Starting from the Bottom: Subflooring Design and Moisture Intrusion Mitigation

An Online Continuing Education Course for Engineers

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Introduction

The problems illustrated below likely began long before a section of the floor collapsed, or mold appeared. They may have begun when poor choices were made selecting materials for the foundation to floor assembly, in conjunction with the type of foundation chosen. As with many failures of flooring, the choices made that result in proper or improper floor design begin at the bottom and work their way upward.

Rotting Floor

Mold Heralding a Moisture Problem

Once a building is completed, it is a poor time to discover problems with a floor system. This is especially true when an issue manifests with an appearance of mold. Despite the care taken in the selection of the assembled materials, this organism can sometimes appear on framing members and especially on the underside of subfloor materials. It doesn't take long before an appearance of mold is followed by compromised indoor air quality, endangering the health of occupants. Once mold growth has appeared on top of the floor, repairs to remediate that problem will usually not end with surface treatment.

A basic problem making it possible for mold to thrive is the unintentional creation of what is termed a "moisture sandwich." This occurs when water is allowed into the internal atmosphere of a foundation, crawl space, or building assembly, but not permitted to escape in a timely fashion or at all. That trapped moisture creates a wet environment at the bottom surface of organic subfloor materials, making them ideal hosts for mold growth. Again, the solution to such flooring problems lies at the beginning of the design process.

The completion of a building is a poor time to find that squeaking sounds are heard when walking. This occurs when something is moving in the floor system or building up internal stress. A release of that stress will result in popping sounds, and additional problems manifest when once adhered flooring begins to delaminate. And being able to feel a floor system bouncing underfoot is always a bit disconcerting.

Knowing the solution to many such flooring problems begins with proper design and specification of flooring system components. We will examine these choices in their entirety in this course.

Designing in Entirety

Creating a successful flooring assembly must include the proper design and specification of all system components. These are listed below, starting from the bottom up.

- The effort begins with an analysis of water movement on a site.
- Water movement on site will help determine what type of foundation should be under and support the floor assembly. Site water characteristics, in conjunction with the foundation chosen, will play a large part in determining the extent and type of moisture present to plague floor systems from below.
- Incoming moisture, whether migrating up from the earth, coming over the top of the grade, leaking in from drainage off the structure or landing as precipitation, must be controlled. If invading moisture cannot be prevented (and some will always be present), then barriers must be put in place to control its migration out, through or into the

structure. This will involve vapor barriers and materials with different permeability in various locations. Equalization and movement of moisture must be allowed to occur. If these processes are prevented, but moisture is continually entering space below the flooring, then water accumulation will occur and result in issues. That buildup happens as increasing amounts of moisture become trapped between impermeable layers, like vapor barriers.

- The choice of a framing system to support a floor and necessary building systems will determine the potential occurrence of excessive movement of the flooring system, which will result in unintended gaps being created, as well as ongoing damage and ongoing repairs.
- There are many options available for insulation systems in floors. This component, used to create a thermal (and sometimes moisture) separation between climates above and below the floor, are sometimes highly absorptive and will usually require special consideration.
- The successful performance of flooring systems also depends on the materials chosen for the subfloor. Whether the chosen subflooring allows movement of moisture in and out, and to what extent the material is permeable, are areas of importance.
- Fasteners selected, especially those between framing members and subfloors, will factor into the long-term performance of flooring assemblies.
- Underlayment choices, if such materials are needed, will depend on installation requirements dictated by the finish flooring materials chosen, and by the manufacturers of that flooring.
- The permeability of the top surface, i.e., the finish flooring, will also be a factor in the long-term performance of a grade to finish floor assembly.

It is the hope that these components work together to achieve the design intent—a firm surface that does not bounce underfoot, excessively deflect, harbor mold or rot or make noise during use. Understanding the strengths and weaknesses of available choices requires a solid understanding of internal and external parameters affecting the long-term performance of each.

External parameters or environmental factors driving the transfer of moisture are largely outside of the influence of a designer. Internal factors are the results of our choices. We will examine those two categories momentarily.

Terminology and Concepts

Defining a few basic terms and concepts will help shape an understanding of the discussion to follow.

Moisture migration: Water enters spaces below floors as groundwater from rain or as water vapor. Like vapor, it moves upward into the conditioned space of the house, by way of diffusion or air leakage.

Water vapor migration by way of air leakage: Moving air carries water vapor with it, up through air leaks in the floor assembly. Controlling that movement requires effective air barriers and sealants.

Water vapor migration by way of vapor diffusion: Water vapor migrates through permeable building materials. Stopping that transfer requires the use of vapor retarders.

Vapor permeance: A measurement of how quickly water vapor diffuses through materials. The lower the "perm" rating, the less permeable, or the more the material resists vapor diffusion.

Relative humidity (RH): A measurement of the amount of water vapor in the air, as compared to the maximum amount of moisture air can hold at that same temperature. Since warm air can hold more moisture than cold air, RH increases if the temperature drops while the moisture in it stays constant.

Dew Point (DP): This is the temperature at which RH reaches 100%, and water vapor condenses into liquid on surfaces.

Moisture content (MC): This is the weight of the moisture contained in wood, compared to how much the wood weighs when it is dry. MC is expressed as a percentage. The upper limit for MC is about 20%, after which decay can begin. MC varies with changes in RH, increasing as RH increases. It also varies somewhat with temperature. Additionally, wood expands and contracts as its MC changes.

Exterior Parameters Affecting Performance

Despite good intentions and wishful thinking, not everything that occurs on a project site is within the power of decision-makers responsible for the project outcome. Some of these uncontrollable variables can contribute to foundational and floor assembly failure. Below are a few examples.

Wrong Place, Wrong Time (material substitutions)

Problems arise when workers on-site decide to substitute other materials or products for those that have been specified in the design. Panel products used on one part of a job will most likely not be suitable to use everywhere on that job. If I-joists have been designated for a span and use, substituting wood joists of the same depth will not yield the same performance.

The use of incorrect materials is not that common, but it does occur. Construction administration and oversight must ensure that substitutions do not occur on-site without prior authorization.

Unskilled Labor

Did We Have the Same Prints?

"The best-laid plans of mice and men …"

The best-designed flooring system that uses the best materials will still fail if poorly or incorrectly placed, especially if components are installed with no regard for manufacturers' instructions regarding the proper use of their products.

Common problems encountered with unskilled labor are:

- Improper storage of materials stockpiled on-site, to properly protect them from moisture exposure and absorption
- Improper protection from the elements after products are installed and before the building is enclosed
- Material damage during h
- Failure to leav nded by manufacturers, to allow for ex
- The improper s eners recommended or mandated
- Placing adhesive much before placing product on it
- Failure to protect of construction

Improper installation can els in the wrong orientation over framing n ould be installed with the strong axis or long ls. Failure to do so can reduce the allowable loadi by 75%.