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Unvented Roof Research:

The "Ridge Rot" Accelerator

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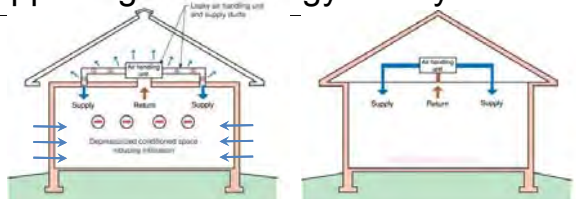
Background

Supporting Zero Energy Ready Homes



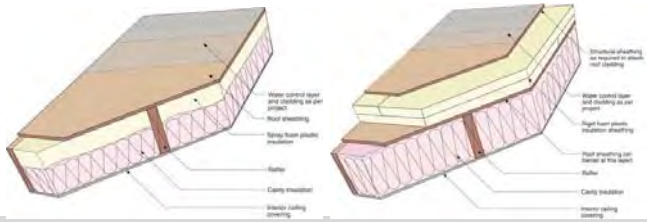
- Ducts in unconditioned attic = huge energy losses
- Solution: bring ducts into conditioned space
  - Builders reluctant to move ducts out of attic
- Unvented/conditioned attic—keeps ductwork in conditioned space, duct leak issues eliminated
- Also, retrofit insulation—cond. space within roof

Why this Project?

- Dense pack insulation of unvented roofs common in cold-climate retrofits
  - Moisture risks (see BSI-043 "Don't Be Dense—Cellulose and Dense-Pack Insulation", Derome's work)
  - Violates I-codes (see IRC § R806.4)
  - "Ridge rot"—localized problems (SIPS same problem)

Why this Project?

- Current code-compliant compact roof assemblies are higher cost (spray or board foams typical)
- Material costs:
  - Cellulose: 2-3¢ (per sf•R-value)
  - Polyisocyanurate: 7-10¢ (per sf•R-value)



Why this Project?

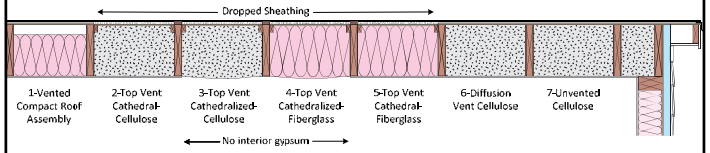
- Unvented roofs without spray/board foams could reduce costs and increase market penetration… IF moisture damage risks are addressed
- Retrofit opportunities (existing uninsulated living space at roof line, without removing finishes)

Experimental Setup

Experimental Design

- Seven roof bays (east-west pairs) in test garage attic in Chicago, IL (5A) area
- **72 F/50% RH interior** conditions through winter: stressing assemblies to failure

Experimental Design



#	Name	Venting	Insulation	Interior
1	Vented	Vent space (2")	Fiberglass	Gypsum Bd
2	Top Vent Cathedral-Cellulose	Cedar Breather (~½")	Cellulose	Gypsum Bd
3	Top Vent Cathedralized-Cellulose	Cedar Breather (~½")	Cellulose	Open
4	Top Vent Cathedralized-FG	Cedar Breather (~½")	Fiberglass	Open
5	Top Vent Cathedral-FG	Cedar Breather (~½")	Fiberglass	Gypsum Bd
6	Diffusion Vent Cellulose	Diffusion Vent	Cellulose	Gypsum Bd
7	Unvented Cellulose	None	Cellulose	Gypsum Bd

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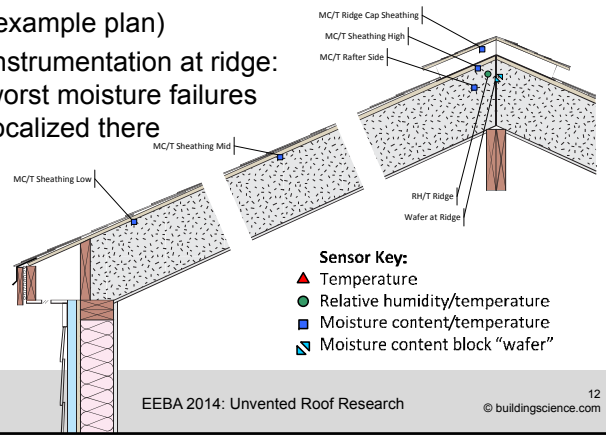
Top Vent Details

Instrumentation, Insulation, Finishes…

Typical Sensor Package

- Unvented cellulose roof (example plan)
- Instrumentation at ridge: worst moisture failures localized there



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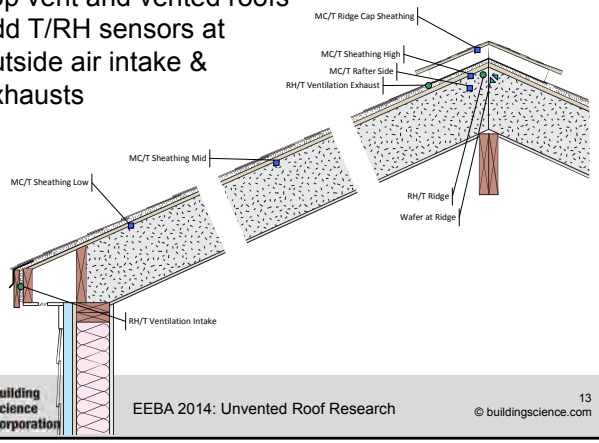
Typical Sensor Package

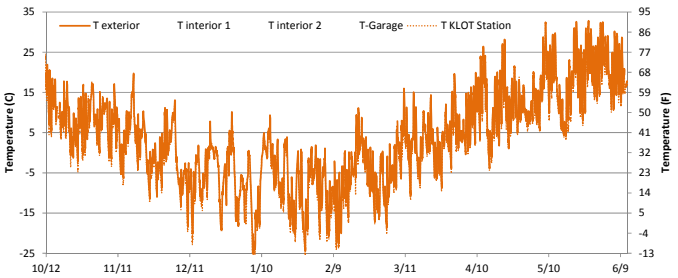
- Top vent and vented roofs add T/RH sensors at outside air intake & exhausts



Typical Sensors & Logger

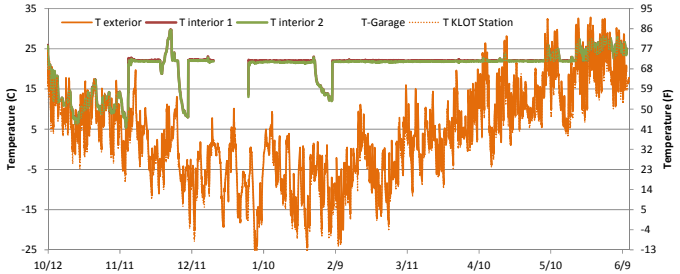
Results

Boundary Conditions (Temperatures)



- Winter of the “polar vortex” (7110 HDD vs. 6460)
- Losses of temperature control due to logger failures

Boundary Conditions (Temperatures)



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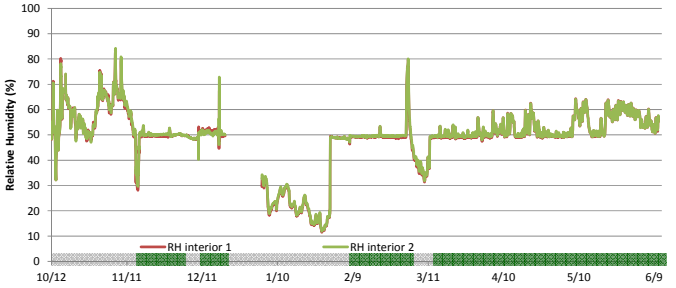

- Various losses of RH control, mostly 50%
- Into spring, interior RH rises above 50% (sheathing desorbing moisture, outdoor DP)

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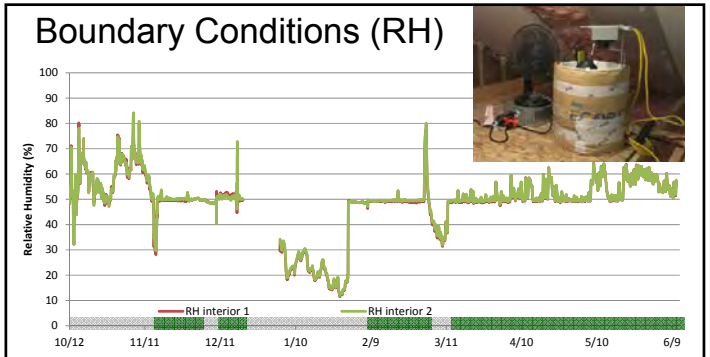

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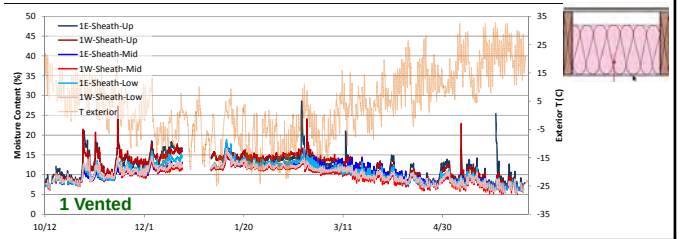
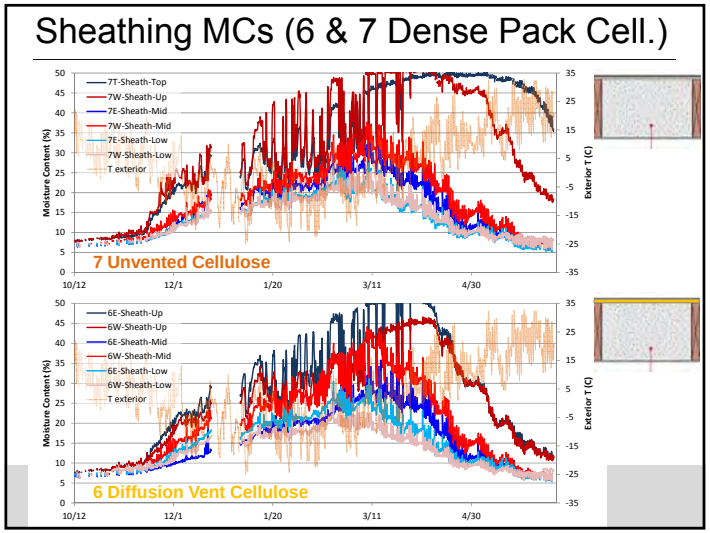
Sheathing Moisture Contents (1-Vented)



- Upper, Middle, & Lower
- East-West Pairings (West = warmer)
- Exterior T shown for reference

#	Name
1	Vented
2	Top Vent Cellulose-GWB
3	Top Vent Cellulose
4	Top Vent FG
5	Top Vent FG-GWB
6	Diffusion Vent Cellulose
7	Unvented Cellulose

Sheathing MCs (6 & 7 Dense Pack Cell.)



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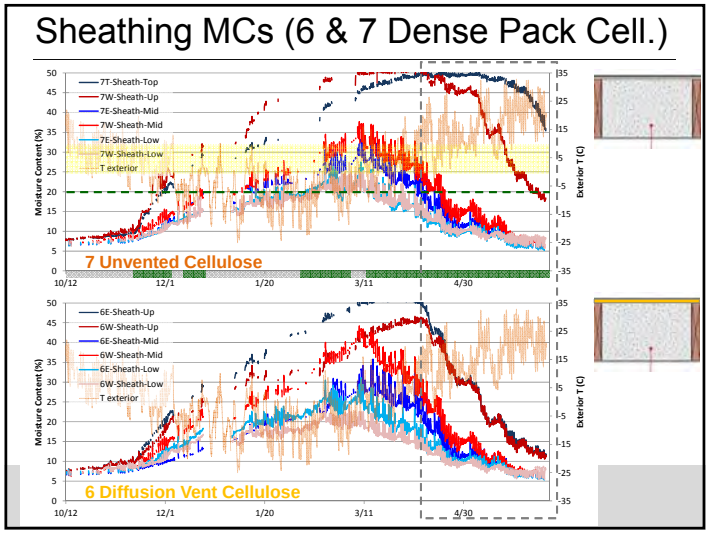
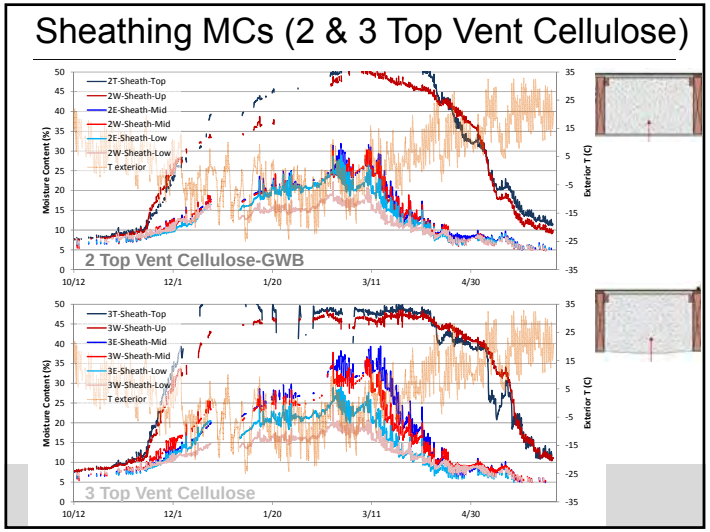
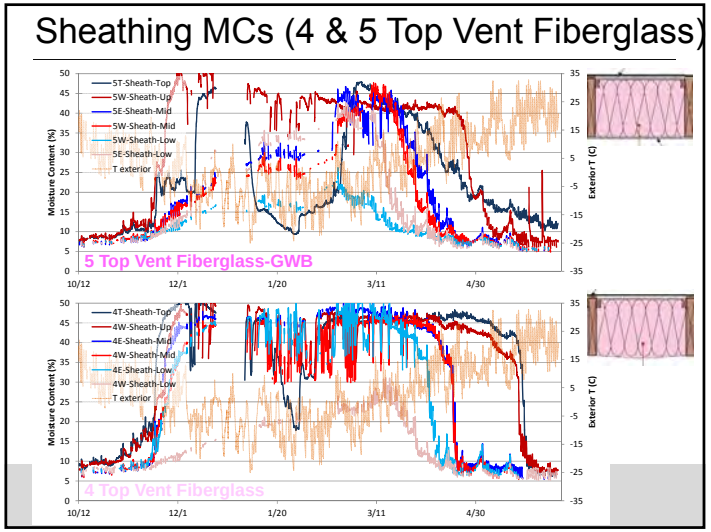


Sheathing MCs (2 & 3 Top Vent Cellulose)

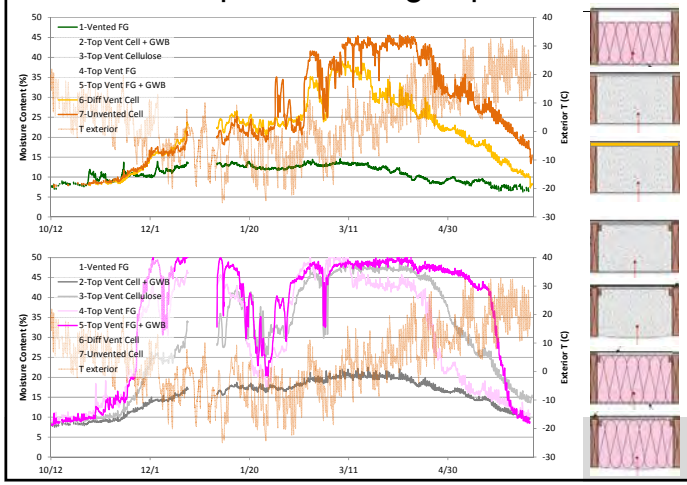


Sheathing MCs (4 & 5 Top Vent Fiberglass)

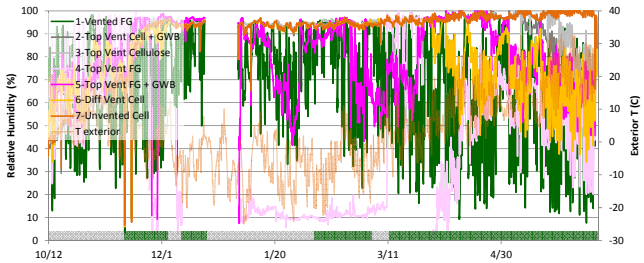


Top Vent Fiberglass-Monitoring vs Reality

Parallel Graphs: Framing Top MC



Roof Peak Relative Humidity



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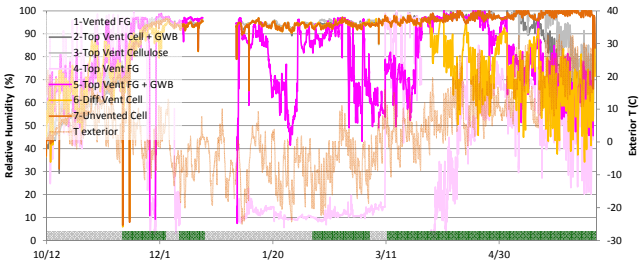

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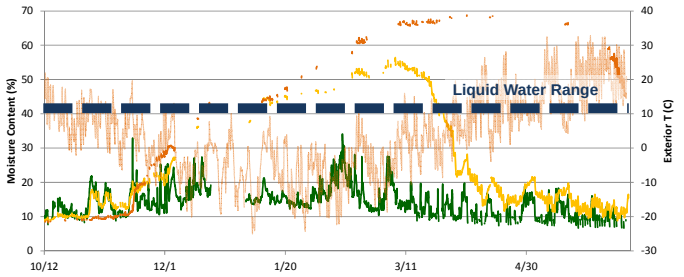
Roof Peak Wafer Sensor



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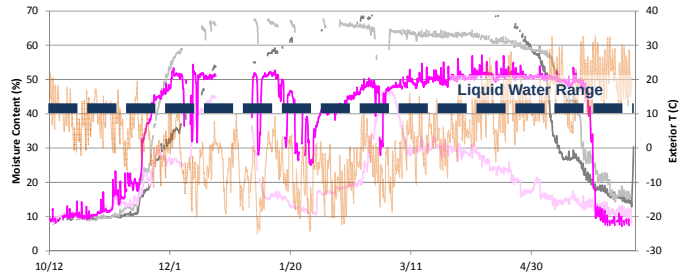
Roof Peak Wafer Sensor



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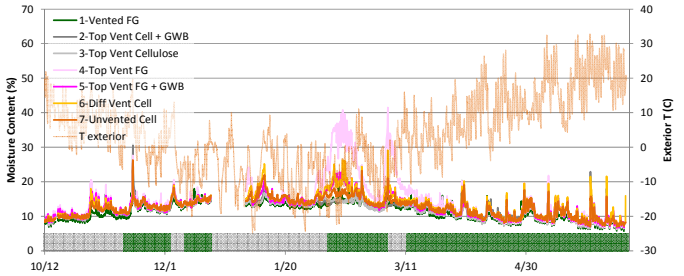
Roof "Doghouse" MCs



Doghouse & wafer MCs suggest air leak to exterior in 4-Top Vent Fiberglass roof

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Monitoring Result Takeaways

- Vented roof=great performance—even @50% RH!
- Unvented cellulose assembly driven to failure
- Cellulose + diffusion vent helps, but not enough
- Top venting not enough to save roofs in:
  - Zone 5A climate
  - With a small (~1/2" vent space)
  - With OSB sheathing
- In top vent roofs, fiberglass roof much worse than cellulose
  - Unless there's an air leak letting the moisture out
- Moisture accumulation driven by RH & outdoor T

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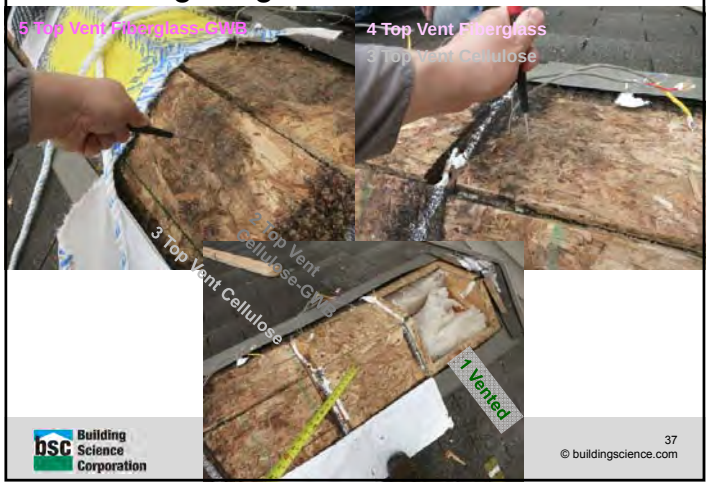
Disassembly

Removal of Doghouse

Sheathing Ridge Condition

Sheathing Ridge Condition

Sheathing Ridge Condition



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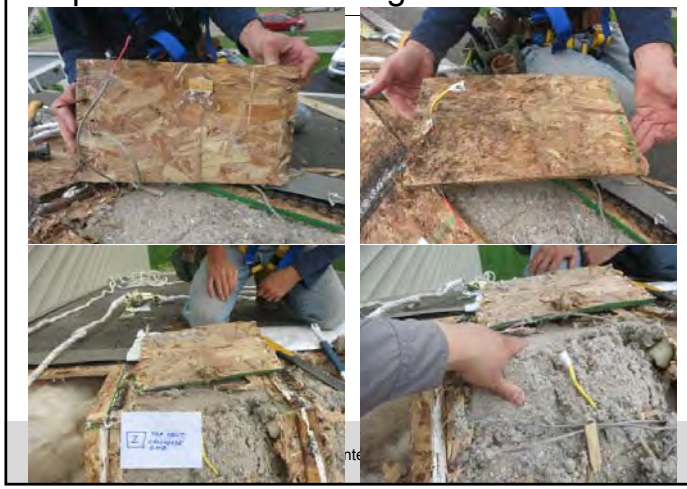
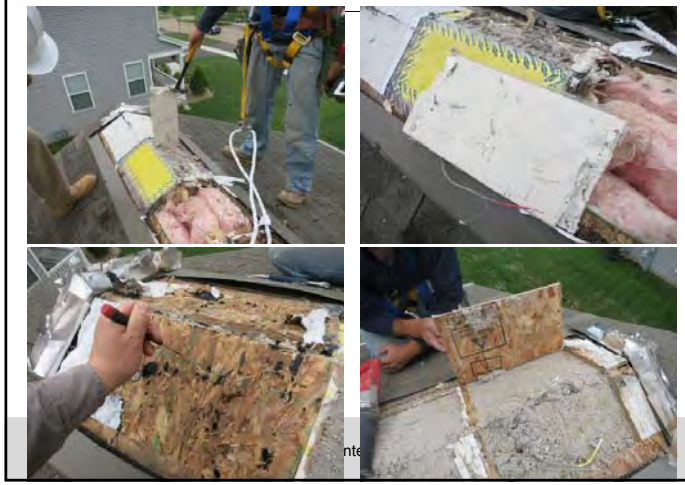
Top Vent Cellulose Ridge Conditions



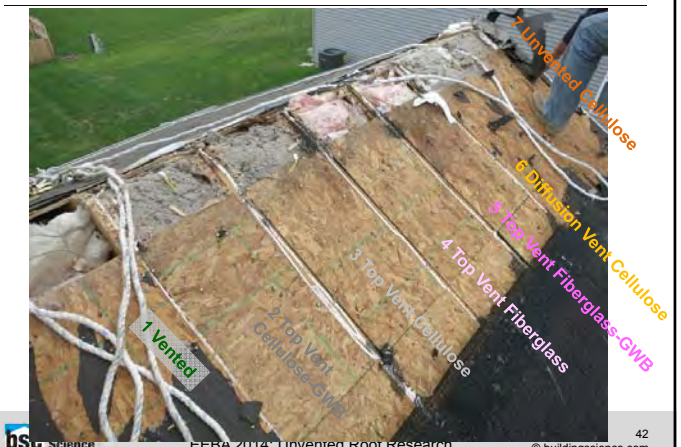
Top Vent Fiberglass Ridge Conditions

Top Vent Fiberglass Ridge Conditions

Diffusion Vent & Unvented



Sheathing Further from Ridge-West



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Sheathing Further from Ridge-East

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More Sheathing-Underside

Interior Disassembly

Disassembly Takeaways

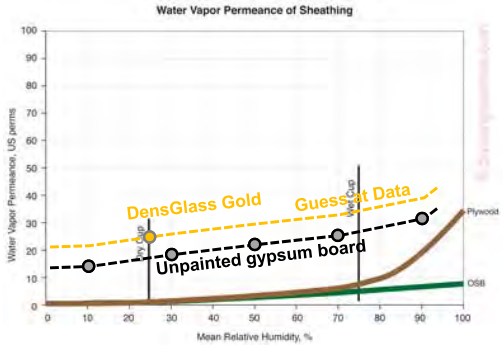
- Results consistent with monitoring data
- Sheathing stained but not punky/structural damage
- Damage concentrated/severe at ridge
- Fiberglass sheathing & framing: extensive damage & staining, possible mold growth
- Cellulose sheathing: some delamination, adhesions, and rusty fasteners—not as bad
- Cellulose did not settle over one winter
- Fiberglass batts leave lots of air leakage paths—possible cross-contamination with Roof 3?
- Liquid water rundown issues in fiberglass roofs

Conclusions

Experimental Conclusions

- No roof except for “control” vented roof showed “safe” performance in Zone 5A @ 50% RH
- Cellulose roofs generally showed lower MCs than fiberglass roofs, less damage to structure
- “Top vent” configuration not effective
  - OSB too restrictive for diffusion drying, even with outward thermal gradient? (part of the time)
  - Ventilation space too small?
- Diffusion vent allowed greater drying than conventional unvented, but still higher MCs than generally considered safe

Further Work-Other Diffusion Vents?



- Cosella Dörken Delta Foxx: **215-550 perms** (?)

Diffusion Vent Work (Houston)

Houston Diffusion Vent Preliminary Info

- Houston Zone 2A (Hot Humid)
  - Not Chicago-level challenging, but have seen failures!
- Data from April 2014-present (spring/summer)
- Unvented roofs vs. diffusion vent roofs, no interior humidification
- Monitoring results so far:
  - Unvented roof wetter coming out of winter, drier in summer
  - Diffusion vent roof drier in winter, wetter in summer
  - Neither roof anywhere near failure levels
  - This winter's data will provide the interesting results

Questions?

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