INTEGRATING PATH TECHNOLOGIES INTO MILITARY FAMILY HOUSING

Status Report on Housing at Beaufort/Parris Island, SC

Prepared for

Partnership for Advancing Technology in Housing

By

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Introduction and Objectives

The overall objective of this effort by the Partnership for Advancing Technology in Housing (PATH) is to develop a strategy to assist contractors and the armed services in integrating innovative technologies into military family housing. Technical support will be provided throughout the project to educate the military and contractors about PATH technologies and to assist them in the evaluation and integration of new technologies. Outcomes of the project will include a strategic plan and topical reports on issues, requirements, and considerations surrounding the use of various technologies. This report focuses on progress from technical assistance activities being provided to a contractor who is building and operating homes for military families at multiple installations in and around Beaufort, South Carolina.

Site Location and Description

The homes in this project are managed by Tri-Command Military Housing, an organization formed jointly by Actus Lend Lease and the Department of the Navy. Under this arrangement, Actus Lend Lease is responsible for construction of new homes, and for rehabilitation and operation of existing homes.

There are multiple locations around the Beaufort area that Tri-Command has under its responsibility. These include Marine housing at Parris Island as well as Navy housing at Laurel Bay. Activities across the different sites will eventually include construction of 448 new homes.

All of the homes are located in the "low-country" along the coast of South Carolina. Perhaps the two most unique design considerations that need to be addressed in this part of the country are the extremely humid conditions throughout most of the year and the potential for flooding along the coast and the many rivers, streams, and other bodies of water that dominate the landscape.

The new homes are a mix of three and four bedroom models for a variety of service ranks. Some of the homes are on slab-on-grade foundations. However, many of the homes are on raised floor foundations that are similar to a crawlspace except the floors are as much as six feet off of the ground. Rather than a continuous footing, the raised floor foundations are on concrete piers with a lattice wood covering around the perimeter as shown in Figure 1.

Figure 1 – Typical raised floor foundation

PATH Involvement and Approach

PATH's involvement with Tri-Command Military Housing arose out of meetings between Newport Partners LLC and Actus Lend Lease staff during the summer of 2005. While discussing opportunities for PATH at other installations, the Actus staff indicated that they were interested in methods to address moisture problems in homes in the Beaufort area. Newport staff subsequently visited some of the homes to determine if PATH technologies could be helpful. Part of the solution that Actus Lend Lease selected to mitigate moisture problems eventually included the use of spray applied insulation to protect building components and reduce air movement that had been one of the major contributors to moisture problems.

Initial Site Visit – August 2005

A Newport representative participated in a site visit in August 2005 to help identify the moisture issues and potential solutions. Others who participated included the project architect and management and site personnel from Actus Lend Lease. The focus of the visit was on problems that were occurring with buckling floors of homes as shown in Figure 2.


Figure 2 – Buckled floor at Parris Island home.

After attempts to mitigate the problem by removing and replacing the sub and finish floor materials in two homes, the Actus staff asked Newport to investigate why the problem returned and to help identify options that could also be used as a best practice for future home construction. Prior to visiting the site, our review of the literature and discussion over the phone with Actus personnel led us to believe that the materials were not the problem, but rather a combination of factors were at work that resulted in condensation on the bottom of the OSB that wicked up into the materials and was then drawn into the building. Site measurements and visual observations confirmed that condensation was contributing to the problems not just in the floors but also to high humidity levels in some of the units that created mold issues in several interior bathrooms.

Weather data was reviewed for the region and showed that the local conditions often produced dew points in the mid to upper 70s (^{o}F) throughout the late spring through mid fall. At the same time, thermostats in the homes were routinely set in the low 70s during the cooling season, creating an opportunity for condensation on building surfaces.

During the site visit, a group of homes were assessed by the team to determine what factors or conditions may have been contributing to the floor problems. The assessments consisted of moisture measurements, temperature measurements, relative humidity (RH), and visual observations made by selecting several locations under the floors and removing the batt insulation to expose the underside of the OSB and the sides of the floor joists. Locations included areas under vinyl floors and under carpeted rooms. We also used an RH meter, chemical smoke sticks, and pressure gauges to assess air flow and pressures in and around the bathrooms with and without visible mold on the ceilings.

After the site visit, we reviewed the related literature and the field observations and concluded the following as the most-likely explanations of what was occurring at the homes:

- Condensation is occurring on the bottom of the first floor system above the batt insulation in the homes with floor buckling. This has resulted in visible mold and increased moisture near the top of the floor joists and in and on the OSB. Although it is possible that some of the high moisture in the materials is the result of exposure during construction, no evidence was found to support or dispute this possibility.
- OSB moisture contents in areas under vinyl floors were above 40% in two of the homes. The carpet may be partially mitigating the impact, since moisture content of the OSB was in the low to mid 20s (%) under carpeted areas. This may be due to the R-value added by the carpet and pad, or the higher permeability of the carpet relative to the vinyl floors is letting moisture pass through into the interior where it is removed by the air conditioning (AC) system.
- Observations and measurements did not positively identify a source of the elevated relative humidity in the bathrooms with visible mold problems. Moisture that migrates into the homes due to the condensation on the raised floor systems is a likely source. However, independent of the source, the air movement into or out of the baths that have visible mold problems is inadequate to remove moisture or any other potential pollutants.

Potential Solutions Using PATH Technologies

Although our general objective was to increase durability in these homes, one of the most promising options also included using a specific technology from the PATH Technology inventory – sprayed foam insulation – to help mitigate the floor moisture problems. The other options included various best practices for dealing with condensation and moisture issues in hot-humid climates. For each problem area – bathrooms and floors - the issues and potential solutions are described as follows:

Bathrooms

This type of problem was initially uncovered in a single home when an occupant returned after several weeks away and reported mold on the ceiling and upper level of walls in the second story bath off of the main hallway (see Figure 3). This problem was thought to exist only in one home that also had the floor buckling problem. Further exploration indicated that it is occurring in other homes and is likely related to a number of factors working together including the moisture condensing on the underside of the first floor sheathing.

Figure 3 – Visible mold on ceiling and top of walls in bath.

The baths in question are located on the interiors of the second floor and do not contain any windows. One could spend considerable time trying to diagnose the issues surrounding air and vapor movement and whether the floor problems are contributing excess moisture load to the bathrooms, but the bottom line seems to be that there is not enough of an air exchange for the baths to keep the moisture levels down regardless of the source(s). Options to address this include:

- Increase the flow into these rooms and consider running the HVAC air handler continuously, although this would induce a minor energy penalty.
- Upsize the fans to exhaust more air from the bath to the outdoors.
- Change from separate switches for the fan and light to one switch that turns the fan on when the light is turned on. However, this may not solve the problem if the occupants do not use the room frequently.
- Install a quiet (low sone), higher capacity, continuous operating fan or a humidity-sensor controlled fan and take the occupants out of the equation altogether.

The first three items are a little bit of the trial and error method. There is more confidence in the last option, but like the continuous operation of the central HVAC blower, it would create a minor energy penalty.

We recommended that the designer or architect of record consider these options in all of the new homes under construction and for retrofit of problem homes.

<u>Floor buckling</u>

The field observations, literature, and our consultation with moisture experts point to the floor system being cooled for extended periods of time to below the dew point temperature and causing the warm, humid outdoor air to condense on the underside of the floor. It is likely that the carpeted areas are helping to mitigate the problem somewhat because they are permitting moisture vapor to pass through into the home, where the AC system removes it. Another possibility is that the R-value of the carpet and pad, although generally small, is just high enough to isolate the OSB sub-flooring from the colder indoor air, at least for extended periods of time.

Options for the floor moisture problems include:

- Raise the thermostats to at least 76^{o}F in all of the buildings to prevent the floors from being cooled to below the dew point. This should be implemented immediately and throughout the life of the buildings. Supplemental dehumidification may make this a more practical option since it would result in more comfortable conditions at the higher indoor temperatures.
- For homes yet to be built or under construction, consider using spray foam insulation under the floors to push the dew point away from the OSB. With the current batt insulation, air can easily move into the floor cavity between the joists. There are also some pros and cons to using a closed or open cell foam. Each can provide a thermal barrier between the OSB and the colder inside air. Likewise, each will reduce or eliminate air movement compared to batt insulation. Closed cell materials offer a better vapor barrier but you want to make sure the materials are dry so you don't trap moisture in the floor assembly. An open cell material will provide equivalent separation of the cooled floor from outside air, but it is not as robust of a vapor barrier.
- As an alternative to spray-in foam insulation, install a well-sealed vapor barrier on the bottom of the floor joists. Although this is frequently recommended, there are questions about its effectiveness and how practical it is to seal all of the penetrations and laps against air leakage. Even small openings may let in enough air to cause isolated problems. According to site personnel, previous attempts at this approach produced mixed results – some floors systems remained dry while in others the vapor barrier had to be removed because of pooled water that caused it to sag.
- Another alternative for new homes is to build on a conditioned crawlspace. Basically, this is a crawlspace that has no vents and is carefully constructed to otherwise keep rain and other moisture from entering the foundation area.
- For the homes already built, the only solution for areas that are severely damaged due to high moisture levels in the materials is to remove the damaged areas and rebuild them with appropriate methods to prevent the problem from re-occurring. Most guidance suggests removing the material at least two feet beyond the damaged areas. We consulted with the American Forest and Paper Association's representative for the southeast United States region on whether there will be permanent damage to the OSB. Generally, if OSB or dimensioned lumber has not lost any material due to the presence of

mold or rot on its surface, it will regain its strength once it dries but any swelling or warping will likely remain.

- For areas that have marginal moisture levels and no signs of degradation, consider methods to dry the materials. Drying options could include:
  - Removing the vinyl and the insulation during the December to March time frame and allowing the moisture to escape. Weather data from NOAA indicates that drying is feasible during these months.
  - Build an enclosed space below the existing floor and condition and dehumidify it.

In any of these scenarios, we recommended taking measurements periodically to make sure the moisture levels are decreasing. We also recommended that the floors be assessed by the engineer to make sure they are acceptable from a structural perspective. Grading, condensate lines and any other sources of moisture that may accumulate around the foundation should also be checked and corrected if necessary. Finally, EPA and others provide recommendations and resources for handling and removal of mold. These resources and/or a professional Industrial Hygienist should be consulted for how to remove mold or contaminated materials on the floors and bathroom ceilings.

Status as of March 2006

Throughout the month of March 2006, Actus began work to mitigate the moisture problems in the homes. The mitigation strategy relies heavily on the recommendations from our assessments, including the key step to isolate the floor from the exterior through the use of spray-in foam insulation. Actus elected to go with Icynene, an open cell product, because they believe it will be more forgiving should some moisture get into the joist cavities.

The basic approach selected by the Tri-Command team is as follows:

- Portions of carpets, vinyl, and subflooring were removed and replaced on 35 homes that had elevated moisture and damage to the OSB.
- On about 80 homes, including the 35 that had parts of the floors replaced, the batt insulation in the floors was removed and the OSB was permitted to dry to below 19% moisture content.
- A mold remediation company was used to treat the underside of the floor deck and the joists as necessary.
- After the drying was complete, Icynene was sprayed into the cavity of the floor joists (See Figure 4).
- All of the lots are being re-graded to make certain that water does not pool under or around the foundations.

Figure 4 – Icynene insulation between joists of raised floor system.

Additional assistance will be provided to Actus as necessary over the next several months to finish the mitigation of the homes for both the floor and bathroom problems. We also will assist them in helping to use this approach to prevent moisture problems at their other projects in hot, humid climates.

Benefits

The benefits of prevention or remediation of moisture problems are difficult to state in terms of initial costs. Rather, the benefits may be more appropriately expressed in terms of avoided costs at a later date. The initial estimates are that the mitigation efforts could cost up to $5000 per building. The homes that did not have the floors replaced will be much less. If they had not acted, the damage would only have continued to increase to the point where entire buildings could have been lost. The practices Actus has adopted will minimize future losses in existing buildings and in future new construction projects.

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