On Stucco Cracking

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Photo Courtesy of Chris Makepeace


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Typical Cracking Patterns-Stucco

- Shrinkage

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Open Cracks-Looks Like a Spider Web

Typical Cracking of Stucco

- Compression of stucco by the structure

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Other Problems

- Wavy Appearance

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12/5/02 12:58
25FT
INCHES
FT. & IN.

Different Pattern

- Cracks not « open »
- Mid-height of panels
- Mostly on South and East Walls
- Mostly on dark stucco

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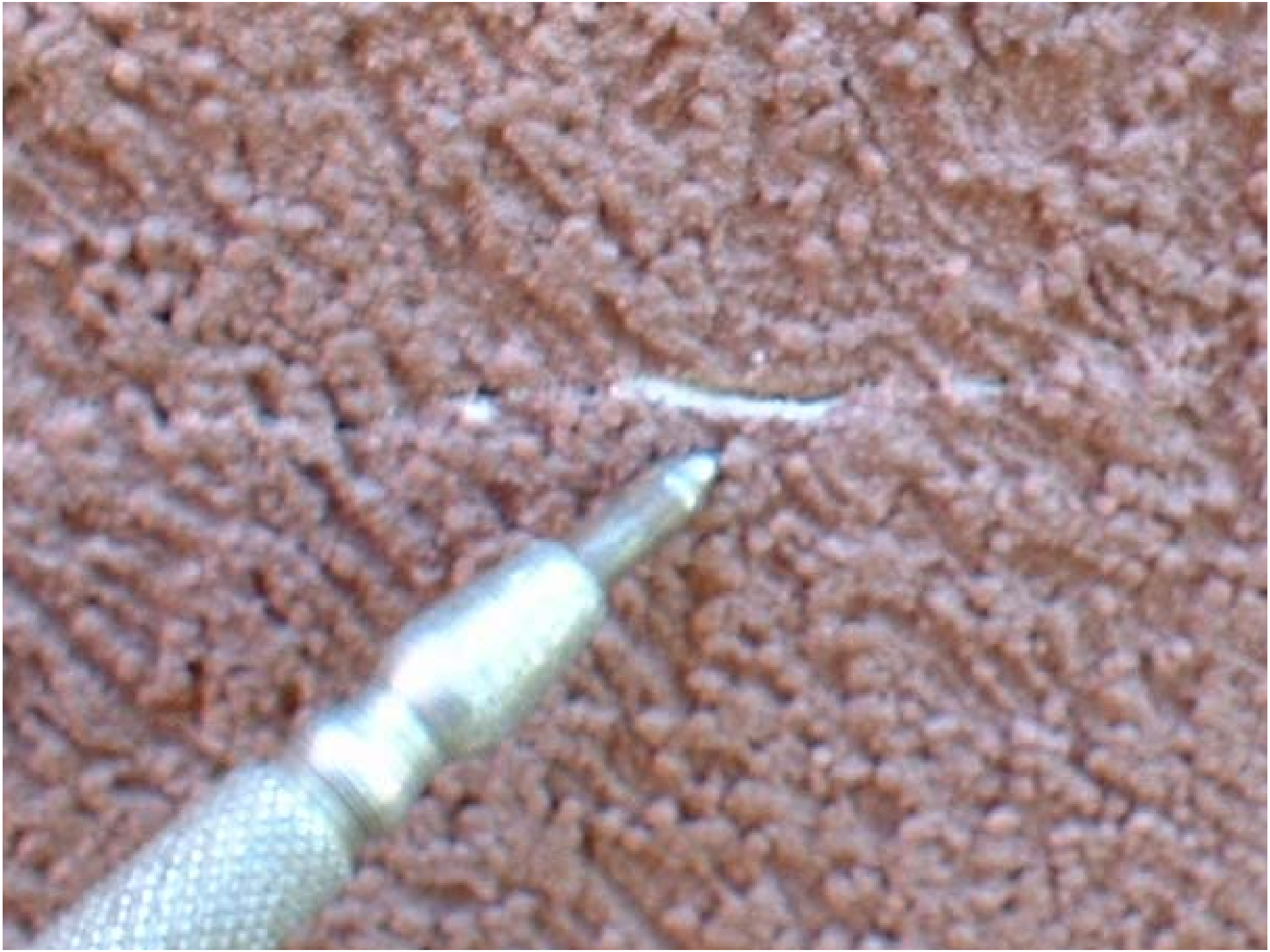



8/15/05 2:51pm

1996-Litigation

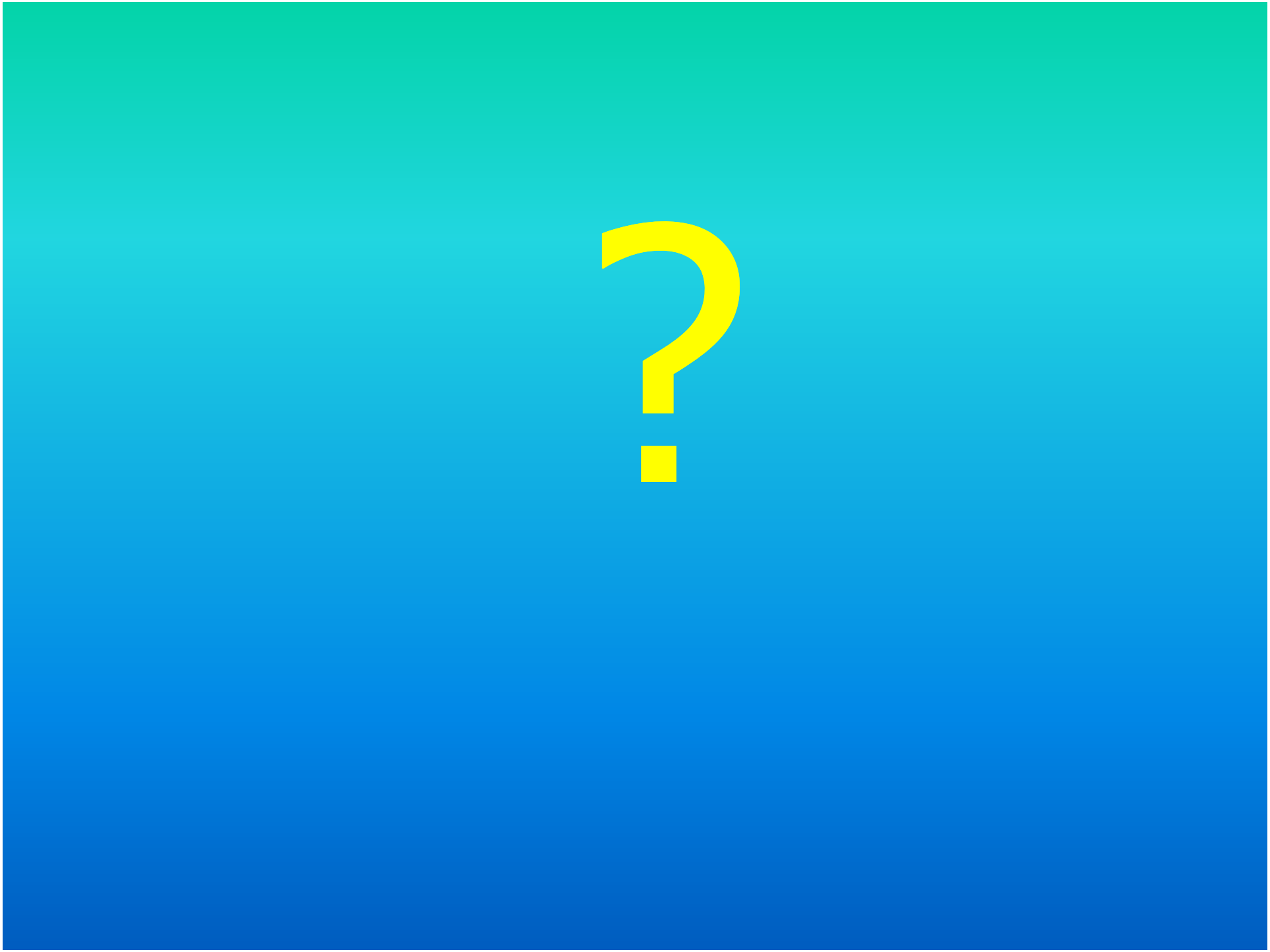
Recently completed building

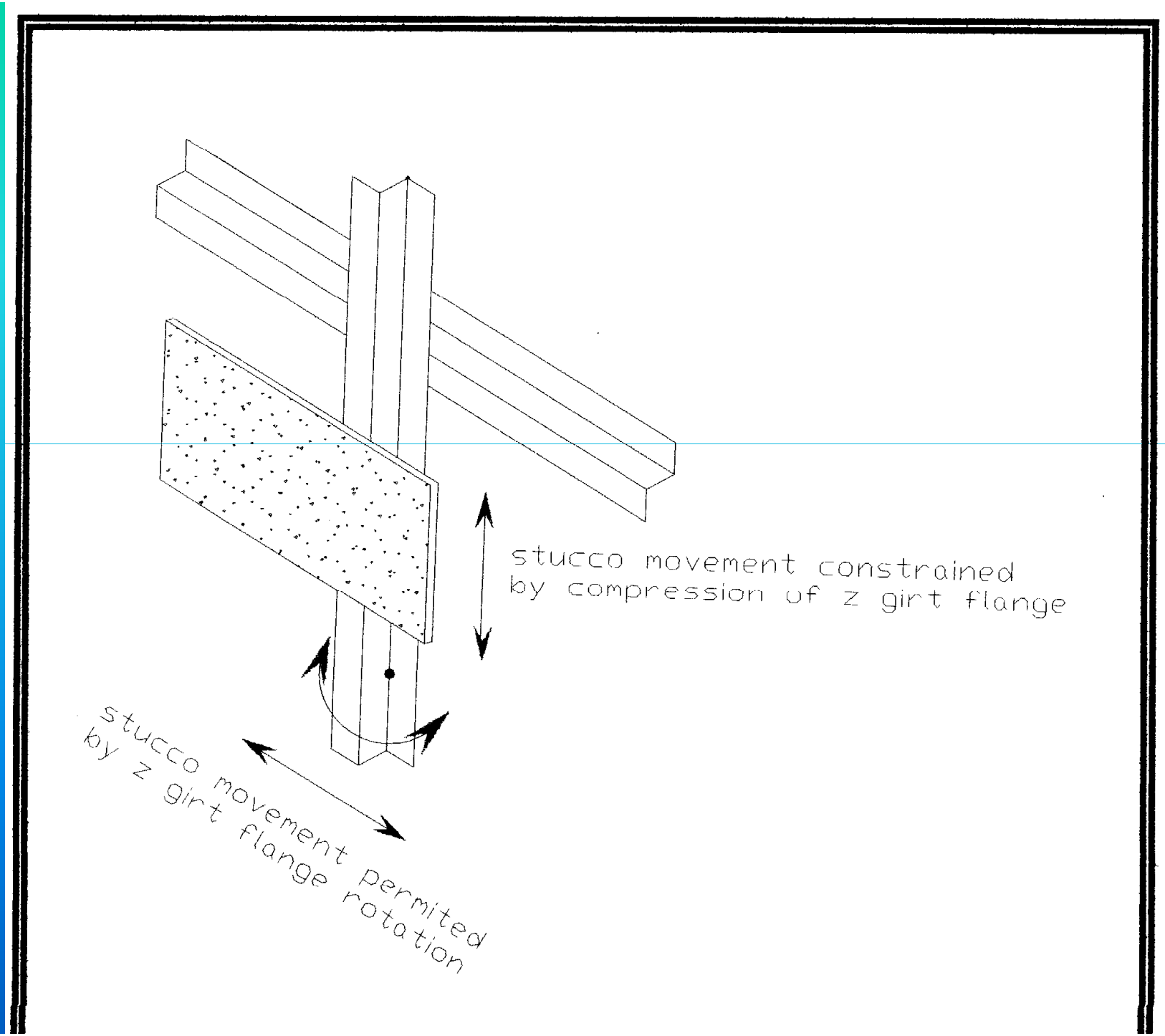
Cracks Horizontal, mid-height

Repetitive pattern

Conclusion of the report:

"Causes of the cracking are varied and complex..."




stucco movement constrained
by compression of z girt flange
stucco movement permited
by z girt flange rotation

2002-2005

- More cracking
- Many consultants report problem

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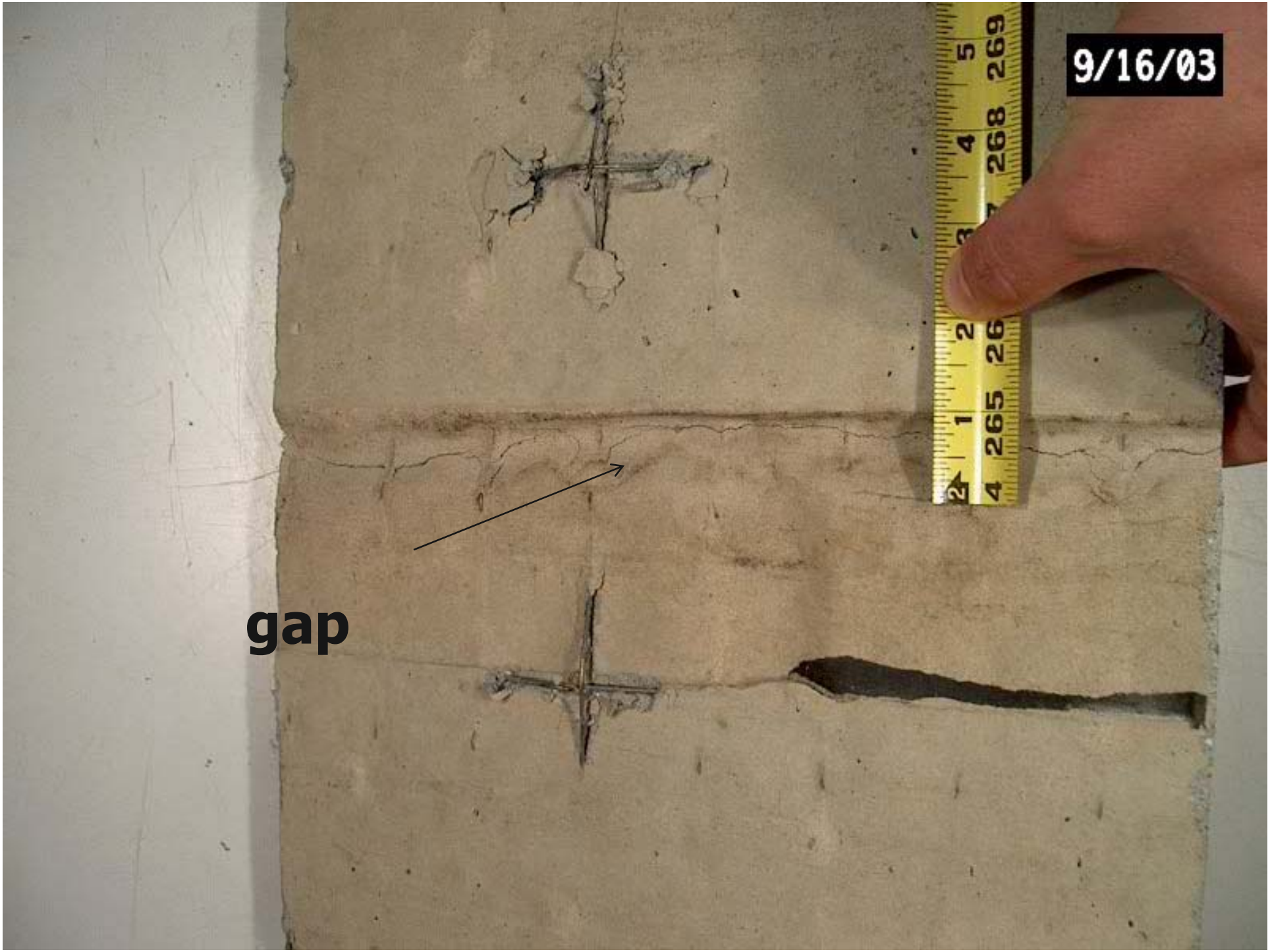
5/21/02
2001


2009/11/16 03:00 pm


8/15/05 2:52pm


Mechanical Rm.


9/16/03


9/16/03
gap


9/16/03

Theory Emerged

- Restraint of stucco by steel …due to uneven warming of the wall elements
- Stucco cracking where it is thinnest to relieve stress

Counter Arguments

Concrete and steel have the same R value (next to 0) they will be at the same temperature

Face Sealed Stucco Wall									
Interior temperature	22.00	**Delta T**	22.00			**Interior Rh**	60	**Vp**	1585.80
Exterior Temperature	0.00					**Exterior Rh**	84	**Vp**	513.24
			T at interface	**M**	**Vr**	**ΔVp**	**Vp**	**VpSat**	**Rh**
	Rsi value	**Delta T**	22.00				1585.80	2643.00	60%
Indoor air	0.12	1.07		15000	0.000067	0.00			
			20.93				1585.80	2471.00	64%
Paint	0.00	0.00		250	0.004000	0.04			
			20.93				1585.76	2471.00	64%
GWB	0.08	0.71		2500	0.000400	0.00			
			20.22				1585.75	2366.00	67%
Kraft Paper	0.00	0.00		300	0.003333	0.04			
			20.22				1585.72	2366.00	67%
Fiberglass (4")	1.98	17.61		1666	0.000600	0.01			
			2.61				1585.71	737.00	215%
Ext Gypsum Board	0.08	0.71		2500	0.000400	0.00			
			1.90				1585.71	686.00	231%
60 min bldg paper	0.01	0.09		300	0.003333	0.04			
			1.81				1585.67	681.00	233%
3/4" furring	**0.03**	**0.30**		**0**	**100.000000**	**1072.38**			
			1.51				**513.29**	**625.00**	**82%**
3/4" Stucco	0.14	1.24		200	0.005000	0.05			
			0.27				513.24	625.00	82%
Exterior air film	0.03	0.27		75000	0.000013	0.00			
			0.00				513.24	611.00	84%
Rtotal	2.47	22.00		**Vrtotal:**	100.017147	1072.56			

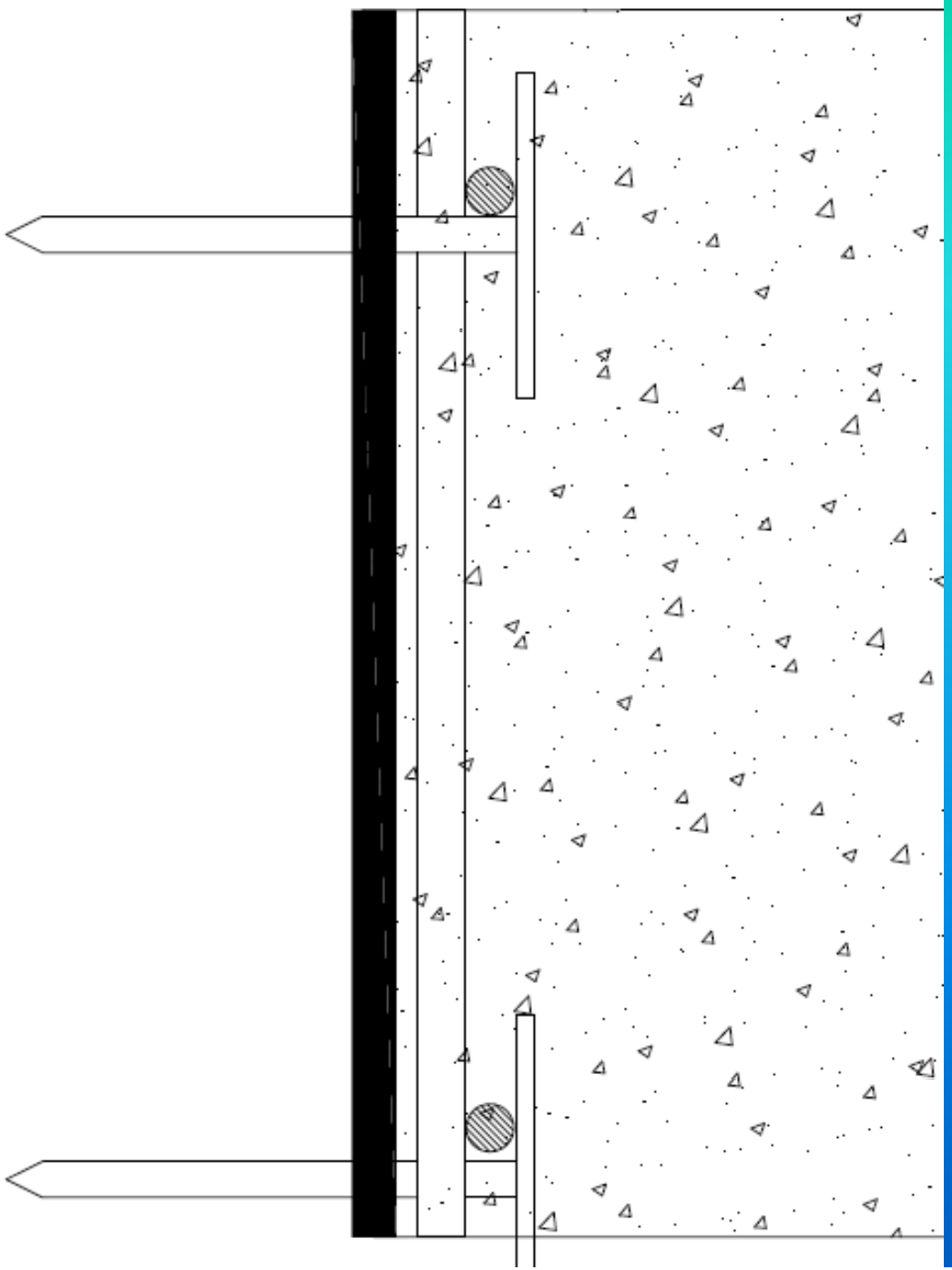
Counter Arguments

Steel and concrete have the same coefficient of expansion and contraction.... There will be no thermally induced stresses

Counter Arguments

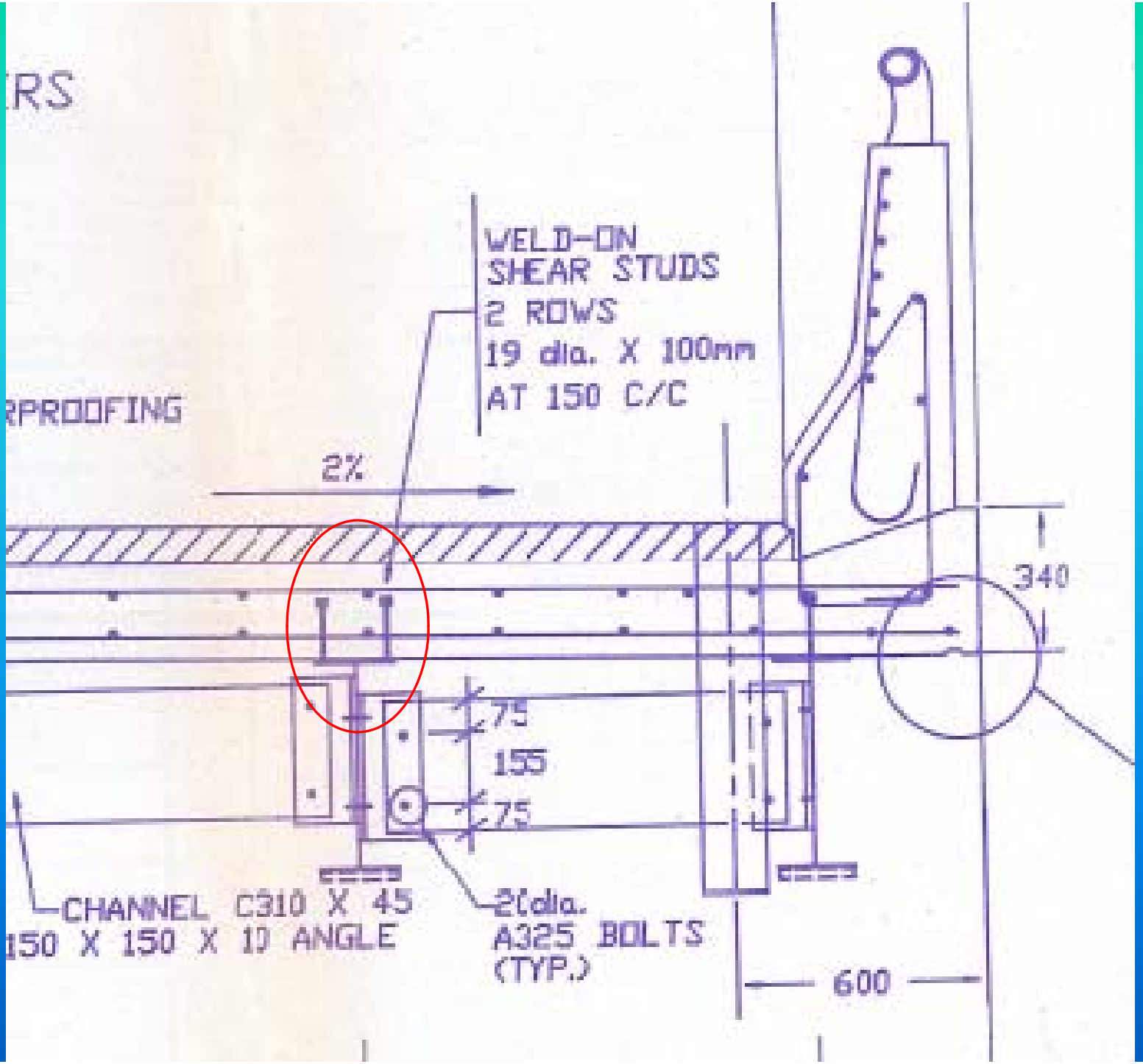
The wall has expansion joints...Movement can take place!


WARNING
is slippery and should not
requirements and those set forth
MISE EN GARDE:
TYVEK est glissant et il ne faut pas



Fasteners in wood-stucco moves as a plate

Fasteners in steel-Movement Restrained


RS
WELD-ON
SHEAR STUDS
2 ROWS
19 dia. X 100mm
AT 150 C/C
RPROOFING
2%
340
75
155
75
CHANNEL C310 X 45
150 X 150 X 10 ANGLE
2 dia.
A325 BOLTS
(TYP.)
600

$$\sigma = E * \varepsilon$$

σ= stress

E=Young's modulus

ε=strain

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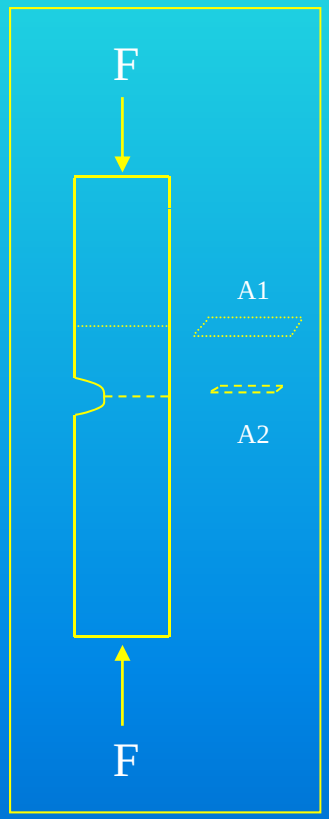
Stress

$$\sigma = F / A$$

Stress is amplified by t_1/t_2

When the cross sectional area is reduced



Thermal Expansion

$$\Delta L = \Delta t * K_{exp} * L$$

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Strain Due To The Thermal Movement

$$\varepsilon = \frac{\Delta L = \Delta t * K_{exp}}{L}$$

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Cracking Stress

$$\sigma_{comp} = \varepsilon * E$$

$$\frac{\Delta L}{L} = \Delta t * K_{exp}$$

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Cracking Stress

$$\sigma = \Delta t * K_{exp} * E$$

Cracking Temperature

$$\Delta t = \sigma / (K_{exp} * E)$$

Cracking Temperature

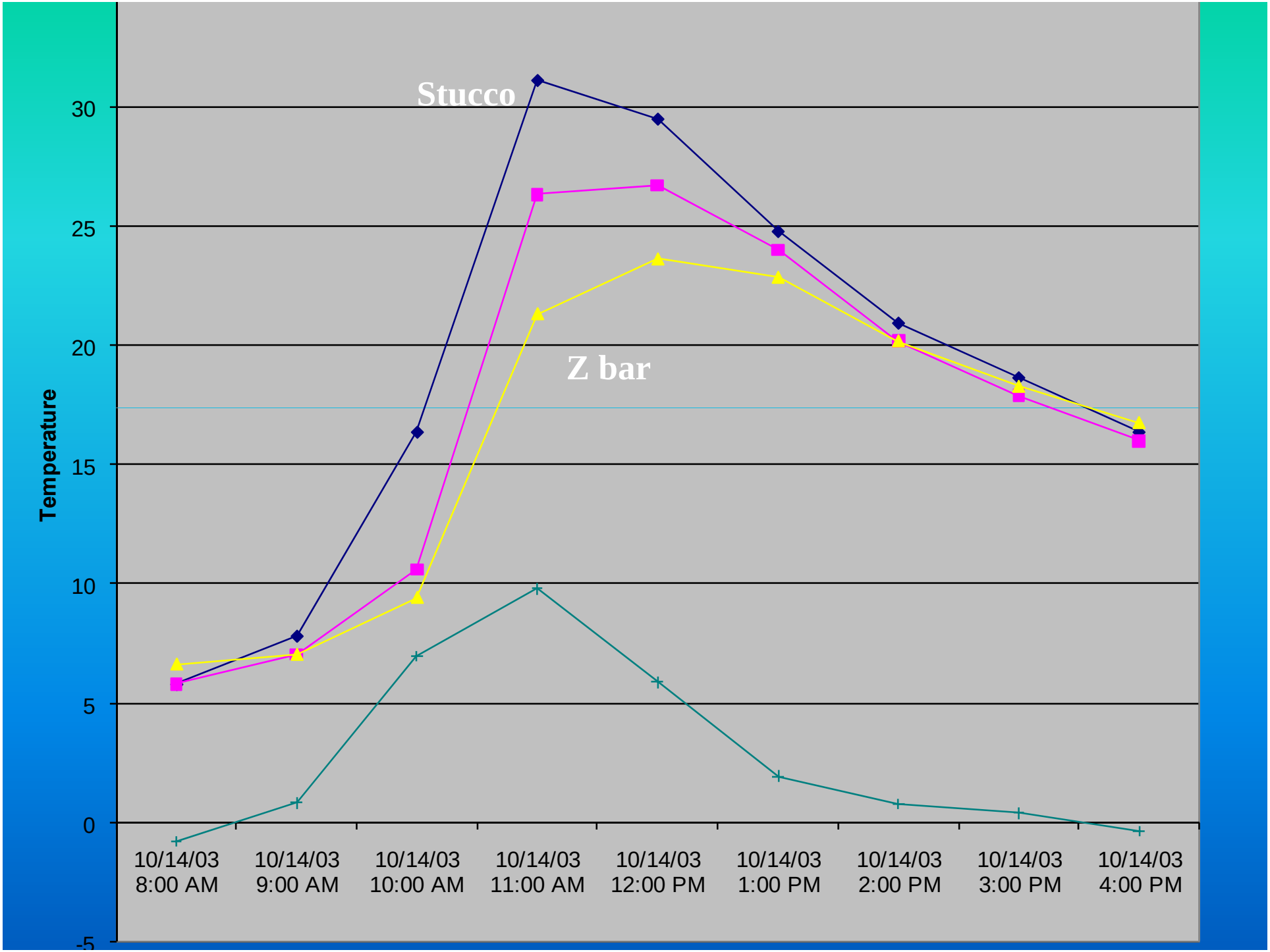
Compressive Strenght of Stucco MPA	Δt_1	Δt_2
20	55	42
15	40	31
10	27	**21**

At the reduced cross section

Night Time Radiation to a Black Body

Tension cracking of the stucco on steel backup walls will occur when there is a 2°C between the support steel and the stucco.

Tension cracking will happen


Stucco
Z bar
Temperature
30
25
20
15
10
5
0
-5
10/14/03 8:00 AM
10/14/03 9:00 AM
10/14/03 10:00 AM
10/14/03 11:00 AM
10/14/03 12:00 PM
10/14/03 1:00 PM
10/14/03 2:00 PM
10/14/03 3:00 PM
10/14/03 4:00 PM

Sol-Air Temperatures

Sol-Air Temperature Minus Air Temperature for 45°N Latitude
for January 21 and July 21, degrees Celsius

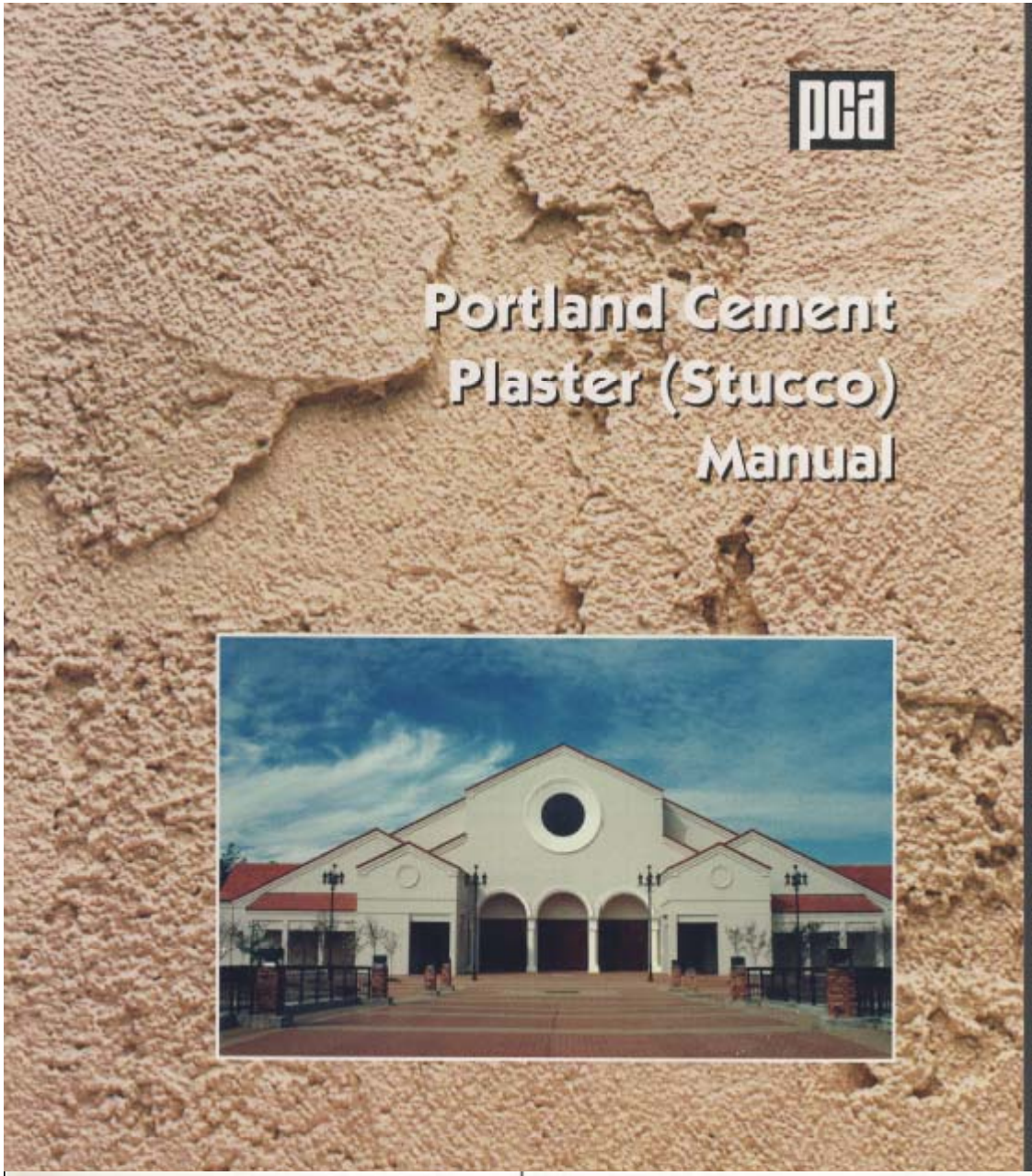
Jan. 21	N	NE	E	SE	S	SW	W	NW	Horizontal
08:00	0	2	12	15	8	0	0	0	-3
09:00	2	2	26	38	28	2	2	2	3
10:00	3	3	22	44	39	10	3	3	9
11:00	3	3	11	41	46	23	3	3	14
12:00	3	3	3	34	48	34	3	3	16
13:00	3	3	3	23	46	41	11	3	14
14:00	3	3	3	10	39	44	22	3	9
15:00	2	2	2	2	28	38	26	2	3
16:00	0	0	0	0	8	15	12	2	-3

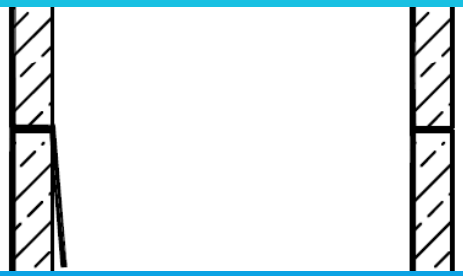
(From Table 9.7,page 225, *Building Science for a Cold Climate*, by Neil B. Hutcheon and Gustav O. P. Handegord. Courtesy of the National Research Council of Canada.)

Conclusion

Restraint of the thermal movement will create stresses.

Cracking simply occurs at thinner stucco cross sections.





		Use lower strength finish coat.
17. Horizontal and vertical cracks at metal lath laps.	Improper laps using backed metal lath.	Lap back metal lath with paper to paper and metal over metal.
18. Cracking	Poor consolidation	Correct rodding and floating procedures

1998 Wall and Ceilings Article

Cracking
in Building Envelopes
by

Moncef Nehdi, Ph.D.

Conclusion:

"… If the expansion is restrained, enormous forces can be generated and will be relieved through a certain form of damage: delamination, warping or cracking…"

Conclusion:

“ . . .

Cracks will be more severe when clearances are insufficient and when fasteners do not allow movement and deformations.”

Conclusion:

"… The designers should also be aware that because of solar heat gain in the summer and radiation heat loss in the winter, the range of temperatures that building elements undergo is higher than the ambient air temperature."

Conclusion:

"… In addition, temperature gradient will depend on color, slope, orientation and insulation backing of the surface."

Conclusion

We normally provide claddings movement ability to relieve movement stresses.

Standard of Care of a Prudent and Reasonable Professional.

Conclusion

We must find a way to relieve thermal induced stresses for stucco applied on steel.

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