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# Alleviating Moisture Problems in Hot, Humid Climate Housing

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**Alleviating Moisture Problems Hot, Humid Climate Housing**

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**Abstract**
Houses in hot, humid climates experience unique and severe climatic conditions that can cause mold, soft drywall, buckled floors, damaged ceilings and other moisture problems. State of the art and research needs are presented for three areas - Manufactured (mobile) Homes, Unvented Attics and Slab-on-grade floors.

**Keywords**
Moisture Problems, Hot-humid climates, Manufactured (mobile) Homes, Unvented Attics, Slab-on-grade floors.

**Introduction**
The Southeastern U.S. experiences hot, humid conditions throughout the summer months and in Florida, one of the high growth states with large number of homes, these conditions can prevail throughout most of the year. As a result it is not uncommon to find extensive mold, soft drywall, buckled floors, damaged ceilings and other moisture problems in new and existing site built and manufactured homes. Since 1999, as a result of participation in the U.S. DOE funded Building America program, the authors have developed first hand experience and conducted research in these areas. This paper provides a brief summary of the state of the art and research needs for three areas - Manufactured (mobile) Homes, Unvented Attics and Slab-on-grade floors.

**Manufactured (Mobile) Homes**

<u>State of the Art</u>

A significant number of new manufactured (mobile) homes built to the HUD Code and located in the hot, humid Southeast are experiencing moisture problems. Soft wallboards, buckled floors, damaged wood molding and extensive mold growth are the most common symptoms. These problems do not respond to the standard service and repair strategies for water intrusion.

At the request of six manufacturers, BAIHP researchers have investigated over 70 such problem homes between 1999 and 2003 to determine likely causes. One time blower door, duct tightness and pressure differential measurements were performed on all homes. Field data on ambient, crawlspace, belly (closed, insulated space between floor deck and crawl space) and house temperatures and RH were also collected in some cases. Recommendations and reports were prepared for the manufacturer’s service, production and design staff. Field repairs were performed in most of these homes by the manufacturer's service team.

As documented (Moyer et. al., 2001) in the reports, generalized themes existed in the houses investigated:

- Low air conditioner thermostat setting (typically 68-73F), which is generally below the ambient dew point over several months
- Negative pressures across the envelope caused by high supply duct leakage (leakage cfm @25Pa > 10 per 100 square feet of conditioned floor area), inadequate return air paths from closed rooms, exhaust fans or a combination thereof.
- Inadequate moisture removal caused by disconnected return ducts, fans set to "On" position (air handler or ventilation), inadequate drainage of condensate, oversized air conditioner or a combination thereof.
- Moisture diffusion from the ground into the house because of poor site drainage, inadequate crawl space ventilation, tears in the belly board (air barrier), or a combination thereof.
- Vapor retarder in the wrong location i.e. vinyl or other impermeable wall or floor coverings located on the cool side of the assembly. colder surfaces. Some times the floor covering is over cooled because air from ceiling registers is directly impinging the floor.

Similar problems were found in the work done by the Manufactured Housing Research Alliance (MHRA, 2003) under funding from HUD/PATH.

<u>Research Needs</u>

It could be argued that one can solve the moisture problems in manufactured housing by taking steps to rectify all of the above deficiencies. However, that may be costly and not preferred by the manufacturers or the consumers.

For instance, several manufacturers are now producing homes with air tight duct systems with the joints and seams sealed with mastic. Although this helps to reduce the a prime driving force (negative pressure) it does not necessarily solve the floor buckling problem. High crawl space moisture levels caused by lack of ground cover and inadequate ventilation, belly board tears, small negative pressures and moisture susceptible flooring material can combine to cause floor buckling problems. At least one manufacturer incorporated FSEC recommendations of installing a vapor barrier on the ground, adequate return air paths from closed rooms and right sizing air conditioners. This manufacturer does not experience any moisture problem homes now despite having some homes with impermeable wall coverings and floor coverings. However other manufacturers have been reluctant to take these additional steps and continue to experience service calls for moisture damage.The following research will assist in advancing the state of the art for all housing, not just manufactured housing, built with crawl spaces:

1. *Vented Crawl Spaces:* Conduct experiments and develop models that better predict the crawl space moisture levels as a function of soil type, presence/absence of ground cover, , ground wetting from rain and irrigation, crawl space ventilation aperture levels and surface grading. The objective will be to quantitatively understand what amount of

ventilation apertures and other parameters are needed to have the crawlspace moisture levels about the same as ambient moisture levels.

2. *Unvented Crawl Spaces:* Develop experimentally validated unvented crawl space designs that are able to successfully deal with initial construction moisture (before the crawlspace is sealed up) as well as flooding in addition to normal interior moisture generation. Research is underway at Advanced Energy Corporation (Davis et. al., 2002) and elsewhere on unvented crawl spaces for site built housing. This research needs to be examined for its applicability to manufactured homes and additional research conducted for manufactured homes if needed

**Unvented Attics**

State of the Art

The vast majority of homes are heated and cooled by ducts installed in vented attics. In hot, humid climates, in some homes, moisture in attic ventilation air can condense on the out side of inadequately insulated ductwork and/or the attic side of the unevenly insulated ceiling drywall when it is overcooled by misdirected supply air at register boots or other leak sites. This has caused moldy, soft or failed ceilings in a few homes. Attic ventilation air creates the thermal load on the duct system itself during both heating and cooling seasons. In addition vented attics are dusty and can have pests and pesticides which can contribute to poor indoor air quality in the home.

Unvented attic construction, where the insulation is applied to the underside of the roof decking can solve the moisture and IAQ problems of vented attics. Dr. Joseph Lstiburek and his colleagues at Building Science Corporation have conducted significant work in this area (Ueno, 2003). In addition, since the ductwork is now within the thermal boundary, energy savings also result (Parker et. al., 2000).

Research Needs

The unvented attic concept has been implemented in several dozen new homes in hot, humid climates. Those with tile or metal roofs seem to have no problems. Unvented attics with shingle roofs have had some problems in some homes (high moisture content in attic peaks, buckled shingles). These are generally a result of solar driven moisture into the attic as has been suggested and described by Lstiburek (2003) who has recommended the use of a vapor retarder roofing paper to solve the problem. However, some roofers are reluctant to use this slippery material.

Another issue is how best to insulate at the underside of the roof decking. Many have used vapor permeable foam insulation to avoid the problems of attaching blanket or blown insulation against gravity. Some have raised the issue of detecting roof leakage points if a roof leak developed with foam insulation.

The research needs are to:

3. *Unvented Attics:* Conduct measurements in unvented attics with shingles to determine the attic moisture conditions as a function of roof slope, type of roofing paper, amount and type of coupling between house and attic, amount of duct leakage. Develop predictive

models and design guidelines. Conduct research to determine how roof leaks are propagated through foam insulated roof decks and suggest design or application guidelines.

**Slab-on-grade floors**

State of the art

The predominant majority of site built houses in hot, humid climates are built with slab-on-grade floors. In much of Florida, stucco walls are common and the stucco extends below the ground.

With lot lines shrinking and prevalence of lawn irrigation sprinklers, the sides of many homes are wet much of the time because of poor grading and excessive watering. (Figure 1)

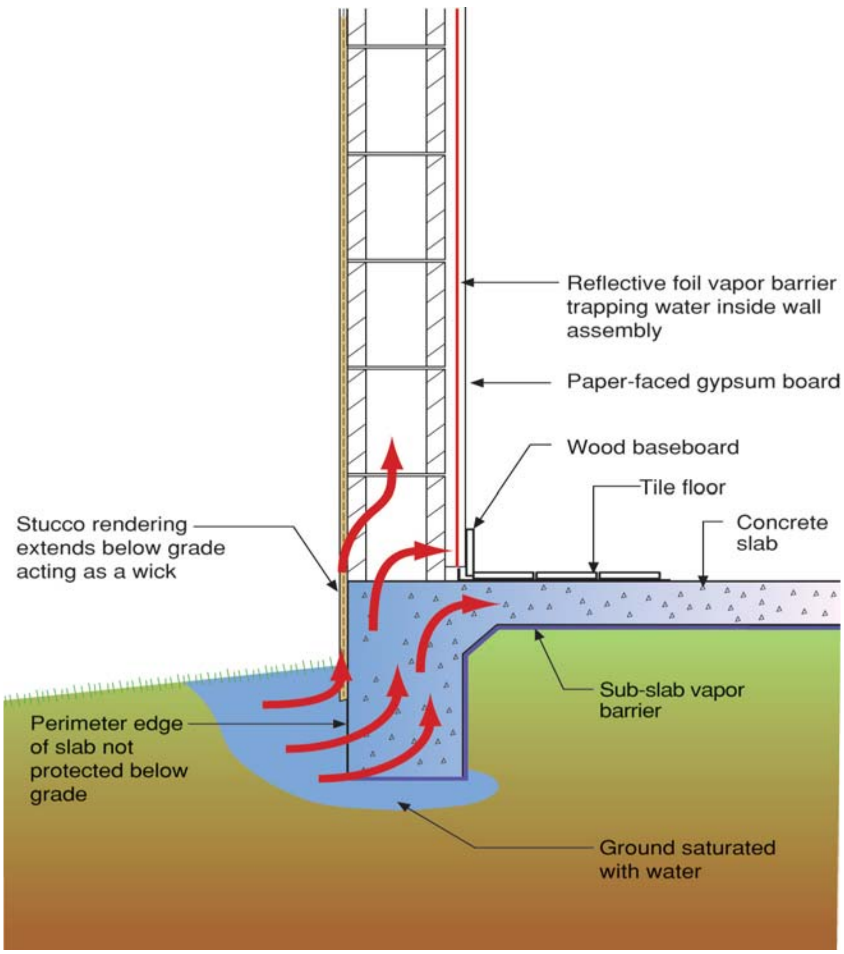


**Figure 1 Slab-on-grade floor detail (illustration courtesy of Dr. Joseph Lstiburek, Building Science Corp.)**

When this water drive toward the inside is present, it is common to find moldy areas at carpets near the baseboard or behind the baseboard

Another poorly understood phenomena is the heat transfer through the slab. If the temperature in the house is maintained above the ground temperature, then a tiled floor can significantly reduce the cooling need, especially in presence of a ceiling fan. Preliminary measurements both at the Florida Solar Energy Center (Parker et. al. 1998) and the Texas A&M University (Kootin-Sanwu et. al. 2000) indicate that ground slab heat transfer can be quite a bit larger than commonly computed in current generation building energy simulation software. This has the possibility of not only justifying more slab edge insulation in mixed climates to reduce space heating, but also may show that greater expanses of tile flooring in hot climates considerably reduces peak air conditioning needs due to beneficial earth-contact cooling. Since this phenomenon is poorly calculated in current building energy software, actual impacts are likely misrepresented.

Research Needs

4. *Slab-on-grade floors (moisture):* Document the extent of mold /moisture problems in slab-on-grade homes by instrumenting several such homes with different construction details in different soil types with different water management levels (eg gutters, sprinklers, drainage, etc.) Develop empirical and analytical models and field tested design guidelines.

5. *Slab-on-grade floors (Heat Transfer):* Conduct a series of experiments with different configurations of slab edge insulation with and without carpet and a comparison to a similar building with an insulated crawlspace. Develop appropriate earth contact heat transfer models. Also investigate measures to be undertaken to mitigate termite and insect infestation in the slab insulation, which is often cited as a secondary reason not to insulate slab-on-grade construction in hot and humid climates. Note that waterproof and pest proof insulation is likely to help in the moisture management area also.

**Conclusions**

Mold related claims are skyrocketing in Florida and other states. Durable and energy efficient buildings are key to sustainability and growing prosperity. The research identified in this paper is by no means comprehensive but it would help to advance better housing for the large numbers of residents of the growing Southeastern U.S.

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