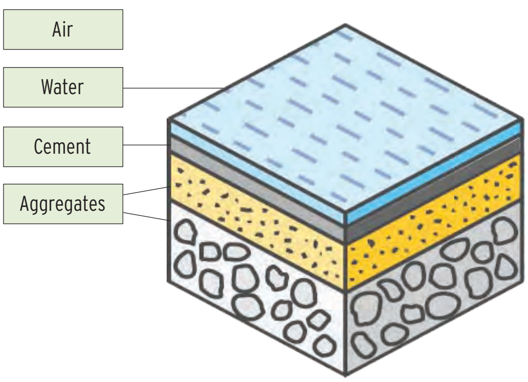
SUBSTRATES: Concrete Subfloors

Understanding the basics of concrete can help ensure successful wood flooring installations. The subfloor is the foundation for the wood floor. The final wood floor installation is only as good as the subfloor it is installed over. In the event of subfloor failure, the wood flooring contractor shall not be responsible for the performance of the subflooring material, or any subsequent flooring damage resulting from prior jobsite damage, unless otherwise contracted to do so.

PART I
Components of Concrete

A. Concrete is comprised of four main materials: Portland cement, coarse aggregate (stone), fine aggregate (sand), and water. When water is introduced to the dry materials, a chemical reaction occurs that is known as hydration.



1. Water comprises about 14 to 21 percent of concrete.
2. Cement comprises about 7 to 15 percent of concrete.
3. Aggregates, which can include materials like sand and gravel, comprise about 60 to 75 percent of concrete.
4. Air can comprise up to 8 percent of concrete.

B. The more water that is added to the cement mixture, the more permeable the cement paste will become. The ratio of the amount of water to the amount of concrete in a mixture is referred to as the water-to-cement ratio (w/c).

1. The w/c is determined from the following equation: w/c equals the weight of the water divided by the weight of the cement.

$$W/C = \frac{\text{weight of water}}{\text{weight of cement}}$$

2. A concrete mixture with a high w/c will produce concrete that is weaker and more permeable than a concrete mixture with a low w/c.
3. The amount of water that is necessary strictly for the hydration of the cementitious materials in a concrete slab mixture falls between 0.25 and 0.28. However, at that low of a w/c, the concrete is not workable. It is for the purpose of creating a workable concrete mixture that additional water is added.
4. Concrete mixtures designed and used for slab construction typically fall between a w/c of 0.42 and 0.50. The excess water that is added to create workable concrete is referred to as "free water," or "water of convenience." This excess "free water" is not consumed in the hydration reaction and is the first source of rising moisture that can adversely affect a wood flooring installation.

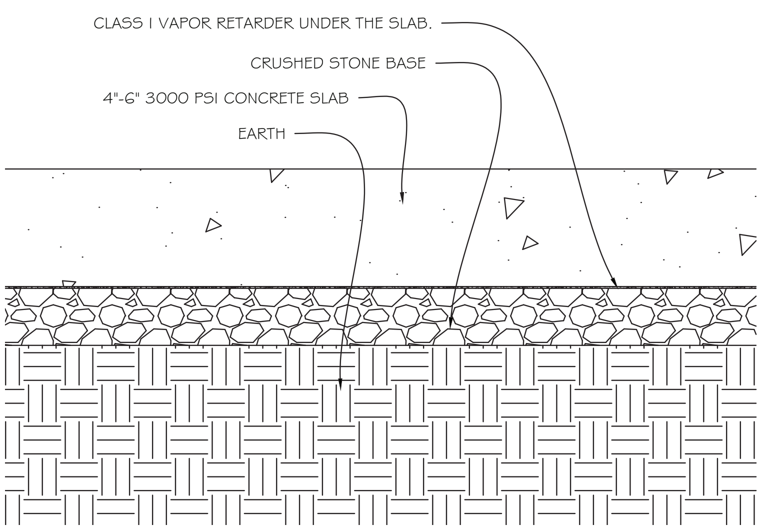
C. Under "ideal" conditions that include concrete with a w/c of 0.50 or lower, a non-burnished concrete finish where a membrane-forming curing compound was not used, and favorable drying conditions surrounding the slab, it may take 30-45 days after placement before you can begin evaluating it for flooring. (This does not indicate that any slab that is 30 days old is ready to receive flooring.)

PART II
Types of Concrete Subfloors

As a flooring installer, you should be able to identify the different types of concrete subfloors over which you will be installing wood flooring. The type of concrete subfloor affects how you will conduct moisture tests, how you will prepare the slab, the type of installation method, and potentially what type of flooring you will be able to use. Follow the adhesive manufacturer's instructions for appropriate subflooring.

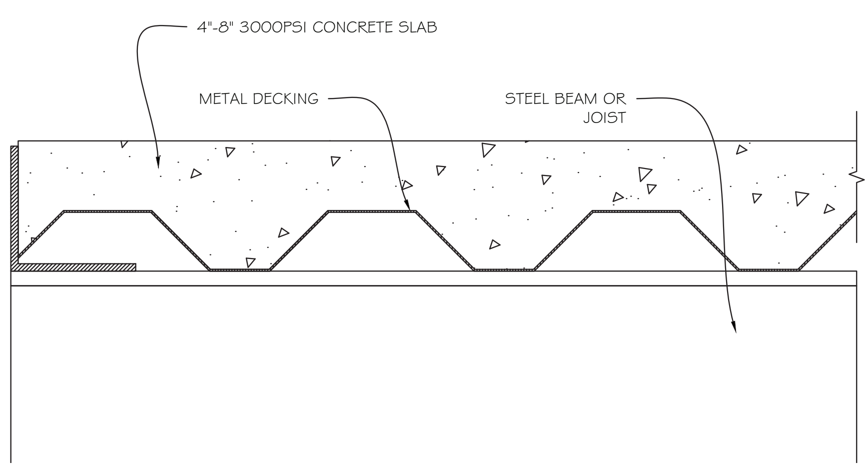
A. **Slab-on-Grade** (also called a slab on-ground) is a concrete slab poured on the ground that is typically 4"-6" in thickness.
   1. The concrete slab is required to be protected from ground moisture with an effective and intact Class I vapor retarder that conforms to the requirements of ASTM E1745 (Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs), or specification ASTM E1993 (Standard Specification for Bituminous Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs) installed in accordance with the recommendations of ACI 302.2R (Guide to Concrete Slabs that Receive Moisture-Sensitive Flooring Materials).
   2. The vapor retarder must be installed directly below the slab.

CONCRETE SUBFLOOR: 4"- 6" CONCRETE SLAB ON-GRADE



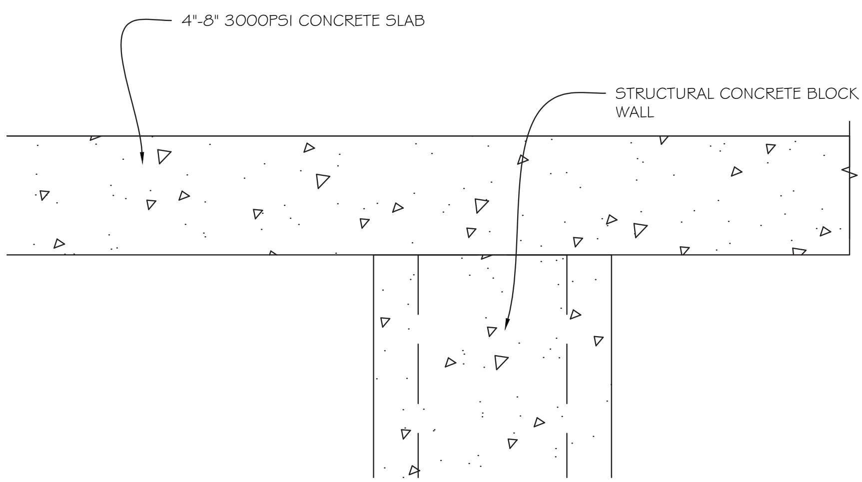
B. An **elevated concrete slab** may be one of the following designs:
   1. Normal or lightweight concrete on metal decking.
      a. Concrete slabs on metal decking experience the greatest measure of deflection.
      b. Because drying is only possible from the top surface, such construction usually requires additional drying time.

CONCRETE SUBFLOOR: ELEVATED SLAB ON METAL DECKING



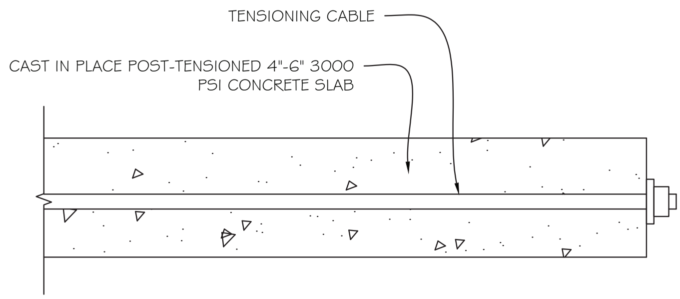
2. Cast-in-place structural concrete. Cast-in-place structural concrete is a technology in the construction of buildings where walls and slabs of the buildings are cast at the site using formwork.

ELEVATED CONCRETE SLAB CAST-IN-PLACE-STRUCTURAL



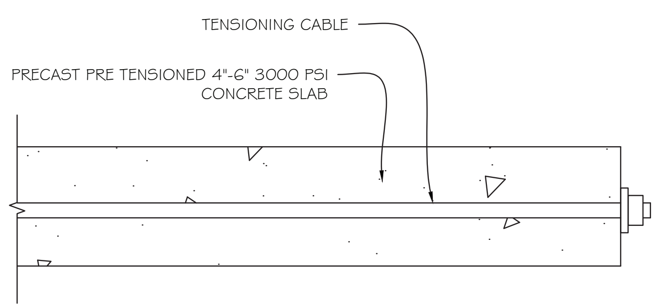
3. Cast-in-place post-tensioned concrete. Post-tensioning is accomplished where the tendons are stressed and each end is anchored to the concrete section after the concrete has hardened.

ELEVATED CONCRETE SLAB CAST-IN-PLACE POST-STRESSED/TENSIONED



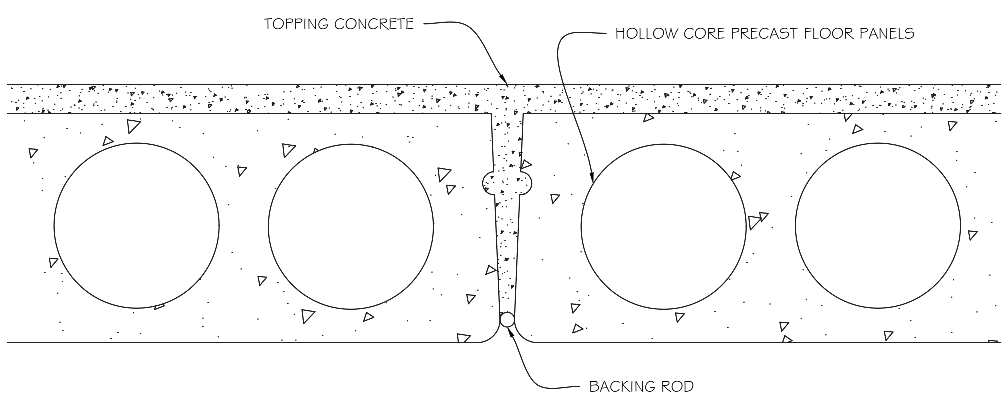
4. Prestressed concrete members.
   a. Prestressed concrete is a method for overcoming concrete's natural weakness in tension.
   b. Pre-tensioning is accomplished by stressing wires or tendons, to a predetermined amount, by stretching them between two anchors prior to pouring concrete.

ELEVATED CONCRETE SLAB CAST-IN-PLACE PRE-STRESSED/TENSIONED



5. Precast concrete is a construction product produced by casting concrete in a reusable mold or "form" that is then cured in a controlled environment, transported to the construction site, and lifted into place. In contrast, standard concrete is poured into site-specific forms and cured on site.

CONCRETE SUBFLOOR: HOLLOW CORE PRECAST PANEL

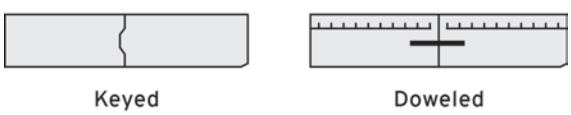


6. When testing moisture in an elevated concrete slab, it is important to know which design is present.
   a. For concrete slabs on fluted metal decking, concrete internal relative humidity tests (ASTM F2170) are to be taken at 40% of the slab thickness in the deepest part of the flute.
   b. For structural slabs, where the concrete is free to lose moisture from both the top and bottom, concrete internal relative humidity tests are to be taken at 20% of the slab thickness.
   c. For any post-tensioned or pre-tensioned slabs, you must identify where the wires or tendons are located within the slab prior to drilling any holes for relative humidity tests.

PART III
Concrete Subfloor Joints

There are three types of joints typically found in residential and commercial concrete floor slabs.

CONSTRUCTION JOINTS

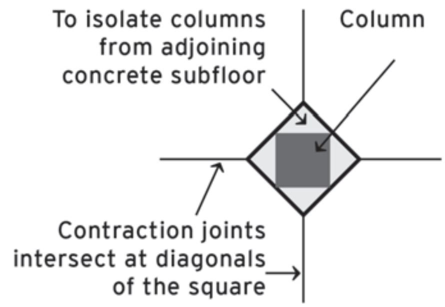


A. **Construction/cold joints:** Construction/cold joints are those points within a concrete placement that either by design, or necessity, the placement of one slab of concrete meets another slab of concrete. Construction/cold joints are weakened joints that, upon movement, will shift, and will affect the flooring installed over them.

CONTRACTION JOINTS
Sawcut or Tooled

B. **Control/contraction joints:** Control/contraction joints are planes of weakness purposely introduced into a concrete floor slab that encourage the cracking that develops due to drying shrinkage to occur in an orderly, predetermined pattern rather than randomly. Control/contraction joints are most commonly created by forming, tooling, or by making saw cuts in the new slab to a prescribed depth, most often 1/4 of the slab thickness.

ISOLATION JOINTS



C. **Isolation joints:** Isolation joints are those joints where the slab abuts a fixed object such as a wall, column, or foundation base, and bond is not desired.

D. Other classes of joints are acoustical joints and expansion joints.
   1. **Acoustical joints** form a non-hardened, rubber-like seal at the perimeter and at all penetrations and retaining surfaces of a floor installation assembly in which a bonded sound reduction membrane has been installed for sound reduction. The primary function of an acoustical joint is to minimize the transmission of sound through joints, penetrations, or structural components within the assembly.
   2. **Expansion joints** allow movement where expansion is likely to exceed contraction. Expansion joints are normally filled with compressible filler material allowing for independent movement between adjoining slabs.

E. Joints in a concrete slab typically are specified by the architect or engineer and noted on the architectural and/or structural drawings.

F. Moving joints must be honored and not be filled with underlayment products or other materials.

G. Wood flooring secured to the substrate should not bridge moving joints without allowing for a breaking point. When concrete decides to move, it is going to move.

H. Transitions and/or expansion space should be built into the wood flooring system to avoid potential wood floor damage at these locations in case of future movement.

I. Identify joints within the slab and address them with the flooring installation appropriately. The end-user should be made aware of the additional installation necessities and costs for any specialized installation methods required when addressing these joints.

PART IV
Compressive Strength

A. The builder or architect should be able to let you know what type of concrete is present in order for you to determine proper preparation of the slab prior to a wood floor installation. If the information is not available, run a nail forcefully across the surface. If it leaves an indentation, it will be necessary to apply a sealer or a densifier that is compatible with the adhesive being used. Check with the adhesive manufacturer for what to use in this situation.

B. Normal weight concrete subfloors are designed and constructed with concrete mixtures with compressive strengths between 3,000 psi and 4,000 psi. A 3,000 psi compressive strength is the minimum requirement for most standard wood floor installations, including glue-down wood floors, or glued/mechanically anchored subfloors.
   1. The compressive strength of concrete can be tested according to ASTM C39.
   2. The compressive strength of hydraulic cement mortars can be tested according to ASTM C109/C109M.
   3. The compressive strength of gypsum can be tested in accordance with ASTM C472.
   4. In all cases, a downward force is applied to the cast, or cored specimen, until it breaks.

C. Lightweight concrete is a lower-density concrete comprised of lightweight aggregate (such as pumice, clay, shale, foamed slag, and sintered pulverized), or has been aerated producing a lightweight cellular material. It is less dense than normal weight concrete. Lightweight concrete is most often used as a subflooring material where a lighter weight on a building's structural load is necessary, as a part of a larger sound-control subflooring system, where higher insulating is required, and/or in conjunction with many radiant heating systems.
   1. For glue-down applications, check with the adhesive manufacturer for applicable installation methods over lightweight concrete subfloors.
   2. Lightweight concrete must be prepared differently than normal weight concrete, and requires additional preparation, such as application of surface densifiers or hardeners properly applied prior to installation of wood flooring.
   3. The aggregate used in lightweight concrete is pre-saturated with water, which is not included in the w/c. Because of this, lightweight concrete can take longer than normal weight concrete to dry.
   4. ASTM F2170 is an approved and recognized testing method for lightweight concrete. Electronic moisture meters, used in accordance with ASTM F2659, can be used to quickly assess the surface moisture of a concrete subfloor, but are not to be used for a go-no-go determination. ASTM has specifically disallowed ASTM F1869 for testing lightweight concrete.

PART V
Subfloor Toppings

There are several types of materials used to level or smooth a concrete subfloor. They include proprietary blends of compounds based on Portland cement, gypsum, and calcium aluminates.

A. Follow the adhesive manufacturer requirements for compatibility and use of subfloor toppings.

B. These subfloor toppings are commonly used for these purposes:
   1. Fire rating requirements.
   2. Where the existing substrate will not provide adequate performance standards.
   3. Floor flattening or leveling.
   4. Where a lighter weight on a building's structural load is necessary and normal weight concrete is not an option.
   5. As a part of a larger sound control subflooring system.
   6. Where higher insulating is required.
   7. In conjunction with many radiant heating systems.

C. Properly mixed subfloor toppings should have a minimum compressive strength of 3,000 psi when tested in accordance with ASTM test method C109/C109M, C472, or C349, whichever is appropriate, for most standard wood floor installations, including glue down wood floors, or glued/mechanically anchored subfloors.

D. Identify existing subfloor toppings that may not be suitable for wood floor installation. Typical characteristics of a subfloor topping that may be inadequate include: surface softness, chalkiness, cracks, surface deformation or irregularities, and loose gypsum that is no longer secured to the plywood or OSB subfloor. Repair options include any or all of the following:
   1. Remove damaged/loose subfloor topping and any loose debris.
   2. Replace damaged areas with manufacturer-recommended patches.
   3. Allow ample dry-time.
   4. Apply a manufacturer-recommended primer or densifier (multiple coats if necessary).

E. Prior to any wood floor installation over gypsum-based underlayment material, the substrate must be completely dry. Once dried, it is often necessary to apply a sealer and/or a densifier/hardener that is compatible with the adhesive being used, in order to provide moisture protection and reduce cracking and degradation caused by natural movement.

F. Dry-times of subfloor toppings vary from product to product, and manufacturer to manufacturer. Check with the manufacturer for dry times and moisture testing requirements.

G. There is no recognized moisture testing method for gypsum-based underlayments. Most manufacturers recommend using either a specifically designated pinless meter, a pin-type meter, or following ASTM F2170. Follow the gypsum-based underlayment manufacturer's moisture testing instructions to determine when it has adequately dried.

H. It is important to know when a gypsum-based topping is being used over concrete. The concrete subfloor must be at an acceptable level of dryness for the wood flooring and the surface of the concrete must be properly prepared and primed with the gypsum manufacturer's specified primer.

I. Fiber-reinforced gypsum underlayments, fiber cement board, and cementitious backerboard are not suitable materials to be used below a wood flooring installation.

PART VI
Integrity

There are several types of materials used to level or smooth a concrete subfloor. They include proprietary blends of compounds based on Portland cement, gypsum, and calcium aluminates.

A. All substrates must be sound. Check for hollow spots, voids, loose or crumbling areas, and stress cracks.

B. Do not install flooring over any issues without first addressing them with the builder, concrete contractor, architect, homeowner, or any other responsible party, prior to preparing the subfloor for new flooring. Many stress cracks, hollow spots, or crumbling areas may be an indication of structural issues, geographic soil conditions, or poor quality concrete that should be addressed by a professional.

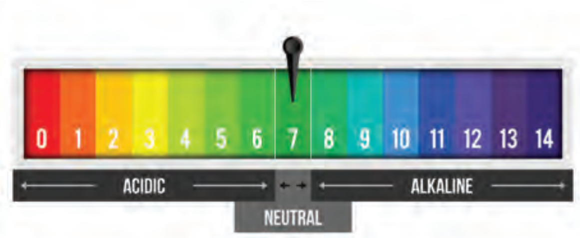
C. Stress cracks in concrete slabs should be addressed with crack isolation membranes, or in conjunction with the adhesive manufacturer's suggested system. Any crack isolation membrane must be compatible with the sealers and adhesives being used. Some adhesives and underlayment materials are designed to have crack-isolating properties.

D. Follow the adhesive and underlayment manufacturers' recommendations to address stress cracks.

E. Document the integrity of the slab by taking photographs and notes in the Jobsite Checklist.

PART VII
Concrete pH

A. pH is a measure of hydrogen ion concentration, a measure of acidity or alkalinity in a solution. The pH scale runs from 0 to 14; where 7 is neutral. Below 7 is considered acidic and above 7 is alkaline.



B. The pH of a new concrete slab typically measures between 12 and 13. However, over time, as the surface of the slab reacts with carbon dioxide in the air, the pH of the surface is gradually reduced to about 8.5. The process is referred to as carbonation.

C. Follow the adhesive manufacturer's instructions on pH testing and acceptable results.

D. When sufficient moisture is present in a slab to create a solution, the high pH solution that develops is capable of breaking down some types of wood flooring adhesives, and can lead to a flooring failure.

E. The current method for measuring the pH level of a concrete slab surface is described in ASTM F710 (Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring). Note: This procedure introduces an external source of liquid water that may not exist in the concrete, which can be misleading. It is far more important for the moisture levels in the subfloor to be at a level where solution chemistry will not develop, than it is to conduct a pre-installation pH test where liquid water from an external source has been introduced.

F. Rinsing and vacuuming the surface of a concrete slab with potable water can lower the surface pH level. Doing so, however, cannot prevent the future development of a high pH condition at the surface of the slab if there is enough moisture in the slab to create a solution. Do not use acid rinses to "neutralize" a high-pH concrete surface. The acid will deposit unwanted salts and can attack interior building finishes and be detrimental to the final installation.

PART VIII
Contaminates

A. The slab must be free from any non-compatible contaminants or foreign materials such as sealers, curing compounds, waxes, oils, paint, dust, or drywall compounds, that might prevent adhesive bond as described in ASTM F710.

B. Test for sealers, waxes, and contaminates by placing a drop of water on the concrete. If it beads-up, the concrete may contain a sealer or waxy substance.

C. All contaminates must be properly removed from the surface. These contaminates can often be removed by using a concrete vacuum grinder, or by using a buffer/rotary sanding machine, equipped with special stripping discs or wire brushes. (Refer to the Health and Safety chapter for silica precautions.)

D. Curing compounds are sometimes applied to the surface of a freshly finished concrete slab to retard the escape of moisture during the initial curing process. Curing compounds that remain on the slab surface may interfere with adhesion of the wood flooring adhesives and should be removed.

E. Cutback adhesive: Some previously manufactured asphaltic cutback adhesives contain asbestos. This material must be tested and properly removed by an asbestos remediation company. It is best to presume all cutback adhesive contains asbestos, until testing proves otherwise. (Refer to the Health and Safety chapter for more information.)

PART IX
Porosity

A. The ability of a concrete subfloor surface to readily absorb water is a key indicator in determining which types of adhesives, moisture control systems, primers, and self-leveling underlayments can be used in the installation process.

B. Follow the adhesive manufacturer recommendations for porosity criteria.

C. ASTM F3191 describes the procedure for assessing the substrate water absorption (often referred to as substrate porosity) of horizontal substrate surfaces prior to the installation of resilient floor coverings. The procedure involves applying a single drop of water to the surface of properly prepared substrate, and then determining whether that drop of water is absorbed within a given time period. Although this test method is specific to resilient floor coverings, many of the procedures included in this practice may be useful for assessing the substrate water absorption for substrates to receive wood flooring as well.

D. Nonporous substrates such as densely machine-troweled concrete, mature and well-hydrated concrete, existing resilient flooring, terrazzo, and others, may require adjustments to the surface preparation method or product selection to ensure a successful installation. (See Concrete Surface Profile section.)

E. Porous substrates, surfaces that are chalky or dusty, or have varying degrees of absorption may require a densifier/hardener that is compatible with the adhesive being used prior to wood floor installation.

PART X

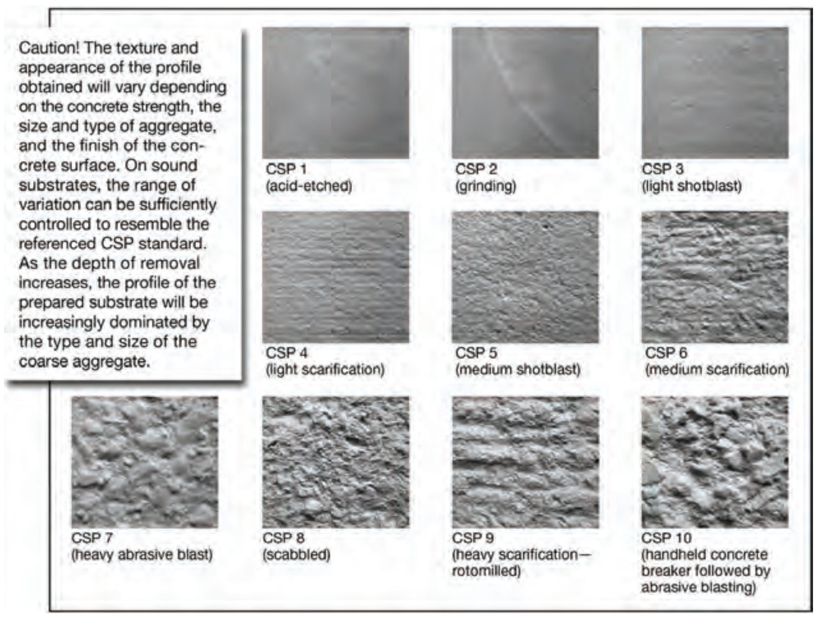
Concrete Surface Profile (CSP)

CSP is a standardized measure for the ‘roughness’ of a surface that is defined by the International Concrete Repair Institute (ICRI).

A. CSP is the measure, under a cross-sectional view of the concrete surface, of the average distance from the peaks of the surface to the valleys. A very rough surface will have a high CSP number, such as CSP 10. A very smooth surface will be a CSP 1.

B. The slab must meet minimum CSP requirements set forth by the adhesive manufacturer. Most manufacturers recommend a CSP of somewhere between CSP 1 and CSP 4. This typically can be found on the adhesive product technical data sheets (TDS).

C. Adequate CSP can be achieved through a variety of methods including grinding, acid etching, needle scaling, abrasive blasting, shot-blasting, high and ultra-high pressure wet-jetting, and scarifying/shaving.



	Concrete Surface Profile									
Surface preparation method	CSP 1	CSP 2	CSP 3	CSP 4	CSP 5	CSP 6	CSP 7	CSP 8	CSP 9	CSP 10
Detergent scrubbing	■									
Low-pressure water cleaning	■									
Grinding	■	■								
Acid etching	■	■	■							
Needle scaling		■	■	■						
Abrasive blasting		■	■	■	■	■	■			
Shotblasting		■	■	■	■	■	■	■	■	
High- and ultra-high-pressure water jetting			■	■	■	■	■	■	■	■
Scarifying				■	■	■	■			
Surface retarder (1)					■	■	■	■	■	■
Rotomilling						■	■	■	■	
Scabbling							■	■	■	
Handheld concrete breaker							■	■	■	■

(1) Only suitable for freshly placed cementitious materials

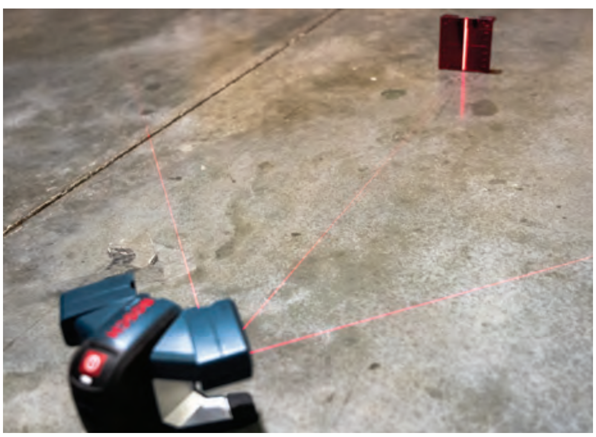
PART XI
Concrete Subfloor Flatness

A. Subfloor flatness should be measured across the span of each individual room receiving wood flooring to get an overall perspective of the topography of the subfloor.

B. Where one room meets another, the subfloor flatness should remain in tolerance. Where adjoining rooms are not within tolerance, are on a separate plane, or are abutting a ramp, a specialty or customized transition will be necessary.

C. Measure subfloor flatness using a laser-level, string-line, or straight-edge by taking measurements across the plane of the line to determine tolerances.

1. **Laser-level**: Place the laser level on the floor in the room receiving wood (ideally at the highest point of the subfloor). Lasers featuring a 360° static or rotating beam that allows you to take measurements from the subfloor to the plane of the laser at any given point within the room should be employed. Measure the deviations in the subfloor by using a tape measure, taper gauge, feeler gauge, depth finder, calipers, or the target provided by the laser manufacturer.



2. **String-line**: Place two blocks of wood (of the same thickness) at each end of the room, and then run a taught string-line across them. Take multiple measurements across the string-line between the blocks from the line to the subfloor. Measure the deviations in the subfloor by using a tape measure, taper gauge, feeler gauge, depth finder, or calipers. Move the blocks to multiple locations down each wall to cover the entire floor space.

3. **Straight-edge**: Place the straight edge across the substrate. Take multiple measurements across the straight-edge between the edge and the subfloor. Measure the deviations in the subfloor by using a tape measure, taper gauge, feeler gauge, depth finder, or calipers. Move the straight-edge to multiple locations, and rotate it 180° at each location to cover the entire floor space.

D. From here, you should be able to mark out any discrepancies on the subfloor itself, giving a good indication of what alterations will be necessary. Document and photograph results.

E. The floor does not need to be level in most situations, but should be flat. The slab should be flat to within minimum tolerance of 1/8″ in 6′, or 3/16″ in 10′, unless otherwise specified by the wood flooring manufacturer.

F. If the slab is out of specification, it will need to be flattened. Flattening a concrete subfloor requires grinding high areas, filling low areas, or a combination of both. (Refer to the Health and Safety chapter for silica precautions.)

G. Grinding high areas:

1. Isolated high spots in concrete can be ground flat by using handheld angle grinders with a dust containment shroud attached to the tool when in use. A diamond cup wheel, or tungsten carbide or diamond disc wheel attachment normally works best for concrete removal.
2. Larger areas of concrete subfloors that need to be flattened may require larger equipment such as walk-behind or riding grinders.

H. Filling low areas:
1. Prior to applying any patching compounds or self-levelers, the moisture conditions of the slab must be assessed through applicable moisture testing methods.
2. Use of approved patching compounds or self-levelers is normally recommended by the adhesive manufacturers to fill low areas in concrete subfloors.
3. Patching compounds and self-levelers containing polymer-based cement normally are recommended and must be compatible with the moisture control and adhesive systems.
4. Most patching compounds and self-levelers require a primer to be applied to the underlying substrate (dependent on the substrate) prior to application. Follow the manufacturer's instructions.
5. Each patching compound and self-leveler must be mixed and applied per the manufacturer's specific instructions. Thickness limitations, mixing instructions, application methods, dry times, and spread rates vary from product to product and from manufacturer to manufacturer. Follow the manufacturer's instructions.
6. Self-levelers and patches are normally applied by use of a gauge rake, a flat edge stainless steel trowel, smoothing trowels/spreaders, and other specialty tools as designated by the manufacturers of these products.

NOTICE: Disparity between concrete floor flatness tolerances and subfloor flatness tolerances designated for wood flooring at the time of installation. The following disparity has been adopted as detailed in the American Society of Concrete Contractors (ASCC) as published in "Concrete International, a publication of the American Concrete Institute (ACI)":

A. Division 3 specifications for concrete floor flatness typically include floor flatness requirements. The specifications also require that floor tolerance measurements be taken in accordance with ASTM E 1155, "Standard Test Method for Determining Floor Flatness (FF) and Floor Levelness (FL) Numbers." Thus, the F-number measurements for meeting Division 3 requirements incorporate the following:
   1. Point elevations measured at regular 12" (300 mm) intervals along each line.
   2. Measurement lines distributed uniformly across the test section.
   3. Minimum # of readings required for statistical approach.
   4. Measurement lines not within 2' (.6 m) of any slab boundary, construction joint, isolation joint, block-out, penetration, or other similar discontinuity.
   5. Flatness measured within 72 hours of concrete placement.

B. Division 9 specifications for concrete floors to receive a wood floor provide floor flatness requirements in terms of an allowable gap (1/8" in 6' or 3/16" in 10') under an unleveled straightedge. There is no ASTM procedure for this measurement. Straightedge measurements for Division 9 incorporate the following:
   1. Continuous measurement at any gap under the straightedge.
   2. Indefinite number of straightedge locations on the floor.
   3. No minimum or maximum number of readings.
   4. Measurements typically taken with the straightedge crossing construction joints, or column blockouts, and near penetrations.
   5. Measurements made just prior to the installation of the floor, which can be between 4-18 months after concrete placement.

C. These two tolerances are obviously not compatible, nor measured with the same specifications. And floor flatness changes with time (due to curling of the slab) which makes it impossible to predict flatness when flooring is ready to be installed. To further complicate the issue, concrete contractors seldom receive Division 9 specification requirements when bidding the job, nor are floor coverings normally selected at this time. Concrete contractors are responsible for meeting the requirements of Division 3.

D. It is recommended by NWFA, American Society of Concrete Contractors (ASCC), National Tile Contractors Association (NTCA), The Flooring Contractors Association (FCICA), Tile Contractors Association of America (TCAA), International Masonry Institute (IMI), and International Union of Bricklayers and Allied Craftworkers (BAC), that the owner of the project provide a bid allowance, established by the architect/engineer and based on the flooring requirements, for any necessary grinding and patching to close the gap between Division 3 and Division 9 tolerances. Providing an allowance enables the owner to compare floor covering bids on an equal basis.

PART XII
Moisture and Concrete

Concrete, whether used as a subfloor or as a building material, can introduce moisture to a structure. Excess moisture can pose problems for wood floors. An otherwise perfect flooring installation can fail if moisture is not addressed.

A. The age of the slab does not coincide with the moisture levels present in the slab. A 50-year-old slab needs to be assessed the same as a newer slab.

B. The point at which a wood floor can be installed over a concrete slab is dictated by the adhesive and flooring manufacturer requirements, and moisture testing results aligning with those requirements.

C. The slab must be dry and meet the moisture condition requirements of the flooring and the adhesive manufacturers. Be certain to follow specific moisture testing protocol as defined in the applicable ASTM testing method. Document and photograph dates, jobsite conditions, and moisture readings. (Refer to the Moisture Testing chapter for details about moisture testing concrete subfloors.)

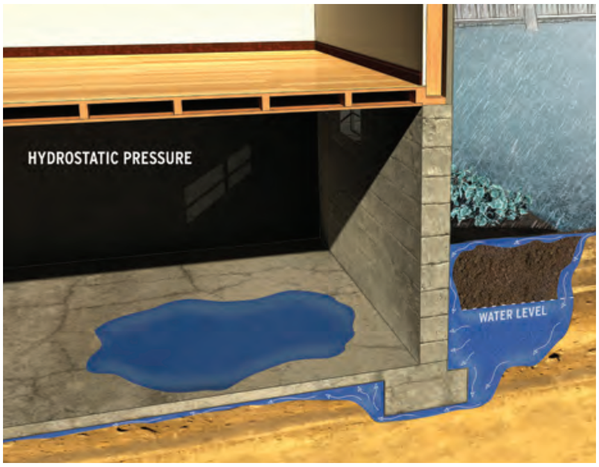
D. There are three main sources of concrete moisture. They include water originating from the mix, water originating from above the slab, and water originating from below the slab.

1. **Water originating from the mix**

   a. Most slabs poured with the intention of being used for a residential or commercial interior substrate, are poured directly over a vapor retarding membrane. Assuming this membrane was installed properly, and remains completely intact, the moisture within the slab is the primary moisture that needs to be addressed.
   b. Under "ideal" conditions, that include concrete with a w/c of 0.50 or lower, a non-burnished concrete finish where a membrane-forming curing compound was not used, and favorable drying conditions surrounding the slab, it may take 30-45 days after placement before you can begin evaluating it for flooring (this does not indicate that any slab that is 30 days old is ready to receive flooring).
   c. Curing compounds inhibit the evaporation of moisture and will also extend the drying time dramatically.

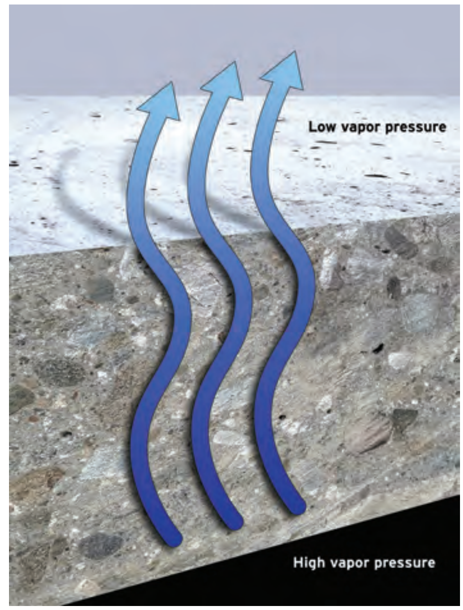
2. **Water from above the slab**
   a. Concrete is a porous material. Once a dried concrete slab becomes wet, it takes time for this water to evaporate from the pores in the slab. The most common external source of moisture during new construction is precipitation, where the building is open to the elements.
   b. If the slab gets rewetted after starting to dry, the "drying clock" must be reset. Rewetting may include exposure to rainwater, power washing, leaks, or floods. The drying clock doesn't start until the slab has been protected from rewetting and the ambient conditions are conducive to drying. Studies have shown that due to the porous nature of all types of concrete, rewetting can greatly affect the dry time of the concrete slab.
   c. Conditions in the space
      i. High RH conditions within the structure can affect the moisture levels within the slab.
      ii. Condensation on a slab occurs when the temperature of the slab allows the dew point to be reached, turning moisture from a vapor to a liquid.

3. **Water from below the slab**: There are three main ways moisture can find its way through a concrete slab. They include hydrostatic pressure, capillary action, and vapor diffusion. Other sub-slab sources may include broken pipe leaks from below or embedded within the slab, landscape irrigation, and breached or degraded vapor retarders.



a. **Hydrostatic pressure**: Fluid pressure that develops when the elevation of groundwater rises above the bottom elevation of the slab. Except in flood conditions, hydrostatic pressure only develops in "below-grade" applications. Moisture issues related to hydrostatic pressure can be avoided by using adequate drainage systems and/or waterproofing membranes around the foundation of the structure. This situation rarely occurs in the field.

b. **Capillary action**: The ability of liquid water to rise above the water table when the soil structure beneath the building is conducive to such rise. Through the forces of adhesion and cohesion liquid water has the ability to climb upward, against gravity, through soil structures where the gap between the soil particles is extremely small. An example of capillary action is the "wicking" up of water into a paper towel. To protect against the rise of liquid water by capillary action, the design team will specify removal of the finer soil beneath the slab to a specified depth and require replacement of that material with a very coarse fill material or crushed stone where the gap between particles is widened and capillary rise is broken.



c. **Vapor diffusion**: The movement of water vapor through a vapor-permeable material from an area of higher concentration to an area of lower concentration. When the moisture level in one area is higher in concentration than another, moisture will diffuse to the area of lower concentration until a state of equilibrium is reached. The relative humidity below a slab-on-ground, regardless of the depth of the water table, will typically be 100 percent. The higher vapor pressure below the slab will naturally find its way to the area above the concrete, which will have a lower vapor pressure. This natural movement of water in vapor form can create an environment that can lead to a flooring failure. An intact Class I vapor retarder that conforms to the requirements of ASTM E1745 installed directly below the slab can minimize or alleviate these issues.