Forum on Moisture Problems in HUD Code homes in hot, humid climates

Case Study

Near the Beaches of N.Carolina

FLORIDA SOLAR ENERGY CENTER
A RESEARCH INSTITUTE OF THE UNIVERSITY OF CENTRAL FLORIDA

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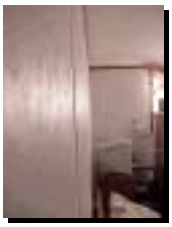
On Wednesday, October 27, I visited the residence with the manufacturer's representative and the local field representative. The purpose of the visit was to try to determine the possible cause(s) of the reported moisture problem noted on the interior surfaces of the exterior walls – especially the bathroom and west bedroom areas.

- **HOUSE DESCRIPTION....**

The house is a doublewide, 3-bedroom 2-bath dwelling. The crawlspace skirting is fairly continuous, and a ground cover doesn't exist underneath the home. The major axis of the roof lays in an east-west direction that places the smallest exposed wall area to the greatest sunloading. Heating and cooling is accomplished with a centralized forced air system. A single air handler unit is located in a "closet" off the utility room. This "closet" acts as a return plenum for the air distribution system. Also in the "closet" is the domestic hot water heater. The duct system is located under the floor space. The air conditioning compressor is located on the north side of the building near the utility room. A manually controlled exhaust fan in the hallway provides ventilation.

- **OBSERVATIONS....**



The interior surface of the exterior wall was soft to the touch in the bedroom and bath area – especially near electrical outlets. Additionally, bowing of the wall could be seen.

- **TESTING....**

The house is a system of components, parts and pieces that are put together to form a system designed to provide shelter and comfort for the occupants. When this system does not function properly, testing is required to determine the source or causes of the problem.

A blower door test was done to determine the airtightness of the building envelope. A series of building pressures and associated airflows was recorded. This provides the necessary inputs to determine the CFM50 of the house.

Blower Door Test Results

CFM50 = 1336

[C=97.2, n=0.67, r=0.99]

A duct system airtightness test was also completed. A duct tester was attached to the air handler unit. The supply registers were temporarily sealed off and the system was then depressurized to 25 pascals. The total and outside leakage flow components were measured. An airtight duct system would have zero leakage or both the $CFM25_{total}$ and $CFM25_{out}$ would be 0.

Duct Test Results
$CFM25_{total}$ = 162
$CFM25_{out}$ = 98

The penetrations of the air handler unit (electrical and refrigerant lines) through the floor were not properly sealed. As the air handler fan operates, a strong negative pressure is created in this area. The negative pressure pulls air from the space below and into the system.

In addition to the duct test with a duct tester assembly, a pressure pan test was also completed. This test will indicate relative leakiness of the duct system at each register and grill. The blower door assembly depressurizes the house to 50 pascals and each register / grill is completely covered with the pressure pan. In general, the lower the number (approaching 0.0), the tighter the duct at that location and the leakier the duct, the larger the number (approaching 50.0).

Pressure Pan Test Results			
Dining	0.7	Kitchen	0.1
Entry	0.4	Hall Bath	1.6
SW Bed	0.7	NW Bed	1.0
LR1	1.1	Mbed	0.4
Mbath	0.7	RA	1.7

Pressure differential measurements were completed to determine a magnitude and direction of flow across the envelope when the air handler fan operates. Interior door closure effect was also measured when the air handler fan operated.

Condition	Pressure differential (house with reference to outside)
All fans off	-0.0 pa
Air handler on	-0.4 pa
Air handler on and master bedroom door closed	-0.9 pa
Air handler on and all interior doors closed	-2.0 pa

The pressure difference was also measured across each closed door when the air handler fan was operating.

Measurement of pressure across closed doors	Pressure differential (room wrt living room)
Master Suite	5.0 pa
Northwest bedroom	2.1 pa
Southwest bedroom	2.3 pa
Hall bathroom	0.5 pa

- **CONCLUSIONS....**

The building experiences extended periods of depressurization. This is created by a number of factors.

- The supply side duct leakage is the dominant leak, which causes a slight long-term negative pressure within the building envelope (at least when the air handler fan is operational). This is because the supply leaks dump the air into the belly pan area that is open to the crawlspace and air is pulled into the building through all of the various cracks, crevices, and openings to make up the lost air.
- When the air handler fan is off, and the dryer or other exhaust fan is operating, air is brought into the conditioned space via leaks in the ductwork. The pathway is from the crawlspace through the various holes and penetrations in the rodent barrier, through the duct leaks and then into the house. This increases the moisture content within the house, creating a higher relative humidity.
- The occupants compensate for the lack of comfort (high humidity) by lowering the thermostat. This lowers the interior temperature of wall surfaces, which is now closer to the dewpoint temperature of the air that is being drawn into the house through various leak sites. When this warm, moist outside air touches the cooler surfaces, condensation occurs at the interface of the vinyl wall coverings and the sheetrock. The sheetrock absorbs the water and swells – thus bowing the wall panels.

- **RECOMMENDATIONS....**

A number of factors must be considered in the proper retrofit of this home to ensure that failure does not happen again. The following should be done:

Air conditioning and heating system:

- All supply duct system leaks should be air sealed with a mastic (such as RCD#6 or equivalent). The seal must be applied to the air barrier ductwork. The areas to be sealed include all of the supply duct risers connections to the main trunk line and the connection of the air handler unit to the main trunk line (this was not checked at the time of my inspection – but should be carefully considered in the retrofit).
- The air balance of the duct system should be checked. This should be done with all of the interior doors closed. The balance will probably include adjustment of supply air to the master bedroom and the addition of a return air grill through the wall directly to the return air plenum of the air handler unit. The pressure differentials across the various closed bedroom doors should be checked and be less than 3 pascals. The pressure differential from the living area to the outside should be 0 when the interior doors are open and no more than 3 pascals when all interior doors are closed (ideally this should also be 0 for best performance.)

Wall assembly:

- All damage wall panels should be removed and replaced. The replacement panels should be finished with a vapor permeable material to allow moisture movement to the inside. The ideal location for a vapor retarder is on the warm side of the wall. In the hot, humid climate, the warm side is the exterior (ASHRAE Fundamentals 1989, Chapter 21). The exterior plywood sheathing will act as a vapor retarder in this case. Every material located to the inside of the plywood should be at least ten times more permeable to allow for drying to the inside. The placement of a vapor barrier behind the gypsum wallboard should be avoided. This may cause condensation to occur within the wall assembly and causing the structure of the building to be damaged.

Crawlspace

- A vapor barrier ground cover would reduce the amount of moisture coming into the crawlspace from the ground. This will tend eliminate some of the moisture in this area, especially with a tighter skirting surrounding the home.