A

DATA COLLECTION PROCESS

A.1 SELECTION AND CHARACTERIZATION OF SAMPLE HOMES

Homes with moisture problems were identified for this investigation from an 8-state coastal region reaching from Texas to North Carolina. Homes in these states referred to as the "humid climate area,"[1] experienced a high rate of moisture problems. These humid areas are identified as having either a wet bulb temperature of 67°F or higher for at least 3500 hours (80% of the time), or a wet bulb temperature of 73°F or higher for at least 1750 hours (40% of the time) during the warmest 6 months of the year. In such environmental conditions, building materials at these or lower temperatures condense moisture upon exposure to humid ambient air.

Homes were identified with the assistance of home manufacturers, retailers and State Administrative Agencies. Once identified, building diagnosticians made visits to these homes and collected information using a protocol developed for the purposes of this study (see Appendix B). Additional homes visited by representatives of Florida Solar Energy Center (FSEC) were included in the study although this data was collected prior to the establishment of the data collection protocol. Since data on these homes was not complete, they were not included in the neural network analysis.

The homes included in this report intentionally represent a more difficult class of moisture problems than average. Many of the sample homes were reported as having been previously repaired (often several times for the same problem) prior to being identified for the study. The sample does not include moisture problems caused by plumbing leaks, obvious rainwater and other bulk water intrusion for which the causal factors are straightforward. Simple moisture problems do not often rise to the attention of the manufacturer; these types of problems are generally investigated and easily resolved by the retailer and are not specific to hot, humid climates.

Other than a self-selection for more difficult moisture problems, homes identified for field investigation were not otherwise screened; thus the sample is asserted to represent a "snapshot" of the moisture problems found in manufactured housing within the study region. This approach to sample selection broadened the study, which was originally focused on moisture problems located within wall cavities. Including the entire range of difficult moisture problems resulted in a more comprehensive characterization of such problems experienced by the industry; however, the diversity of the problem types posed some difficulty for the analysis. The ideal analytical methodology would group homes with similar problem types and compare characteristics of the homes in order to isolate common contributing factors. Studying similar problems as a group should result in a higher correlation of probable causes with the problems. However, no two problems were identical, and grouping homes into numerous sets with similar types of problems would result in sample sizes too small for analysis. Thus, moisture problems groupings were broadly defined to encompass as large a sample as possible. Moisture problems in floors were grouped separately from those found in walls and ceilings because the construction, types of problems, and moisture driving forces differ significantly.

A critical measurement in the field investigation was a clear and quantifiable description of the moisture problems so that it could be considered in the numerical analysis. Some moisture problems

[1] ASHRAE has (ASHRAE Fundamentals F-21.13, 1989)

proved more difficult to describe than others. Bowing of the wallboard material, for example, was dynamic and reportedly peaked in the summer months and subsided during fall and winter months. In such cases the moisture problem was described to best quantify the worst condition and extent of the affected area by the homeowner and manufacturers, supported by photographs whenever possible. Most of the problems were documented between July and September, when the problems were reportedly worst.

A.2 FIELD DATA COLLECTION RESULTS

Data was gathered to identify both the type and extent of the various moisture problems encountered. Moisture problems were first categorized based on the building component(s) where they occurred; either walls, floors or ceilings. Many homes had multiple problems and problem sites; in 22% of the sample homes more than one building component had visible problems and half of the homes reported three or more types of moisture problems.

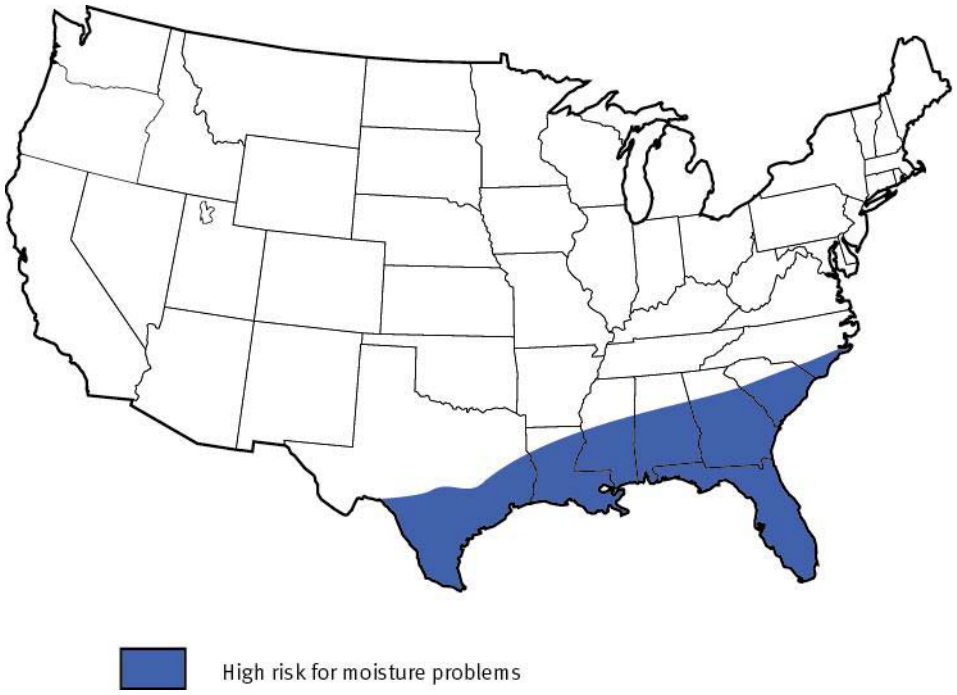

Figure A-1. The hot, humid climate region

The majority of homes investigated were in either Louisiana or Florida. The geographical distribution of study homes is not assigned any particular significance. Indeed, there is scarce data about the demographics of these problems and it is not assumed that any particular portion of the 8-state coastal region is more or less prone to moisture problems (Figure A-1).

Homes investigated include both single- and multi- sectional homes. The average study home age was 4.3 years old, and ranges from 8 months to 11 years. The fieldwork effort resulted in the characterization of 82 distinct moisture problem cases ranging from homes with no problems to homes with significant problems often in more than one area of the home from a total of 67 homes. Eleven homes with no identified problems were included in the investigation to serve as control group for the study.

Moisture problems were scored to provide an index for problem intensity. Moisture problems with a single element such as “odor” received a lower score than a home with “odors and structural softening”.

During the summer of 2001, when the majority of the data was gathered, moisture problems did not arrive until later in the season, and were reported to be less frequent than in previous years. This

could be due to manufacturers who have made changes to address moisture problems, or weather conditions that were less prone to cause moisture problems. Regardless of the cause, fewer reported problems made it difficult to find sufficient active moisture problems for the study. When homes were identified for study, the field contractors conferred with the manufacturers' contact to make arrangements for the data collection. The typical study home had undergone previous visits from retailers and manufacturers' representatives in attempts to repair the problem. The data collected included both homeowner perceptions and building science diagnostic measurements of the house. A summary of the protocol is included in Appendix B.

A.3 LIMITS OF THE DATA COLLECTION EFFORT

The type of data that was required for this study is by nature difficult to consistently gather over a large sample of homes. Certain data were not possible to collect on all homes. Many areas of the home where measurements were required lacked physical access, such as underneath homes where the ground-vapor retarder and bottom board are located. Since these were occupied homes, actions that could result in damage to the home such as measuring pressures inside wall cavities were often difficult to complete. The degree of ventilation in wall cavities were impossible to determine since it would involve removing finish materials. Finally, modifications to the home such as a site-built addition or an ongoing renovation project precluded some measurements.

A few examples illustrate the difficulty of ensuring accurate data. One of the factors analyzed that showed a strong association with moisture problems was the increase in house pressure caused by closing a bedroom door. It was not possible to determine with any certainty the duration of time that a door was typically open or closed, though it was possible to measure pressure differentials within the home, and between the home and outside. Pressure measurements were also taken with doors opened and closed throughout the home. The interior temperature used for analysis was the lowest of several reported temperatures. Interior temperature habits were reported by the homeowner, recorded from the thermostat setting and measured. The lowest of these temperatures was used in the analysis. It is not clear how this reported temperature related to actual average summertime temperature or if temperature was the same from one room to another. These and similar uncertainties in the data decrease the capacity of the model to explain the data and lower the correlation coefficient.

Certain of the objective data were directly measured, including duct and shell leakage, while others, such as ground-vapor retarder and bottom board holes were estimated. As explained below, the moisture damage was scored on a relative scale and assigned a point value. The analysis will only be as good as this subjective assessment.

With these shortcomings in mind, the data was still judged to be of sufficient quality to conduct the neural network analysis. Eliminating the most suspect data still resulted in a correlation coefficient that was deemed acceptable.

A.4 TEST PERFORMED DURING THE DATA COLLECTION PROCESS

In addition to the considerable number of descriptive data logged for each home, the following tests were completed in order to measure air flow, infiltration and pressure differentials. For a complete list of data logged, see Appendix C.

- Duct leakage with a duct blaster test - volumetric flow at -25Pa
- Shell leakage rate with a blower door test - house volumetric air flow at -50Pa

While the home was de-pressurized during the blower door test, pressure measurements were taken throughout the house to determine the integrity of building cavities against air flow. Pressure drops were measured between the following building cavities in selected locations in selected homes:

- House to floor cavity

- House to attic
- House to damaged wall cavity
- House to good wall cavity
- House to marriage wall cavity
- House to problem wall – master bedroom closed – Air handler unit (AHU) only on

Pressure mapping was also performed without the de-pressurization of the blower door. The pressures were measured in order to show the differential pressures during normal operating conditions. These measurements helped determine how well the air distribution system was designed.

- House to out, AHU off
- House to out, AHU on, interior doors open
- House to out, AHU on, master bedroom door closed
- House to out, AHU on, all interior doors closed
- House to out, AHU on, all bedrooms or all interior doors closed and exhaust vents on
- Master bedroom to living room, AHU on, master bedroom door closed
- Bedroom 2 to living room, AHU on, bedroom 2 door closed
- Bedroom 3 to living room, AHU on, bedroom 3 door closed