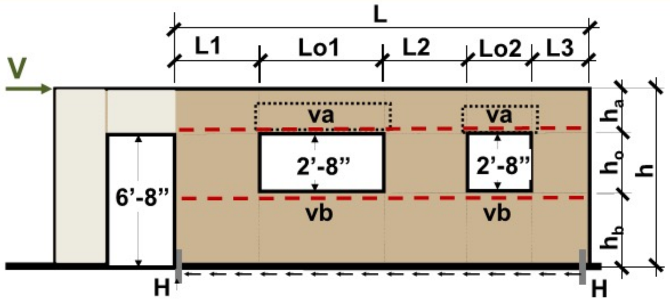
4- Calcualte Pier Segements Tributary Widths:

Lp1=	7.00	ft
Lp2=	8.07	ft
Lp3=	4.43	ft
Lp4=	0.00	ft

5- Calcualte Pier Shear Stresses

Vp1=	1346	lb	vp1=	337	plf
Vp2=	1551	lb	vp2=	388	plf
Vp3=	853	lb	vp3=	244	plf
Vp4=	0	lb	vp4=	0	plf

FTAO Approach



Source: AWC-DES415-FTAO-2017-08-17

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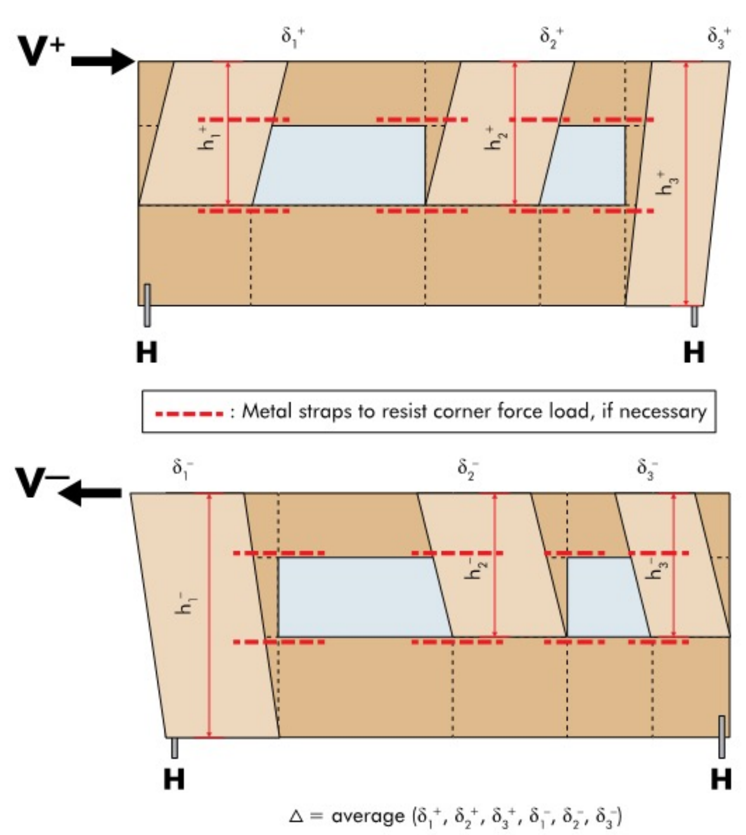
Deflection

FIGURE 2

CONCEPTUAL METHODOLOGY FOR ESTIMATING DEFLECTION OF WALLS WITH OPENINGS



Source: APA Technical Note T555, Figure 2

- Suggested Method by APA Technical Note “T555A”

(This Method Does not preclude any other Rational Analysis and Engineering Judgement)

- Unit Strip Method ; 2012 IBC SEAOC Structural/Seismic Design Manual, Vol 2

(Analysis similar to computing stiffness for concrete wall with an opening in it)

- Perforated Shear wall Method

(Calculate Shear Capacity Adjustment Factor, “C0” per SDPWS 4.3.3.5)

$$\delta_{sw} = \frac{8\nu h^3}{EAb} + \frac{\nu h}{1000G_a} + \frac{h\Delta_a}{b} \qquad (4.3\text{-}1)$$

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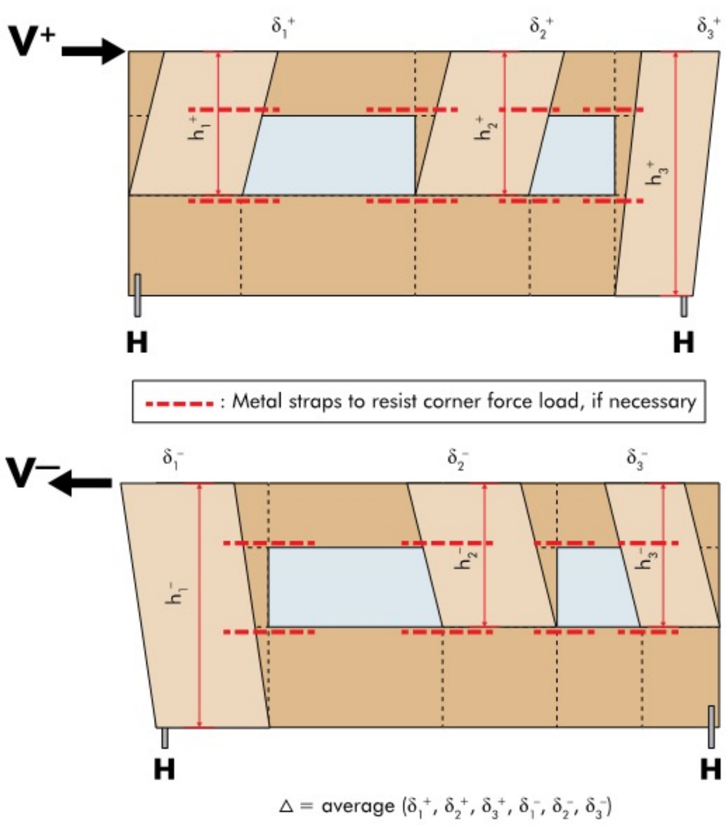


Source: APA Technical Note T555, Figure 2

2012 IBC SEAOC Structural/Seismic Design Manual, Vol 2 Comparison between Methods 2 (92%) and 3 (59%).

Window Strip Method Overestimates Stiffness.

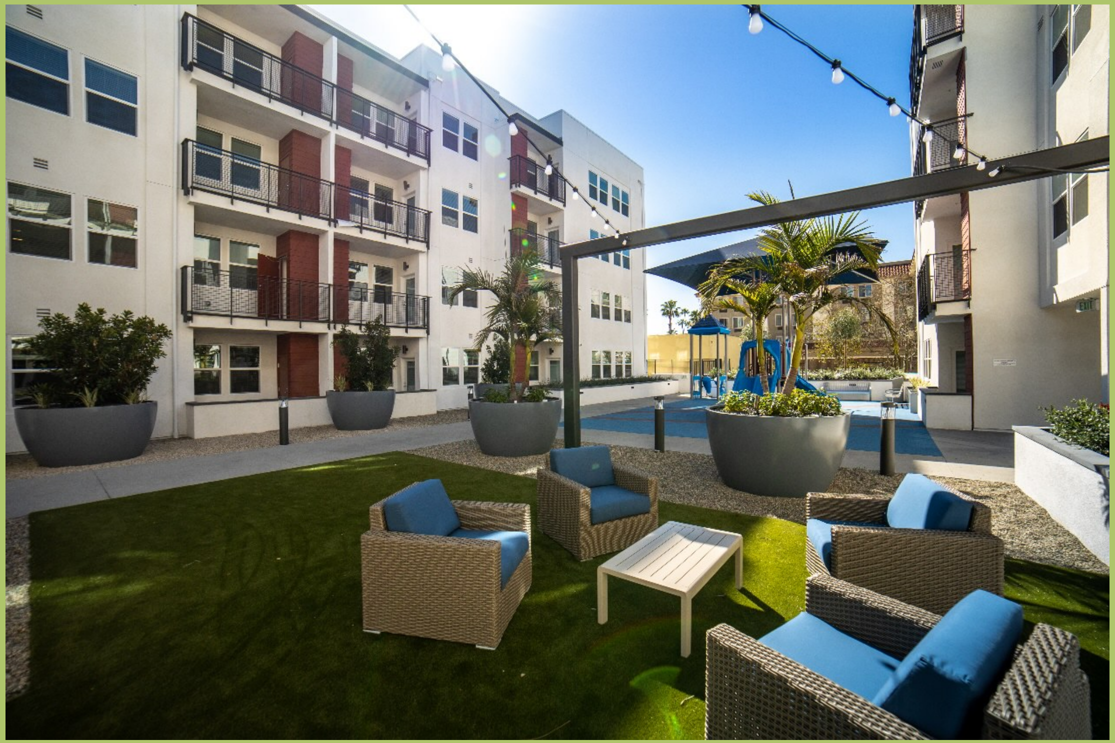
Perforated Wall Method appears to be the Most Conservative and used for Las Ventanas

T555 3 Term Deflection: 0.352 in

Value Calculated using Perforated Method (same example): 0.361 in

(C0=~1.0, vmax= V/(C0xΣLi) = 466 plf (SD Level), b=Σli=11.5 ft)

QUESTIONS?



Las Ventanas Courtyard, Photo Courtesy of AMCAL

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