

## Flooring Systems

Residential floors are typically an assembly of structural floor joists, overlaid with a subfloor sheathing and covered by any of a wide range of finish materials. Alternatively, floors can be constructed of a material that acts as both structural subfloor and finished floor. Materials such as concrete (both cast-in-place and pre-cast panels) and tongue & groove dimensional lumber can be used in this way.

### Floor Finishes

Among the many floor finishes available are engineered (laminated) wood, bamboo, cork, vinyl, rubber, linoleum, natural- or synthetic-fiber carpet, tile, and stone. The choice of finish material will depend on many factors. Comfort and appearance are high priorities in the living areas of the house. Durability and ease of maintenance are important in high-use rooms and especially in wet rooms such as kitchens and bathrooms. Affordability and ease of installation are factors that vary greatly among floor finishes. Finally, the impact on the environment and the indoor air quality of the house should be considered.

### Environmentally Preferable Products

A variety of environmentally preferable flooring products are available. Some, such as bamboo, cork, and other woods, are produced from fast-growing, renewable sources. Others, such as carpeting and tile, can include recycled content. Products that contain rubber, formaldehyde, harmful sealants, or other materials that off-gas should be avoided or used only in well-ventilated areas. Linoleum, which uses more renewable materials and off-gasses less, is an environmentally preferable alternative to vinyl. Carpeting should be avoided, as it collects dirt and mold, especially in moist climates, and adhesives and backers can off-gas; area rugs are an environmentally preferable choice.



**(FIG.A) TONGUE AND GROOVE FLOORING** This 2x6 southern yellow pine floor will be sanded and finished with a stain or sealer.



**(FIG.B) FINISH MATERIALS** are applied on top of the subfloor. In the past decade more sustainable finish materials have become widely available.



**(FIG.C) SUSPENDED CAST-IN-PLACE DECKS** can be used in combination with ICF walls and a concrete foundation system.

floors	construction process	speed	delivery method	required equipment	specialized labor	wind resistance	water resistance	fire resistance	thermal performance	life span	environmental impact	product versatility	market exposure	code approval	affordability	coastal considerations
subfloors w/ finishes			+	+	+							+	+			
2x6 tongue & groove	-	-	+			+					+		-			+
pre-cast panels		+	-	-	-	+		+		+		-	-		-	
cast in place floors	+	+				+		+		+		+			-	

### Tongue and Groove Wood Floors

Tongue and groove floors are assembled using dimensional lumber with pre-routed tongues and grooves that allow the boards to be fitted together securely. These floors take longer to install than a plywood subfloor, but once sanded and sealed, the result is an attractive and comfortable finished floor. The strength of the continuously interlocked deck allows increased joist spacing and provides additional lateral strength to the house, an important consideration in hurricane- and tornado-prone areas.

### Suspended Cast-In-Place Deck

Suspended cast-in-place decks are an elevated floor system that utilizes site-cast reinforced slabs supported by cold-formed steel joists. The steel joists are designed to house the formwork for the slabs above, so that formwork either remains a part of the structure after the concrete has cured, or is removed and re-used for other projects. This system is often used in combination with ICF walls and a concrete foundation system.

### Pre-Cast Floor Panels

Pre-cast concrete panels are more common in multi-family units and commercial construction than in single-family homes. As concrete becomes common in residential construction, manufacturers are attempting to scale down the size and cost of these pre-cast panels in order to make them a more viable option for home construction.



**(FIG.D) PRE-CAST FLOOR PANELS** can be tensioned off-site and are often hollow. Pre-cast panels can be utilized for quickly assembled, strong and fire-resistant floor systems.

#### FURTHER INFORMATION

- *The Short and Long of Floors* ([www.short-andlongofit.com/renovate/flooring.html](http://www.short-andlongofit.com/renovate/flooring.html))
- *GreenHomeGuide* ([www.greenhomeguide.com/index.php/know-how/entry/803/C220/](http://www.greenhomeguide.com/index.php/know-how/entry/803/C220/))
- Toolbase (<http://www.toolbase.org>)

#### NOTES ON FLOORING

---



---



---



---



---

# 6

## FLOORING SYSTEMS

### subjects

<b>6.1</b>	2x6 Tongue and Groove Decking
<b>6.2</b>	Suspended Cast-in-Place Decks
<b>6.3</b>	Floor Finishes

## INSTALLATION

### 2x6 Tongue and Groove Decking

**Overview:** A tongue and groove floor system, assembled of pre-routed 2x6s of solid wood such as southern pine, is both subfloor and, after sanding and sealing, finished floor. The strength of a continuous interlocked 2x deck provides additional lateral bracing, making the system well-suited for hurricane zones. It also allows for a greater joist spans than a typical subfloor. Installation takes more time and care than a plywood subfloor but the end result is an attractive natural wood floor.

Like any other flooring material, tongue and groove decking must be well-insulated from below. A construction adhesive is applied to the joists before laying the 2x6s, and the tongues are nailed to every joist with 8 penny spiral-shank nails.

**Construction Process:** As the 2x6s will be the finished floor, care must be taken during installation to prevent surface damage. If the wood is of inferior quality or left exposed to the elements before installation, warping will most likely occur, making it difficult to align the boards and securely interlock them. The floor must be fully installed before contractors can frame walls on top of it.

**Speed of Construction:** The tongue and groove wood takes longer to lay out than a OSB/plywood subfloor, because care must be taken to provide a finish-quality installation. Once it is installed, however, no further flooring needs to be applied, saving time on finish work.

**Delivery Method:** Tongue and groove is readily available from most local lumber yards. If not in stock, it can be ordered quickly. Lumber is delivered on-site by the lumber yard.

**Required Equipment:** A nail gun and 8d spiral shank nails are required for installation, but no special equipment. Once flooring is installed, a floor sander can be rented to finish the floor.

**Specialized Labor:** No specialized labor is required, only the attention to detail required of a finish carpenter.



**(Fig.1)** 2x6 tongue and groove decking is simply stock lumber routed with tongues and grooves along its sides. Its additional depth makes it a strong and simple floor material.



## PERFORMANCE

**Wind Load:** The 1½" thick interlocked flooring is twice the thickness of standard plywood subfloors, and adds minimal additional wind load resistance.

**Water Resistance:** No significant change in water resistance over conventional subfloors. With only one layer of flooring, no gutting is required to dry out component pieces in case of flooding.

**Energy/Thermal:** No significant change in thermal performance.

**Life Span:** When properly moisture-protected and insulated, the flooring will last at least as long as a traditional subfloor/finish-floor system. Gouges or dents in the surface of the wood can at any point be sanded down and refinished.

**Common Failure:** Flooring must be well-nailed and glued along the rim joists to prevent the floor system from becoming a weak point.

## DESIGN

**Environmental Impact:** Wood is a renewable resource, if harvested sustainably. Locally sourced lumber is readily available, particularly pine. Construction adhesive can contain harmful gases, but products identified as "low VOC" can be used.



**Versatility/Flexibility:** This flooring system is adaptable to first floors or second floors, and is very strong.

**Market Exposure:** 2x6 tongue and groove flooring is not common in residential work. The tongue and groove is more often a roof deck visible to the floor below. Contractors may not have experience installing this system.

**Code Approval:** No known code approval issues.

**Affordability:** This system is slightly more expensive than a standard subflooring system, although homeowners save on the cost of a finish floor. Additionally, its strength allows joists to be spaced farther apart, which may save lumber costs.

**Coastal Considerations:** Additional strength from the thicker boards helps reinforce buildings against hurricane-strength winds.

## GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

2x6 tongue and groove decking is available at several lumber yards along the Gulf Coast. Often it is carried in stock, but may also be special ordered.



(Fig.2-3) Workers can nail through the tongue or groove into joists at an angle, which results in a single smooth surface both above and below. Two-story houses are particularly well-suited to this system.

## INSTALLATION

### Suspended Cast-in-Place Decks

**Overview:** A suspended cast-in-place deck refers to an elevated floor system that utilizes site-cast reinforced concrete slabs that are supported by cold-formed steel joists. The steel joists are designed to house the formwork for the slabs above, so that formwork either remains a part of the structure after the concrete has cured, or is removed and reused for other projects. This system is most commonly used in combination with ICF walls and a concrete foundation system.

**Construction Process:** The ease of construction of a suspended cast-in-place deck is dependent on the steel joist and its assembly. The most commonly used system in residential construction is composed of a steel joist with punched holes that hold reusable lockbars in place. The lockbars support 4'x8' sheets of plywood or OSB that serves as the formwork for the slab. The steel joists also have a raised lip from which steel mesh reinforcement is hung.<sup>1</sup>

**Speed:** Installation of a suspended cast-in-place deck takes approximately the same time as a typical stick-framed floor system, if using a steel joist that is manufactured with the above features to eliminate the need for site built formwork.<sup>2</sup>

**Delivery Method:** Steel joists can be delivered to the site by a flat-bed truck.

**Required Equipment:** Standard concrete equipment and tools are needed for installation of the concrete slab. Manufacturers of the floor joists may suggest or require special hand tools for installing the joists properly.

**Specialized Labor:** An experienced builder familiar with standard concrete installation is preferable for pouring the slab. In addition, steel joist manufacturer warranties may require that a certified contractor perform the installation.<sup>3</sup>



**(Fig.4)** Reusable steel lockbars being set into the joists. These lockbars support the plywood while the concrete is being poured and are removed after installation.

## PERFORMANCE

**Wind Load:** Lateral wind loads are generally not accounted for in floor systems. The resistance to uplift for a suspended cast-in-place system will be higher than typical stick-framed floor systems, although the ultimate strength of the system depends on the strength of the connection to the foundation system.

**Water Resistance:** Exposed steel joists are susceptible to moisture and salt damage, which will result in oxidation and corrosion. Periodic maintenance and cleaning will decrease oxidation. Concrete slabs are subject to damage if flooding occurs; elevating the structure at or above the base flood elevations will decrease the likelihood of flood damage.<sup>4</sup>

**Energy / Thermal:** Thermal resistance of concrete depends on the thickness of the slab, although a typical 3" suspended concrete slab has negligible R-values (below 0.5).<sup>5</sup> The floor may act as a thermal mass, moderating building temperatures throughout the year.

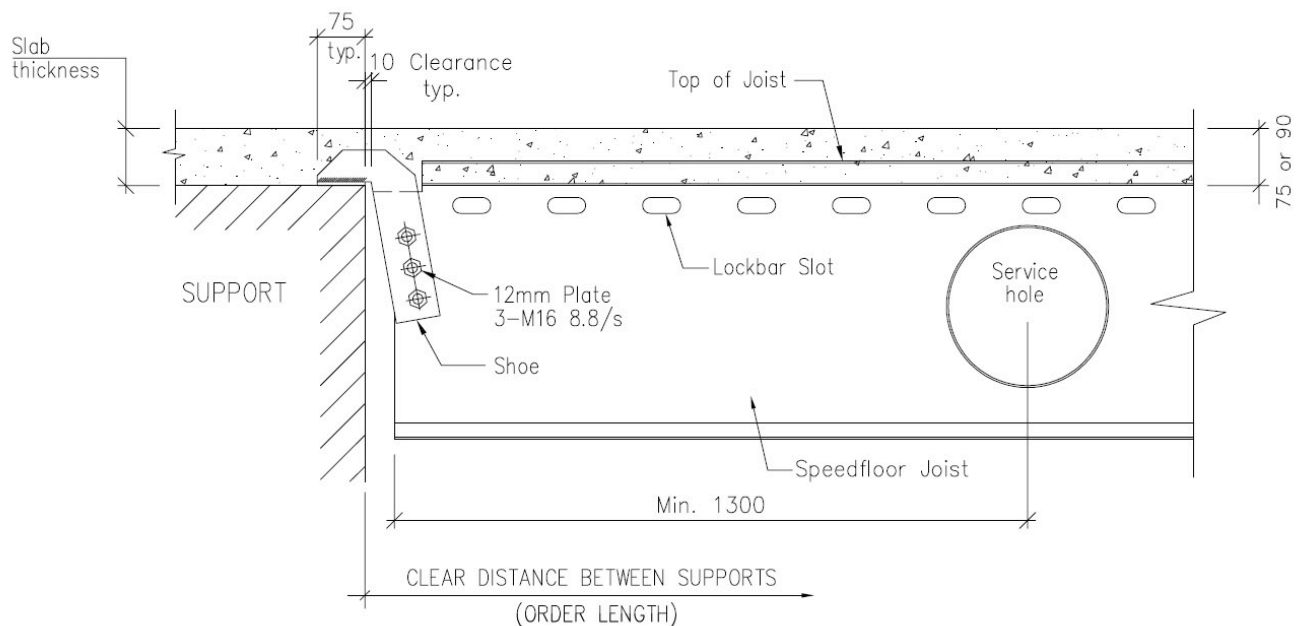
## DESIGN

**Environmental Impact:** Forms and installation materials used for the steel joists and the concrete slab can be reused, reducing on-site waste. Concrete and steel production requires high levels of embodied energy. Steel can be recycled easily, while concrete recycling is more limited.

**Versatility / Flexibility:** The suspended concrete slab can be used as a finished floor material, eliminating the need for additional floor coverings. The concrete can be oiled, stained, or imprinted with textures for a variety of finished looks. The steel joists can support longer spans than wood, so fewer piers or piles are needed for foundation designs. Also, the steel joists can be manufactured with punched openings for running mechanical and plumbing systems through the joists. Typically, this system is used with concrete foundation systems and works well with ICF or masonry walls.<sup>6</sup>

**Market Exposure:** Suspended cast-in-place decks in the residential sector could serve an emerging market as designers and homeowners are seeking stronger and more rigid floor systems than typical stick-framed systems. Cast-in-place decks are used fairly often in large scale commercial applications.

**Code Approval:** Suspended cast-in-place systems should be engineered for specific projects to meet all code requirements regarding slab reinforcement and steel joist strength and installation.



(Fig.5) Steel joists are produced in a variety of sizes to accommodate longer spans.



## 6.2 | Suspended Cast-in-Place Decks

**Affordability:** This system is one of the most expensive floor systems for residential construction. The cost for materials for a residential project is approximately \$15.00 per square foot, not including labor.<sup>7</sup>

**Coastal Consideration:** This floor system qualifies as wind-resistant construction, and homeowners may be eligible to apply for a reduction in insurance rates in Mississippi.<sup>8</sup>

### GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

#### Retailers in the Gulf Coast area include:

- Green Elephant Construction Supply  
4107 Popps Ferry Road  
D'Iberville, MS 39540

#### Manufacturers being used in the area include:

- Speedfloor USA  
299 Haskel Lane  
Batavia, Ohio 45103

#### Installers in the Gulf Coast area include:

- Bailey Homes
- Delta Builders



(Fig.6) Steel joists are anchored to foundation walls with an extended shoe (as shown above) that is then set into concrete.



(Fig.7) The steel joists are spaced 49" on center to allow for 4x8 sheets of plywood to slide in between. The plywood is removed after the concrete is cured.



(Fig.8) A professional concrete installer spreads concrete over the formwork. Here, rebar is used instead of steel mesh for reinforcement.



## Floor Finishes

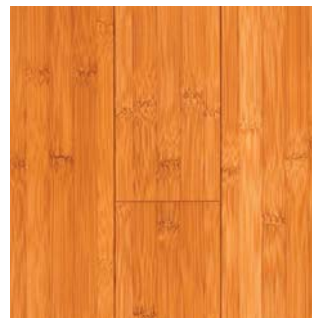
**Overview:** Most residential floors consist of a structural subfloor (such as a concrete slab or 3/4" plywood) covered by a finish flooring material that creates the finished surface. A wide range of flooring materials and floor coverings can be used to create a floor with the desired durability, appearance, environmental benefits, and other qualities.

Many types of floor finishes are available, including solid wood, engineered wood, laminate, vinyl, rubber, linoleum, natural- or synthetic-fiber carpet, ceramic tile, and stone. The choice of finish material will depend on many factors. Comfort and appearance are high priorities in the living areas of the house, while durability and ease of maintenance are important in high-use areas and especially in wet rooms such as kitchens and bathrooms. Affordability and ease of installation are key factors that vary greatly among floor finishes. Finally, the impact of the choice on the environment and on the indoor air quality of the house should be considered.

## INSTALLATION

**Construction Process:** The finish floor is installed late in the process to protect it from damage during construction. Many finish floors are installed directly on top of the subfloor using a variety of methods including construction adhesive and nails. Laminate and engineered wood floors can be glued down or installed as a "floating floor" that is laid over a foam underlayment but not glued to the subfloor. Some tile floors may require an additional layer of a cement-based tile backer board to ensure durability.

(Figs.9-18) Shown at right are examples of typical floor finishes used in residential applications.



(Fig.9) Bamboo



(Fig.10) Cork



(Fig.11) Hardwoods: Oak



(Fig.12) Wood Laminate



(Fig.13) Wool Carpet



(Fig.14) Rubber



(Fig.15) Ceramic Tile



(Fig.16) Stone: Slate



(Fig.17) Vinyl



(Fig.18) Linoleum

### 6.3 | Floor Finishes

**Speed of Construction:** Some flooring materials, such as laminate wood, carpet, and bamboo, are made to be installed quickly. Even unskilled workers may need only hours per room. Other materials, such as tile and hardwood floors, require more time and care for a high quality installation.

**Delivery Method:** A small truck can deliver most types of flooring. Depending on the material, weight can be a factor. Flooring ordered in quantity may come in pallets that can be lifted by a forklift. Carpet comes in large rolls that may require two or more people to handle.

**Required Equipment:** Flooring installed using construction adhesive requires little more than a caulk gun or trowel. Other installations may require a nail gun equipped with finish nails, per manufacturer's specifications. Tile requires simple tools such as trowels; a specialized tile saw may also be required.

**Specialized Labor:** Many types of flooring are suitable for homeowner installation. For instance, tile requires preparation and care, but can be done by unskilled workers. The same applies for many manufactured finishes. High-quality materials such as hardwood floors may require skilled professional installation to ensure proper installation and prevent damage to the flooring.

## PERFORMANCE

**Water Resistance:** Resistance to stains and damage by water and other substances is a key factor to consider when choosing a flooring material. Unfinished wood floors (floors that have not been sealed) are easily stained by water and other liquids. Carpeting, especially light-colored carpeting, shows stains easily. Therefore, in wet rooms such as bathrooms, as well as kitchens, dining rooms, and other food areas, durable and stain-resistant flooring should be chosen. Ceramic tile, linoleum, and some vinyl, wood, or laminate products are good choices.

**Life Span:** Overall durability is another important consideration. Life span of flooring depends on the expected use. Flooring in hallways, living areas, and other high-traffic areas must be able to withstand heavy use. Resistance to scratching by heavy furniture and pets is another factor. Durable materials such as ceramic tile, engineered wood, hardwood, and linoleum can be expected to last for decades if cared for properly. Hardwood floors can often be refinished if worn or damaged, while laminate and engineered floors cannot. Carpeting and some vinyl and synthetic flooring materials are not as durable. Area rugs or carpet tiles are a better choice and much easier to replace than carpeting if stained or worn.

**Common Failure:** Floor finishes fail in different ways. Stone and ceramic tile, if not sealed and cleaned regularly, can accumulate grime and mildew. If not properly installed, they can also crack. Laminate and vinyl flooring can wear out with heavy use; inexpensive products may fail within a few years. Hardwood floors can scratch and, if not sealed properly, stain or discolor. Carpet can wear out, stain, and collect dirt and mold. Linoleum and vinyl can crack or peel. Flooring must be carefully selected and maintained to avoid common sources of failure.



(Fig.19) Tile flooring is a durable, easy to clean choice for kitchens, bathrooms, laundry rooms, entryways, and other areas.



(Fig.20) Tile can be installed by professionals or homeowners. Shown here, 12" ceramic tile is being installed by skilled and unskilled volunteers.



## DESIGN

**Environmental Impact:** Materials used for flooring vary in both sustainability and their impact on the indoor air quality of a house. Rare or slow-growing woods, petroleum-based products such as vinyl, and certain types of stone, such as marble or granite, have environmental drawbacks.

A variety of environmentally preferable flooring products are available. Some, such as bamboo, cork, and other woods, are produced from fast-growing, renewable sources. Bamboo, however, is typically sourced from China, and the impact of shipping offsets some of its environmental benefit. Others, such as carpeting and tile, can include recycled content. The type and source of material should be carefully considered for its environmental impact.

Products that contain formaldehyde, harmful sealants, or other materials that off-gas, such as synthetic rubber and vinyl, should be avoided or used only in well-ventilated areas.<sup>9</sup> Linoleum is an environmentally preferable alternative to vinyl and can last 30-40 years. Carpeting should be avoided, as it collects dirt and mold, especially in moist climates; area rugs are a better choice.

**Versatility / Flexibility:** The wide range of products and materials available means that there is a flooring type for every application. Rarely will a single type of flooring be suited for all of the rooms of the house. At minimum, one type of flooring for wet rooms (kitchen, bathroom, laundry room) and one type of flooring for living areas (living, dining, and bedrooms) should be chosen. Additional types of flooring can be added for their aesthetic qualities or for special applications. While carpeting has its drawbacks, its comfort and quiet may be desirable for bedrooms. A high-quality, aesthetically pleasing hardwood, stone, or parquet floor could be chosen for an entrance-way or main living area for design impact.

**Market Exposure:** While flooring materials are sold everywhere, local selections can be limited, particularly when it comes to environmentally preferable flooring. However, materials such as bamboo are increasingly common. Shop around and check specialty flooring stores as well as major building supply outlets for a greater selection of products.

**Affordability:** Flooring is subjected to a great deal of wear and greatly impacts the look and feel of a house. It makes sense to choose a high enough quality flooring to meet the expected need while still being affordable. For wood floors, consider, in addition to hardwood, the range of high-quality laminate and engineered wood floors (such as bamboo and cork). Softwoods, such as pine, can be used as well. In bathrooms and kitchens, consider lino-

leum, ceramic tile, and some laminate or engineered materials. Carpeting, although affordable, should be avoided in most cases; consider area rugs instead.



**(Fig.21)** Laminate flooring can recreate the look of many different types of wood. However, low-quality laminate flooring may wear out within just a few years.



**(Fig.22)** While hardwood flooring is more common, some soft-woods, like pine (shown here), can make warm, comfortable floors.



## GULF COAST AVAILABILITY / LOCAL MANUFACTURERS

Most flooring is widely available at building material or flooring suppliers, including Lowe's, Hood's, and The Home Depot. The following is a partial list of suppliers that carry specialized and/or sustainable flooring materials:

### Earth Weave Carpet Mills, Inc. (Dalton, GA)

- Carpet (Bio-floor)

### Carpet Mart Gautier (Gautier, MS)

- Cork (USFloors Natural Cork)
- Bamboo (USFloors, Teragren)

### Carpet Mill Connection (Gulfport, MS)

- Cork (USFloors Natural Cork)
- Bamboo (USFloors)

### Bay Carpet & Interiors (Waveland, MS)

- Cork (USFloors Natural Cork)
- Bamboo (USFloors)

### Stafford Tile & Stone (New Orleans, LA)

- Glass tile (Oceanside Glasstile)

### Libbies Flooring (Biloxi, MS)

- Bamboo (Teragren)

### Steve Nall Tile & Install (Ocean Springs, MS)

- Bamboo (Teragren)

### Accent on Design (Ocean Springs, MS)

- Bamboo (Teragren)

### King & Co., Inc. (Jefferson, LA)

- Carpet (InterfaceFLOR Carpet Tiles)

### Dal-Tile (Ridgeland, MS)

- Tile (Quarry Tile Natural Hues Tile)

### Rickert Tile (Metairie, LA)

- Tile (Terra Green Ceramics)



(Fig.23) Stone flooring, such as slate tile shown here, can be beautiful and durable. However, slate can be hard to clean and can stain if not properly sealed.



(Fig.24) Bedrooms are a good place for carpeting, which is quiet and comfortable. However, carpeting can collect dirt and mold, and can off-gas.