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crawl space research update

Informing builders, code officials, and homeowners about crawl space issues

Moisture Results

Crawl Space Mold and Moisture Problems

Building mold has emerged as a major issue for the entire home building industry. The issue stems from thousands of insurance claims and lawsuits, including successful, multi-million dollar settlements, that identify building mold as a health problem for tenants and homeowners.

Crawlspaces fitted with traditional foundation vents (wall vented) are particularly vulnerable to moisture and mold problems. Typical problems found in wall vented crawlspaces include:

- Standing water on top of ground poly
- Water condensation droplets on cold water pipes and ductwork
- Muddy soil
- Stained walls from water penetration and efflorescence
- Wet floor batt insulation and or fallen batts
- Visible mold blooms

Ongoing dampness encourages mold blooms to grow in crawlspaces. Crawlspace mold readily grows on the wood joists, sills, support beams and subflooring. Generally these are surface molds (common crawlspace molds include Aspergillus, Penicillium and Cladosporium). Mold coverage ranges from light spotting to thick mold blooms that cover large surface areas.

Crawl spaces in the southeast, the Gulf Coast states and northwest regions are most prone to surface mold problems. This is because during rainy and humid weather, wall vented crawl spaces often stay damp with relative humidity above 70 percent for long periods of time. When this happens, the excess moisture encourages mold to grow on the wood and on any other organic material such as cardboard, dust, and paper-faced sheetrock.

Crawlspace mold is most readily noticed when it grows on the floor joists and joist beams but it also grows on the ground surface, in settled dust, and on plumbing lines and HVAC ductwork. During construction, as soon as the subflooring is installed, a crawlspace can trap excess moisture and start growing mold even before the construction of the house is finished. Now that most homes are air conditioned, the crawlspace mold problem has worsened. Crawlspace moisture readily condenses on cold floor framing and ductwork in air conditioned homes.

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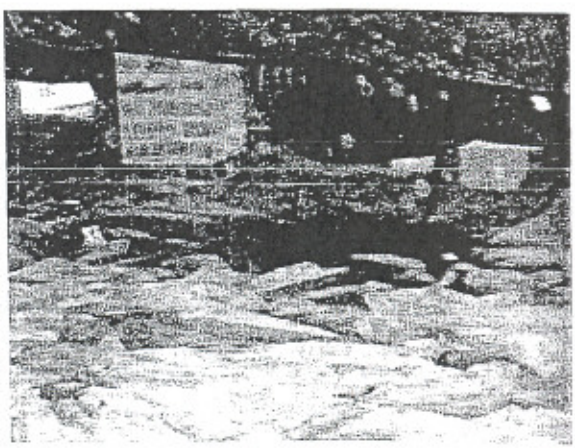

A too common sight: large puddles collect on top of the ground poly vapor barrier. Until these puddles evaporate, this crawlspace will maintain high relative humidity levels that encourage mold growths.

This project is funded by the U.S. Department of Energy and co-funded and managed by Advanced Energy.

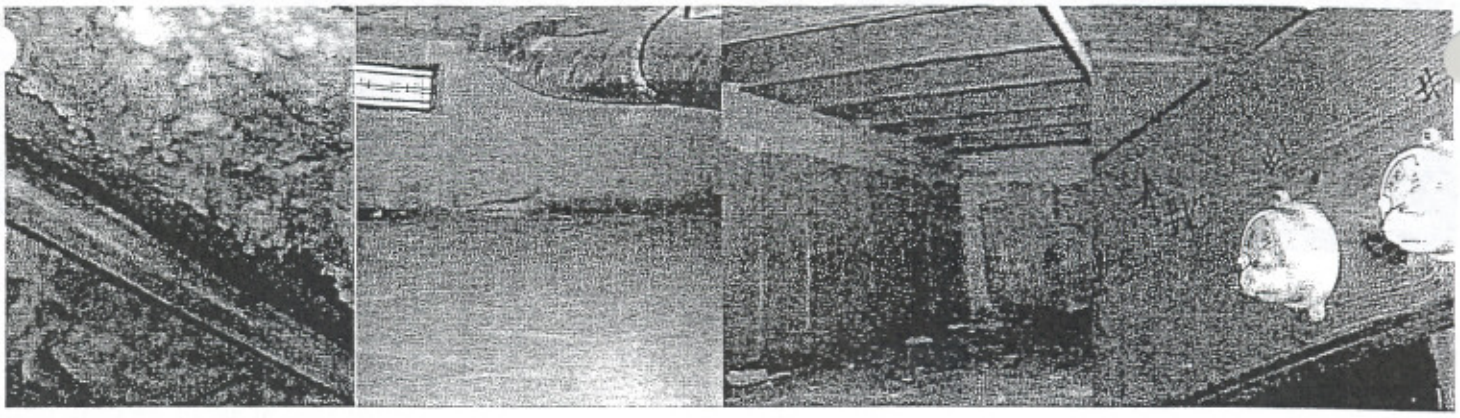

Photo one: Builders and homeowners are increasingly concerned about crawl space mold stains and odors.
Photo two: Four wall vented crawl spaces serve as the control group in the study. Note that all exposed ground is fully covered with 6-mil polyethylene.
Photo three: In the closed crawl spaces, the foundation vents are sealed and 6-mil polyethylene is brought up the walls leaving a 3-inch termite inspection strip at the top.
Photo four: Battery operated sensors measure the crawl space temperature and relative humidity every 15 minutes.

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Summary of Moisture Testing Results

In the spring of 2001, a research project began to study how crawl space moisture levels can be controlled and reduced. This project is funded by the U.S. Department of Energy and co-funded and managed by Advanced Energy, Raleigh, N.C. The field test research monitors 12 identical, new homes to compare traditional crawl spaces with foundation vents (wall vented) to closed crawl spaces without foundation vents.

The crawl space field test has been monitored now for nearly two years. The experiment has operated long enough that the moisture performance characteristics have become stable and predictable. The chief finding is that the closed crawl spaces stay significantly drier than the wall vented crawl spaces.

Supporting Findings

- Foundation vents add excess moisture to crawl spaces during humid and wet weather, particularly in the summer. This excess moisture promotes mold-growing conditions.
- Ground vapor retarders (ground poly) by themselves do not keep crawl spaces dry enough to prevent mold growth.
- Closed crawl spaces without foundation vents stay dry all the time, particularly during the summer and humid weather.

Field Test Houses

A new 12-home Habitat for Humanity subdivision in eastern North Carolina was recruited to serve as the field test site in the spri of 2001. The homes were selected and setup to provide a hi degree of uniform operating conditions among the homes. Details about the test houses and the experiment setup are available at www.crawlspaces.org under the reports section (report title: Field Study Setup).

The crawlspace homes are divided into groups to compare traditional crawl spaces with foundation vents (wall vented) to closed crawlspaces without wall vents. The control group for the field test is four wall vented crawl spaces.

The remaining eight homes were setup as closed crawl spaces and serve as the experiment group. These homes were converted to closed crawl spaces by sealing the foundation vents and by installing 6-mil polyethylene (poly) as a full interior liner. All poly edges and seams are sealed.

Battery operated sensors record the temperature and relative humidity (RH) in the crawl spaces, inside the homes, and outdoors every 15 minutes. Wood moisture content is measured during site inspections.

Moisture Results

The experiment results clearly show that the closed crawl spaces stay significantly dryer than the wall vented crawl spaces. Figure 1 compares crawl space relative humidity (RH) levels during the summer of 2002.

RH in the wall vented crawl spaces (red line) closely follows outdoor humidity levels (green line). Consequently, the wall vented crawl spaces stayed damp (above 70 percent RH) most of the time during the humid summer weather.

In sharp contrast, RH levels in the closed crawl spaces (blue line) do not follow outdoor humidity. Instead, the closed crawl spaces stayed dry (below 60 percent RH) throughout the summer.

Figure 2 shows that from June through August 2002, the wall vented crawl spaces stayed above 70 percent relative humidity 79 percent of the time while the closed crawl spaces never exceed 60 percent relative humidity (RH). To effectively prevent mold blooms, crawl space moisture levels should be kept below 70 percent RH.

Relative humidity levels in the closed crawl spaces during the summer are lower than expected. It is believed that these low levels result, in part, from the fact that the crawl spaces are partially conditioned with air-conditioned dry air that is introduced into the crawl spaces through typical duct leakage and the added ventilation air movement.

Figure 3 shows what the absolute humidity conditions were for an entire year. Absolute humidity is a measurement of how much water vapor is in the air. This graph reveals that during the winter, both the wall vented and closed crawl spaces reached their driest conditions and ended up performing about equally well. Since winter results in drying conditions for both groups, crawl space moisture control efforts need to focus on the wetting effect that hot humid weather has on wall vented crawl spaces.

These results also bring into question the effectiveness of ground vapor retarders in controlling crawl space mold. Many building professionals have thought that a full coverage layer of 6-mil poly was the main strategy needed to control crawl space moisture. The field test results do not support this belief when it comes to mold prevention. Despite the carefully installed, 100 percent coverage ground poly, excess moisture continues to enter and

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Figure 1

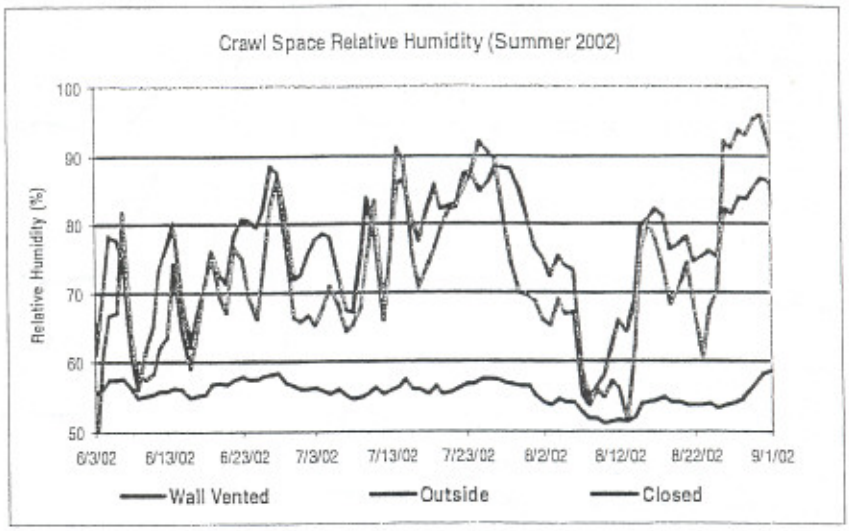
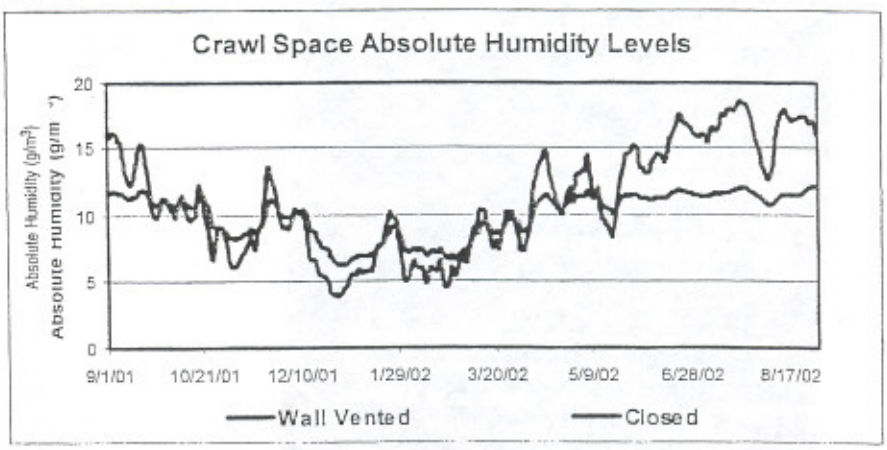


Figure 2

Crawl Space RH Summary (June - August 2002)

Percentage of Time	Vented	Closed
Above 80% RH	39%	0%
Above 70% RH	79%	0%
Above 60% RH	94%	0%
Above 50% RH	100%	100%

Figure 3



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main in the wall vented crawl spaces. This excess moisture creates a damp, mold-friendly climate in the crawl spaces during humid weather conditions, particularly in the summer. Where is the excess moisture coming from? The two main sources are water vapor in humid outdoor air that enters the crawl space through the wall vents and rain and ground water that wicks through the block walls into the crawl space.

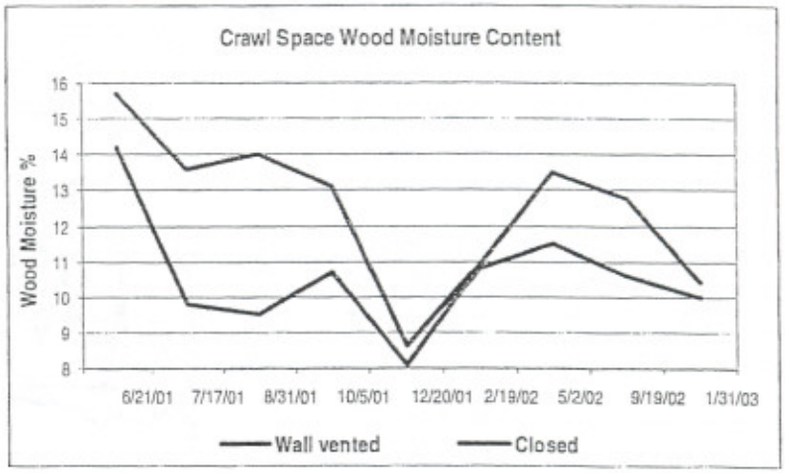
Wood Moisture

The last measured moisture condition is wood moisture content, shown in Figure 4. A total of 10 pin-meter moisture readings are made in each crawlspace during site data collection trips. The pin moisture readings parallel the space moisture readings. The closed crawl spaces have lower wood moisture content than the wall vented crawl spaces. Dry wood framing discourages surface mold, wood rot and insect infestation of wood boring pests.

Summary

While there is a lot of disagreement about mold and health, scientists, mold specialists and government agencies like the U.S. EPA, all agree that the key to controlling mold is to reduce excess moisture. The field test results demonstrate that foundation vents add excess moisture to crawl spaces for long periods of time during humid summer weather. Builders seeking to construct dry crawl spaces should consider building homes with closed crawl spaces.

Figure 4



For More Information

Several more volumes of the *Crawl Space Research Update* are planned for 2003 and 2004. To receive future updates, go to the project Web site at **www.crawlspaces.org** and sign up to be placed on the crawl space email list. Starting in the spring of 2003, the Web site will be periodically updated with reports, articles, construction details, and how-to information about crawl space moisture and mold control and energy features. Check this Web site often to keep informed.

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