High Performance Intervention Houses in North Carolina, An Attempt to Control Indoor RH to 50% Year Round

Moisture Results from The Healthy Homes, Healthy Lives Phase 1 Study

2003 – 2006

BEST 1 Conference June 2008

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Study Idea of an Inherently Healthier Home

- Not reliant on homeowner behavior
- Based on a house package of:
  > Tight house and ducts
  > Closed crawl space
- Uses off the shelf products, can be readily installed and is achievable
Study Partners

- U.S. Department of Housing and Urban Development - Office of Healthy Homes and Lead Hazard Control
- National Institutes of Environmental Health Sciences
- UNC School of Medicine - Center for Environmental Medicine, Asthma, and Lung Biology
- Habitat for Humanity Affiliates
- Advanced Energy
Study Goal

Test if a market based high performance home specification can effectively maintain an indoor relative humidity of 50% in a mixed-humid climate.
How did the intervention houses perform?

- Crawl spaces drier
- However, living space not
- No difference in allergen levels between two groups

Overall

- Just keeping the crawl space drier is not enough for a drier living space
In North Carolina Climate, intervention protocol would control indoor relative humidity to $\leq 50\%$ and allergens year round by addressing:

- Infiltration
- Filtration
- Moisture Management
- Combustion safety
- Planned ventilation
Summary of Phase I Results

- Intervention protocol:
  > Kept closed crawl spaces drier than vented crawl spaces
  > But did not keep indoor RH level not below the 50% study target
  > And provided no difference in indoor allergens between groups

- Just providing a drier crawl space was not enough
Presentation Overview

- Study design
- Results
  - Relative humidity
  - Allergens
  - Lessons learned
- Next steps
National Context of Moisture

IRC 2000, Figure R301.2 (7) Probability of Above-Ground Decay
Indoor Health Risks are Moisture Dependant

- U.S. EPA and its Science Advisory Board stated indoor air is among the top environmental risks to public health.(2005)
- Arlian stated that house dust mites live indoors at 50%+ RH.(2001)
- The Institute of Medicine of the National Academy of Sciences concluded that exposure to damp indoor environments is clearly associated with some important respiratory health effects, including asthma symptoms in sensitized asthmatic people.(2004)
Moisture Sources

- Infiltration
  - Cleaning
  - Breathing
  - Showering
+ Allergens
  »- Asthma
  »- Respiratory complications

Ventilation

Moisture

Mold
### Methods - study design

<table>
<thead>
<tr>
<th>Group</th>
<th>Control</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td># of houses</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>Built by</td>
<td>Production Builders</td>
<td>4 Affordable Builders</td>
</tr>
<tr>
<td>Building Reference</td>
<td>Code Min.</td>
<td>Energy Star “plus”</td>
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- All electric
- Similar in size and socioeconomic status of homeowner
- ~ 1200 SF per house, 2-3 beds, 2 baths
Is the intervention protocol “healthier”?

- In North Carolina climate, specifically addressed:
  - Infiltration
  - Moisture management
  - Combustion safety
  - Planned ventilation
    - Using supplied outdoor air
    - Spot exhaust fans

- Can they overcome the house or homeowner?
  - Exhaust fan use (or not)
  - Standard leaky house
  - Standard leaky duct system
  - Typical vented crawl space
Features of the intervention

- Tight construction: leakage $\leq 5.6 \text{ M}^3/\text{hr per m}^2$ (0.30 CFM per ft$^2$) of envelope at 50 Pascals
- Tight duct work: leakage $\leq 3\%$ of conditioned floor area at 25 Pascals
- Room pressure balancing to $\pm 3$ Pascals with reference to outside
- Closed crawl space
- Spot exhaust ventilation
  - Kitchen flow of 2.8 M$^3$/min (100 CFM)
  - Bathroom flow of 1.4 M$^3$/min (50 CFM)
- “Right-sized” HVAC systems per ACCA Manual J
- Supply ventilation of 1.1 M$^3$/min (40 CFM)
- MERV 11 whole house filtration
### House and Duct Tightness

#### HOUSE PERFORMANCE VALUES BY INTERVENTION

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<tr>
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<tbody>
<tr>
<td>Intervention</td>
<td>34</td>
<td>30%</td>
<td>862</td>
<td>0.25</td>
<td>106</td>
<td>58</td>
<td>56</td>
</tr>
<tr>
<td>Non-Intervention</td>
<td>122</td>
<td>104%</td>
<td>1142</td>
<td>0.31</td>
<td>0</td>
<td>38</td>
<td>37</td>
</tr>
<tr>
<td>% Diff (I from N)</td>
<td>72% tighter</td>
<td></td>
<td>25% tighter</td>
<td>n/a</td>
<td>53% higher</td>
<td>52% higher</td>
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</tbody>
</table>
The Closed Crawl Space

Poly liner sealed to piers and wall, 3” termite view strip

Supply air provides drying
Remote Temperature, RH and Wood Moisture Sensors
How the crawl spaces perform – % RH

% Relative Humidity

Non-Intervention

Intervention

Fixed crawl space installations

70 %
 Moisture dependant allergens examined were:

- House dust mites
- Mold (Alternaria alternate)

No statistical difference between intervention and control levels.
Met goal of “do no harm” – did not adversely influence the houses when tightening them

Tight intervention houses with outdoor air intake + timer don’t have higher indoor RH than leakier non intervention houses

In these houses, mechanical ventilation did not statistically reduce dust mite or mold activity
Summary of Results

- Closed crawl space interventions were dryer than control
- However, intervention indoor RH levels no different from control levels and thereby did not meet 50% target
- And no difference in indoor allergens

- Just providing a drier crawl space is not enough
Next Steps

► More research needed
  > mechanical whole house dehumidification

► Get what works to:
  > Builders
  > Retrofit industry