How to Prepare a Concrete Subfloor for Wood Flooring

A Special Report about wood flooring over concrete.

Created by

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Concrete Subfloor and Wood Flooring

To most hardwood flooring mechanics in the North East, the thought of dealing with concrete in their wood floor installation is summed up well by Churchill, "…a riddle wrapped in a mystery inside an enigma." To the uninitiated hardwood floor contractor, dealing with concrete can represent a puzzling aspect to the job at hand. The purpose here is to alleviate these concerns and develop a better understanding of such a universal construction substrate. Concrete is used more than any other man-made material in the world!

Estimating a job involving wood flooring over concrete will require several critical factors for proper installation. Onsite observations at the time of the estimate/inspection should include:

- Condition of concrete slab
- Type of concrete
- Location of slab
- Moisture
- Flatness

Careful understanding of these five key elements leads to a successful finished floor installation. The **condition of the slab** pertains to the physical state of the surface. Take note of any and all cracks, curling, spalling, and other loose material. The condition also includes existing coverings. Is there glued down carpet or VCT tile? Is an epoxy coating installed? Or even another type of wood floor? The **type of concrete** also needs to be determined. Is it lightweight (below 3000# psi) or gypsum based? When noting ***location***, we are referring to whether or not the slab is located on grade, below grade, or above grade (think condominium). When the concrete was placed, there were, more than likely, specifications written for level and **flatness** (F_L and F_F). While the placement contractor surely did his best, it is most assuredly not to the standard specifications of the wood flooring manufacturer or the recommendations of the NWFA (National Wood Flooring Association). Pulling a string, shooting a laser, or laying a straight edge are all the methods used to give a ball park flatness indication. Last and most certainly not least is **moisture**. Given all of the improvements in wood flooring over the past ten years, none has meant more to the installer than the ability to measure and prevent moisture migration from concrete slabs. Test methods for determining moisture issues have improved by leaps and bounds. While not something that can be "eyeballed" on the first site visit, like flatness and the other key elements, moisture cannot be overlooked. It takes time, education and due diligence to perform proper moisture testing on a concrete slab.

Before discussing the five elements of a jobsite slab in detail, let's gain a little more understanding of the concrete substrate itself. That is, how concrete is made, materials that are used in the process, how it cures, and how it is placed. Understanding these items will help us solve some of the perplexing "riddles" that baffle the hardwood installer when a wood floor fails. Concrete is a composite of fine aggregate (sand), coarse aggregate (gravel) and cementitious components, water, and chemical admixtures. The quantity of each of these ingredients adds or detracts from the overall compressive strength, porosity and surface hardness of the concrete. Some cementitious components include: fly ash, cement, slag, and silica to name a few. The hydraulic nature of the latter components and their reaction to lime and water is what gives concrete its well known strength. This chemical reaction is referred to as hydration. When water is added, a reaction takes place with the cement and a binding of all the other components takes place. When less water is added concrete is stronger, but harder to place. When more water is added, it is easier to place the concrete, but risks a weakened final product.

A proper water to cement ratio (W/C) is crucial. Weakening concrete with a high W/C can wash the sand portion away and create space, making the concrete porous. The addition of chemical admixtures to the concrete can aid in its workability and solve issues of curing, color and strength. However, these admixtures can have a negative effect on the use of adhesives or sealants that a hardwood floor contractor may intend to use.

So, what does the chemistry lesson of concrete have to do with wood floor installations? A successful installation requires an understanding of the make-up of concrete. You see, knowing for instance, that a curing compound was used when the pad was placed gives you important information in the prep work needed to allow adhesives to "stick." Was the pad hard panned or rotary trowled? Was a vapor barrier used under the slab at placement? This type of information allows you to prepare a bid that is accurate and cost effective. If the mixture was placed with a high W/C and becomes porous, water vapor transmission is easier and directly affects a finished floor. Another detrimental effect of a high W/C resulting in weaker concrete is dusting and spalling. Wood flooring adhesives are very strong and may fail to bond when concrete has a dusting issue. Leveling compounds that cure over several weeks can have a PSI twice that of a concrete slab. Putting a high PSI-material over failing concrete will cause the finished floor to fail. Armed with useful information on what goes into the formation of a concrete slab, we can inspect a jobsite, and have a thorough understanding of the five fundamental conditions on a successful wood floor installation over a concrete slab.

Condition of the Slab

We know all wood is not alike. Concrete slabs are just as unique. Inspection of a jobsite requiring wood floor installation over a concrete slab, the condition of the slab needs to be determined. What is the state of the surface of the concrete? If there are large cracks, can patching compound fix them? Are the cracks structural? And will the cracks require a concrete contractor to fix, or can they simply be patched? Is there spalling? Can it be repaired easily? If there is curling at the expansion joints, know that these may need to be milled down which may require extensive equipment.

Are there high spots that can simply be ground down with a rotary buffer and carbide or titanium blocks? This would also be a good time to check the porosity of the slab. A few drops of water added to the surface is a good indicator if a curing compound was used when the slab was placed. If the slab has been placed with curing compounds added, it will need to be scarified or ground to a broom finish. Certain adhesives require a Concrete Surface Profile (CSP) of CSP 2-4. Low areas will need flash patching (Bostik Fast Patch 102) or the entire surface may need to be "leveled" (Bostik SL150 Leveling Compound). Think of leveling in terms of flatness rather than "bubble level." NWFA recommends a flatness of 1/8" to 3/16" in a 10-foot radius. We can also achieve these recommendations by floating a secondary subfloor over a slab with failing surface conditions. Using a minimum of two layers of 3/8" plywood, lay them perpendicular to one another staple or glue them to one another. 3/4" Plywood cut into 16" x 8' strips and scored along the bottom side with 3/8" kerf cuts will also work. There are many ways to repair a slab below par surface conditions. Feel free to consult with the NWFA's *"Subfloor Guidelines Specifications"* in their Technical Resource Manual for further details.

Type of Concrete

A slightly more difficult determination upon inspection of a slab is what type of concrete you are dealing with. Remember, hardly any concrete is ever placed without certain specifications. Before installing a wood floor, we determine location, purpose or use of the floor, species of wood to be used, and expectations of the owner. The same is true with concrete. Architects, builders and engineers will write the specifications for concrete. These will often include PSI, CSP, and F_L, and F_F and F-min. To increase PSI, chemical admixtures may be needed. When a truly level and flat slab is required (Example: Movie studios) the F_L, and F_F numbers will be high. Some specs may include lightweight concrete. Often, testing for lightweight concrete can be determined with a nail scratch test. Most adhesive manufacturers will require a "topping" of this type of concrete in order to gain the best performance. Again, be cognizant of the PSI of your topping and that of the concrete you are trying to cover. Most Portland based leveling compounds can have a PSI over 5,000 after several weeks of curing time. Composite improvements in light-weight concrete are being achieved all the time, however currently the NWFA recommends a ***Floated Subfloor*** be installed on such a slab.

Location of the Slab

Location, location, location - a statement of fact when trying to build a retail business with successful traffic. Just as important to you, the hardwood floor contractor who is being asked to install a beautiful wood floor in that successful retail business. Above grade slabs have less moisture issues aside from the initial placement. However, should a slab require flattening, depending on how "out" the slab is, an engineer may be required for load and bearing strengths for the fix you need on your installation. There have been instances where the slab on the 30th floor was so far out, that a structural engineer required tapered 2 x 6 shims and plywood rather than leveling compound. The shear weight that the amount of leveler would have added to the upper floor of the building would have had structural consequences. Is the slab below grade, or on grade? Most residential slabs below grade are basements, and it would not be uncommon for a homeowner to want a nice hardwood floor installed there. Below grade installations are done successfully throughout the country everyday by contractors understanding what is required of them and using the proper flooring and materials for the installation.

The tendency to worry about moisture in slabs below grade is not unfounded. Basement slabs do not always have proper vapor barriers if one is used at all. Moisture can be the single most cause of finished floor failures on a concrete slab. The industry has come to the table with an unbelievable array of measuring devices, barriers, coatings, adhesives and engineered flooring products to combat moisture transmission to the finished goods. The makeup and curing process of concrete tells us that concrete is porous. It is this porosity that allows moisture to travel from below grade and transmit up through the slab. Often times transmission is mitigated be a moisture barrier (10-15 mil) polyethylene film.

Moisture

It is not always apparent to the finish floor contractor whether or not a vapor barrier exists under the slab. Moisture testing is the most important test in determining what course of action a hardwood contractor must take. Testing, as with other technologies, has come light years from one foot by one foot plastic sheet duct taped to the slab (ASTM D-4263) to determine a moisture problem. There are five tests recognized for detecting moisture in a concrete slab:

- Electrical resistance and impedance
- Phenolphthalein
- Relative humidity (in-situ and hood method)
- Calcium chloride
- Calcium carbide

The industry, in general, is leading itself down the path of the Relative Humidity Testing, specifically the In-Situ. In-Situ relative humidity testing conforms to the guidelines in ASTM F-2170.

The ASTM F-2170 standard test is a quantitative test for measuring relative humidity in a concrete slab. It is intended to allow the finished flooring contractor the ability to follow installation guidelines set out by adhesive, coating and flooring manufacturers. The following guide relates to the use of the in-situ probes from Wagner Electronics.

Quantification of Relative Humidity at 40% of Concrete Thickness:

A. The test site should be maintained at the same temperature and humidity conditions as those anticipated during normal occupancy. These temperature and humidity levels should be maintained for 48 hours prior and during test period. When a building is not under HVAC control, a recording hygrometer or data logger shall be in place recording conditions during the test period. A transcript of this information must be included with the test report.

B. The number of in-situ relative humidity test sites is determined by the square footage of the facility. The minimum number of tests to be placed is equal to 3 in the first 1,000 sq. ft. and 1 per each additional 1,000 square feet.

C. Determine the thickness of the concrete slab, typically from construction documents.

D. Utilizing a roto-hammer, drill test holes to a depth equal to 40% of the concrete thickness*, i.e. 2" deep for a 5" thick slab, or 1 1/2" deep for a 4" thick slab. Hole diameter shall not exceed outside diameter of the probe by more than 0.04". Drilling operation must be dry.

E. Vacuum and brush all concrete dust from test hole.

F. Insert a relative humidity probe (sensor) to the full depth of test hole. Place cap over probe.

G. Permit the test site to acclimate, or equilibrate for 1-2 hours prior to taking relative humidity readings.

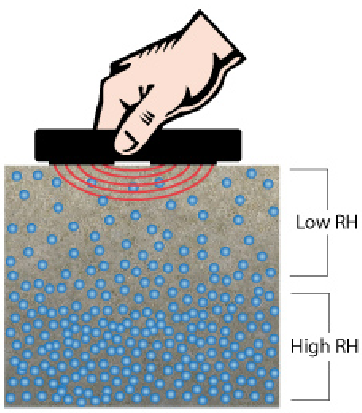
H. Remove the cap, insert the cylindrical reading device, and press button on the device to obtain readings.

I. Read and record temperature and relative humidity at test site

**Elevated structural slab (not poured in pans) should be tested at depth equal to 20% of its thickness.*

The method used by the Wagner Rapid RH allows the contractor to save time and money over other quantitative test methods. By reading the relative humidity at the bottom of the bored hole and not requiring the entire hole to equilibrate, saves time. Certain style probes require a greater waiting period before a reading can take place. Other quantitative methods, such as calcium chloride, require several days.

Relative humidity readings are taken at a depth equal to 40% the thickness of the slab. This measures what the slab will eventually equilibrate to, once a finish floor is installed. ASTM F-710 is the guideline used for hardwood flooring over concrete when a relative humidity test is used. It is important to note that the slab, once “capped”, it will always try to reach equilibrium moisture content throughout. An uncovered slab will typically have some sort of airflow across it, making any surface readings inaccurate. Electrical impedance and resistance meters have depth restrictions that don’t allow for a slab’s equilibrium moisture to be quantitatively measured. Again, once a slab is capped the moisture is going to seek balance within the slab, as the surface airflow that wicks way migrating moisture is eliminated.



Moisture Meters can only measure the top "drier" portion of a concrete slab.

Two other quantitative tests that have ASTM standards written for them are calcium chloride (ASTM F-1869) and calcium carbide (ASTM D-4944-04). Calcium chloride test measures the water vapor emission rate using Anhydrous Calcium Chloride. Calcium carbide is a gas pressure test used primarily in Europe. Both of these tests require significant time periods for evaluation. Many adhesive and flooring manufacturers today still have specifications on their installation instructions regarding ASTM F-1869 and maximum pounds (#) allowed for the use of their products. A typical limit reads 3#/1000sf/24hr. Usually anything over a measured 3# per 24 hours is going to require a vapor retarder on older concrete or possible further curing on newer concrete. As more installers are certified for the use of in-situ relative humidity testing, manufacturers will use this method as a specification standard for their products.

“There are many reasons why calcium chloride moisture emission testing cannot do what a Relative Humidity test can accomplish. The bottom line is that RH testing is a far better predictor of whether or not a floor covering or coating on a concrete slab will succeed or fail. It is unnecessary to perform moisture emission tests in addition to Relative Humidity.”
-Howard Kanare, Senior Principal Scientist, CTL Group

Mitigating moisture for a concrete floor in which a relative humidity test revealed a reading above 75% in three tests on the first 1000 sq. ft. and one for every 1000 sq. ft. thereafter, can be handled several ways. There are a large number of products to handle moisture and moisture vapor. Some penetrate deeply into the concrete like Bone Dry, react within the slab and form a barrier. Some are sealers coupled with glues that can handle up to 85% and 90% readings such as Bostik’s Ultra Set Single Step adhesive.

While others are High density polyethylene (HDPE) when overlapped and taped properly are excellent barriers and have no limit over what the relative humidity readings are. All of these allow for the installer to be "within spec" of the flooring manufacturer's requirements.

Flatness

Moisture and moisture vapor emission may be the biggest cause of a finished floor failure. What can be overlooked and is often difficult to evaluate, is the flatness of a slab. Many flooring manufacturers and organizations call for a subfloor to be 3/16" in a 10' radius or 1/8" over 6'. Unless concrete is being placed at a movie studio in Hollywood where very rigid F_L and F_F ratings are specified, most residential slabs are poured and screeded to the forms that contain them. Yes, they will be relatively level and flat, but will they meet the criteria flooring to be installed? Not very likely. In most cases, some amount of flattening will be necessary. There are a variety of ways to measure the flatness of a slab including the use of a ten foot straight edge, drawing a mason's string, or shooting a laser. For the hardwood flooring contractor, bringing a slab to within flatness requirements can go several ways. Use a combination of patching compound and leveling compound, an installed subfloor over the concrete slab, or abrading and grinding the high spots.

Self leveling and patching compound can be an effective way in attaining the flatness requirements needed for a hardwood floor installation. There are variations in type, from gypsum based to very high PSI Portland based levelers. Bostik SL150 can be used up to 5" in thickness on one pour if an aggregate is added. Most leveling compounds will require some sort of aggregate or screen in thickness over 2". Patching compounds fill small voids and cracks that are not structural problems. Floor levelers will require most large, non-structural cracks to be filled in order to optimize the flow and spread of the level compound. For slabs with poor surface conditions, that would cause a high PSI Portland leveler to fail, an alternative would be gypsum based leveler. Typically, a gypsum based leveler has a low PSI and exhibits less tension on the surface as it cures, allowing for the "topping" to remain in place rather than pull apart and fail. Leveling compounds have ratings and limitations as to how much relative humidity is allowable in the slab. Some have sealers that are required, particularly on porous slabs, so the moisture from the mixture is not wicked away as soon as it is poured out. Leveler manufacturers are very specific as to the amount of water added to the mix. Follow the instructions for adding water precisely.

There are instances where flattening the floor with leveling compound is just not practical. The floor may be off specification to the point where skids and skids worth of leveling compound would be needed. There are floors currently being flattened in high rise buildings that require 40 pallets worth of leveler. That is over 50 tons of dry material without the addition of water. An alternative could be an installed subfloor. The NWFA has a set of specifications under *Section II: Subfloor Guidelines and Specifications* of their installation manual that help explain the various types of plywood subfloors. Some of these specifications are discussed here under the ***Conditions of the Slab.***

When a slab is in great condition and flatness readings are within a tolerance across a majority of the surface, abrading or grinding may be enough. While this can be one of the least expensive ways to flatten a slab, if larger areas require grinding this method may prove time consuming and difficult. There are products made that allow the hardwood contractor to use their 175 RPM buffer and prepare the slab for the proper CSP (Concrete Surface Profile) and flatness specification. Most of these grinding plates use either metal bonded diamonds or very course brazed segments. Tooling of this type can be expensive, particularly if heavier weighted grinding equipment is necessary for stock removal. Diamond consumption will vary depending on the hardness of the concrete and the type of metal bond the diamond is brazed with.

Being that concrete is the most common man-made construction material in use, the hardwood floor contractor needs to have a firm handle on its composition, integrity, placement, and structure so that a successful installation is the end result. Armed with a little knowledge, some up to date materials and equipment, we can take some of the guesswork out of the pre-installation inspection.

Final Thoughts

Remember the five key elements to the concrete slab inspection: condition of the slab, type of concrete, location of the slab, flatness of the slab, and moisture content of the slab. Answering all of these thoroughly will allow for a successful installation and a floor that will last a lifetime.

The National Wood Flooring Association has gone through tremendous lengths to help with successful installs over concrete. Please consult their ***Installation Guidelines Manual, Section II: Subfloors*** or contact **City Floor Supply** (1-800-737-1786) for more information.

This white paper is for informational purposes only. Always consult the manufactures' guidelines when using machinery or applying product. Although the paper may include some discussion of installation and/or application techniques, the paper is not intended as an instructional manual.

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