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APPLYING LESSONS FROM CLAY-BRICK VENEER TO DESIGN OF A STUCCO MIX

Marcin Pazera and Mark Bomberg

Senior Engineer, Simpson, Gumpertz & Heger

Research professor, Syracuse University

Stucco misconceptions

- Reported moisture-originated failures in stucco-clad walls, attributed in most cases to poor detail design, highlight misconceptions about moisture control of exterior stucco (plaster/rendering) systems.
- For stucco to perform well, the new paradigm should be based on moisture balance in combination with moisture management that relates to climatic and service conditions.

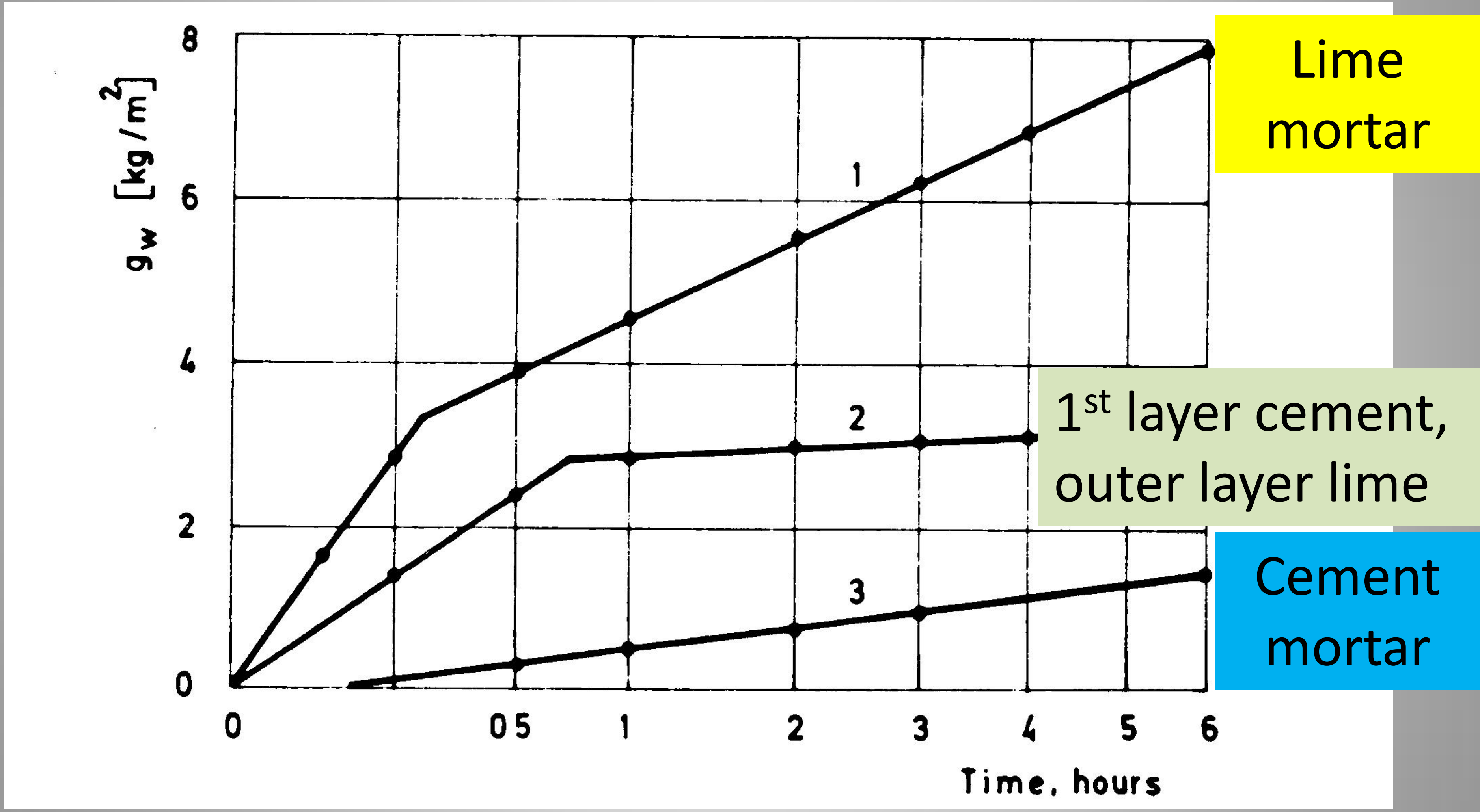
Reported moisture problems

- by Merrill and TenWolde (1989); (Williams et al, 1998), Desjarlais et al, (2001),
- particularly for coastal regions: Gulf of Mexico (Trechsel, 1987), British Columbia (MH,1989; Chouinard and Lawton, 2001), Washington State and North Carolina (Brown et al 1997, 1997a, Crandell and Kenney, 1996), and for
- cold, dry climates of Northwest (Tsongas,1990, 1992), Minnesota or (BEE, 2000) Alberta.

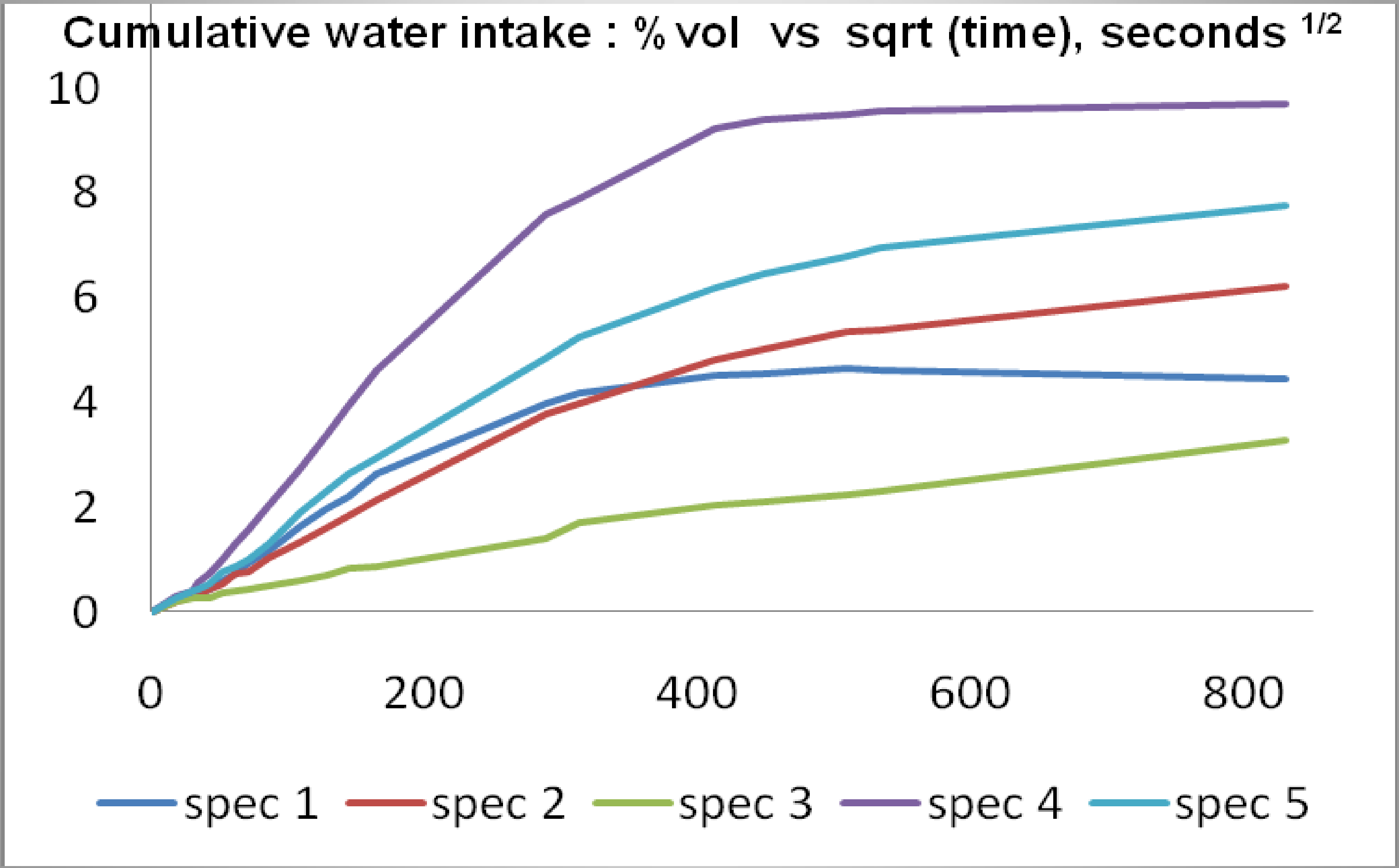
Some hygrothermal (HT) characteristics

- *Water absorption (A-coefficient)* is a relation between the cumulative water flow from the free water surface and the square root of time.
- *Water vapor permeance (WVP)* is typically measured between 50% RH and desiccant.
- Drying rate at 24 h in kg/m2s There is no HT characteristics that can directly describe drying. (Traditional materials display good correlation between wetting and drying)

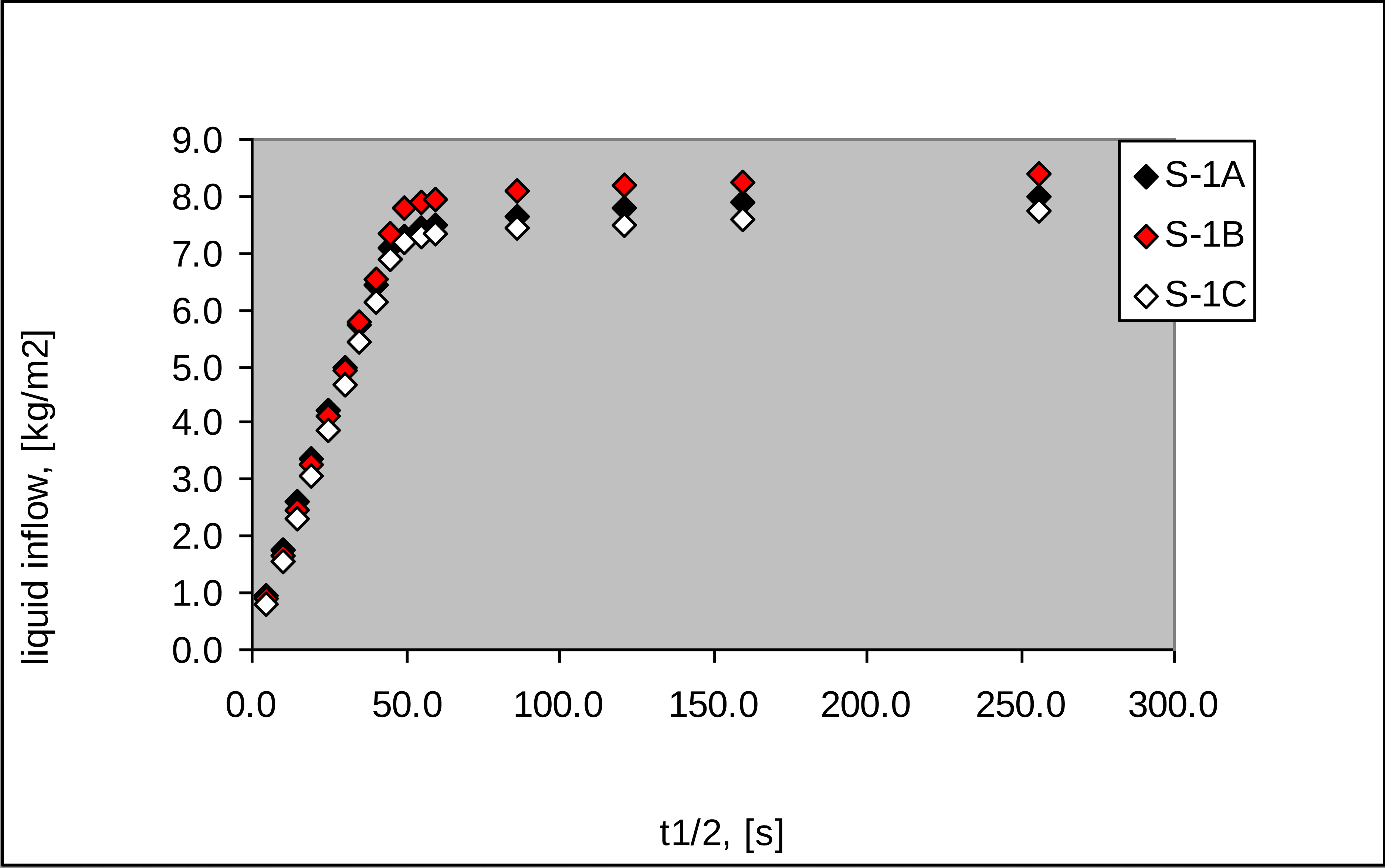
Clay brick with mortar layer (1925)



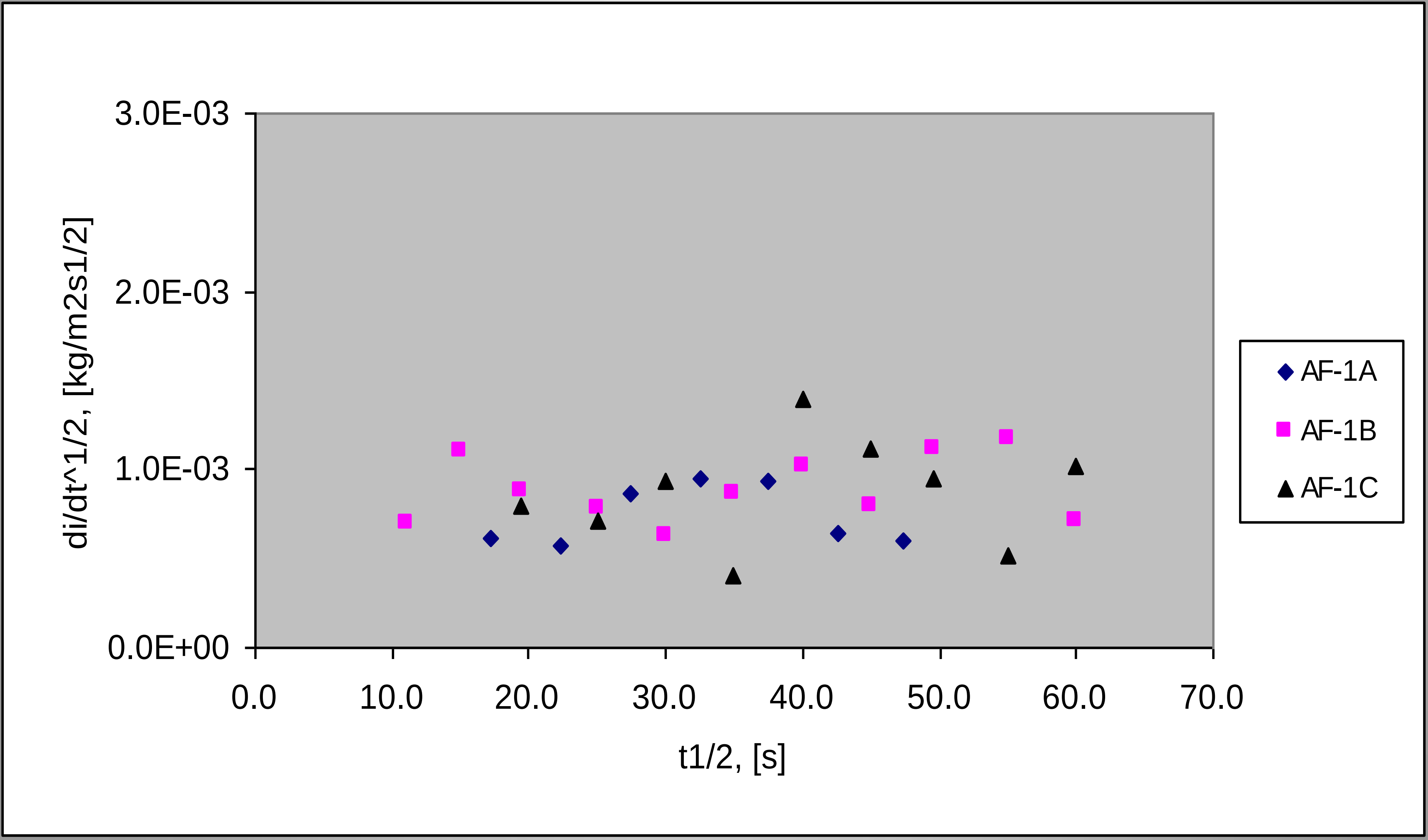
5 random samples taken from the existing stucco-clad buildings in the same region



Lime-cement stucco 1: 1: 5.5 gives mean value of A = 0.16 $kg/m^2s^{1/2}$.



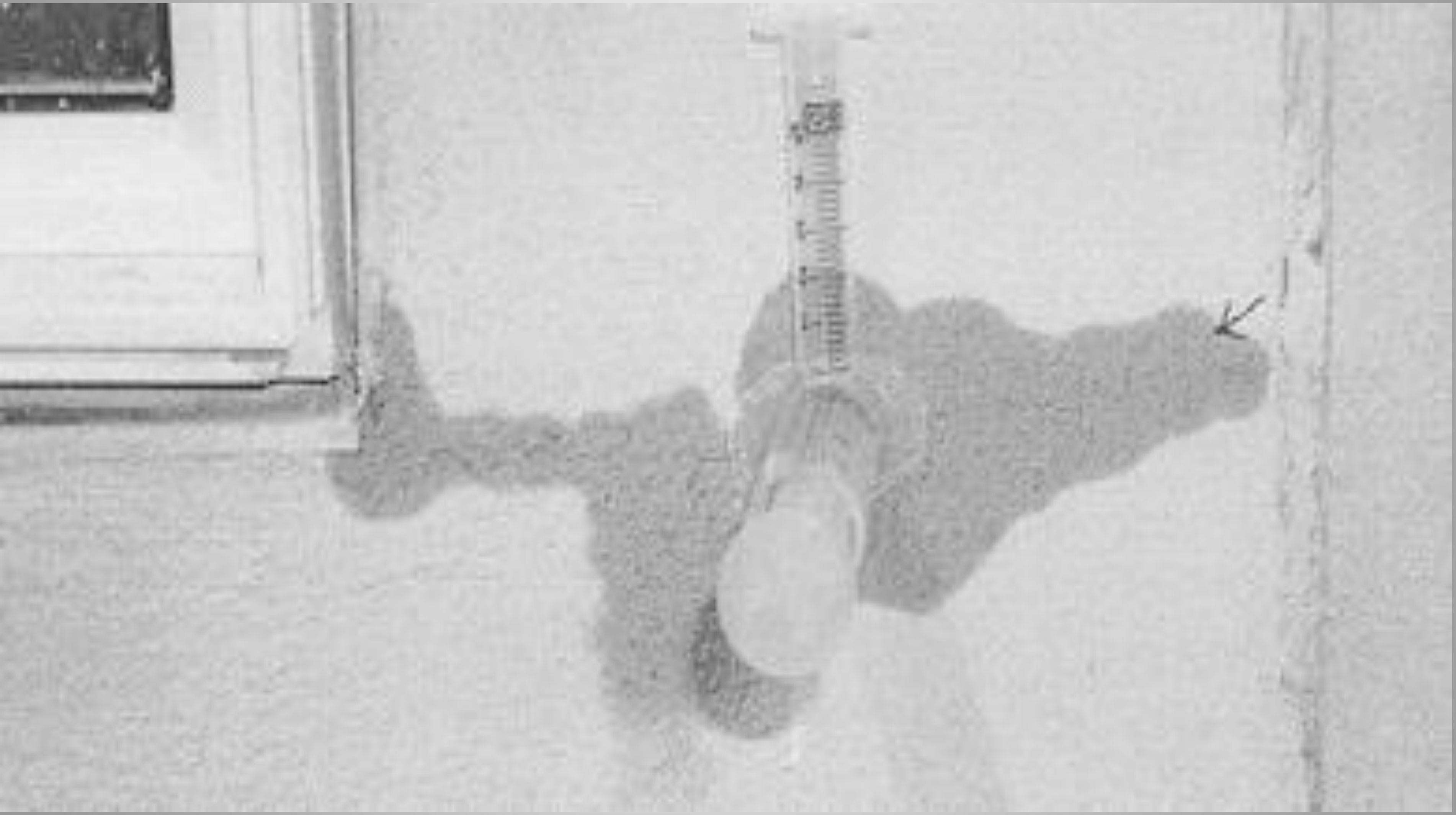
Acrylic-modified finish coat from Northeast gave a mean value of A = 0.00092 kg/m²s^1/2.



Compare to A-coefficient on German stuccos (measured at TUD)

- High A=0.17 $kg/m^2s^{1/2}$ for a low density stucco
- Median A = 0.07 $kg/m^2s^{1/2}$ for standard density
- Lowest A = 0.013 $kg/m^2s^{1/2}$ for low density
- Lime mortar wets/dries at the rate of clay-brick
- Cement mortar wets/dries at the rate of concrete i.e. about 10 times slower
- A-coefficient and WV permeability of US material is one magnitude lower than those in Germany!

Effect of a crack - water spread along the crack



Three critical contributions of lime elasticity, autogenous healing and water tightness

- Slow-hardening of high lime content mortars “accommodates stresses caused by building movement and cyclical changes without excessive cracking.
- The combination of hydrated lime, moisture and carbon dioxide from the air can help to seal the hairline crack by the formation of limestone (calcium carbonate).
- Lime-cement mortars of 1:1:5 or 1:1:6 were found water-tight

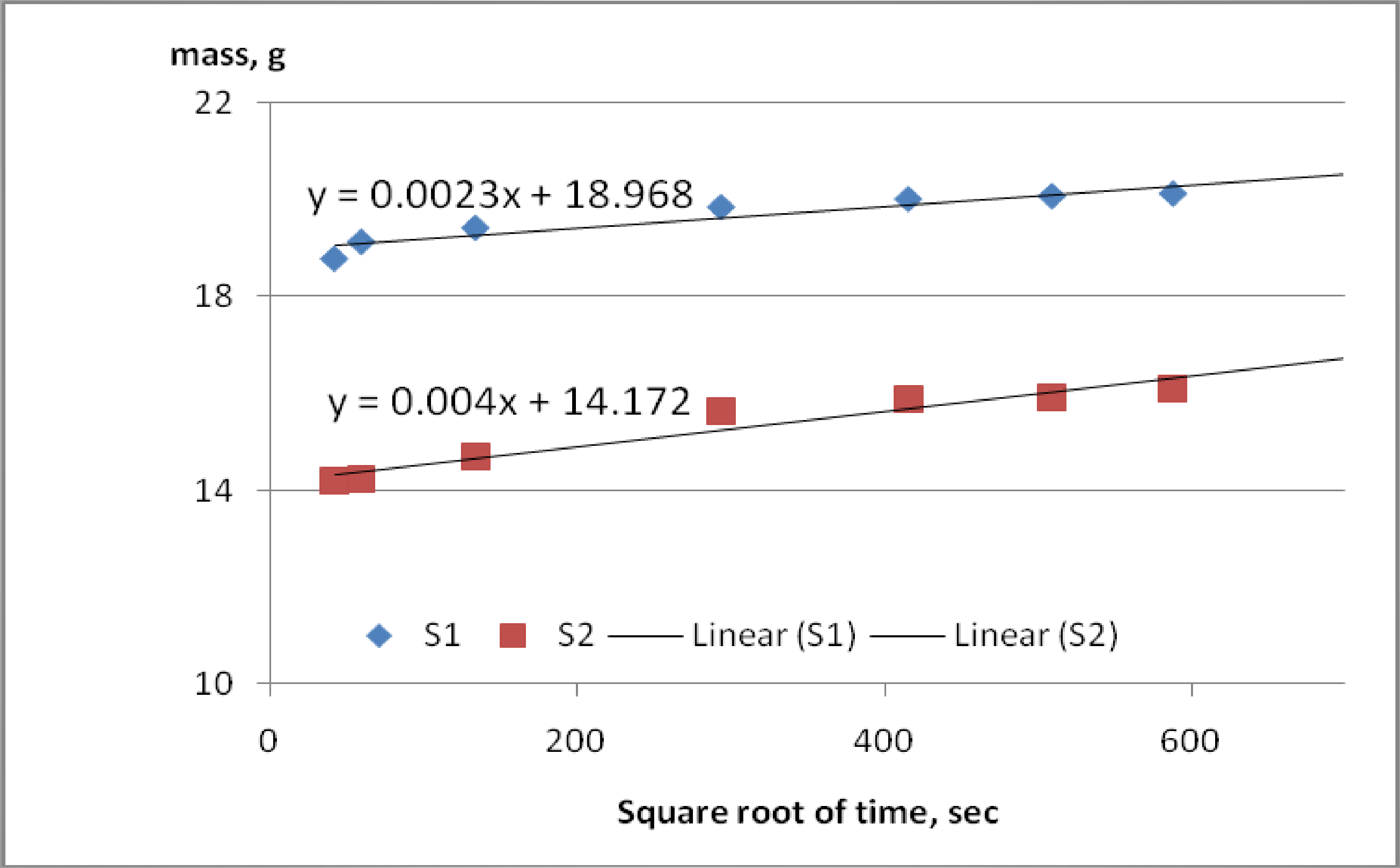
Is 3-coat better than 2-coat stucco? Alberta survey is non-conclusive

Description	3-coat stucco	2 coat stucco
No deterioration		1
Normal deterioration	15	67
Minor distress	8	76
Significant deterioration		9
Needs immediate repair		8

Comparison of traditional stucco

- A = 1: 1: 4.5; measured A = 0.047kg/($m^2s^{1/2}$)
- B = 1: ¼: 4; measured A = 0.026kg/($m^2s^{1/2}$)
- D = 1: ½: 6 measured A = 0.096kg/($m^2s^{1/2}$)
- E = 1: 1: 5 measured A = 0.060kg/($m^2s^{1/2}$)
- C = 1: 1: 1: 6 (fly ash) A = 0.065kg/($m^2s^{1/2}$)
- i.e., effect of porosity and type of the binder

Positive effect of admixture increasing water retention (S2)



Pilot series of stucco mixes

Description	Shrinkage, 14 (28) day in percent	Density, kg/m^3 – (lb/ft^3)	*Compres*. strength 14th day psi - MPa
Design criterion	Max 0.25 (0.30)	Max 1100 (69)	Min 400 – (2.8)
Mix S1	0.23	1100 – 69	972 - 6.7
Mix S2	0.14	1200 – 75	841 - 5.8

Selected properties of pilot stucco

Description	Shrink., 14 (28) day in percent	Compres. strength 14d psi - MPa	A-coeff kg/ $m^2s^{1/2}$	drying rate at 24 h kg/m2s
Design criterion	0.25 (0.30)	Min 400 – 2.8	--	--
Mix S51	0.29 (0.30)	392 - 2.7	0.040	1.11E-05
Mix S60	0.37 (0.39)	392 - 2.7	0.076	0.95E-06

Closing remarks

- This paper shows that 2-coat, lime-cement stucco with admixture of fly ash and water retaining admixture can be a viable alternative to cement-based stucco.
- Such a stucco can be applied in thickness of 10 to 15 mm
- In addition to improved hygrothermal properties, when comparing to cement stucco, this stucco can also have a lower shrinkage.