On Stucco Cracking

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Typical Cracking Patterns-Stucco

- Shrinkage
Open Cracks-Looks Like a Spider Web
Typical Cracking of Stucco

- Compression of stucco by the structure
Other Problems

- Wavy Appearance
Different Pattern

• Cracks not « open »
• Mid-height of panels
• Mostly on South and East Walls
• Mostly on dark stucco
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 permitted by Z girt flange rotation
2002-2005

- More cracking
- Many consultants report problem
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**          | Rsi value      | Delta T        | M              | Vr             | ΔVp            | Vp | VpSat   | Rh |
| Indoor air                  | 0.12           | 1.07           | 15000          | 0.000067       | 0.00           | 1585.80 | 2471.00 | 64% |
| Paint                       | 0.00           | 0.00           | 250            | 0.004000       | 0.04           | 1585.76 | 2471.00 | 64% |
| GWB                         | 0.08           | 0.71           | 2500           | 0.000400       | 0.00           | 1585.75 | 2366.00 | 67% |
| Kraft Paper                 | 0.00           | 0.00           | 300            | 0.003333       | 0.04           | 1585.72 | 2366.00 | 67% |
| Fiberglass (4")             | 1.98           | 17.61          | 1666           | 0.000600       | 0.01           | 1585.71 | 737.00  | 215% |
| Ext Gypsum Board            | 0.08           | 0.71           | 2500           | 0.000400       | 0.00           | 1585.71 | 686.00  | 231% |
| 60 min bldg paper           | 0.01           | 0.09           | 300            | 0.003333       | 0.04           | 1585.67 | 681.00  | 233% |
| **3/4" furring**            | 0.03           | 0.30           | 0              | 100.000000     | 1072.38        | 513.29 | 625.00  | 82% |
| **3/4" Stucco**             | 0.14           | 1.24           | 200            | 0.005000       | 0.05           | 513.24 | 625.00  | 82% |
| Exterior air film           | 0.03           | 0.27           | 75000          | 0.000013       | 0.00           | 513.24 | 611.00  | 84% |
| Rtotal                      | 2.47           | 22.00          |                |                |               | Vp | 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!
Fasteners in wood-stucco moves as a plate

Fasteners in steel-Movement Restrained
WELD-ON SHEAR STUDS
2 ROWS
19 dia. X 100mm
AT 150 C/C

CHANNEL C310 X 45
150 X 150 X 10 ANGLE
2 dia.
A325 BOLTS
(TYP.)
\( \sigma = E * \varepsilon \)

\( \sigma = \) stress

\( E = \) Young’s modulus

\( \varepsilon = \) strain
Stress

\[ \sigma = \frac{F}{A} \]

Stress is amplified by \( \frac{t_1}{t_2} \)

When the cross sectional area is reduced
Thermal Expansion

\[ \Delta L = \Delta t \cdot K_{\text{exp}} \cdot L \]
Strain Due To The Thermal Movement

\[ \varepsilon = \Delta L = \Delta t^* K \exp \frac{\varepsilon}{L} \]
Cracking Stress

\[ \sigma_{\text{comp}} = \varepsilon \cdot E \]

\[ \Delta L = \Delta t \cdot K \cdot \text{exp} \]

\[ L \]
Cracking Stress

\[ \sigma = \Delta t \times K_{\text{exp}} \times E \]

Cracking Temperature

\[ \Delta t = \frac{\sigma}{(K_{\text{exp}} \times E)} \]
### Cracking Temperature

<table>
<thead>
<tr>
<th>Compressive Strength of Stucco (MPA)</th>
<th>$\Delta t_1$</th>
<th>$\Delta t_2$</th>
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<td>15</td>
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<td>27</td>
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</table>

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
Sol-Air Temperatures

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

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<th>E</th>
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(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.
<table>
<thead>
<tr>
<th>Issue</th>
<th>Cause</th>
<th>Solution</th>
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<tbody>
<tr>
<td>17.</td>
<td>Horizontal and vertical cracks at metal lath laps.</td>
<td>Improper laps using backed metal lath.</td>
</tr>
<tr>
<td>18.</td>
<td>Cracking</td>
<td>Poor consolidation</td>
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<td></td>
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<td>Lap back metal lath with paper to paper and metal over metal.</td>
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<td>Correct rodding and floating procedures</td>
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</table>
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.