What's Behind the Stucco?

An Evaluation of Exterior Wall Moisture Issues

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Background

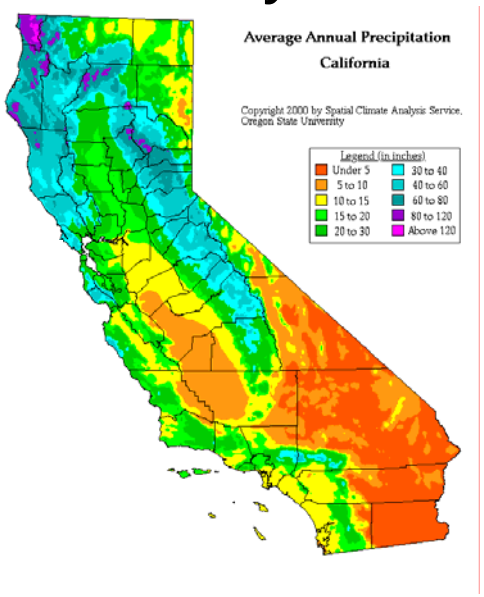
- Moisture management issues
  - Energy efficiency advances
  - Less air infiltration
  - Building wall systems
- Understanding through modeling
  - Simulation of wall systems
  - 1-D water vapor diffusion
  - Moisture content in wall components
  - Psychrometric conditions at surfaces

Overview of Software

- Capabilities
  - 1-D water vapor diffusion
  - Transient behavior of wall system
  - Hourly weather conditions
    - Driving rain
- Limitations
  - 1-D water vapor diffusion
  - Other dominant phenomena
    - Bulk water intrusion
    - Heat, air and moisture transfer

Weather Conditions

- 16 climate zones in California
- Hourly data generated by software
  - World Meteorological Organization monthly climatological normals
  - 30 year NCDC weather data



CA Climate Zones

CZ	Representative City	County	Latitude	Longitude	Altitude (ft)	Precip (inches)	Wind Rain
1	Arcata	Humboldt	40.98	-124.10	216.5	36.83	S
2	Santa Rosa	Sonoma	38.52	-122.82	124.7	23.93	W
3	Oakland	Alameda	37.73	-122.22	9.8	20.93	W
4	Sunnyvale	Santa Clara	37.37	-122.03	102.0	19.95	SE
5	Santa Maria	Santa Barbara	34.90	-120.45	252.6	12.07	W
6	Los Angeles	Los Angeles	33.93	-118.40	105.0	12.07	W
7	San Diego	San Diego	32.73	-117.17	29.5	9.59	NW
8	El Toro	Orange	33.67	-117.73	380.9	11.36	SE
9	Pasadena	Los Angeles	34.09	-118.09	863.8	11.41	E
10	Riverside	Riverside	33.97	-117.33	1049.9	9.69	SE
11	Red Bluff	Tehama	40.15	-122.25	354.3	21.61	W
12	Sacramento	Sacramento	38.70	-121.58	23.0	17.85	E
13	Fresno	Fresno	36.77	-119.72	334.6	10.34	SE
14	China Lake	Kern/San Bernardino	35.68	-117.70	2230.0	5.58	SE
15	El Centro	Imperial	32.80	-115.67	13.1	1.69	SW
16	Mount Shasta	Siskiyou	41.32	-122.32	3543.3	16.96	S

Wall Systems Modeled

- *Three Coat Stucco (Wall 1)*
  - Traditional 3-coat, 7/8th inch thick stucco
  - 2 layers of building paper, OSB sheathing, insulation, gypsum board and latex paint as the interior finish.
  - Relatively massive, significant moisture sorption and capacitance effects.
- *One Coat Stucco (Wall 2)*
  - "1-coat" stucco wall, 1/8th inch thick finish coat & 3/8th inch thick base coat on metal mesh over a rigid expanded polystyrene (EPS) insulation board.
  - 1 layer of building paper, OSB sheathing, insulation, gypsum board, and latex paint as the interior finish.
  - Thinner layer of stucco than the traditional 3-coat stucco wall.
- *EIFS Wall System (Wall 3)*
  - Exterior insulation and finish system (EIFS) wall, 1/8th inch thick finishing coat of acrylic stucco applied over a resin coated, fiberglass mesh on top of rigid expanded polystyrene (EPS) insulation board.
  - 1 layer of building paper, OSB sheathing, insulation, gypsum board, and latex paint as the interior finish.
  - Thin, but low permeance stucco coating, which influences the transport of moisture into and out of the wall system.

Variations in Walls

- Type of building paper/housewrap over the OSB
  - Variation A: 2 layers of building paper
  - Variation B: 1 layer high permeance housewrap
  - Variation C: 1 layer low permeance housewrap
  - Wall 1: 1 layer building paper + Variation B or C

Properties/Materials	Units	Building Paper	High Permeance Housewrap	Low Permeance Housewrap
Thickness	(inches)	0.0400	0.0055	0.0140
Bulk Density	(lb/ft3)	17.48	4.058	4.058
Porosity	(ft3/ft3)	0.001	0.001	0.001
Heat Capacity	(Btu/lb*F)	0.358	0.358	0.358
Heat Conductivity	(Btu/hr*ft*F)	6.94	1.387	1.387
Permeability (@ RH=0%)	(perm*in)	0.9230	0.3190	0.0938
Permeance	(perms)	23.0750	58.0000	6.7000
Varies w/%RH (Y=Yes, N=No)		Y	N	N

Measurement of Wall Performance

- Focused on Oriented Strand Board (OSB)
  - Vulnerable to decay and mold problems
  - Average moisture content of OSB layer
  - Relative humidity at both surfaces
- Moisture Concerns
  - **Wood Decay** occurs when wood fibers reach saturation
  - Typically around 30% moisture content (Sherwood, 1994)
  - Average readings over 20% are of concern
  - **Mold Growth** occurs when relative humidity of adjacent surface is above 70% (Lstiburek and Carmody, 1994)
  - Mold growth increases dramatically above 90% RH (Harriman, 2001)

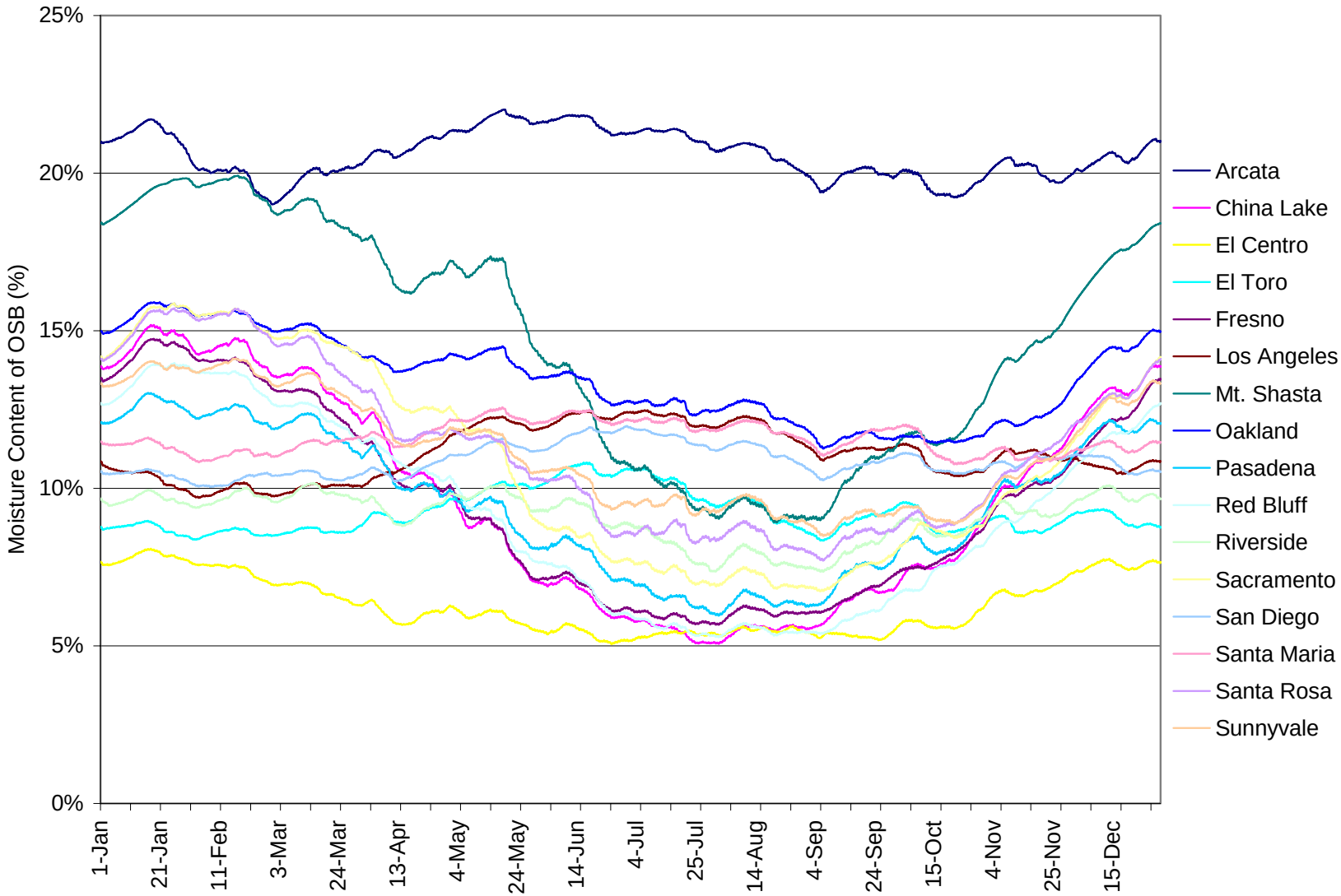
General Results

- 1 of the 16 climate zones showed distinct potential for OSB decay and possible mold
- Many of the climate zones had larger numbers of hours with RH >70%
- Only Arcata showed RH>90%

General Results: Moisture Content

OSB % Moisture Content	Minimum Value	Maximum Value	Average Value
Arcata	19.01%	22.02%	20.58%
China Lake	5.07%	15.19%	9.69%
El Centro	5.06%	8.08%	6.29%
El Toro	8.34%	10.82%	9.23%
Fresno	5.67%	14.74%	9.56%
Los Angeles	9.70%	12.48%	11.11%
Mt. Shasta	8.92%	19.92%	14.67%
Oakland	11.26%	15.91%	13.48%
Pasadena	5.96%	13.03%	9.52%
Red Bluff	5.28%	13.97%	9.25%
Riverside	7.35%	10.17%	9.10%
Sacramento	6.73%	15.87%	10.89%
San Diego	10.05%	11.98%	10.87%
Santa Maria	10.76%	12.57%	11.59%
Santa Rosa	7.71%	15.71%	11.28%
Sunnyvale	8.48%	14.12%	11.17%

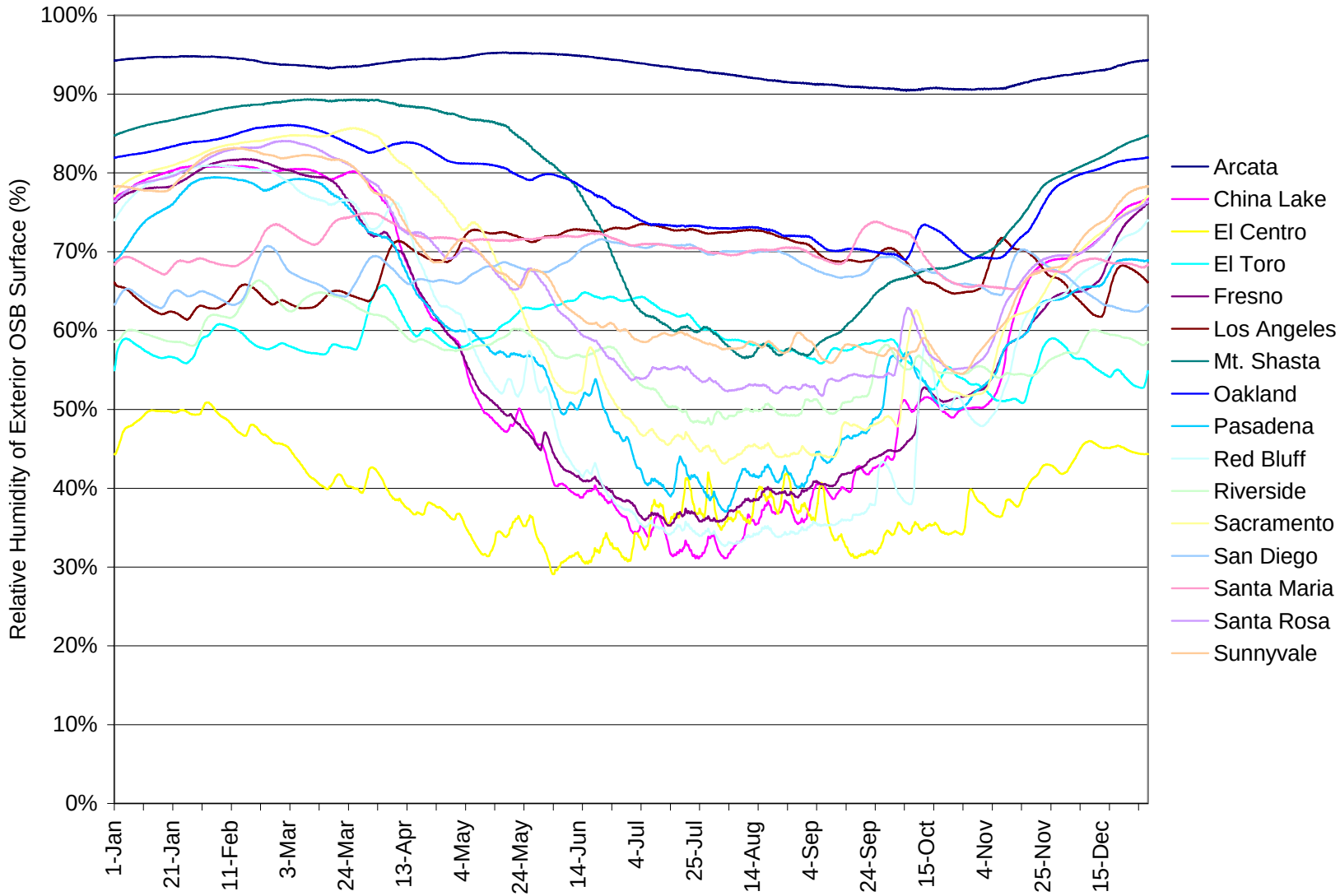
General Results: Moisture Content



General Results: Relative Humidity

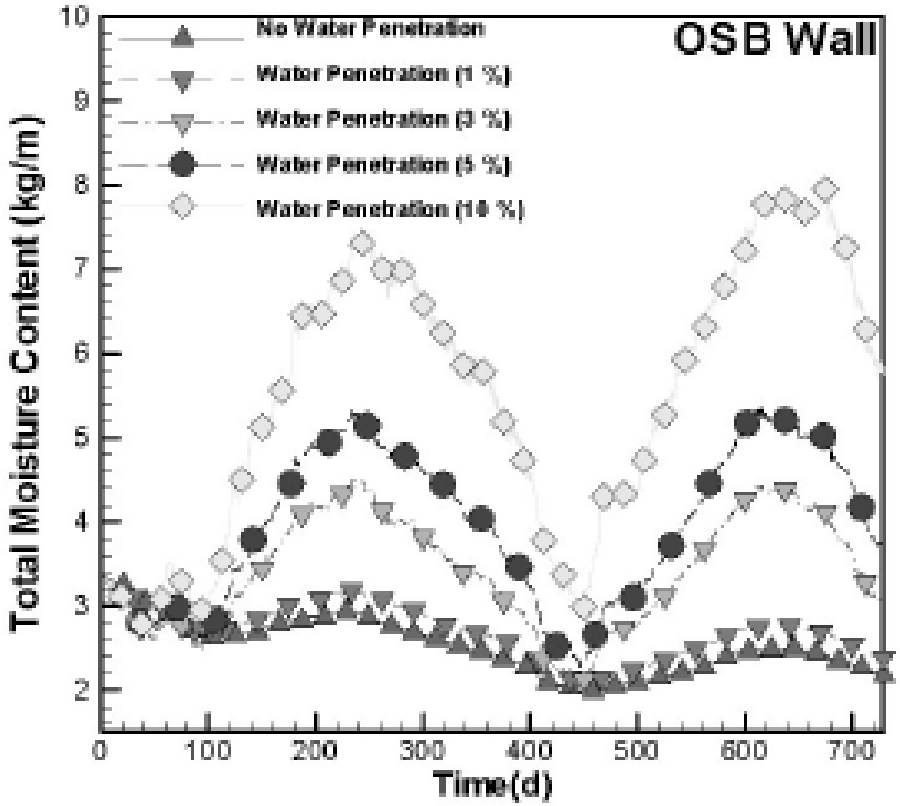
	RH Exterior Surface OSB				RH Interior Surface OSB			
City	Mini	Max	Avg	Hrs >70%	Min	Max	Avg	Hrs >70%
Arcata	90.41	95.30	93.18	8760	80.91	94.79	90.68	8760
China Lake	31.08	80.91	57.38	2993	32.29	89.93	61.43	3380
El Centro	29.08	50.89	39.15	0	30.35	61.51	44.53	0
El Toro	50.79	65.81	58.48	0	47.96	72.71	61.06	250
Fresno	35.24	81.76	57.45	2737	35.29	89.33	61.07	2910
Los Angeles	61.38	73.56	68.35	3700	56.03	77.83	68.43	3209
Mt. Shasta	56.49	89.36	76.34	5567	53.16	95.96	79.93	6742
Oakland	68.99	86.11	77.87	8057	62.69	87.16	76.77	8068
Pasadena	37.00	79.47	59.23	2325	36.87	82.97	60.81	2283
Red Bluff	32.66	80.98	56.91	2866	32.43	84.57	58.80	2453
Riverside	48.07	66.39	56.89	0	43.33	73.81	60.98	410
Sacramento	43.10	85.71	64.46	3787	39.89	91.62	66.28	3916
San Diego	62.37	71.61	67.36	1666	57.55	75.35	67.26	2237
Santa Maria	65.21	74.95	70.23	4943	59.21	79.65	70.95	5302
Santa Rosa	51.71	84.08	66.57	3449	45.33	91.81	69.50	4414
Sunnyvale	54.51	83.18	67.86	3515	50.12	84.92	69.02	3787

General Results: Relative Humidity



Water Penetration Effect

- Wind driven rain that penetrates behind the stucco
  - cracks
  - joints
  - around windows



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Conclusions

- Based only on 1-D water vapor diffusion:
  - Greater stucco thickness and its water uptake lead to larger increases in moisture content and surface RH of the OSB
  - Insulation type had a significant impact on the moisture content of the OSB
    - Cellulose had increased moisture capacitance
    - Cellulose seemed to draw moisture away from OSB
  - Selection of building paper/housewrap had the least effect on the OSB moisture content

Conclusions

- If other hygrothermal effects were able to be modeled the results may be substantially different
  - bulk water penetration
  - surface drainage
  - air movement
- Research continues to develop and refine the moisture modeling tools to account for these effects

Thank you