BUILDING RESEARCH AND INFORMATION VOLUME 20 NUMBER 3 1992

#6450

Moisture damage in South Carolina housing

EXCESS MOISTURE OF INCREASING FREQUENCY IN BUILDINGS IS CAUSING CONCERN IN THE UNITED STATES COSTING OVER $2BN IN 1978–1980 RISING TO AN ESTIMATED $15.6BN BY THE YEAR 2000

Linda L Gardner[1] and Craig A DeWitt[2]

[1]109 Barre Hall, Clemson University, Clemson, SC 29634-0312, USA
[2]223 McAdams Hall, Clemson University, Clemson, SC 29634-0357, USA

In the results of a 6000 homeowner/occupant survey in 16 South Carolina counties in January 1989, 69% of respondents reported moisture problems in their home. The results obtained by Professor Gardner's team are particularly significant in relation to the correct use of insulation and ventilation, similar results have been found in the UK.

Selon un sondage de janvier 1989 auprès de 6000 occupants-propriétaires dans 16 comtés de South Carolina, 69% de ceux qui ont réagi ont indiqué qu'il existait un problème d'humidité dans leur foyer. Les résultats obtenus par l'équipe du Professeur Gardner ont une rélévance particulière en ce qui concerne l'utilisation correcte du calorifugeage et de l'aération. On a déjà constaté des résultats comparables dans le Royaume-Uni.

Keywords: housing, moisture, insulation, ventilation, CIB Montreal

Introduction

Mildew, decay, and structural damage to homes and furnishings from excess moisture have been reported with increased frequency by South Carolinians since the mid-1970s [1]. Estimates of annual damages to homes in the United States from moisture and moisture-related insects include over $2 billion in 1978–1980 and $15.6 billion by the year 2000 [2, 3]. In addition, the future value of a house may be reduced by moisture problems [4]. The economic loss does not stop with homeowners, but may also occur to any industry segment whose work may have knowingly or unknowlingly contributed to the problem. Additional losses occur to government jurisdictions in decreased real estate value and tax base. Home moisture damage creates unnecessary drain on forests [5] (see Fig. 1).

Excessive moisture in wood-frame homes is a significant danger to indoor air quality and the health of occupants [6, 7] and will always result in the major indoor air pollutant biocontamination [8].

Similar concerns face other nations including the United Kingdom, northern Europe, Japan, Canada, Sweden, Denmark, and semi-tropical countries like Israel. Amburgey [9] reported that wood decay is a major economic drain in countries worldwide.

Purpose and objectives

A house is the single largest financial commitment most US families make in a lifetime [10], and housing takes the largest share of the monthly budget for most consumers [11]. The added expense for cleaning, damage repair, decreased real estate tax base, increased demand for replacement wood from forests, and health problems pose unnecessary additional financial burdens and cost millions of dollars that could be utilized for more productive purposes.

Consumers and the housing industry can prevent home moisture damage costs if they are aware of the potential for problems and how to identify, prevent and correct them. Data on the frequency of occurrence of home moisture damage and causes was needed to alert SC consumers and housing industry professionals to the magnitude of the problem. Research was initiated to learn (a) the frequency of occurrence of home moisture damage in South Carolina (SC) (a warm, humid climate), and (b) the probable cause(s) of such damage. The presence of such damage symptoms was the dependent variable, with 30 housing characteristics as independent variables.

$ $ Importance $ $

- Moisture related damage in US homes costs $2-$15 billion per year
- Decay costs are higher than costs of termite and other insect damage
- Real estate values decrease and tax base drops
- Excess moisture is a real danger to indoor air quality and the health of occupants

Fig. 1.

Related research

Research on home moisture damage in the US and other countries has focused on problems experienced by climatic region: (a) cold climate/cold winters, and (b) warm, humid climates. Many questions are still unanswered [12]. There is less recent data available on moisture problems in warm, humid climates, particularly studies that include energy conservation impacts. Even less data is available on warm climate, energy efficient housing occupied by people carrying on the daily activities of living. One such study in Florida, US, examined the occurrence of mildew in homes and related aspects of (a) construction moisture; (b) heating and air conditioning practices including latent (dehumidification) load; (c) energy management practices (d) building design; and (e) age of house [4].

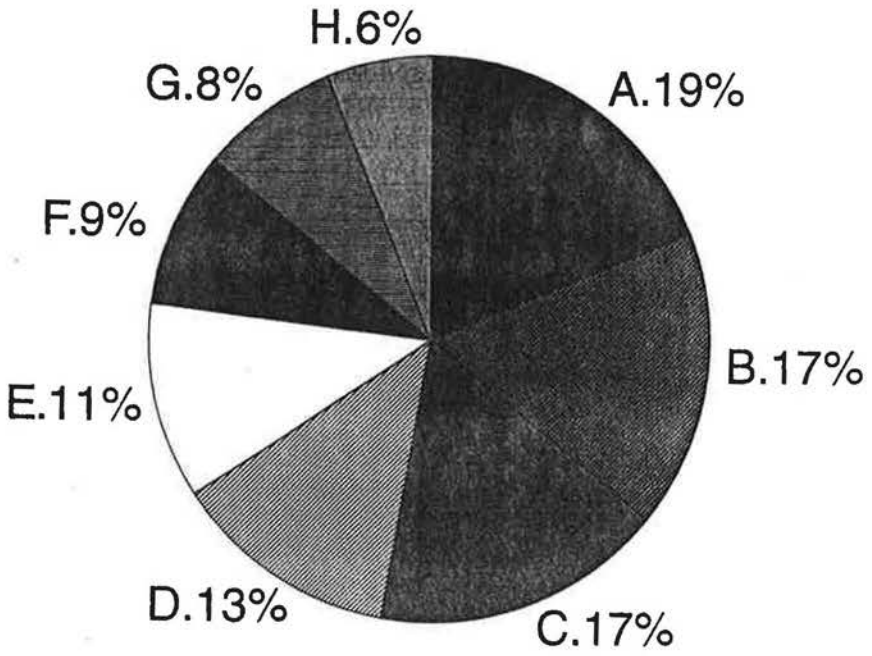
In a 1987 SC study of home moisture problems using data from a small, non-random sample of all consumer housing complaints filed with two state regulatory agencies during a 12 month period, 52 per cent of cases also involved moisture damage [13]. The major moisture-related problems reported were attributed to these probable causes (in order from most to least frequent): (a) violation of residential building codes; (b) poor workmanship by the builder; (c) lack of maintenance of the home and/or use by the owner; (d) poor or inadequate design details and specifications and inadequate codes; (e) non-attributable problems; and (f) inadequate standards of materials and components.

Methods

Data were collected via a questionnaire mailed in January 1989 to 6000 homeowner/occupants in 16 SC counties. The counties represented the varying geographic, topographic, climatic, and soil types occurring in SC. The number of owner/occupants selected to receive the survey form was stratified by county. The form was mailed to addresses drawn randomly from the residential owner/occupied real estate tax rolls (public records). A concentrated newspaper and television effort was used to build public awareness of the problems, the project, and the request for survey recipients to complete and return the forms. Frequency distributions were derived for each question. Categorical data analysis was used to compare the reported frequencies. This indicated whether some frequencies were significantly different from any or all of the other frequencies. Comparisons of frequencies in pairs were used to determine which frequencies were significantly lower or higher than others.

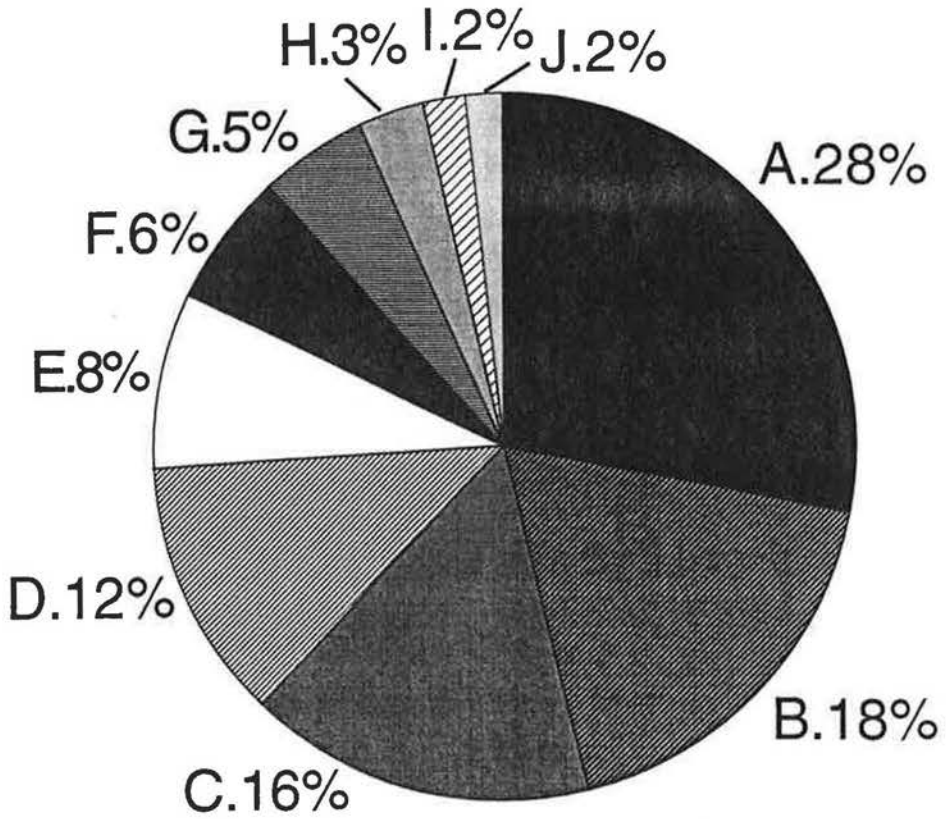
Results

Of the 1329 usable forms returned, 917 (69%) indicated that the house had a moisture problem. Variables related to occurrence of problems were: geographic region/location of home, age of house, foundation type, site level, exterior drainage, water seepage in or under the house, level of ground in the crawl space, presence of crawl space drains, and houses with some alterations made to the house sometime after initial construction.



A. Mildew on exterior siding or walls
B. Musty odour
C. Seepage of water in or under house
D. Presence or evidence of condensation
E. Mildew on furniture, carpet, clothes
F. Decayed wood or sagging floors
G. Water stains on walls
H. Fungus growth on wood members

Fig. 2. Symptoms reported.



A. Inadequate ground/surface water drainage away from house
B. Standing water or dampness in crawl space
C. No or incorrectly installed crawl space ground cover vapour barrier
D. Too little ventilation in crawl space
E. Plumbing leaks
F. Appliances vented to crawl space
G. Inadequate crawl space height
H. Untreated lumber in contact with soil
I. Air conditioning ducts contacting subfloor or blocking ventilation
J. Debris in crawl space

Fig. 3. Causes of substructure problems.

Alterations included: bathroom remodeled, insulation added, planting beds added against house, exterior siding added or changed, central air conditioning added, room(s) added, and paved areas added.

Other housing descriptors for which no significant differences in the frequency of moisture damage were found are:

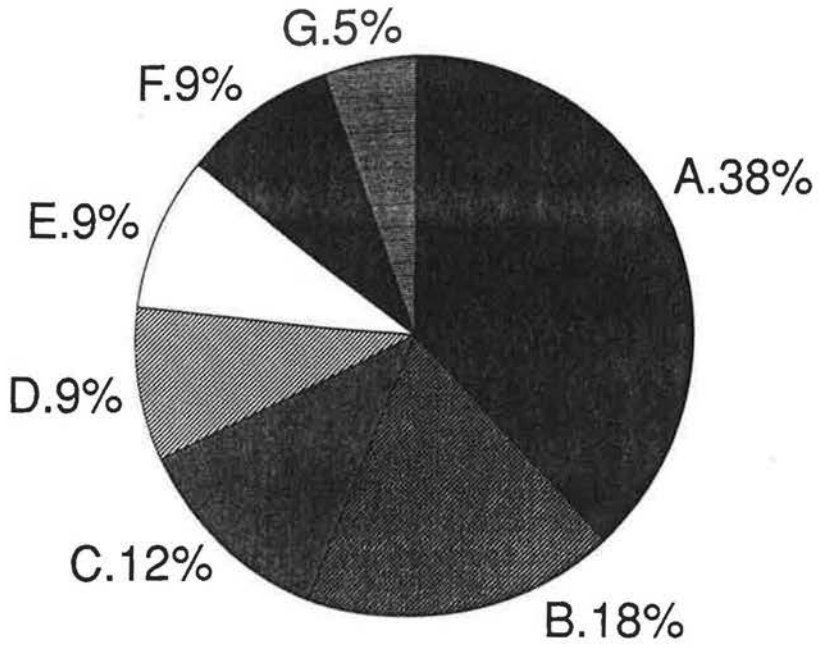
(a) location of house by extension district;
(b) attachments such as garages, carports, patios/decks, porches, or driveways touching the house;
(c) number of stories in a house;
(d) type of builder;
(e) size of house in square feet;
(f) type of exterior siding;
(g) presence or absence of footing foundation drains;
(h) type of building; and
(i) three alterations to the house after initial construction (major landscaping changes, porch added, patio added).

Houses less than 5 years old had significantly fewer moisture problems than houses in other age groupings. Of houses over 30 years old, all age groups had about the same percentage of homes with problems (average 73%).

The majority of the foundation types reported were crawl spaces (45%). Houses built on slabs or piers had significantly fewer moisture problems. Houses with combination foundations had a significantly higher incidence of moisture problems.

Houses on sloping sites had significantly more moisture problems than houses built on level sites. Houses built where the surface water drains away from the house at least 10 feet in all directions had significantly fewer moisture problems than houses on less well-drained sites. Houses with water seepage in or under the house had significantly more moisture problems than those without seepage. Houses with a crawl space soil level below that of ground outside the foundation wall had significantly more moisture problems than did houses where the crawl space level was at or above the level of the outside ground. Houses with drains in the crawl space had significantly more moisture problems than houses without crawl space drains.

Changes found to be related to significantly more problems were ones which (a) had the potential to alter exterior soil levels, surface materials, or drainage patterns; (b) might alter patterns of heating, cooling, and



A. Inadequate/no guttering or downspouts
B. Improperly sealed or caulked doors and windows
C. Inadequate roof overhang
D. Inadequate/no flashing at doors, windows
E. Attic problems (inadequate ventilation/insulation)
F. Inadequate or damaged roof flashing
G. Improperly installed insulation in walls

Fig. 4. Causes of superstructure problems.

ventilation and thereby dewpoint in walls; or (c) used construction and finish materials with characteristics (e.g. vapour permeability) different from original materials, upsetting a prior balance of conditions. Changed conditions in a house, either physical or occupant activity, can affect the occurrence of home moisture problems [14, 15].

Symptoms most frequently reported include mildew on exterior siding or walls, musty odor, water seepage in or under the house, and the presence or evidence of condensation (see Fig. 2). Inadequate surface drainage and standing water or dampness in crawl space were most often cited as causes of substructure problems (see Fig. 3). Reported probable causes of superstructure problems include factors of design, construction, and maintenance (see Fig. 4).

How architects, builders, and HVAC contractors employ energy conserving features is vital. Energy cost reduction, increased insulation, and use of vapor retarders may be extremely dangerous if they impede the natural flow of moisture vapor out of the living area of the structure or change the location of the dew point in such a way as to cause condensation in walls or ceilings. Such insulation practices, if not based on adequate knowledge and theory, though well-meaning in their intent, may end up costing more energy than they save in terms of replacement of wood which they have made vulnerable to rot [16]

Conclusions and implications

Of respondents, 69% reported moisture problems in their home. Fifteen of 30 variables were significantly linked to the occurrence of home moisture problems. The numerous variables which can cause or contribute to moisture problems may in some cases make diagnosis a complex process, requiring several steps in a dynamic effort to identify the problem and cause(s).

The frequency with which home moisture damage occurs and reoccurs in this warm humid climate, and the resources required to correct the damage and causes clearly indicate that excessive home moisture causes significant economic loss to the homeowner. Wood kept dry will not decay and is less susceptible to moisture-realted insect pest damage.

Homeowners and industry professionals worldwide who know how to identify, prevent, and correct home moisture damage can minimize the costs for repairs and litigation. To do so, they must

(a) carefully select and prepare an adequate house site,
(b) design and construct a house properly in relation to building code requirements, geography, climate, soil, and other site characteristics,
(c) properly manage,
(d) routinely inspect, and
(e) maintain and repair a home to get maximum value for the dollars spent.

Acknowledgements—technical Contribution Number 3279 of the South Carolina Agricultural Experiment Station, Clemson University. Additional funding was provided by the Clemson University Cooperative Extensive Service and the Clemson University Housing Institute.

References

1. Gardner, L. (1986) Residential conservation: energy and environment, (Narrative Accomplishment Report [NARS]SC72), Clemson University, Clemson, SC.
2. Levi, M. (1978) The Standard Building Code and wood decay in homes, *Southern Building*, 22–25.
3. Levi, M. (1980) Cutting home building costs, *Extension Review*, **52**(1), 10–11.
4. Peart, V. (1989) Southern mildew problems: weather and psychrometrics; in *Proceedings of the Symposium on Improving Building Systems in Hot and Humid Climates*, B2–B11, Dallas, TX.
5. Wilcox, W. W. (1979) Decay of wood in structures, *California Agriculture*, 32–33.
6. Bill, P. (1989) Estate problems cast shadow over timberframes revival, *Building*, **7**.
7. Sterling, E., Arundel, A. and Sterling, T. (1985) Criteria for human exposure to humidity in occupied building, *ASHRAE Transactions*, **91**, Pt. 1
8. Berry, M. (1990) Risk assessment, in *Proceedings of Indoor Air Quality in Homes Symposium*, St. Louis, MO.
9. Amburgey, T. (1972) Preventing wood decay, *Pest Control*, reprint.
10. Pifer, G. (1988) *Housing and the Environment/Situation and Issues*, USDA, Cooperative Extension Service, Washington, DC 3.
11. Schwenk, N. (1988) Housing expenditures, *Family Economics Review*, 1.
12. TenWolde, A. and Mei, H. (1986) Moisture movement in walls in a warm, humid climate, *ASHRAE/DOE/BTECC Conference*. Washington, DC.
13. Gardner, L., Fleming, F. and Griffith, A. (1990) *Phase I: home moisture damage*, Bulletin 669, SC Agricultural Experiment Station, Clemson, SC.
14. Study shows indoor humidity highest in bedrooms (1987) *Energy Design Update* **6**(9), 5.
15. TenWolde, A. (1988) *Moisture damage in manufactured homes in Wisconsin*, Technology Series, Vol. 1. Building Thermal Envelope Coordinating Council, Washington, DC, 87–103.
16. Wilcox, W. W. (1986) Wood: decay during use, in *Encyclopedia of Materials Science and Engineering*. Pergamon Press, Oxford. 5412–5416.
17. Gardner, L. and DeWitt, C. (1991) *Phase II and III: Home Moisture damage, Bulletin 670*, SC Agricultural Experiment Station, Clemson SC.