Chapter 7. Water Intrusion and Condensation Problems in Conventional, Energy-Efficient Wood Frame Construction

7.1 Introduction

Now that you understand the desired properties of a wall system as we see it, let us examine how well today's building industry fulfills those goals. In the area of water intrusion, the report card is not so good. Valiant attempts have been made to correct the situation with unsatisfying results. In this chapter we provide a detailed review of the problem and end by offering specific solutions using the materials and approaches recommended by our profession.

Practicing building biologists and mold investigators around the country are finding that current wood-frame construction is rife with mold that often affects the health of occupants. Mold grows because walls constructed with plastic vapor retarders (less rigorously known as "vapor barriers") and house wrap with fiberglass as the insulation do not allow moisture trapped within them to fully and easily dry out.

Moisture generally enters modern wall cavities in two ways. The first is direct rainwater intrusion from the outside. The second is leakage of moisture-laden interior air through interior sheeting materials, including plastic barriers. Whichever way moisture enters a wall, once it does so it can cause mold and structural damage, if the wall cavity cannot dry out. The problem is compounded by the use of materials that decompose rather than simply drying out when they become wet. We shall also see that, despite efforts to keep liquid water and water vapor out of walls, plastic house wrap and vapor retarders themselves can fail as moisture barriers.

We take the time to explore this issue for one important reason. Wood frame thin-wall construction is pervasive in this country and so is the idea that a vapor retarder is absolutely necessary. Yet mold is pervasive as well. The problem is that builders still adhere to the notion that the only way to solve the problem is to tighten the house even more in a valiant attempt to keep moisture completely out. Even those pushing to become "greener" try to keep the walls tight. Unfortunately, doing so is simply not possible. The sad reality is that when conventionally built walls fail, they fail in a big way, leaving homeowners sick and financially strapped trying to fix them.

The Building Biology® profession, on the other hand, offers alternatives that stand outside mainstream thinking and are not known by most conventional builders and architects. We join a small but growing subset of builders who recommend wall systems that provide a realistic solution to water intrusion and mold issues while providing thermal performance, durability and increased health for occupants.

Let us first discuss how mold grows and then consider the extent of the problem.

7.2 Mycology

To fully understand water intrusion and condensation and the problems they create, it is helpful to know some basic facts about mold growth. Larry Gust, a Ventura, California building biologist, tells us why the first 24 hours is critical:

1. Fungal growth starts with a small number of dormant spores that are ever present within the indoor environment, having entered over a period of months or years. Some of these spores are viable while others are not.
2. Upon moistening with water, these preexisting spores begin to grow long, branching filaments called *hyphae*.
3. If the fungal life cycle is not interrupted, the hyphae proceed to grow stalks called *conidiophores*.
4. The conidiophores grow and release new *conidiospores*, or "spores," which are capable of renewing the life cycle.
5. Spores produced and ejected are blown away by the indoor air to other locations. (When the environment dries, more spores are ejected.)
6. The fungus is vulnerable at the early stages of germination, when the only things that would be growing beyond the original spore and germ tube (and maybe a couple of mitotic divisions) would be yeasts, which are not harmful to people or pets. These will not survive without continuing moisture.
7. Later on it becomes progressively more difficult to stop further growth because many spores will have grown protective walls. At this point we're on the steep part of the exponential growth curve. This is a dangerous situation for the homeowner.

It is generally accepted that mold needs three ingredients for optimal growth: (1) a bio-film as a food source, present on virtually every surface on earth; (2) moisture; and (3) low air flow. Many experts also include a fourth on this list, darkness, although there are some species that require light to sporulate.

Since the food source cannot realistically be eliminated, mold growth is controlled primarily by keeping materials dry and providing good air circulation. In order to accomplish this without excessive heat loss, thick envelope materials are a wise choice because they possess the capacity to allow drying and slow air circulation through hygroscopic adsorption/desorption, vapor permeability and diffusion, and capillary absorption/desorption, all mechanisms discussed in detail in the preceding chapter. To modern builders this is a novel concept not thought possible, but it is practiced by old-timers in the trade.

As noted above, mold spores can start to germinate within a few hours of the wetting of building materials, whether in a wall or elsewhere in the home. All materials are susceptible, except for sheet metal used in air ducts, upon which it is said mold generally will not grow. (Builders claim, however, that they have

building wall and foundation systems that do not trap moisture in the first place. Build walls that allow moisture to dry out within the critical first 24 to 48-hour period while maintaining superior thermal performance. The systems recommended in this manual do just that.

7.3 The extent of the problem

News reports such as a May 13, 2007 article in the Minneapolis Star Tribune[92] entitled, "Water Woes," document the large number of homes that are literally rotting from within because moisture that seeps into walls cannot escape. Most of the homes built throughout the nation in the 1990s used non-breathable materials. Additionally, improper techniques were used in many homes in installing windows, decks and roofs. Structural damage and mold has often been the result, and repairing damaged walls can be quite costly. The article indicated that moisture that had accumulated over years under non-breathable stucco caused substantial structural damage and mold costing homeowners hundreds of thousands of dollars to correct.

Louise Goldberg, an engineer at the University of Minnesota, was quoted in the article as saying, "The fact is, the waterproofing systems in these homes have failed…. If the windows leak or the waterproofing is installed incorrectly, you have a failure condition." She and other experts interviewed for the article stated that the materials chosen did not dry out when water entered due to improper installation. Goldberg also stated that, "Older stucco homes don't have these problems because different construction materials and methods allow them to breathe."

Oak Ridge National Laboratories says:

> If moisture accumulates above a critical material-dependent threshold, the building components begin to rot, corrode, or otherwise degrade in structural or functional integrity. Damage induced by moisture includes rotting of wood studs and other components, corrosion of steel frame members, salt transport, mold growth, and efflorescence. Such damage is related to the inability of the building owner to control moisture within acceptable limits.[93]

Neil Carlson, Industrial Hygienist and mold expert for the University of Minnesota, states that a good percentage of the current building stock will "self-compost" in ten years from mold formation due to improper construction. News reports throughout the country echo these sad statistics. Articles abound with story after story of homeowners moving into expensive new homes, only to have mold develop with no recourse from the builder or insurance carrier to help remedy the situation. The burden to fix the problem falls on the ill homeowner who cannot sell their house and must live in moldy conditions because they often cannot afford to live elsewhere.

[92] Jackie Crosby, "Water Woes," May 13, 2007, www.startribune.com.
[93] See http://www.ornl.gov/sci/roofs+walls/research/envelope.htm.