

# **Structural and Hygrothermal Field Monitoring of Thick Continuously Insulated Wall Assemblies Utilized in a Multi-Story Residential Building**

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# Agenda

- **Continuous Insulation**
- **Vancouver BC Case Study**
- **Retrofit Structural Design**
- **Research Questions and Measurements**
- **Results and Conclusions**

# Continuous Insulation Hypothesis

- A ci rain screen wall system with:
  - 7/8" Z-girts located 16" oc
  - Attached outboard of insulation with 4 ½" #10 self tapping corrosion resistant screws every 6" oc
- Provides a structurally robust wall
- Dimensionally stable
- Complies with ASHRAE 90.1

# Vancouver BC Case Study – Before



## Original Wall System

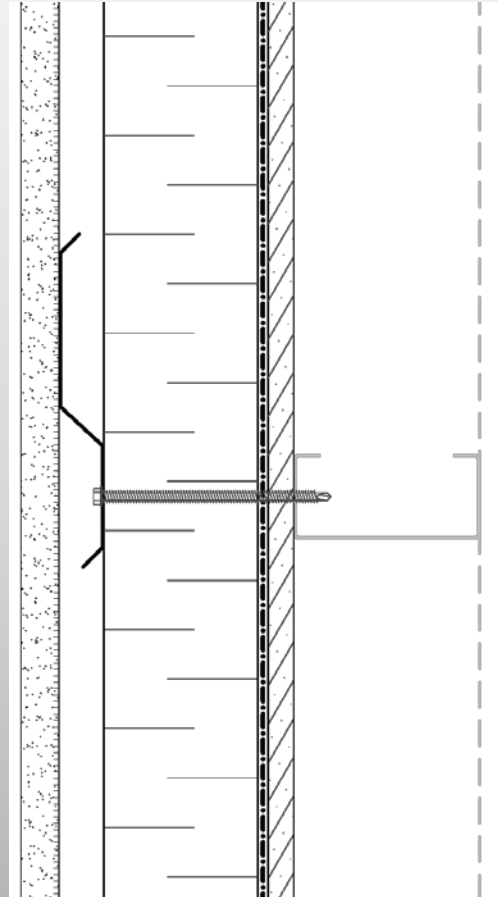
- Cement stucco with wire lath
- Semi-rigid fiberglass insulation (~ one inch thick)
- 3½ inch steel studs with fiberglass batt insulation infill
- Polyethylene air/vapor barrier
- ½ inch interior drywall

# Vancouver BC Case Study – After



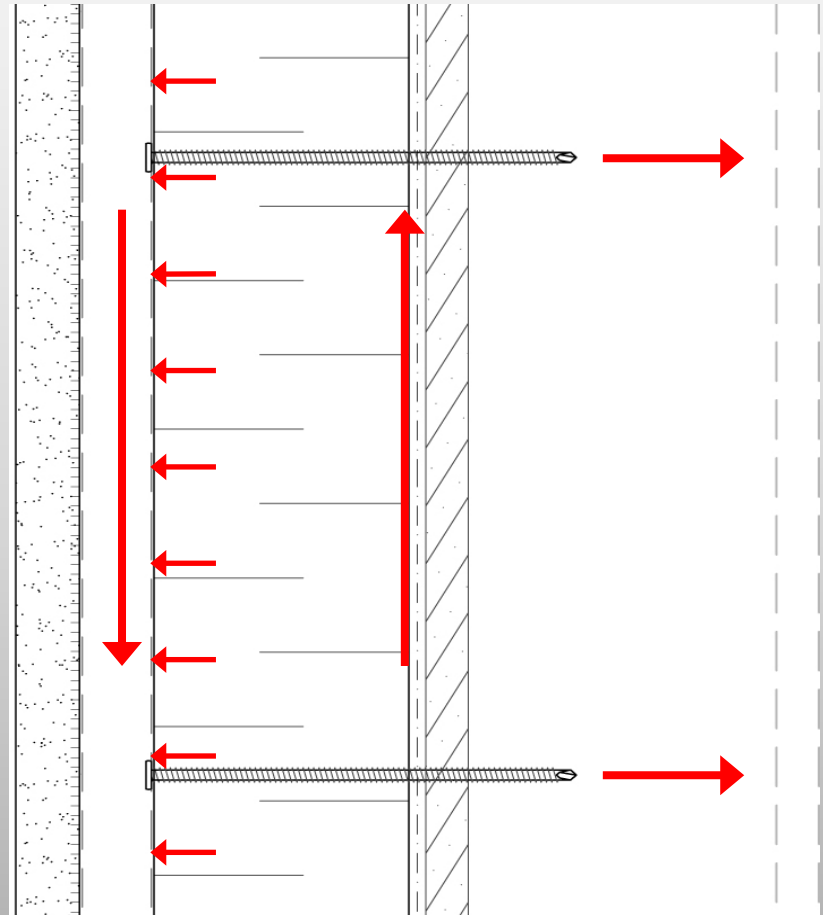
## New (Rehabilitated Wall System)

- $\frac{7}{8}$  inch acrylic stucco on paper backed lath
- $\frac{7}{8}$  inch Z-girts at 16 in oc fastened with self-tapping screw fasteners at 6 in oc
- 3 in Type 4 rigid insulation (R15) with taped joints
- SA Membrane
- $\frac{1}{2}$  inch fiberglass faced exterior gypsum sheathing
- Existing  $3\frac{1}{2}$  inch steel studs
- Existing  $\frac{1}{2}$  inch interior drywall



# Structural Design

- Wind and gravity loads are transferred through exterior the vertical Z girts to the insulation and back up wall
- Rigid girt spreads gravity and wind load onto rigid insulation
- Gravity load puts a tension load on the fastener since rotation is constrained by insulation (fastener cannot rotate unless foam compresses) and a shear load
- Wind and gravity put a compression load on the rigid insulation or tension load on fastener



# Structural Design

Compression of foam

FS=24.9

Fastener Tension FS=25.5

Stucco lath fastener

FS=20.8



# Research Questions

- **What is the dimensional performance of a retrofit wall system designed with only cladding attachment screw penetrations through the insulation?**
- **What is the hygrothermal performance of the system?**

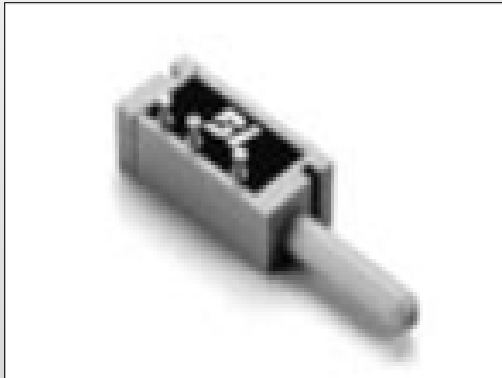


# Background Work

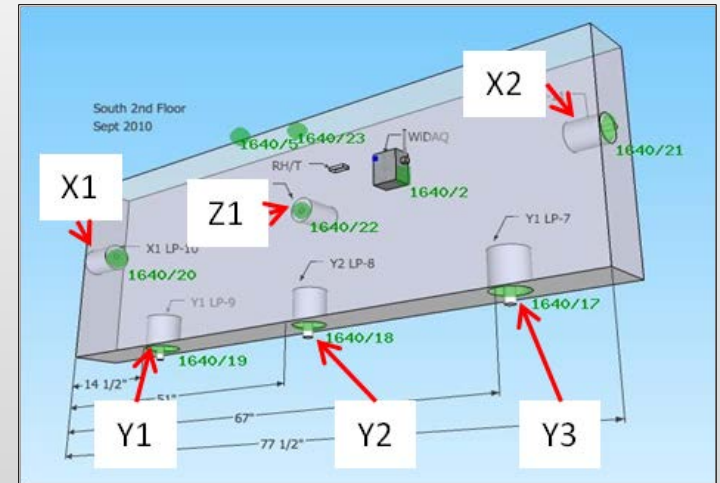
- **Why are we comfortable doing this?**
- **What has Dow done in the past?**
  - *Dow/Knight Kishwaukee College (see case study) plus others in design and construction.*
  - *“Strategies to Successfully Meet the New Energy Codes Using Foam Plastic Continuous Insulation” Jeff Hansbro, Dow Chemical*
  - *“Requirements for attaching Thermax ci Exterior Insulation and 3 Coat Stucco Cladding to Steel Stud Walls” TER Report – Dow Building Solutions & Jay Crandall, ARES Consulting*
- **What has JRS done in the past?**
  - *Burien Towne Square in Washington State, Several wood framed buildings, similar roof systems (metal over continuous XPS or polyiso), testing with Knight Wall*

# Measurement – Instruments

## Displacement



BI Technologies  
Model BI-404  
linear  
displacement  
sensors .  
Accuracy 0.085  
mm +/- 5%



## Hygrothermal



Relative Humidity Sensor  
Humirel HTM2500



CANTHERM MF52 Thermistor

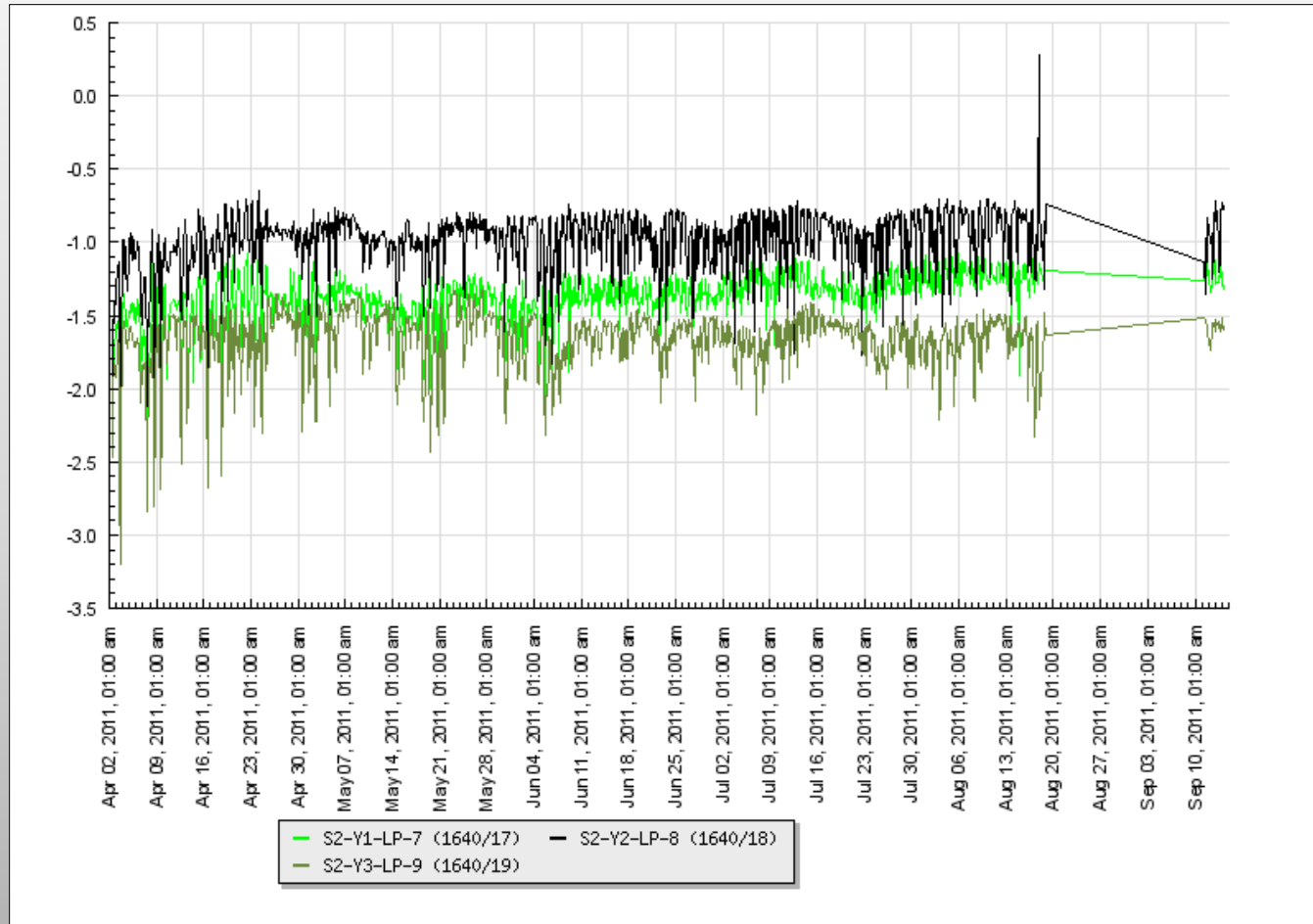
# Measurement–Location and Installation



N Elevation

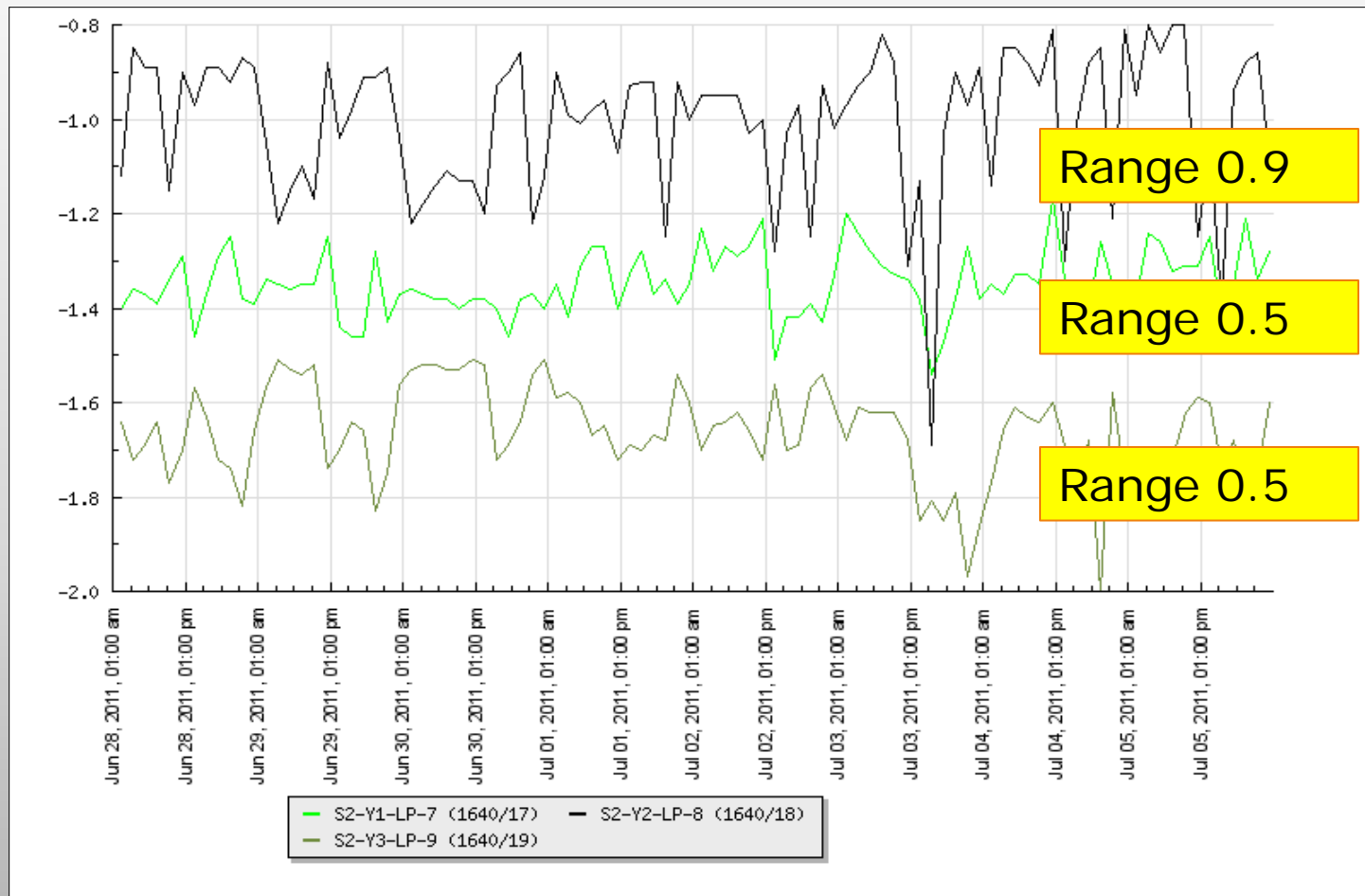


# Y Direction Measurements



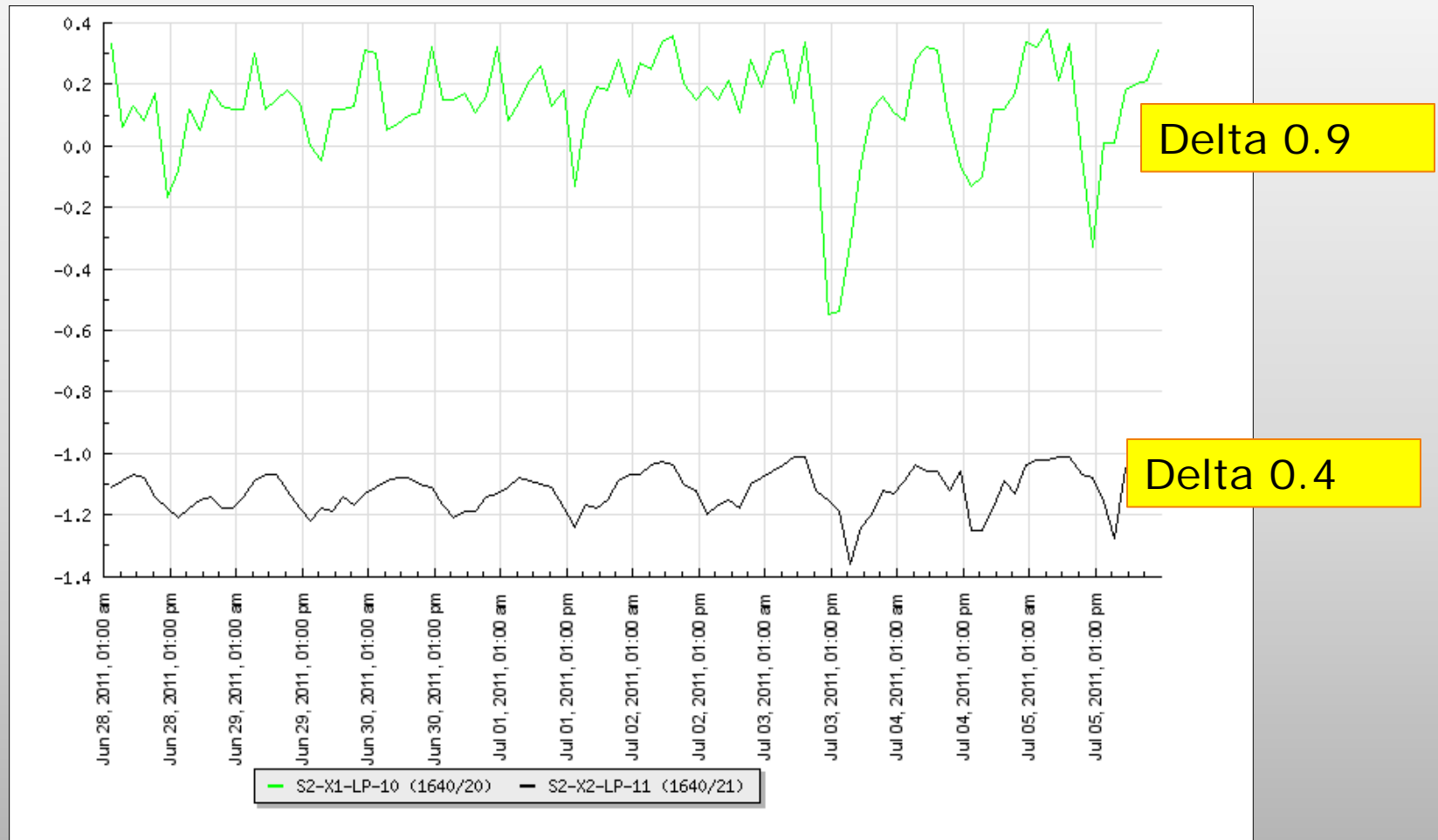
Vertical Displacement (2<sup>nd</sup> floor, South)

# Y Direction Measurements



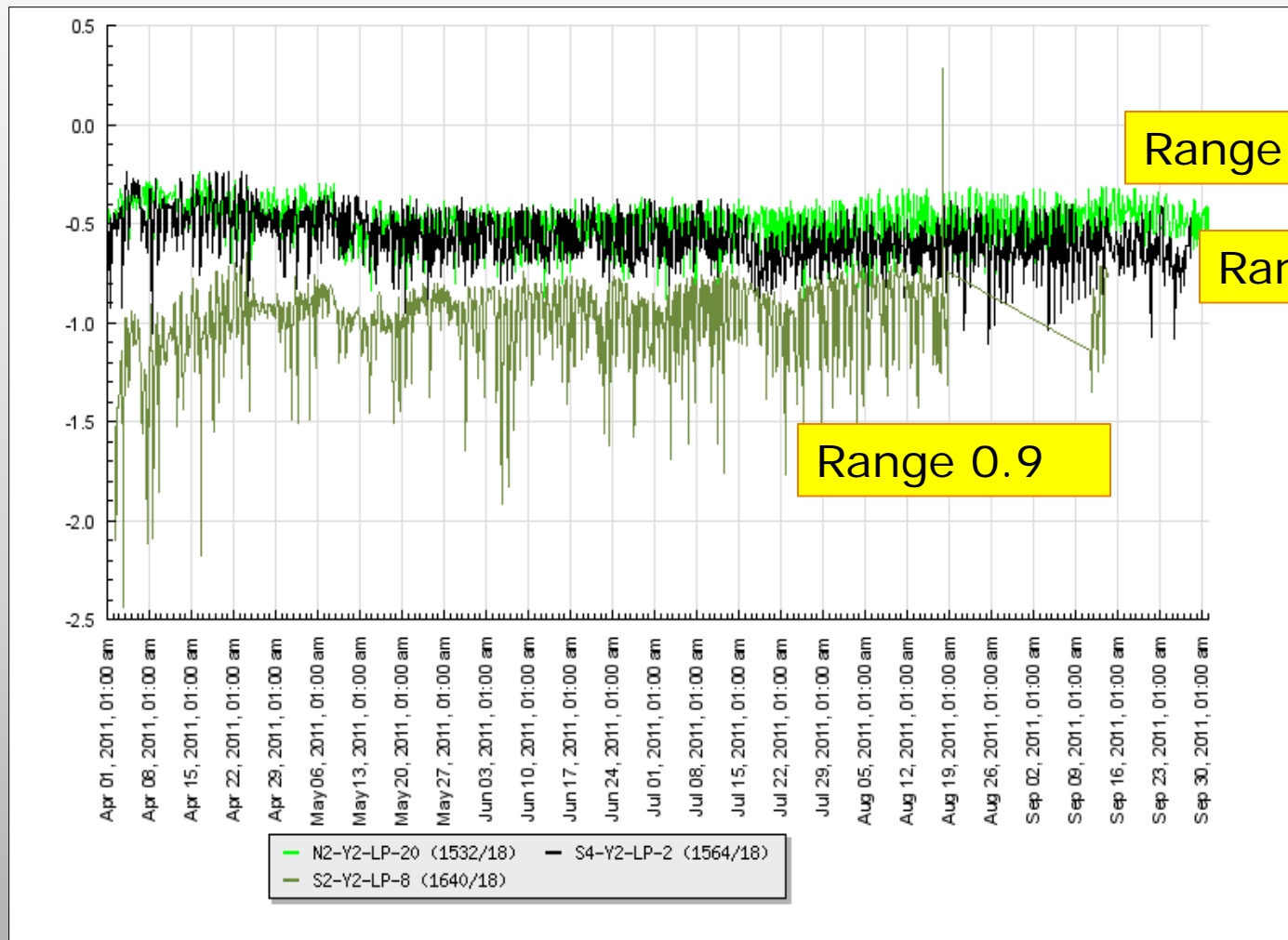
Y Displacement (2nd floor, South)

# X Direction Measurements



2<sup>nd</sup> floor, South

# North Facade vs. South Facade



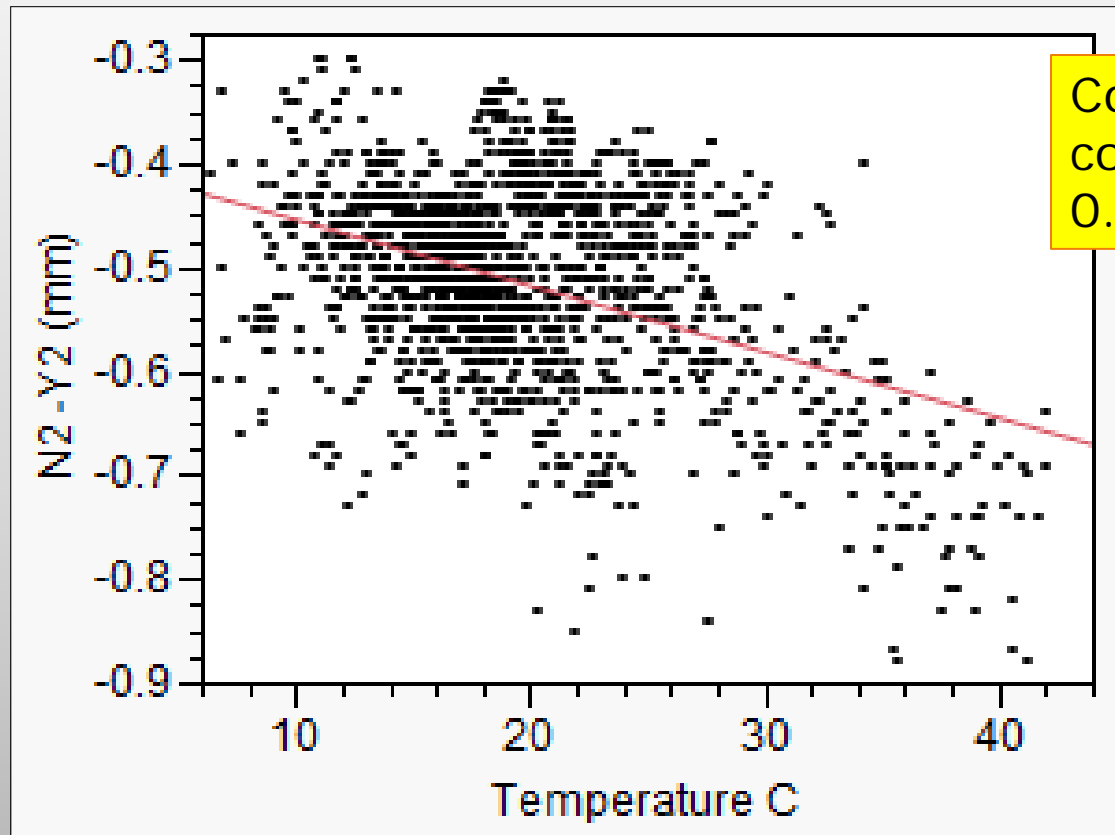
Vertical Displacement Measurements of N and S Panels

# Thermal Expansion & Correlation to CTE

Material	Coefficient of Thermal Expansion (m/m K)	Coefficient of Thermal Expansion (in/in F)	$\Delta T=35^{\circ}\text{C}$ $\Delta L$ over 1.2m (48")	$\Delta T=22^{\circ}\text{C}$ $\Delta L$ over 1.2m (48")
Mortar (Stucco)	$(7.3-13.5) \times 10^{-6}$	$(4.1-7.5) \times 10^{-6}$	0.3mm-0.57mm	0.19mm-0.36mm
Steel	$13.0 \times 10^{-6}$	$7.2 \times 10^{-6}$	0.54mm	0.34mm
XPS, Polyiso, EPS	$62.7 \times 10^{-6}$	$35 \times 10^{-6}$	2.63mm	1.65mm

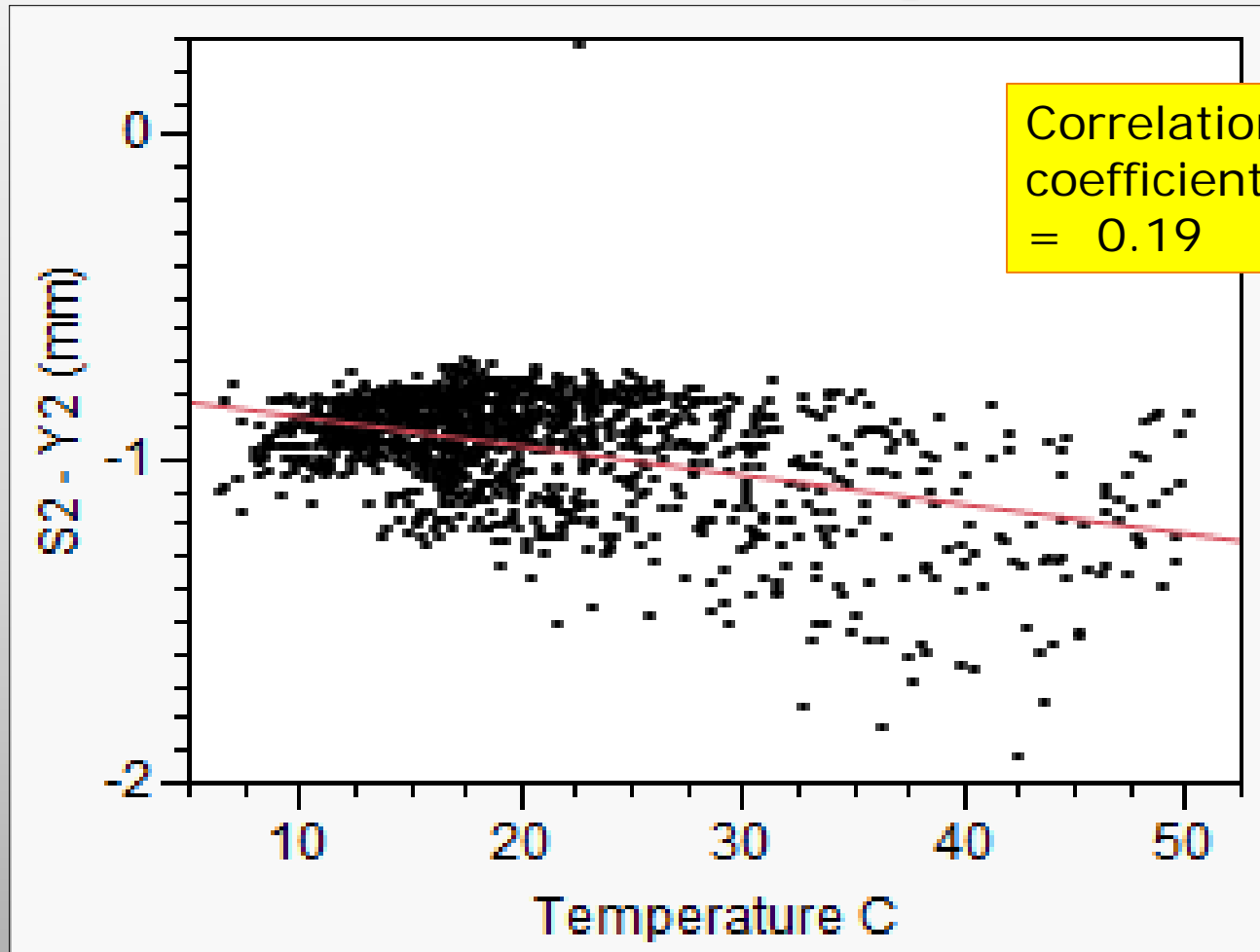


# Displacement vs Temperature

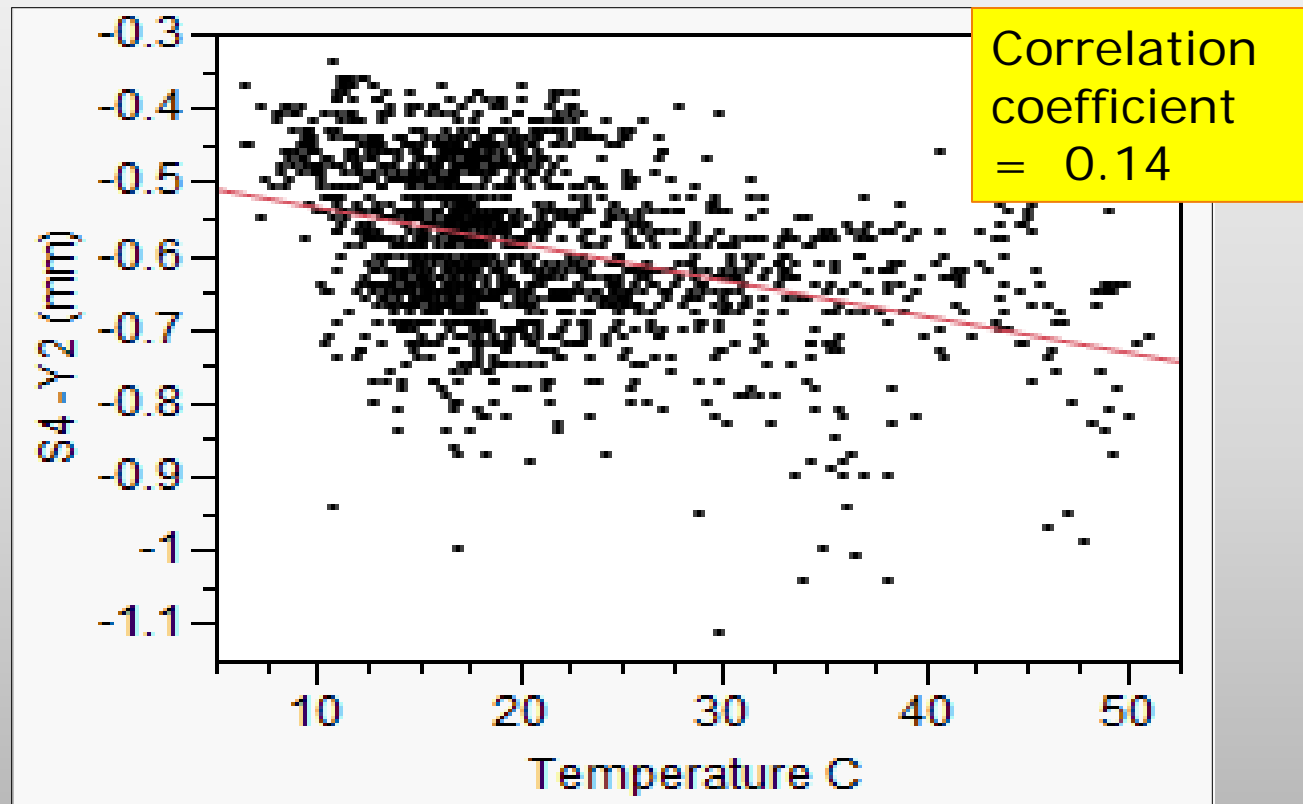


Correlation  
coefficient=  
0.18

# Displacement vs Temperature

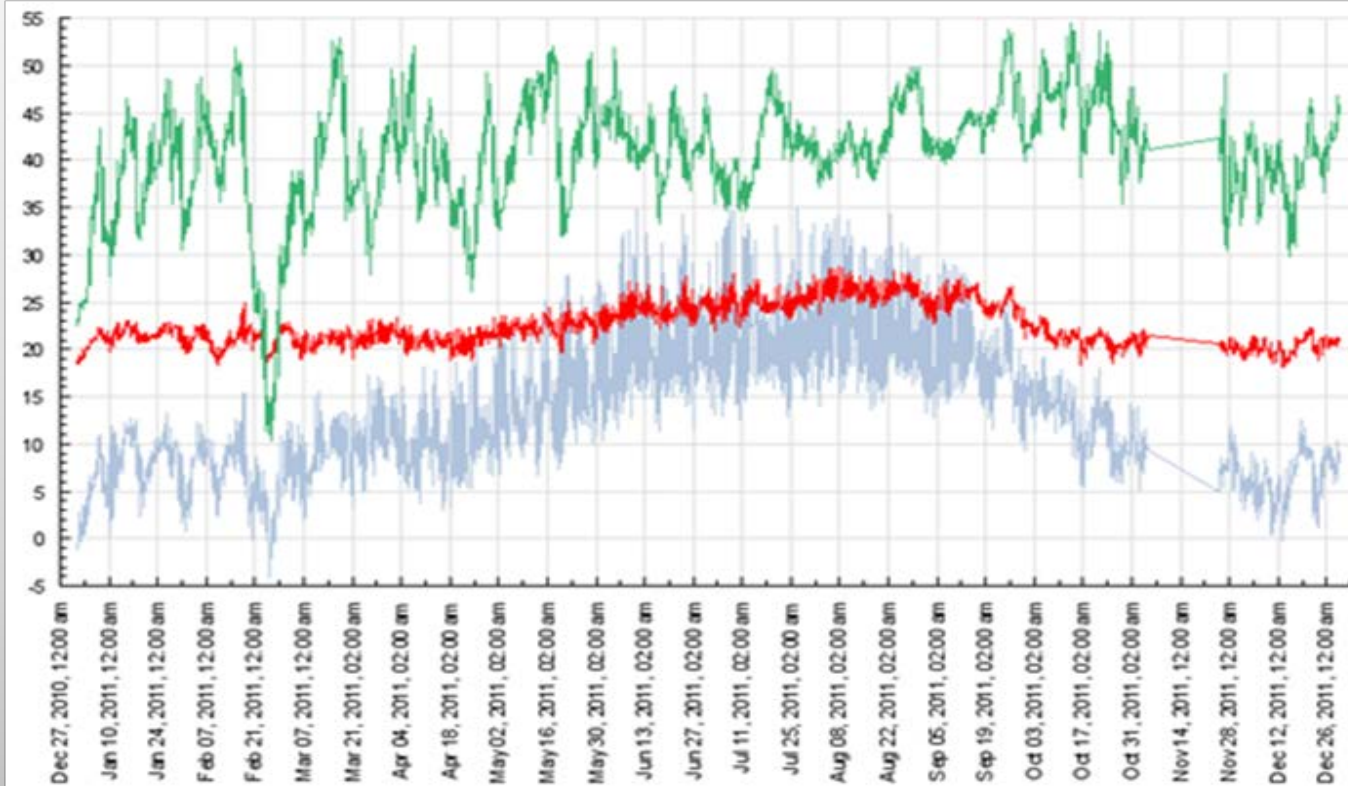


# Displacement vs Temperature



# Hygrothermal Performance

Temperature (C) or Relative Humidity (%)



Green – Relative Humidity (%)

Red – Temperature Inside Cavity (C)

LT Blue – Temperature Panel Exterior (C)

**North Wall**

# Conclusions

- The ci rain screen system is a structurally robust wall and complies with ASHRAE 90.1.
- X,Y,Z displacement ranges are negligible and not dependent on measurement location.
- Temperature-displacement correlation is poor.
- Hygrothermal performance confirmed to be good, with low condensation risk.
- No stucco performance problems have been reported to date.

# Future Work

- **Research expected movement of foamed plastic insulation due to differential temperature conditions and under restraint.**
- **Establish structural design parameters for designing rigid foam to support cladding and to withstand compression and bending loads that will vary depending on the design approach taken.**

# Questions?

