
Structural Design Criteria for Raised Floor Systems

Course No: S04-013

Credit: 4 PDH

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Our 2002–2003 Project House is a 5,800 square-foot Mediterranean style custom home, designed by the Evans Group of Florida, and built in North Dallas. Due to the expansive nature of the soil at this site, our engineer recommended that we build the house on a classic pier-and-beam foundation.

My company partnered with the Southern Pine Council to construct a raised wood floor foundation that will not only stand the test of time but also handle the expansive clay soil problems in the area. Another goal was to ensure that the family has a comfortable home – built on a sturdy, dry, and stable foundation.

A raised floor system is an assembly of beams, girders, joists and sheathing panels comprised of various engineered wood framing products, all properly sized and connected together. A raised floor system is designed to elevate the living space off the ground, isolating it from moisture and pests. American homes have been built on raised wood floor systems since Colonial times, and the aesthetic and practical reasons for building a raised home still apply today.

Many terms are frequently used to describe raised floor systems in different regions of the country. Examples include *raised wood floor*, *raised wood platform floor*, *raised floor foundation*, and *crawlspace construction*. A raised floor can also be supported by a variety of foundation types. Examples of the most common foundation types include spot pier-and-beam foundations, continuous foundation walls (stem walls), and grade beam foundations.



Regardless of the exact term or foundation type used, a raised floor system provides numerous advantages. This publication takes an in-depth look at these advantages and explains the tangible and intangible benefits of raised floor living. It also addresses basic construction elements, providing valuable guidance to builders constructing a raised floor.

Together, homeowners, builders, insurance underwriters, architects and others can use this publication to examine the benefits of a raised floor system during the planning of a residential or commercial structure, and to make informed decisions. Once a raised floor is selected, the construction section of this publication provides the details required to properly design, specify and build the system.

The raised floor system can help a builder deliver customer satisfaction for discerning clients who demand homes with comfort and distinction. With the know-how to properly construct a raised floor, smart builders can establish a reputation for quality and craftsmanship that distinguishes them from the competition.



YNH Media, LP, based in Dallas, Texas, produces the national television series, *Michael Holigan's Your New House*, seen on 135 broadcast stations and cable by more than 2 million viewers every week. MichaelHoligan.com receives over 400,000 unique visitors per month. Both the TV show and Internet site are popular with builders and consumers who are interested in building, buying, or remodeling their home.



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The Southern Pine Council does not test lumber or establish design values. The purpose of this construction guide is to collect and organize data available from other sources for the convenience of builders, engineers, architects and other professionals. Neither the Southern Pine Council, nor its members, warrant that the data from such sources on which the recommended uses of Southern Pine lumber contained herein are based is correct, and disclaim responsibility for injury or damage resulting from the use of such data.

The conditions under which lumber is used in construction may vary widely, as does the quality of workmanship and construction methods. Neither the Southern Pine Council nor its members have knowledge of the quality of the workmanship or construction methods used on any construction project, and, accordingly, do not warrant the design or performance of the lumber in completed structures.

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WOOD-FRAME CONSTRUCTION

Wood-frame construction is the predominant method for building homes and multi-family structures in America, resulting in the world's best-housed population.

Increasingly, wood framing is also being used in commercial and industrial buildings. Raised floor systems can readily be used in "ordinary" construction of commercial buildings where exterior fire exposure is a concern. In ordinary construction, exterior walls are constructed with noncombustible materials or fire-retardant treated wood, with floors, roofs and interior structural elements built with wood framing.

Wood-frame buildings are economical to build, heat and cool, and provide maximum comfort to occupants. Wood construction is readily adaptable to traditional, contemporary and the most cutting-edge building styles. Its architectural possibilities are limitless and its durability spans the centuries.

Throughout history, wood has found favor as a building material due to its strength, economy, workability and beauty, and its ability to last has been demonstrated again and again. From the ancient temples of Japan and the great stave churches of Norway to the countless historic North American buildings, wood construction has proven it can stand the test of time.

With any building material or product, sound construction and installation practices must be followed to assure durability and trouble-free performance.

Building codes generally focus on life-safety issues, with minimal considerations given to serviceability. The details and recommendations contained in this publication reflect construction practices that are intended to not only comply with building codes, but also produce sound, low-maintenance wood-frame buildings. Primary emphasis is on the foundation and the raised floor system. Wherever possible, the provisions described in this publication conform to typical building code provisions; however, consult your local building code official for specific requirements.

The Raised Floor Advantage

Reasons to Select a Premium Floor System

THE PREMIUM FLOOR SYSTEM

Satisfying the higher expectations of today's homebuyer can present challenges to the design-build professional.



Meeting these challenges begins with a premium floor system.

Designers and builders who offer the raised floor option, framed with strong, durable, renewable wood, create value for themselves and their clients. In regions where raised floors are not common, builders can establish a market niche by offering a distinctive and affordable alternative. Clients who

invest in this type of home accrue lifelong benefits such as curb appeal, comfort, practicality and lasting value.

SUSTAINABLE CONSTRUCTION

The raised floor is also the right choice for the environment — it is a sustainable construction system. First and foremost, wood is a renewable resource that takes far less energy to produce than concrete or steel. Furthermore, future structural modifications, additions or repairs can be performed more easily, extending the useful life of the structure. Builders can complete these tasks with less environmental impact, consuming less energy and avoiding expensive technologies. Finally, construction of a pier-and-beam foundation in association with the raised floor system is far less disruptive to the natural surroundings than a slab-on-grade (slab-on-ground) foundation. With a pier-and-beam foundation, less damage occurs to the root systems of neighboring vegetation.

“A raised floor separates the living area from the earth in the classic sense of distinguishing the sacred from the profane. The home is sacred, and symbolically you make it more suitable for living by removing it from the ground. In so doing, you isolate the structure from earth-bound perils — the profane — such as animal and insect pests, flooding and other moisture sources that lead to illnesses, rot and decay.”

Kevin Harris, Architect – Baton Rouge, LA
www.kevinharrisarchitect.com

VALUE-ADDED OPTIONS

The raised floor system gives the builder and client an opportunity to explore ideas that can expand the livability and appeal of the home.

- The raised floor takes full advantage of amenities such as a front porch, a screened back porch, or a deck because they are natural extensions of the structure's elevated platform.

- Inside the home, attractive wood flooring is a great upgrade to offer the client, adding a dash of sophistication. A wood floor installed over wood joists also makes for a very comfortable, allergy-free walking surface.

- Another value-added option becoming quite popular in coastal areas of the United States where decay and termite infestation is a problem is “whole-house” pressure-treated framing. Pressure-treated lumber can readily be used throughout the whole house or in the floor system alone. With the new generation of wood preservatives (see pages 12-13), the homeowner and builder have even more choices today.

Construction Advantages *The flexibility of the raised floor offers several advantages in the construction phase*

easy scheduling

Construction of a raised floor may help accommodate the scheduling of trades, saving time. For example, concrete and masonry work does not have to wait on plumbing installation and inspection, which is the case with slab-on-grade. This can help expedite construction.

flexible design

Changes to the floorplan, such as relocation of a toilet or lavatory, are simple and economical compared to slab systems.

soil variations

A raised floor can be a cost-effective solution to construction in poor soil conditions, where movement of expansive clays or the subsidence of organic soils is a concern.

reduced cut and fill

For sloped lots, a raised floor on piers can be more economical and practical than building a “cut and fill” slab foundation. Less soil is disturbed, reducing erosion. The piers eliminate the need for reinforced retaining walls and other extraordinary measures to provide proper site drainage, and plumbing connections to city services may be simplified.

floodplain fix

Flooding is always a concern. Raising a slab with fill to meet minimum flood zone elevation can be expensive, and takes time and care to properly compact. A raised floor system provides a practical and affordable solution for meeting code requirements in flood-prone areas (see pages 8-9).

BUILDING TO HIGHER EXPECTATIONS

Homebuyers expect more from their home than ever before, and more is not always measured in total square feet of living area. After all, a home is often a person's largest investment, so value is placed on both the tangible and intangible elements that make a home livable, not merely functional.

A recent national survey¹ asking consumers to define their American Dream House revealed more interest in comfort and style than size. And almost half the respondents – 49% – characterized their dream house as a safe, comfortable haven instead of a designer show house.

So, homebuyers of today desire a living environment that nurtures and protects. The home should nurture the spirit with amenities that provide comfortable, special places for family gatherings, personal retreat and self-expression. The home should offer occupants protection from moisture and pests, providing a healthy indoor environment and a structurally sound, long-lasting living space.

¹ Taylor Nelson Sofres Intersearch, Princeton, NJ for The Hardwood Information Center, 2002.

PEACE OF MIND FOR BUILDER AND CLIENT

Although no system is perfect for all conditions, the raised floor offers some real advantages when it comes to design reliability, especially where moisture is an issue.

- By design, the raised floor removes a structure from contact with the ground, isolating the living space from ground moisture. Therefore, a raised floor system is less susceptible to foundation-related moisture problems.

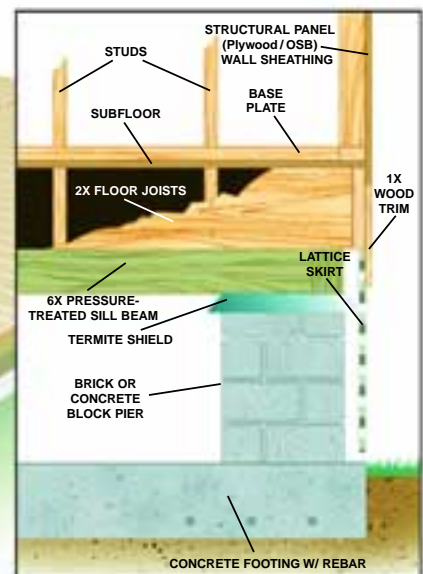
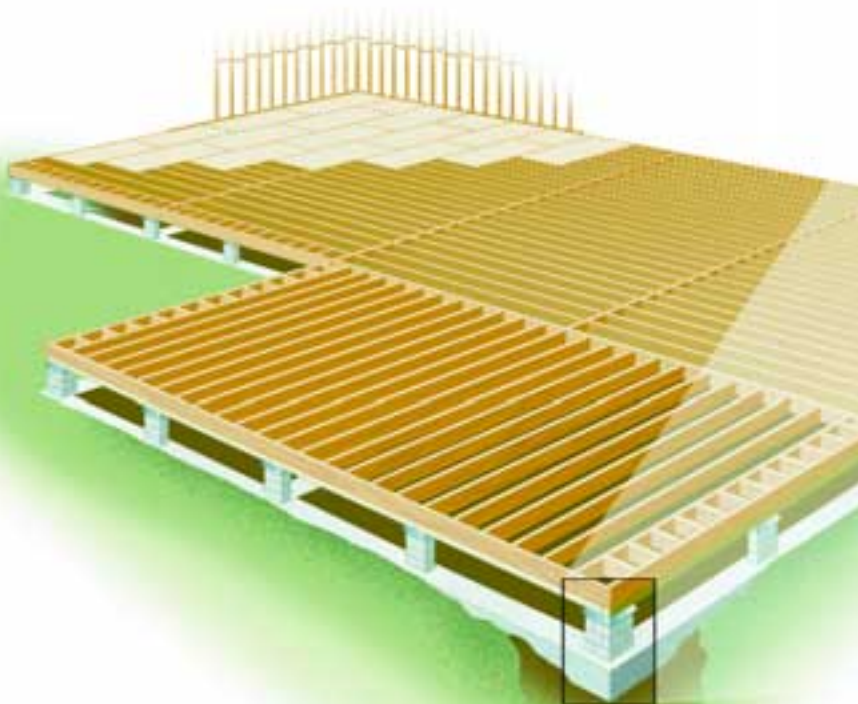
- Callbacks for foundation-related problems are much easier to fix. For example, a plumbing leak below a slab is difficult and costly to locate, access and repair.

The leak may also drive moisture into the living area. This is not a problem with the raised floor.

- The raised floor helps keep moisture and termites at bay. Properly installed termite shields help repel these unwelcome visitors and the crawlspace makes termite inspection simple and infestation easier to spot. In slab construction, termite infestation or moisture intrusion may not be apparent until it is too late, and cracks in the slab can be expensive to repair.



Key Elements of the Raised Floor System



Detail of a pier-and-beam system on a continuous footing.

Architecturally Speaking

Classic style.

Homebuyers are rediscovering the classic elegance that a raised floor design adds to the look of the American home. Drive through the older neighborhoods of your community. The homes with ageless grace and beauty are usually raised. Visually, the raised foundation functions as a pedestal, enhancing curb appeal regardless of architectural style.



GEORGIAN — The strong stature of this Georgian style residence is enhanced by raising it above ground. The portico is transformed into a ritualistic entry process with the addition of a few steps. It punctuates the building's facade versus yielding a mundane transitional space. A more evocative entry concedes to the prominence of the raised residence.



CARIBBEAN — The dual-pitched roof form envelopes the expansive, wrapping porch space of this rural abode. By raising the structure, one becomes more contained in this space producing a welcoming, social feeling. Sometimes adding height to a structure can be overpowering but here it is celebrating.

Building Professionals Speak

"From the beginnings of architecture, well-designed homes have all had a top, middle and a bottom. The introduction of slab-on-grade foundations removed the 'bottom' and the homes look awkward. As I review home styles with my clients, typically the houses they like are elevated. A lot of this goes back to historical associations."

Kevin Harris, Architect – Baton Rouge, LA

"Usually my clients are asking for traditional houses. A raised floor provides architectural proportioning that is much more enticing than slab-on-grade. Then I explain the flexibility that a raised floor allows with adjustments and changes to plumbing and other mechanicals."

Dennis Brady, Architect – New Orleans, LA

"With a traditional style, such as a Williamsburg look or a raised cottage, the elevated first floor adds something to the overall aesthetic of the project. Typically, people like to have that raised front porch."

Derry Hargett, Architect – Mobile, AL



BUNGALOW — The simplicity of the interaction of two masses, the entry porch and the house, creates this Bungalow style. The porch mass maintains a presence in both the slab-on-grade and raised-floor versions, yet competition develops with the house in the slab-on-grade version.

The slight elevation of the raised Bungalow amplifies its simple design. A small gesture such as this keeps one form from overpowering the other.



WEST INDIES — The exposed piers of the raised residence elongate the narrow, linear porch columns, in turn, stretching its height beyond its physicality. The heavy, flat presence of the slab-on-grade model can be contrasted to the strong, welcoming air of the raised model. Raising the design simply allows the West Indies style to visually own its site instead of weighing it down.

Uplifting comfort.

Inside the raised floor home, there are special qualities that nurture the body and soul. The feeling is warmer, more intimate.

Raise the floor above the ground and the visual perspective changes. The feeling is more secure. An ordinary view from the window becomes a vista. There is calm and quiet above the din of street noise. The subtle "cushion" of a wood floor system provides a more comfortable walking surface, putting less stress on the back, legs and feet.

“A conventional foundation benefits from the aesthetics and the function of the house. You have tremendous flexibility to make modifications with a raised floor. On slab, you’re cast in concrete. With a raised floor, you can adjust the construction schedule to meet your trades. We can get the house underway and not have to wait for the plumber. With slab, you can’t pour until the plumber finishes.”

Carson Looney, Architect – Memphis, TN

“I have a little saying that has always served me well with clients, ‘Good home building should be a marriage between practicality and aesthetics.’ The raised floor works in both respects with homes of all sizes. Homebuyers are discovering that truly wonderful and aesthetic spaces can be built on a smaller scale with quality lumber, adding nice amenities and finishes. A raised foundation enhances their investment.”

Bobby DeVillier, Builder – Baton Rouge, LA

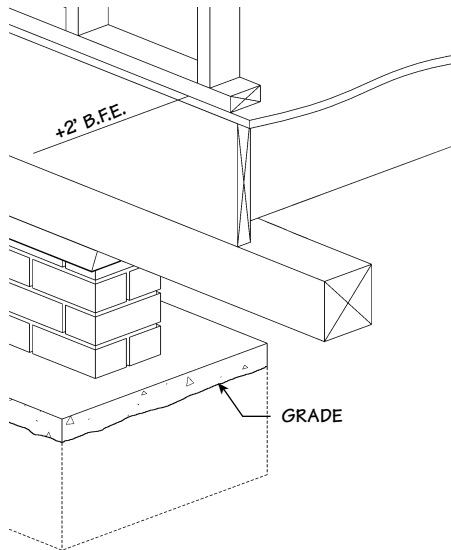
Build the Affordable Alternative

The 2,744 sq. ft. footprint of this two-story custom home was used as the basis for the foundation cost comparisons in Table 1, and for calculating foundation + flood insurance costs in Table 3, page 9. The footprint includes the porches, but not the garage.

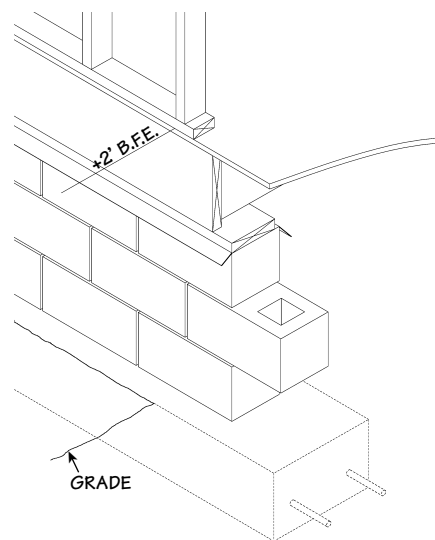


A raised wood floor system is a cost-competitive alternative to a concrete slab system, especially in areas where the builder must meet a minimum “lowest floor elevation” at or above the Base Flood Elevation (BFE) required by local floodplain management ordinances.

As shown in Table 1, the cost of building a raised floor compares favorably to the cost of a slab. Table 1 summarizes the cost of just the foundation for four common system types – two raised floor options and two slab options. The spread between the four options is only \$1,735, with



Raised Floor – Pier-and-Beam Foundation



Raised Floor – Stem Wall Foundation

Table 1 Cost-Comparisons: Raised Floor vs. Slab						
RAISED FLOOR OPTION – PIER-AND-BEAM FOUNDATION + 2 BFE						
	Item	Amount	Material	Labor	Unit Cost	Cost
Excavation	Footings	10.9 CY	–	23.45	23.45	\$ 255
Termiticide	Soil Treatment	333 SF	0.24	0.21	0.45	\$ 150
Footings	Concrete	14.4 CY	92.00	39.78	131.78	\$1,899
	#5 Rebar	296 LF	0.29	0.26	0.55	\$ 163
Foundation	CMUs	500 Units	1.68	2.61	4.29	\$2,145
	#5 Rebar	222 LF	0.29	0.26	0.55	\$ 122
	Concrete	2.7 CY	92.00	39.78	131.78	\$ 354
Beams	6x6 PT	346 LF	3.08	0.60	3.68	\$1,273
Band Joists	2x12 PT	216 LF	1.70	0.55	2.25	\$ 486
Joists	2x12 PT	1910 LF	1.70	0.55	2.25	\$4,298
Anchor Straps	1-1/4x20 ga.	62 Each	0.89	–	0.89	\$ 55
Porch	PT T&G Flooring	585 LF	0.41	0.20	0.61	\$ 359
Insulation	R-19 Fiberglass	1920 SF	0.35	0.10	0.45	\$ 864
Subfloor	19/32 Sturd-I-Floor	1920 SF	0.57	0.29	0.86	\$1,651
Total Estimated Cost for Raised Floor Option – Pier-and-Beam						\$14,074
RAISED FLOOR OPTION – STEM WALL FOUNDATION + 2 BFE						
	Item	Amount	Material	Labor	Unit Cost	Cost
Excavation	Footings	10.9 CY	–	23.45	23.45	\$ 255
Termiticide	Soil Treatment	650 SF	0.24	0.21	0.45	\$ 293
Footings	Concrete	7.3 CY	92.00	39.78	131.78	\$ 961
	#5 Rebar	442 LF	0.29	0.26	0.55	\$ 243
Foundation	CMUs	734 Units	1.68	2.61	4.29	\$3,150
	#5 Rebar	311 LF	0.29	0.26	0.55	\$ 171
	Concrete	1.8 CY	92.00	39.78	131.78	\$ 242
Beams	6x6 PT	125 LF	3.08	0.60	3.68	\$ 460
Band Joists	2x12 PT	216 LF	1.70	0.55	2.25	\$ 486
Joists	2x12 PT	1910 LF	1.70	0.55	2.25	\$4,298
Sill Plates	2x8 PT	221 LF	1.03	0.22	1.25	\$ 276
Anchor Bolts	1/2x6"	50 Each	0.28	–	0.28	\$ 14
Porch	PT T&G Flooring	585 LF	0.41	0.20	0.61	\$ 359
Insulation	R-19 Fiberglass	1920 SF	0.35	0.10	0.45	\$ 864
Subfloor	19/32 Sturd-I-Floor	1920 SF	0.57	0.29	0.86	\$1,651
Total Estimated Cost for Raised Floor Option – Stem Wall						\$13,723

SOURCE: Estimate prepared by Thomas Stevens, III, Florida Certified Building Contractor, St. Pete Beach, Florida, using MEANS cost data, January 2003. Based on a 2,744 sq. ft. foundation footprint for a two-story house required to meet the strict Florida Building Code. BFE = base flood elevation CY = cubic yards SF = square feet LF = lineal feet CMUs = concrete masonry units PT = pressure treated T&G = Tongue & Groove

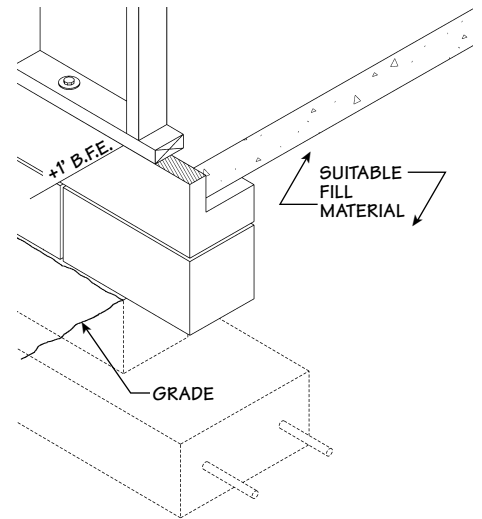
the cost of the elevated concrete slab option (at +1 BFE) the most expensive at \$14,751, and the monolithic concrete slab-on-grade (at BFE) the least expensive at \$13,016. The two raised wood floor options (at +2 BFE) priced in between at \$14,074 for the pier-and-beam and \$13,723 for the stem wall system.

In addition to cost-competitive construction for the builder as shown, a raised floor can mean significant savings for homeowners in flood-prone areas. Tables 2 and 3 (pages 8 and 9) show how homeowners can realize dramatic

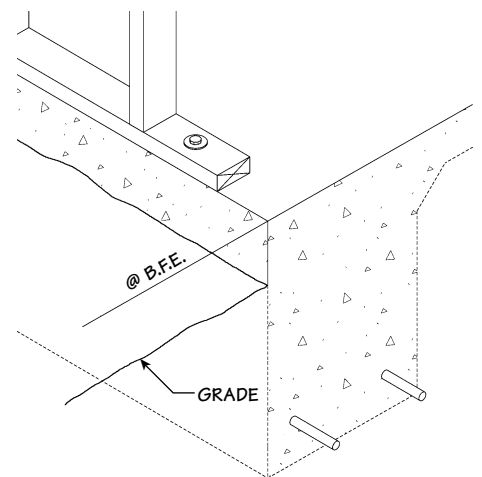
reductions in annual flood insurance premiums with a raised floor system. Furthermore, the initial investment in a raised floor more than pays for itself over a 30-year mortgage. For this example, the net result for choosing a pier-and-beam raised wood floor at +2 BFE instead of a concrete slab-on-grade (slab-on-ground) at BFE is an overall savings of \$6,605 for the homeowner as shown in Table 3 on page 9. Savings begin immediately and grow larger during the life of the mortgage as shown in Figure 1 on page 9.

Table 1 Cost-Comparisons: Raised Floor vs. Slab (continued)

SLAB OPTION – ELEVATED ON BACKFILLED PERIMETER WALL + 1 BFE						
	Item	Amount	Material	Labor	Unit Cost	Cost
Excavation	Footings	10.9 CY	–	23.45	23.45	\$ 255
Termiticide	Soil Treatment	2500 SF	0.24	0.21	0.45	\$1,125
Exterior Footings	Concrete	7.3 CY	92.00	39.78	131.78	\$ 961
	#5 Rebar	442 LF	0.29	0.26	0.55	\$ 243
Foundation	CMUs	734 Units	1.68	2.61	4.29	\$3,150
	#5 Rebar	311 LF	0.29	0.26	0.55	\$ 171
	Concrete	1.8 CY	92.00	39.78	131.78	\$ 242
Interior Footings	Concrete	8.2 CY	92.00	39.78	131.78	\$1,076
	#5 Rebar	502 LF	0.29	0.26	0.55	\$ 276
Anchor Bolts	1/2x6"	50 Each	0.28	–	0.28	\$ 14
Fill	Compacted Fill	156 CY	10.00	3.13	13.13	\$2,049
Slab	Finish	2504 SF	–	0.42	0.42	\$1,052
	Concrete	30.6 CY	92.00	43.20	135.20	\$4,137
Total Estimated Cost for Slab Option – Elevated						\$14,751
SLAB OPTION – MONOLITHIC ON GRADE at BFE						
	Item	Amount	Material	Labor	Unit Cost	Cost
Excavation	Footers	10.9 CY	–	23.45	23.45	\$ 255
Termiticide	Soil Treatment	2500 SF	0.24	0.21	0.45	\$1,125
Exterior Footings	Concrete	22.9 CY	92.00	39.78	131.78	\$3,020
	#5 Rebar	442 LF	0.29	0.26	0.55	\$ 243
Interior Footings	Concrete	8.2 CY	92.00	39.78	131.78	\$1,080
	#5 Rebar	502 LF	0.29	0.26	0.55	\$ 276
Anchor Bolts	1/2x6"	50 Each	0.28	–	0.28	\$ 14
Fill	Compacted Fill	82 CY	10.00	3.13	13.13	\$1,075
Formwork	2x8 Exterior	221 LF	0.90	1.59	2.49	\$ 550
	2x4 Interior	95 LF	0.40	1.59	1.99	\$ 189
Slab	Finish	2504 SF	–	0.42	0.42	\$1,052
	Concrete	30.6 CY	92.00	43.20	135.20	\$4,137
Total Estimated Cost for Slab Option – Monolithic on Grade						\$13,016



Slab – Elevated on Backfilled Perimeter Wall



Slab – Monolithic on Grade

SOURCE: Estimate prepared by Thomas Stevens, III, Florida Certified Building Contractor, St. Pete Beach, Florida, using MEANS cost data, January 2003. Based on a 2,744 sq. ft. foundation footprint for a two-story house required to meet the strict Florida Building Code. BFE = base flood elevation CY = cubic yards SF = square feet LF = lineal feet CMUs = concrete masonry units PT = pressure treated

Flooding: Rise Above the Risk

Elevating a structure can prevent or significantly reduce flood damage. Properly elevated and constructed, a raised floor foundation can help keep a home far above flood waters. In addition, a raised floor can provide significant savings in flood insurance premiums as shown in Table 2.



Tropical Storm Isidore flooded the slab-on-grade home on the right. The raised floor home on the left stayed dry.

Many homeowners have incorrectly assessed flood risks to their property. The Federal Emergency Management Agency (FEMA) estimates that 10 million households are located in flood-prone areas. But between 20% and 25% of all flood insurance claims are paid to people living outside the high-risk areas. According to FEMA, there is a 26% chance of experiencing a flood during the life of a 30-year mortgage compared to a 4% chance of fire.

In the face of mounting flood losses and escalating costs to taxpayers for disaster relief, Congress created the National Flood Insurance Program (NFIP) in 1968. The federal government makes flood insurance available to NFIP participating communities that adopt and enforce ordinances to reduce future flood risks. This insurance is avail-

able to all owners of insurable structures whether in or outside the floodplain.

It is the task of FEMA to identify and map flood hazards nationwide. Flood Insurance Rate Maps (FIRMs) distinguish several flood hazard zones, including the Special Flood Hazard Area, defined as an area inundated by a flood that has a 1% chance of being equaled or exceeded in any year. This benchmark is also called the Base Flood Elevation, or BFE. The fundamental NFIP requirement for every participating community is that any new or substantially improved residential building must have its lowest floor elevated to or above the BFE on the FIRM.

By elevating a home to meet NFIP requirements, a property owner can reduce the annual flood insurance premium by hundreds of dollars. The higher the floor elevation, the lower the flood insurance premium. Over the life of a mortgage, this can result in significant savings. See Tables 2 and 3. However, elevating to or above the BFE does not eliminate the requirement to purchase flood insurance in a Special Flood Hazard Area.

Considering other options – slab atop dirt fill or slab on a backfilled perimeter wall – the raised floor may be the most practical and cost-effective way to protect your property and meet local building ordinances in flood-prone areas. Regardless of the foundation you choose, raising the floor to (or above) BFE can help avoid costly mitigation measures such as relocation, demolition, or rehabilitation in the aftermath of a flood.

For more information on flood risk and flood insurance, visit www.fema.gov.

REDUCE FLOOD RISK AND INSURANCE PREMIUMS WITH A PRACTICAL RAISED FLOOR

There are substantial savings in annual flood insurance premiums when a home is raised above the base flood elevation (BFE), as Table 2 illustrates. Actual savings could be even greater because the Federal Emergency Management Agency expects flood insurance premiums to increase 5% per year to cover anticipated flood claims.

Dwelling Value	SINGLE-STORY RESIDENTIAL CONSTRUCTION				MULTI-STORY RESIDENTIAL CONSTRUCTION			
	At BFE ²	Plus 1 foot ³	Plus 2 feet ³	Plus 3 feet ³	At BFE ²	Plus 1 foot ³	Plus 2 feet ³	Plus 3 feet ³
\$ 75,000	\$727	\$461	\$299	\$264	\$537	\$330	\$299	\$264
\$100,000	\$747	\$481	\$319	\$284	\$557	\$350	\$319	\$284
\$125,000	\$767	\$501	\$339	\$304	\$577	\$370	\$339	\$304
\$150,000	\$787	\$521	\$359	\$324	\$597	\$390	\$359	\$324
\$175,000	\$807	\$541	\$379	\$344	\$617	\$410	\$379	\$344
\$200,000	\$827	\$561	\$399	\$364	\$637	\$430	\$399	\$364
\$225,000	\$847	\$581	\$419	\$384	\$657	\$450	\$419	\$384
\$250,000	\$865	\$599	\$437	\$402	\$675	\$468	\$437	\$402

SOURCE: Table provided by Alpha Insurance LLC, Gretna, Louisiana (www.alpha.com).

¹ National, unadjusted rates for Flood Zone A. Includes \$30 policy fee.

² BFE is Base Flood Elevation or the elevation that a flood will reach with a 1% probability any given year.

³ Plus 1 foot means the living area floor elevation is at least 6 inches above BFE, Plus 2 feet means at least 18 inches above BFE, and Plus 3 feet means at least 30 inches above BFE.

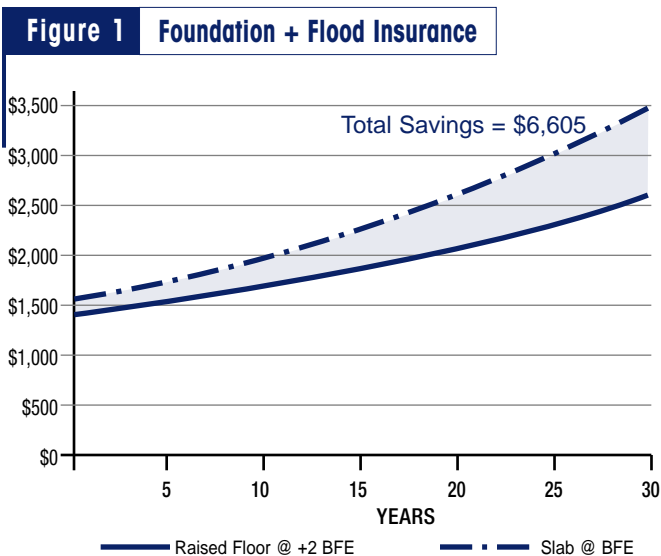
A RAISED FLOOR MORE THAN PAYS FOR ITSELF OVER A 30-YEAR MORTGAGE

In a flood hazard area, the raised floor can mean real savings in annual flood insurance premiums, lower annual housing costs, and overall lower cost over the lifetime of a fixed-rate 30-year mortgage.

The owners of the example raised floor home pictured on page 6, will save \$6,605 (\$36,630 minus \$30,025) over their 30-year mortgage. The savings calculation, shown in Table 3 and Figure 1, is based on annual payments of principle plus interest (P+I) for only the cost of the foundations (Table 1), at an interest rate of 6%. In addition, the corresponding annual flood insurance premiums for a multi-story residence (Table 2) were used, assuming 5% annual increases. Finally, the savings calculation is based upon the net present value of the foundation plus insurance, discounted back to today's dollars at a rate of 4%.

Year	RAISED FLOOR + 2 BFE			SLAB-ON-GRADE at BFE		
	P + I (annual)	Flood Insurance (annual)	Total	P + I (annual)	Flood Insurance (annual)	Total
1	\$1,008	\$ 379	\$1,387	\$ 932	\$ 617	\$1,549
10	\$1,008	\$ 588	\$1,596	\$ 932	\$ 957	\$1,889
15	\$1,008	\$ 750	\$1,758	\$ 932	\$1,222	\$2,154
20	\$1,008	\$ 958	\$1,966	\$ 932	\$1,559	\$2,491
30	\$1,008	\$1,560	\$2,568	\$ 932	\$2,540	\$3,472
Total Cost in Today's Dollars: \$30,025			Total Cost in Today's Dollars: \$36,630			

SOURCE: Southern Pine Council calculation based on Tables 1 and 2.
P + I = Principle plus Interest, BFE = Base Flood Elevation



Raised Floors Help this Community Meet Floodplain Management Goals



The National Flood Insurance Program (NFIP) Community Rating System (CRS) provides discounts on flood insurance premiums in those communities that establish floodplain management programs that exceed NFIP minimum requirements.

St. Tammany Parish in Louisiana is one of those communities. Citizens of St. Tammany receive a 5% discount on their premiums due to ordinances that more strictly define the systems and techniques used to construct a foundation in flood-prone areas. Raised floors are part of the solution.

In designated flood zones, the parish limits the volume of fill that can be placed to elevate the floor of a structure above base flood elevation (BFE). These measures help prevent displacement of floodwaters onto adjacent property. Furthermore, if the structure must be raised over a certain height above natural ground grade to meet BFE, then the builder must use pier-and-beam or pile construction. These open foundations do not displace floodwaters and also allow high velocity waters to flow under the structure.

St. Tammany is also an active participant in the Federal Emergency Management Agency (FEMA) floodproofing program. Under programs such as Flood Mitigation Assistance, FEMA provides grants to help owners of flood-prone homes have their houses raised. To qualify, a homeowner must have a federal flood insurance policy in effect and must have made at least two claims on the policy within the past 10 years.



Raising a house can be a costly option for the homeowner. This slab-on-grade home in St. Tammany Parish, Louisiana, was raised at a total cost of approximately \$150,000. A matching grant from FEMA's Pre-Disaster Mitigation program pays 75% of the expense to raise a home, with the homeowner bearing the remaining 25% of the cost.

Wood Framing Products¹

To ensure construction of a safe and durable structure, wood products need to conform to appropriate product standards as specified in building codes.

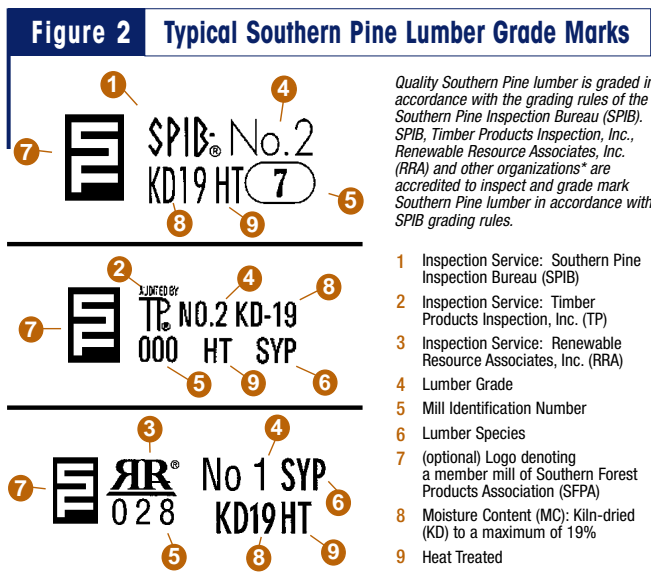
Traditional solid-sawn lumber became the first wood framing product to be governed by a set of industry standards in 1924. Since that time, industry standards have been established for many other engineered wood framing products. Today, the building consumer can choose from a wide range of excellent wood framing products of consistent quality and uniformity.

LUMBER AND TIMBERS

Dimension lumber, 2" to 4" in thickness, includes solid-sawn and end-jointed lumber. In a floor system, solid-sawn lumber is most commonly used for floor joists, sill beams and girders. Timbers, 5x5 and larger, are frequently used for girders and sill beams in a floor system.

Lumber and timbers must be properly grademarked. Grade marks (Figure 2) identify the grade, species, moisture content, producing mill, and inspection service. The *American Softwood Lumber Standard PS 20*, of the U.S. Department of Commerce, establishes lumber sizes, methodology for assigning design values, nomenclature, inspection and re-inspection procedures, the National Grading Rules, an accreditation program, and other functions.

¹ Additional product information (design values, span tables, etc.) about the materials described in this section can be obtained online from the organizations listed in Table 19 on page 45. ASTM = American Standards for Testing and Materials; AWWA = American Wood-Preservers' Association; ANSI = American National Standards Institute; AITC = American Institute of Timber Construction; TPI = Truss Plate Institute; APA = APA – The Engineered Wood Association; APA EWS = APA Engineered Wood Systems.



*NOTE: Other agencies are accredited by ALSAC to inspect and grade all or selected Southern Pine products according to SPIB Grading Rules, including: California Lumber Inspection Service (CLIS); Northeastern Lumber Manufacturers Association (NELMA); West Coast Lumber Inspection Bureau (WCLIB); and Western Wood Products Association (WWPA).

SOUTHERN PINE LUMBER

Southern Pine is the strongest structural lumber species for framing applications. Due to its high strength and treatability, Southern Pine is a preferred lumber species for building a raised floor. Southern Pine lumber is readily available in a wide range of grades and sizes.

Southern Pine lumber is graded according to the *Standard Grading Rules for Southern Pine Lumber* published by the Southern Pine Inspection Bureau (SPIB). Strength and stiffness values for Southern Pine products in current SPIB rules have been approved by the Board of Review of the American Lumber Standard Committee. These design values enable determination of allowable spans for lumber in specific end uses, including floor joists. Refer to the SPC publication, *Southern Pine Use Guide*, for complete grade descriptions, design values and sample specifications.



Pressure-treated Southern Pine 2x10 floor joists.

TIMBER PILES

Foundation piles are typically peeled, round, pressure-treated Southern Pine timber members, driven and embedded in the ground. Timber piles may be required as a deep foundation for a raised floor system in areas where soil conditions dictate. *ASTM D25 Standard Specification for Round Timber Piles* establishes physical properties and manufacturing requirements. Round timber piles in service for foundation, land and freshwater use should meet AWWA standards in *Use Category 4C* and/or *Commodity Standard C-3, Piles – Preservative Treatment by Pressure Processes*.

GLUED LAMINATED TIMBER

Glued laminated timber, or glulam, is comprised of individual pieces of lumber end-jointed together to produce long lengths, and then bonded together with adhesives to create the required beam dimensions. Glulam is generally used as a girder or beam in a floor system. Glued laminated timber must meet the provisions of *ANSI/AITC A190.1 American National Standard for Structural Glued-Laminated Timber*, or the manufacturer's proprietary code report.

METAL PLATE CONNECTED WOOD TRUSSES

Wood trusses are assembled using dimension lumber and metal connector plates. Trusses used as joists in floor systems are usually the parallel-chord type. Assemblies using prefabricated wood trusses shall meet the provisions of the governing building code, and any additional requirements as set forth in *ANSI/TPI 1 National Design Standard for Metal Plate Connected Wood Truss Construction* and the truss design drawings.

PREFABRICATED WOOD I-JOISTS

Wood I-joists are manufactured using sawn or structural composite lumber flanges and structural panel webs, bonded together with exterior-type adhesives, forming an “I” cross-section. I-joists are commonly used for floor joists. Assemblies using wood I-joists shall meet the provisions of *ASTM D5055 Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists*, the governing building code, and any additional requirements as set forth in the manufacturer’s proprietary code report.

STRUCTURAL COMPOSITE LUMBER

Structural composite lumber (SCL) is manufactured with parallel-laminated veneers or a network of wood strands laminated together with a waterproof adhesive. Common forms of structural composite lumber include parallel strand lumber (PSL), laminated veneer lumber (LVL), and laminated strand lumber (LSL). Structural composite lumber is generally used as a girder, beam or band joist (rim board) in a floor system.



Structural composite lumber beam supports floor trusses.

Structural composite lumber is required to meet the provisions of *ASTM D5456 Standard Specification for Evaluation of Structural Composite Lumber Products*, the building code, and any additional requirements as listed in the manufacturer’s proprietary code report.

STRUCTURAL WOOD PANELS

Wood panels can be manufactured in a variety of ways – as plywood (cross-laminated wood veneer), as oriented strand board or OSB (wood strands arranged in cross-oriented layers), or composite panels (veneer faces bonded to wood strand cores). Structural wood panels are commonly used as floor sheathing in a raised floor system.

Plywood used in structural applications shall meet the provisions of U.S. Department of Commerce *Voluntary Product Standard 1 (PS1) Construction and Industrial Plywood*, or U.S. Department of Commerce *Voluntary Product Standard 2 (PS2) Performance Standard for Wood-Based Structural-Use Panels*, or the manufacturer’s proprietary code report. Oriented strand board (OSB) used in structural applications shall meet the provisions of *Voluntary Product Standard 2 (PS2) Performance Standard for Wood-Based Structural-Use Panels* or the manufacturer’s proprietary code report.



Rim board attaches to prefabricated I-joists.

RIM BOARDS

Rim board can be manufactured using plywood, OSB, glulam, or SCL. Rim board is designed to work in concert with a wood I-joist system, filling the space between the sill plate and the bottom wall plate, or between the top plate and bottom plate in multi-floor construction.

Wood structural panel rim board must meet the provisions of the *Performance Standard for APA EWS Rim Boards* or the manufacturer’s proprietary code report. Glulam rim boards are a resawn grade of glued-laminated timber manufactured in accordance with the *Performance Standard for APA EWS Rim Boards* and *ANSI/AITC A190.1*.

Preservative-Treated Wood Products

Where moisture and termites are a concern, such as in the Southeastern U.S., pressure-treated framing is a prudent choice for floor systems.

PRESSURE-TREATED LUMBER

Generally, when wood is exposed to the elements, excessive moisture, or in contact with the ground, it is susceptible to fungal decay and insect attack. Four conditions are required for decay and insect attack to occur: wood moisture content in excess of 19%, a favorable temperature range (approximately 50° to 90° Fahrenheit), oxygen, and a source of food (wood fiber). If any one of these conditions is removed, infestation and decomposition will not occur. Pressure treatment eliminates wood fiber as a food source.

When treated lumber or plywood is specified for most residential, commercial and marine building applications, waterborne preservatives are preferred. These preservative treatments are clean, odorless and paintable, plus they are EPA-registered for both interior and exterior use.

The American Wood-Preservers' Association (AWPA) has approved several preservative treatments suitable for residential or commercial enclosed (interior) framing applications. For all structural framing uses, pressure-treated lumber must be dried after treatment (air or kiln-dried) to a moisture content of 19% or less before enclosure.

AWPA sets preservative retention levels for treated lumber, based upon intended use. Retention levels refer to the amount of preservative that remains in the cell structure after the pressure treating process is completed. Retentions are expressed in pounds per cubic foot of wood. The higher the number, the harsher the conditions to which the wood may be exposed. Refer to Table 4 (retention levels).

Jobsite fabrication cuts and borings should be field treated with copper naphthanate having a minimum 2% metallic solution (1% solution if 2% not available) in accordance with *AWPA Standard M4*.

Southern Pine has long been a preferred species when pressure treatment with preservatives is required, because of its ease of treatability. The unique cellular structure of Southern Pine permits deep, uniform penetration of preservatives, rendering the wood useless as a food source for fungi, termites and micro-organisms. For more information, refer to the SPC publications *Pressure-Treated Southern Pine* and *Pressure-Treated Southern Pine Takes the Bite out of Formosan Termites*, available at www.southernpine.com.

TREATED STRUCTURAL PANELS

Just like lumber, structural panels (plywood, OSB) can be treated with preservatives. Properly treated according to AWPA standards, treated structural panels maintain their

strength and stiffness, thermal properties, workability, light weight and economy. For more information, refer to the APA publication *Preservative-Treated Plywood*, available at www.apawood.org.

DESIGN VALUES

Design values published in the *SPIB Standard Grading Rules for Southern Pine Lumber* apply to both treated and untreated Southern Pine. Also, design value adjustment factors in the *National Design Specification® for Wood Construction (NDS®)* apply to both treated and untreated lumber, with the exception that load duration factors, C_D , greater than 1.6 shall not apply to structural members pressure treated with waterborne preservatives.

Design values for dimension lumber are based on normal use conditions (moisture content \leq 19%). They are intended for use in covered structures or where the moisture content in use does not exceed 19% for an extended period of time. For applications where the moisture content will exceed 19% for an extended period, tabulated design values must be multiplied by the appropriate wet service factor, C_M . For additional information about design values and design value adjustment factors, refer to the SPC publication *Southern Pine Use Guide* or the *National Design Specification®*.

THE NEW GENERATION OF WOOD PRESERVATIVES

For more than 70 years, Chromated Copper Arsenate (CCA) has served as the leading waterborne wood preservative in the United States and throughout the world. It's availability and widespread uses, including hundreds of applications ranging from decks and patios to wood-frame homes to marine structures, made it the preferred choice for preserved wood products. However, changing perceptions and consumer interest in alternative preservatives has transformed the market, offering more choices for the builder and homebuyer.

Over the past decade, the major wood preservative manufacturers have developed and refined a number of new and highly effective waterborne wood preservatives. After discussions with the U.S. Environmental Protection Agency (EPA), and in light of the growing interest in alternative products, key preservative manufacturers have voluntarily agreed to make a transition to "new generation" wood preservatives for the consumer and residential market. The EPA continues to support the use of CCA-treated wood products for a variety of industrial and commercial applications. Table 5 lists the leading waterborne preservatives currently available, suitable for the structural framing components of residential or commercial buildings.

Table 4 Southern Pine Preservative Retentions & Applicable AWP Standards
(applicable for structural framing)

	Retention Assay of Treated Wood (pcf)					Use Category (UC)	Commodity Standard
	Alkaline Copper Quat – Type A (ACQ-A)	Alkaline Copper Quat – Type B (ACQ-B)	Alkaline Copper Quat – Type C (ACQ-C)	Alkaline Copper Quat – Type D (ACQ-D)	Copper Azole – Type A (CA-A)		
Lumber, Timbers & Plywood							
Above Ground	0.25	0.10	0.20	0.25 ¹	0.17/0.25 ²	UC1-3	C2/C9/C31
Soil & Freshwater Use	0.40	0.21	0.41	0.40 ¹	NR	UC4A	C2/C9
Permanent Wood Foundation (PWF)	0.60	0.31	0.61	0.60	NR	UC4B	C22
Sawn Post – Building Construction	0.60	0.31	0.61	0.60	NR	UC4B	C15/C16
Piles							
Land or Freshwater Use & Foundations	0.80	NR	NR	0.80	NR	UC4C	C3

pcf = pounds per cubic foot NR = Not Recommended

SOURCE: Book of Standards, American Wood-Preservers' Association (www.awpa.com).

1 Effective December 31, 2003, CCA is not available for most residential consumer use treated lumber applications.

2 Borates B₂O₃ (SBX) may be used in above-ground applications continuously protected from liquid water, such as sill plates or other enclosed structural framing at retentions of 0.17 pcf or 0.25 pcf where formosan termites are confirmed.

Table 5 New Generation Wood Preservatives*




Preservative Types	Popular Brand Names	History/Uses
Alkaline Copper Quat (ACQ)	 <p>Preserve® Preserve Plus® (built-in water repellent) Nature Wood® Nature Wood® with water repellent</p>	<p>ACQ-treated wood was first introduced in the United States 10 years ago. It has been successfully used in Europe, Japan, New Zealand, Asia, and Australia for the last 15 years.</p> <p>Uses: ACQ is a fixed preservative approved for full exposure to above ground, ground contact, and freshwater applications.</p>
Copper Azole (CA)	 <p>Wolmanized® Natural Select™ Wolmanized® Natural Select™ with water repellent</p>	<p>Wood products treated with Copper Azole have been used effectively around the world since 1992.</p> <p>Uses: Copper Azole is a fixed preservative approved for full exposure to above ground, ground contact, and freshwater applications.</p>
Sodium Borates (SBX)	 <p>Advance Guard® SillBor® TimberSaver PT® FrameGuard™</p>	<p>Wood products treated with Borates were initially established in New Zealand in 1950. Before being introduced into the United States more than 10 years ago, Borates were widely used in New Zealand, Europe, and Southeast Asia.</p> <p>Uses: Borates are a diffusible preservative approved only for above ground applications that are continuously protected from liquid water, such as sill plates and other enclosed structural framing.</p>

Photo: Osmose, Inc.

*This table represents leading preservative types and popular brand names currently available. Additional preservative types and brand names may enter the market in the future.

Moisture Control

Protecting wood products from moisture is an important factor in preventing fungal decay. Wood framing maintained at a moisture content of less than 20% will not decay.

A raised floor foundation separates a structure from one of the biggest sources of moisture – the ground itself. With proper design, construction and maintenance practices, a raised floor system can remain dry and free of moisture-related problems.

Moisture control can be accomplished primarily through the application of basic, proven construction practices:

- Positive site and building drainage
- Proper crawlspace design and construction details to separate wood elements from known moisture sources and to prevent condensation
- Use of pressure-treated wood where required or recommended
- Regular inspection and maintenance

For additional details, see the *Design of Wood Structures for Permanence – Wood Construction Data No. 6* from the American Wood Council at www.awc.org.

SITE AND BUILDING DRAINAGE

Providing proper site and building drainage is critical to moisture control for any foundation system. Proper drainage is needed to keep the foundation and underfloor areas dry. For a raised floor system, it is especially important that standing water be kept out of the crawlspace.

Controlling moisture requires effective control of rainwater and ground water. Managing rainwater drainage from the building's

roof helps to keep the foundation and underfloor areas dry. Most important is the use of gutters, downspouts and splash blocks or drainpipes to direct the water runoff away from the foundation.



The ground beneath an open pier-and-beam foundation should be graded to provide drainage away from the structure.

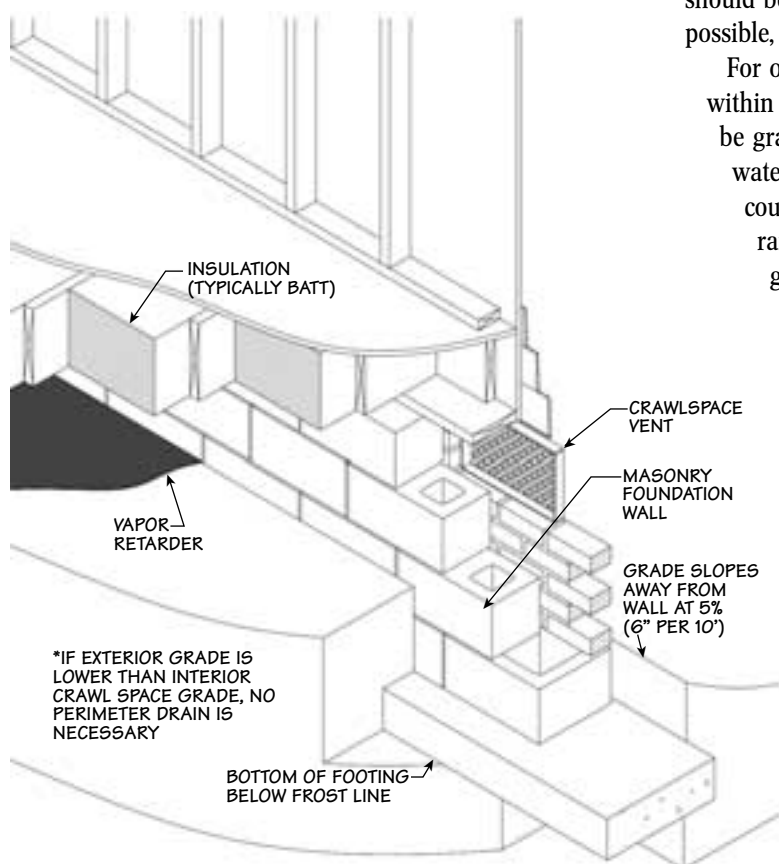
Also, floor areas of adjacent porches or patios should be sloped to drain rainfall away from the structure.

Whenever possible, the elevation of the crawlspace floor should be higher than the exterior grade. When that is not possible, perimeter drains should be included.

For open pier-and-beam foundations, positive drainage within the crawlspace is important. The ground should be graded to maintain a dry crawlspace and to drain water away from the structure. On a level site, this could involve slight crowning, centered beneath the raised floor. On a sloped site, the ground should be graded so the water exits through and away from the pier system.

For continuous wall foundations, drain tiles installed around the entire footing perimeter can greatly reduce moisture within the crawlspace. The drain tiles should lead to a storm drain, a sump with a pump, or other positive drain system that carries the water away from the structure.

Figure 3 Unconditioned and Vented Crawlspace



The finish site grade for any project should slope away from the structure to provide positive drainage away from foundation walls. This is important for keeping any type of foundation dry and trouble free. A minimum slope of 5% away from the structure is recommended. Typical site grading creates a fall of at least 6" over the first 10' away from a foundation. Drains or swales can also be provided to ensure drainage away from the structure.

CRAWLSPACE DESIGN AND CONSTRUCTION^{1,2}

Designers, contractors and homeowners must understand the connection between the crawlspace of a raised floor system and the living space above. Every effort should be made to keep moisture out of the crawlspace. Provisions should also be made to maximize drying of any moisture that does manage to get into a crawlspace. Local climatic conditions will dictate the specific design and construction details for a particular raised floor system.

The subject of moisture control in crawlspaces is an area of ongoing research. Most crawlspaces today are constructed as unconditioned and vented systems, with building codes mandating minimum ventilation requirements. As an alternative, conditioned and unvented crawlspace systems are sometimes used and also recognized in the codes.

Unconditioned and Vented Crawlspaces. Figure 3 provides design detail considerations for unconditioned and vented crawlspaces. Important elements for the best moisture control include:

- Ground drainage
- Ground cover (vapor/gas retarder)
- Insulation installed within the floor cavity
- Plumbing within the floor cavity or well insulated
- Air distribution ducts within the floor cavity or the interior of the structure

HVAC systems of many houses built over crawlspaces deliver conditioned air through ducts located in the crawlspaces. Whenever possible, ductwork should be located within the floor cavity (e.g. between joists, or between or through trusses or I-joists). When that is not possible, adequate clearance between the bottom of the ductwork and the ground should be provided to maintain proper ventilation. All ductwork should be meticulously sealed to avoid unnecessary energy losses from air leaks. Penetrations for plumbing, wiring and air ducts should also be sealed to minimize air exchange between the crawlspace and the living space. Ductwork should also be insulated to prevent condensation on the ducts. In addition, insulation should

be carefully installed to the underside of the floor within the floor cavity. Never vent moisture or heat-producing sources (e.g. clothes dryers, kitchen or bath vents) into the crawlspace.

Crawlspace Ventilation. Building code requirements for ventilation openings through foundation walls are intended to reduce moisture levels in the crawlspace. Section 1203.3 of the *2003 International Building Code* sets forth the underfloor ventilation openings and cross ventilation requirements for enclosed crawlspaces, such as within stem wall foundations. Open pier-and-beam foundations, commonly used with raised floor systems, already create a fully vented crawlspace.



Vent openings in a stem wall foundation provide cross ventilation.

Generally, building codes mandate that the minimum net area of ventilation openings required are not less than one square foot for each 150 square feet of crawlspace area. When an approved vapor retarder covers the underfloor ground, the minimum vent opening area can be decreased to one square foot for every 1500 square feet of crawlspace area. Vent openings are placed to provide cross ventilation of the underfloor space. These vent openings should be screened to inhibit pest entry into the crawlspace (see Pest Management on page 17). They also should not allow rain water or runoff to enter into the crawlspace.

Conditioned and Unvented Crawlspaces. Conditioned and unvented crawlspaces are only recommended when mechanical systems distribute conditioned air within the underfloor area. A conditioned and unvented crawlspace typically has insulated walls and can be thought of as a short basement. This type of crawlspace is designed to communicate with the living space. It should be dry, temperate, and have good air quality. Conditioned air spaces should not be ventilated with outdoor air.

Conditioned and unvented crawlspace systems should have a continuous ground cover sealed to insulated perimeter walls and any supporting piers. Care should be taken with all air-sealing construction details. This is necessary to minimize the unintentional introduction of unconditioned air, reducing the possibility of condensation on cold surfaces. In addition, extra care should be taken to prevent moisture from being trapped in the crawlspace. Any moisture that does get into the crawlspace should be remediated immediately.

1 *Handbook of Fundamentals*, American Society for Heating, Refrigerating and Air Conditioning Engineers, 2001.

2 *The Case for Conditioned, Unvented Crawl Spaces* by Nathan Yost, M.D., Building Safety Journal, International Code Council, May 2003.

Ground Cover (Vapor/Gas Retarder). Draining storm water away from the foundation, preventing standing water beneath the crawlspace, and making provisions to remove excess moisture entering the crawlspace, are all-important elements needed to provide a dry, trouble-free raised floor system. Control of ground moisture is also essential. One of the best ways to control this moisture is through the use of a ground-applied vapor retarder.

Exposed soil in crawlspaces and under porches and decks should be covered with an approved vapor retarder. A ground cover that retards transmission of water vapor from the soil into the crawlspace provides an effective way to prevent moisture and humidity problems. It should have



a permeance of no more than 1.0 perm, complying with *ASTM E1745*, to resist alkali and other chemicals that can be contained in soils. It should also be rugged enough to withstand foot and knee traffic. The most commonly used ground cover material is a 6-mil (0.006 inch) polyethylene.

Before installation of the ground cover, the crawlspace floor should be smooth and free from sharp rocks and construction litter. Exact installation details will vary depending on the primary function of the ground cover (i.e. moisture control or radon gas control). For any crawlspace system, it is important to avoid standing water on top of the ground cover.

For unconditioned and vented crawlspaces, the edges of the cover should be overlapped 4" to 6". The cover does not need to extend up the face of the foundation wall, and no sealing is required. If the control of radon or other soil gases is not of primary importance, the ground cover may be cut in several low spots to provide drainage if needed.

Conditioned and unvented crawlspaces should have a continuous ground cover over all crawlspace soil. The ground cover should be sealed at the joints, as well as sealed to the perimeter wall and any piers. A thin layer of concrete added over the ground cover provides a better seal and further inhibits the entry of rodents.

Radon Gas. In areas where radon gas is a concern, care should be taken to vent radon away from the building. By its very nature, an open pier-and-beam foundation readily dissipates radon gas. In enclosed, continuous wall foundations, the components of a passive, sub-membrane depressurization system are readily installed during construction. The soil within the crawlspace should be covered with a continuous layer of 6-mil polyethylene (minimum) soil-gas retarder. In addition, enclosed crawlspaces should be provided with tightly sealed pipes vented to the exterior of the building in accordance with the code. For more details, see *Radon Reduction in Wood Floor and Wood Foundation Systems* from the American Wood Council at www.awc.org.

Additional Moisture Control Requirements. In geographic areas where experience has demonstrated a need for more protective moisture control measures, the preceding general requirements should be modified to meet local climatic conditions.

PRESSURE-TREATED WOOD

Treatment with preservatives protects wood exposed to the elements, in contact with the ground, or subjected to high-moisture conditions. Generally, building codes require pressure-treated or naturally durable wood for the following applications:

- Joists or the bottom of structural floors without joists that are within 18" of exposed soil
- Beams or girders closer than 12" to exposed soil
- Framing members (including sheathing) which rest on exterior foundation walls and are less than 8" from soil
- Plates, sills and sleepers on concrete or masonry
- Wood in permanent structures closer than 6" to soil
- Girders entering exterior masonry or concrete walls without a minimum 1/2" air space on top, sides and end
- Posts or columns not separated from concrete piers by an impervious moisture barrier
- Wood supports that are embedded in, or in contact with, the ground

INSPECTION AND MAINTENANCE

As with any structure, long-term performance of a raised floor system requires regular building inspections and maintenance. Building codes require access to all under-floor spaces, with a minimum opening of 18" by 24" through a floor, or 16" by 24" through a perimeter wall.

The crawlspace should be inspected periodically to check for excessive moisture conditions from leaky plumbing, HVAC ducts, or standing water. The crawlspace should also be inspected periodically for the presence of damaging pests. Needed corrective actions or repairs should be made promptly to avoid problems related to moisture or pests.

Pest Management

A crawlspace should allow entry for inspection and maintenance, but inhibit entry of outdoor pests. Whether it's a continuous foundation, or a pier-and-beam with its open crawlspace, practical and effective methods and materials are available to impede pests.

CONTINUOUS FOUNDATIONS

In continuous (stem wall) foundations, pest entry is restricted with properly specified ventilation coverings. The *2003 International Building Code* (Section 1203.3.1) prescribes a variety of materials for covering ventilation holes, provided the openings in the covering do not exceed 1/4":

- Perforated sheet metal plates not less than 0.070" thick
- Expanded sheet metal plates not less than 0.047" thick
- Cast-iron grills or gratings
- Extruded load-bearing vents
- Hardware cloth of 0.035" wire or heavier
- Corrosion-resistant wire mesh, with the least dimension of the openings not exceeding 1/8"

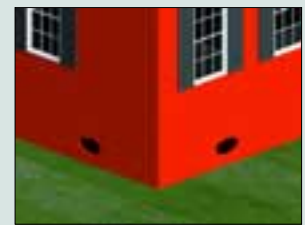
PIER-AND-BEAM FOUNDATIONS

Figure 4 gives an underfloor view of pest management strategies for a pier-and-beam system. This figure illustrates two strategies to inhibit pest entry – either a perimeter or under-floor barrier. At the foundation perimeter, pressure-treated decorative latticework backed with corrosion and pest resistant screening can be framed between

piers. If a brick curtain wall is installed between piers along the perimeter, the opening requirements and coverings prescribed for a stem wall should be used.

For protection under the floor, a breathable pest barrier is typically attached at the bottom edge of the joists to prevent pests from nesting in insulation and damaging wiring or other systems. Common materials used for this application include: house wrap, hardware cloth, fiberglass insect screen, plastic webbing or netting, corrosion-resistant wire mesh, and perforated vinyl or fiber-cement soffit panels.

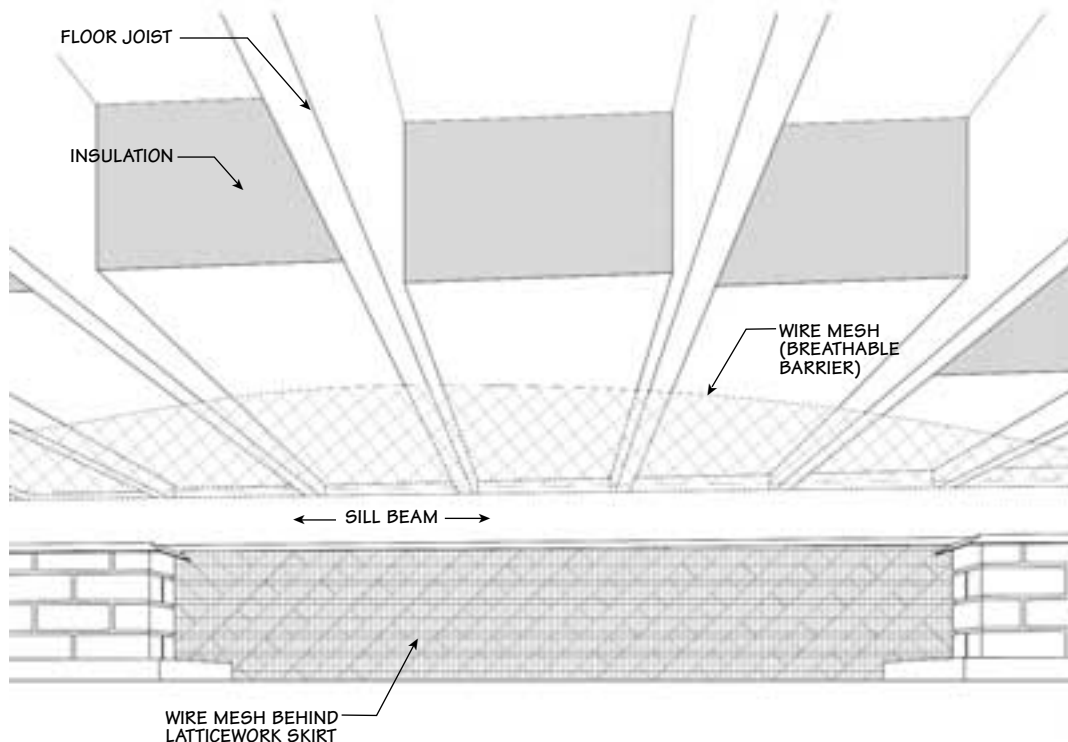
VENT AND SCREEN STYLES



Pier-and-beam

Continuous wall

Figure 4 Pest Barriers



Termite-Resistant Framing

Question: “If I lived in an area where termites are a problem like much of the Southeastern U.S., won’t my raised wood floor system be more vulnerable to attack than a comparable concrete slab-on-grade constructed home?” The short answer is NO!

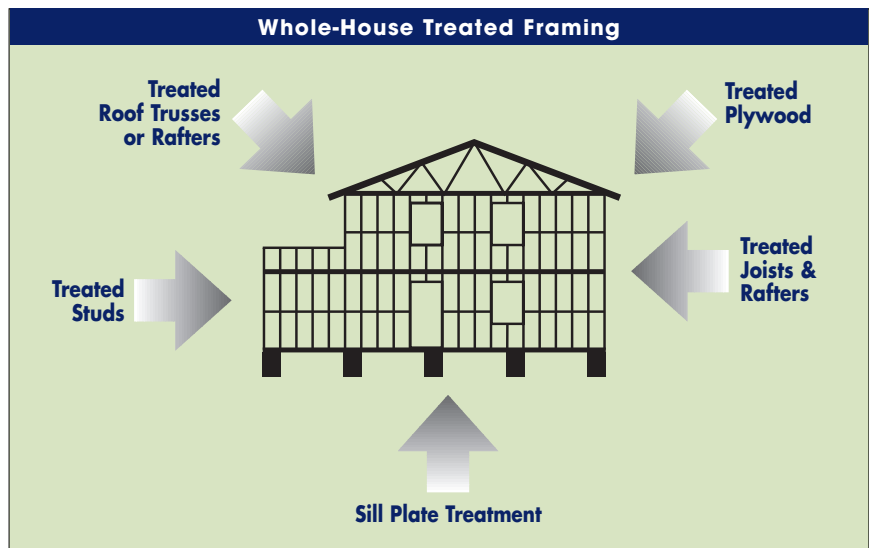
The question is understandable, since termites consume wood, or more specifically any cellulose material (paper, cardboard, or solid wood). The truth is, a home constructed on a concrete slab is just as vulnerable, if not more so, to termite infestation than a comparable home properly constructed on a raised floor.

Subterranean termites are ground dwellers. They rely on ground moisture to survive and thrive. Concrete slab-on-ground foundations rest directly on the damp earth, giving termites a very short commute from their natural habitat to house framing. In addition, slabs often crack, offering termites a virtually undetectable entryway into the house.

On the other hand, a raised floor elevates the structure above the ground, isolated from the moisture source, and away from termite habitat. The raised floor system makes termite detection simple for trained pest control exterminators who can easily inspect underfloor areas.

TREATED FRAMING ADDS VALUE AND PROTECTION FOR MINIMAL COST

Finally, if concerns exist over vulnerability to pests, the raised floor system – or even the entire house – can be



A typical home framed entirely with pressure-treated wood adds about 2% to the cost of the home.¹

framed with pressure-treated Southern Pine lumber, structural panels, and other engineered wood components. The “whole house” concept of using pressure-treated wood framing components in high-moisture areas of the home for added protection against decay and termite attack is nothing new.

Informed builders and homeowners have used pressure-treated lumber for optimum protection of structural framing members. In fact, analysis by the Louisiana Department of Agriculture and Forestry indicates that a typical home (about 2,000 square feet) could be framed entirely with pressure-treated components, while adding about 2% to the overall cost of the home.¹

Widespread damage by the Formosan termite has put considerably more emphasis on the use of pressure-treated framing, whether in the raised floor system or for the entire framing of the home. The American Wood-Preservers’ Association has approved several preservative treatments effective against Formosan termites that are suitable for residential or commercial enclosed (interior) framing applications; see Table 5 on page 13.



Optimum protection against Formosan termites is attained by using all pressure-treated Southern Pine kiln-dried after treatment (KDAT) lumber and sheathing for this 14,000 square-foot lakefront home in suburban New Orleans.

¹ Research conducted as part of the Economic Impact Committee of the Louisiana Department of Agriculture and Forestry (a working group organized within the Louisiana Formosan Termite Initiative Project), September 2000.

For all structural framing uses, pressure-treated lumber must be dried after treatment to a moisture content of 19% or less. To learn more, see *Termite Resistant Structures* at www.southernpine.com.

The use of pressure-treated wood offers homeowners the most practical, cost-effective and safest way to fully protect framing components from termites and fungal decay.



Soil treatment

After removal of all scrap wood from the building perimeter, treatment of the soil around the foundation with an approved termiticide is an effective protection against subterranean termites.



Termite shield

Properly installed termite shields also provide effective protection. Regular inspection and termite treatment is recommended. Termite shields may be required in certain localities by the building code.

Habitat For Humanity Uses Treated Framing and a Raised Floor System



Habitat for Humanity constructed its first home featuring all pressure-treated framing and sheathing in New Orleans. The raised floor design for this home of 940 sq. ft. called for 8,500 board feet of Southern Pine materials that were kiln-dried after treatment (KDAT).

Since 1983, the New Orleans Area Habitat for Humanity has built more than 50 homes throughout the metropolitan area. Executive director Jim Pate notes that, considering the threats of Formosan termites and flooding, a raised floor foundation system and pressure-treated Southern Pine framing are the solutions to a challenging building environment. During 2003, Habitat built 14 project homes within New Orleans, all using the raised floor system.



Using volunteer labor – college students, women's groups, retirees – the homebuilding process takes about twelve weeks. Once the site is cleared and a reinforced-concrete grade beam is in place, crews of 10 volunteers build concrete block piers to support pressure-treated Southern Pine 6x6 sill beams. Next, a crew of up to 20 arrives to install 2x10 Southern Pine floor joists 16" on center, and a plywood subfloor. With minimal building skills on hand, construction manager Valarie Smith appreciates the simplicity of building a raised floor home, noting "...it's not rocket science!"

Founded in 1976, Habitat for Humanity International has built more than 150,000 homes, providing shelter for some 750,000 people in 87 countries worldwide. Visit www.habitat.org.



Fire Performance

Contrary to concerns over its combustibility, wood can be an excellent performer under fire conditions. This is because of wood's unique charring properties, which actually protect it from fire. Properly designing a building for fire safety means faithfully executing building code regulations. For more information about fire endurance, refer to the *SPC Southern Pine Use Guide* at www.southernpine.com.

FRAMING AROUND CHIMNEYS AND FIREPLACES

Wood framing must be adequately separated from fireplace and chimney masonry. See Figure 5 for fireplace framing details. All headers, beams, joists and studs must be kept at least two inches from the outside face of chimney and fireplace masonry. Prefabricated metal fireplace and chimney assemblies must be installed in accordance with the manufacturer's recommendations and approved by the code authority.

FIREBLOCKING

Fireblocking is an important fire safety feature in wood-framed buildings with concealed spaces that can serve as ducts or chimneys for the spread of flames, gases and smoke. Fireblocking is an integral part of a building's passive fire protection. Fireblocking can protect against the passage of flames, deadly gases and toxic smoke through hollow vertical spaces created by joints and gaps in walls, floors and floor/ceiling assemblies. In short, hollow vertical spaces need to be firestopped at every floor level.

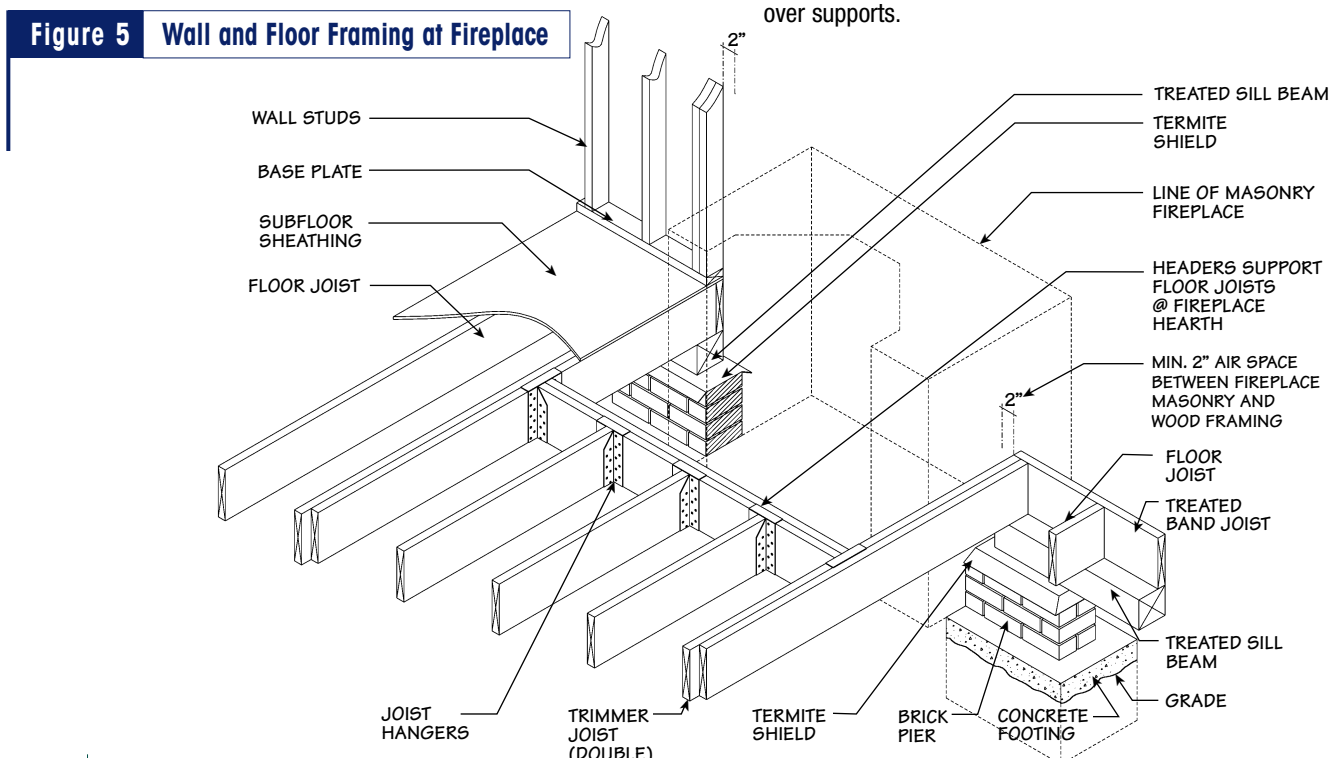
In light wood-frame construction, 2" dimension lumber

has proven to be very successful in fireblocking if tightly fitted in place. Codes recognize 2" lumber for use as fireblocks, as well as wood panels if the joints are backed. For sealing around vents, pipes, and ducts, the codes permit the code official to approve other fireblocking materials available in cans, tubes, and strips for ease of installation. Typically, materials meeting *ASTM E814 Standard Method of Fire Tests for Through-Penetration Firestops* for use with tested commercial firestop systems are acceptable for fireblocking around ducts and pipes.

Although fireblocking between floors is automatically built into the framing in most instances, care still needs to be exercised where certain designs require studs to pass floor levels. The bottom sill plate of wall framing usually acts as a fireblock. The use of furring strips, which create horizontal or vertical concealed spaces, must be fireblocked. For example, in ordinary construction, the space created when a masonry wall is furrowed needs to be fireblocked.

Fireblocking should be installed in these locations:

1. Concealed spaces of stud walls and partitions, including furred spaces at ceilings and floor levels.
2. Concealed spaces between stair stringers at the top and bottom of the run.
3. Openings around vents, pipes, ducts, chimneys and fireplaces at ceiling and floor levels.
4. Interconnections between concealed vertical stud wall or partition spaces and concealed spaces created by an assembly of floor joists. With respect to concealed spaces created by an assembly of floor joists, fireblocking should be provided for the full depth of the joists at the ends and over supports.



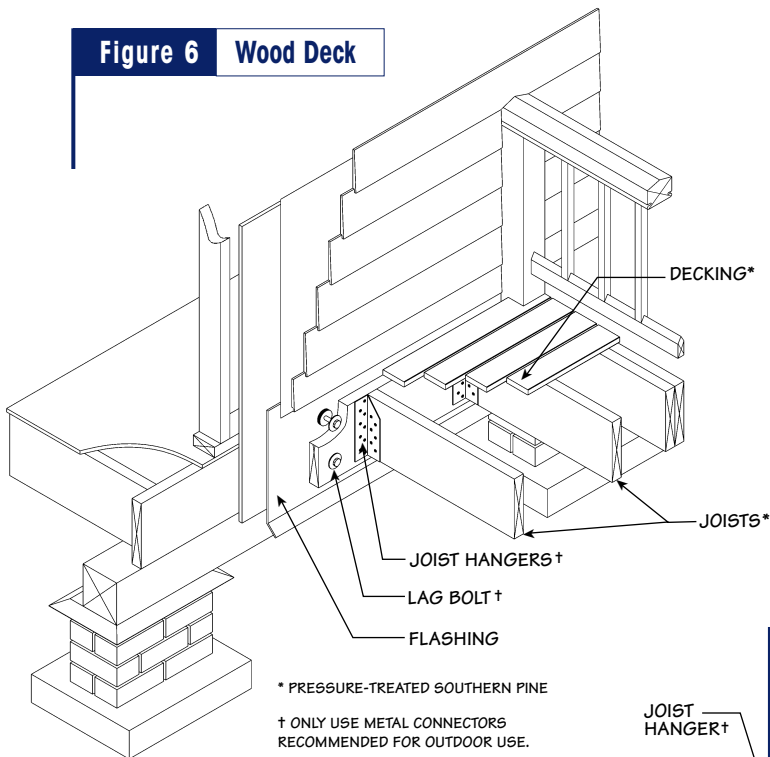
Decks and Porches

Wood decks and porches are a special feature of many new houses and a useful addition to others. These features are natural extensions of a raised floor's elevated platform. Decks and porches provide more living and recreational space, making them valuable amenities in the design of a new home or remodeling project.

Use of pressure-treated lumber makes these outdoor structures as permanent as the house itself. Supporting joists, posts, porch flooring, and decking lumber must be properly grademarked and identified as pressure-treated

wood by quality-control agencies. See Figures 6 and 7 for wood deck and porch framing details, respectively.

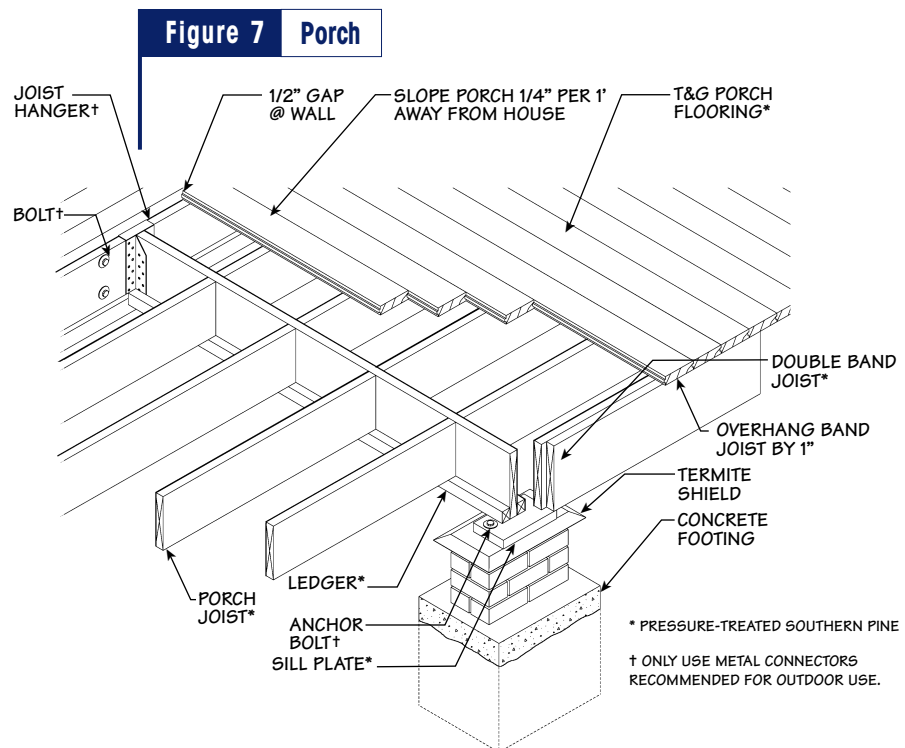
More details on decks, porches and other outdoor amenities are found in *Wood Decks: Materials, Construction and Finishing*, the *Guide to Southern Pine Porch Flooring*, and the *Garden & Outdoor Idea Book* available from the Southern Pine Council at www.southernpine.com. Also refer to *Details for Conventional Wood Frame Construction* from the American Wood Council at www.awc.org.



A deck is the floor of an outdoor living room. Treated Southern Pine resists decay and termite attack even in the most severe exposures.



The porch has become an icon of American architecture.



The Raised Floor Process

Steps to Construct a Premium Floor System

Pre-design

- Determine site and environmental conditions
 - Climatic and geological conditions
 - Elevation / Base Flood Elevation (pp. 8-9)
 - Grade
 - Soil characteristics (pp. 24-26)
 - Vegetation (pg. 26)
- Determine design criteria
 - Building regulations
 - Design loads (pg. 27)
 - Zoning
 - Covenants

Design

- Design building layout
- Locate building on site
- Select footing and foundation system (pp. 28-32)
 - Types of footings (pp. 28-29)
 - spot footings
 - continuous spread footing
 - grade beam footing
 - Types of foundations (pp. 30-32)
 - pier-and-beam
 - continuous foundation wall (stem wall)
 - pile
 - permanent wood foundation
- Determine floor framing system (pp. 10-11, 34-41)
 - Select sill beam / girder system (pg. 33)
 - solid-sawn (pp. 10, 40)
 - glued laminated timber (pp. 10, 40)
 - nail laminated (pg. 40)
 - structural composite lumber (pg. 11)
 - Select joist system (pp. 34-38)
 - solid-sawn lumber (pp. 10, 41)
 - trusses (pp. 11, 41)
 - I-joists (pg. 11)
- Determine connections (pg. 33 - 38)
- Select subfloor compatible with finish floor (pg. 36)

Construction

- Site preparation (pg. 26)
- Construction (pg. 22-43)

Construction Snapshots



1 After laying in rebar, workers prepare to pour the continuous spread footing for a 5,000 sq. ft. assembly building. See case study D, page 43. **2** Concrete blocks are installed over rebar anchors, then filled with concrete to form sturdy piers supporting a 4,200 sq. ft. addition to an assisted living center. See case study B, page 42. **3** Pressure-treated 6x6 Southern Pine sill beams bear on concrete block piers in construction of this 2,700 sq. ft. two-story residence. Note termite shields. See case study A, page 42. **4** Concrete block piers supporting this 2,600 sq. ft. New Orleans residence rest on a grade beam footing. Note termite shield atop each pier. **5** Worker installs pressure-treated 2x10 Southern Pine floor joists on a pier-and-beam foundation supporting a 5,000 sq. ft. two-story custom home. **6** Pressure-treated Southern Pine 2x10s bearing on a pressure-treated sill beam illustrate proper joist overlap. Note termite shield. **7** Metal anchor straps connect joists to sill beams beneath this residence. This type of connection may be required in certain regions to resist high wind or seismic forces. See case study A, page 42. **8** Glued-laminated beams bearing on poured concrete piers will support the floor truss system of this 6,000 sq. ft. custom home in North Dallas. **9** Pressure-treated Southern Pine trusses are then installed atop the beams of the North Dallas home. **10** Southern Pine floor trusses bear on a pressure-treated sill plate atop a stem wall supporting a 4,200 sq. ft. addition to an assisted living center. See case study B, page 42. **11** Nail-laminated 2x12 Southern Pine beams support 2x10 joists bearing on 2x2 ledgers, all pressure-treated. Note termite shield atop pier. **12** Bearing on concrete block piers, the treated joist system for the porch of this 2,600 sq. ft. New Orleans residence awaits installation of pressure-treated tongue-and-groove porch flooring. See details on decks and porches, page 21. **13** Orienting the hollow side of concrete blocks perpendicular to neighboring blocks creates a series of simple openings around the perimeter of this stem wall, providing needed cross ventilation under this assembly building. See case study D, page 43. **14** With the subfloor installed, workers begin installation of perimeter support walls for this 5,000 sq. ft. assembly building. See case study D, page 43. **15** An access panel in this 2,700 sq. ft. two-story residence (case study A, page 42) provides convenient entry for crawlspace inspection and repair. Latticework shown between piers provides decorative screening. Other decorative treatments for pier and stem wall systems are shown on page 17.



Soils and Site Preparation

Raised floor assemblies may be constructed in any soil type. In fact, they perform very well even in problematic soils, such as expansive soils which often crack conventional slabs. To ensure durability and trouble-free performance, a raised floor foundation system must be capable of accommodating all design loads and transmitting those loads to the foundation soil without excessive settlements. Footings should be supported on undisturbed natural soils or engineered fill. Foundation systems supported on fills should be designed, installed and tested in accordance with accepted engineering practices. For example, gravel fill used in foundation systems such as wood foundations should comply with local building code requirements.

SOIL CONDITIONS

The type of soil and the general grading conditions at the building site are important factors in determining foundation construction details, such as footing design, backfill



and drainage. Soils are classified depending on several physical and engineering parameters including their grain size distribution, liquid and plastic limits, organic contents, drainage character-

istics, frost heave potential, and swell potential. There are several types of classification systems: for example, the Unified Soil Classification System, the AASHTO Soil Classification System and the U.S. Department of Agriculture (USDA) Classification System. The USDA (www.usda.gov) publishes soil maps that cover most counties and parishes within the U.S. These maps provide a general guide on the type of soils that may be found in any given region.

Ground materials can vary from rocks to loose sand or saturated clays. The selected engineering properties of soils are determined from several sources, including:

- published soil maps by the USDA Natural Resources Conservation Service and other government offices
- a review of borings from nearby sites
- geophysical exploration (e.g., seismic reflection and refraction, cross-hole testing, electrical resistivity soundings, etc.)
- in-situ testing (e.g., Cone Penetration Test, Standard Penetration Tests, Vane Shear Tests, etc.)
- soil borings at the construction site
- a test pit dug at the construction site

The USDA Natural Resource Conservation Service categorizes and describes soil types in four large groups depending on Unified Soil Classification System, their estimated engineering behavior, drainage characteristics, frost heave potential, and swelling potential (see Table 6). Suggested values for soil bearing capacities, undrained shear strength, and friction angles are presented in Table 7. These values are only estimated values to be used for light construction applications when other data are not available. It is also important to note that soil properties can vary significantly from one site to another and even within a single site. It is necessary to consult a geotechnical engineer when any unusual or unknown soil conditions are encountered.

CONSIDERATIONS FOR PROBLEMATIC SOILS

In poorly drained soils (Group III), an open pier-and-beam foundation system (e.g. photo 15 on page 23) is the best way to provide adequate ventilation for raised floor systems. This recommendation is especially applicable for sites having a high water table, or where extreme amounts of rain often fall in short periods of time.

For building sites where expansive clay soils in Groups III or IV are predominant, a geotechnical engineer should determine the requirements for footings, piles, and drainage around the foundation. In such cases, special design considerations may be necessary to avoid excessive expansion and shrinkage, which might otherwise adversely affect foundation and structure performance. For example, spread footings may need to be constructed below the layer of expansive soil, or piers may need to be supported on pressure-treated piles (or other pile systems) driven below the troublesome soil. Furthermore, piles or grade beam footings may be required for soil types with minimal bearing capacities (for example, soils in Group III and IV). Regardless of soil type, crawlspace foundation systems have the benefit of minimum excavation and backfill.

When a raised floor system is built on soils that are highly compressible (e.g. plastic soils in Groups II, III and IV), a settlement analysis should be performed as these soils have the potential to settle more than admissible values. Also, highly compressible and swelling soils should not be used as fills unless they are stabilized within each active zone by chemical, preloading, dewatering, or pre-saturation processes.

In all areas where problematic soils may be found, a geotechnical engineer should determine whether soil tests are needed to better characterize the engineering behavior of the soils. Tests may range from classification and index tests to consolidation and triaxial tests. These tests should be performed by an approved laboratory or geotechnical engineer using standardized methods.

Table 6 Types of Soils and Engineering Characteristics

Soil Group	Unified Soil Classification Symbol	Soil Description	Drainage Characteristics ¹	Frost Heave Susceptibility ²	Volume Change Potential Expansion ³
Group I Excellent	GW	Well-graded gravel, gravel-sand mixtures, little or no fines	Good	Low (F1)	Low
	GP	Poorly graded gravels or gravel-sand mixtures, little or no fines	Good	Low (F1) to Medium (F2)	Low
	SW	Well-graded sands, gravelly sands, little or no fines	Good	Medium (F2)	Low
	SP	Poorly graded sands, gravelly sands, little or no fines	Good	Medium (F2)	Low
	GM	Silty gravels, gravel-sand-silt mixtures	Medium	Low (F1) to High (F3)	Low
	SM	Silty sand, sand-silt mixtures	Medium	Medium (F2) to High (F3)	Low
Group II Fair to Good	GC	Clayey gravels, gravel-sand-clay mixtures	Medium	High (F3)	Low
	SC	Clayey sands, sand-clay mixtures	Medium	High (F3)	Low
	ML	Inorganic silts and very fine sands, rock flour, silty fine sands or clayey silts with slight plasticity	Medium	Very High (F4)	Low
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium	High (F3) to Very High (F4)	Medium
Group III Poor	CH	Inorganic clays of high plasticity, fat clays	Poor	High (F3)	High to Very High
	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils	Poor	Very High (F4)	High
Group IV Unsatisfactory	OL	Organic silts and organic silty clays of low plasticity	Poor	High (F3)	Medium
	OH	Organic sands of medium to high plasticity, organic silts	Unsatisfactory	High (F3)	High
	PT	Peat and other high organic soils	Unsatisfactory	High (F3)	High

SOURCE: Table modified from the U.S. Department of Agriculture (www.usda.gov).

1 Percolation rate for good drainage is over 4 inches per hour, medium drainage is 2 to 4 inches per hour, and poor drainage is less than 2 inches per hour.

2 After Coduto, D. P. (2001). *Foundation Design*. Prentice-Hall. F1 indicates soils that are least susceptible to frost heave, and F4 indicates soils that are most susceptible to frost heave.

3 For expansive soils, contact a geotechnical engineer for verification of design assumptions. Dangerous expansion might occur if soils classified as having medium to very high potential expansion types are dry but then are subjected to future wetting.

Table 7 Engineering Properties of Soils

Soil Group	Unified Soil Classification Symbol	Bearing Capacity (psf)	Undrained Shear Strength ¹ (psf)	Angle of Internal Friction (degrees)
Group I Excellent	GW	2,700-3,000	NA	38-46
	GP	2,700-3,000	NA	38-46
	SW	800-1,200 (loose)	NA	30-46 (loose to dense)
	SP	800-1,200 (loose)	NA	30-36 (loose to dense)
	GM	2,700-3,000	NA	38-46
	SM	1,600-3,500 (firm)	NA	28-40 (firm)
Group II Fair to Good	GC	2,700-3,000	NA	38-46
	SC	1,600-3,500 (firm)	NA	30-34 (firm)
	ML	2,000	NA	30-34 (dense)
	CL	600-1,200 (soft) – 3,000-4,500 (stiff)	0-250 (soft) – 1,000-1,200 (stiff)	NA
Group III Poor	CH	600-1,200 (soft) – 3,000-4,500 (stiff)	250-500 (soft) – 2,000-4,000 (stiff)	NA
	MH	2,000	1,600	NA

SOURCE: Table modified after the U.S. Department of Agriculture (www.usda.gov), FEMA *Costal Construction Manual* (www.fema.gov), and Bardet, J. (1997). *Experimental Soil Mechanics*. Prentice-Hall.

1 The undrained shear strength is also commonly referred to as cohesion in saturated clays.

psf = pounds per square foot NA = not applicable

SLOPE STABILITY

Soil slope stability is an important design consideration that is often difficult to predict. A history of slope failures at or near the site is a strong indication of the presence of a problem, and further investigation and careful design considerations may be needed. A geotechnical engineer can predict whether slope failures are likely to occur at a particular site based on the slope angle, the characteristic drainage and seepage of the site, the shear strength properties of the soils (friction angle or undrained shear strength), and the external loads. The *International Building Code (IBC)* provides some guidance on the placement of footings near slopes. For example, the *2003 IBC* indicates the bottom of a footing should be located at a distance from the face of the slope equal to or greater than one-third the height of the slope.

SITE PREPARATION

Site clearing and excavation methods for raised floor systems are no different than for any other conventional foundation system. Compacted backfill should be free of organic materials, including tree stumps or other vegetation, voids, chunks of clay, and should be no more permeable than the surrounding soil.



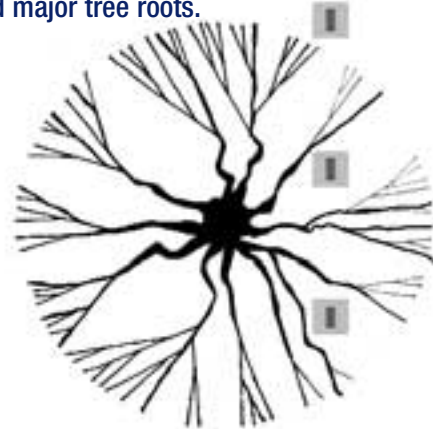
Existing trees thrive in close proximity to this pier-and-beam foundation home.

RAISED FLOOR

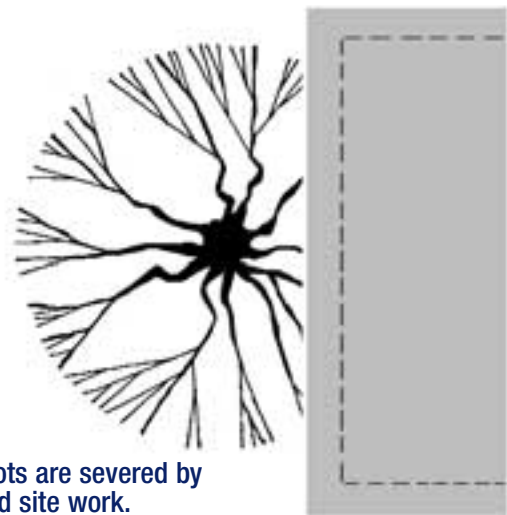
can save trees

Root-severing slab construction often demands the removal of existing trees in close proximity to the structure. Near a raised floor, however, valuable, beautiful and energy-saving shade trees can be preserved. Only the footings of a raised pier-and-beam structure penetrate the root system, allowing trees to thrive.

Open pier spacing can be adjusted to avoid major tree roots.



Tree roots thrive between piers.



Tree roots are severed by slab and site work.

Design Loads

All elements of a raised floor system must be properly sized to support the design loads. See Table 8, Typical Building Loads.

CONTINUOUS LOAD PATH

A continuous load path must be provided to transfer all lateral and vertical loads from the roof, wall, and floor systems to the foundation. A load path can be thought of as a “chain” running through the building. Because all applied loads must be transferred to the foundation, the load path chain must connect to the foundation. To be effective, each “link” in the chain must be strong enough to transfer loads without breaking. A continuous load path is especially important in areas subject to high winds and/or seismic forces.

WIND AND SEISMIC CONSIDERATIONS

Construction in areas subject to high-wind and earthquake forces can pose unique problems to the designer and builder. Refer to Figure 8, Wind Loading.

The *ANSI/AF&PA Wood Frame Construction Manual for One- and Two-Family Dwellings (WFCM)* provides engineered and prescriptive design requirements for wood-

frame construction in areas subject to 85-150 mph wind speeds (3-second gusts) and seismic design categories A-D. To obtain the *WFCM*, visit www.awc.org or www.southernpine.com.

Where wind speeds are less than 110 miles per hour, construction should be in accordance with the *International Residential Code*. In regions where wind speeds equal or exceed 110 miles per hour, raised floor systems should be designed and constructed in accordance with the *WFCM*.

Figure 8 Wind Loading

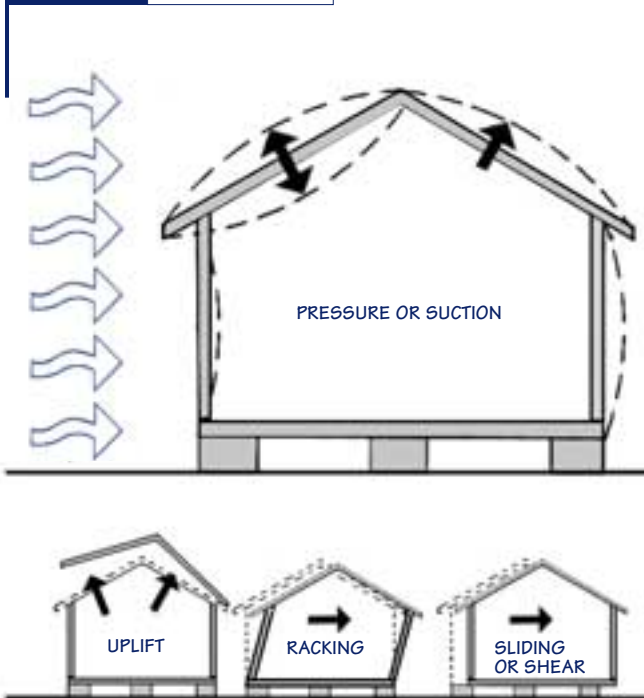


Table 8 Typical Building Loads

Typical Occupancy Live Loads		
WEIGHTS IN POUNDS PER SQUARE FOOT (psf)		
40 psf	Residential – living	
30 psf	Residential – sleeping	
10 psf	Residential – attic without storage	
Typical Dead Loads		
WEIGHTS IN POUNDS PER CUBIC FOOT (pcf)		
130 pcf	clay brick masonry	
144 pcf	plain concrete	
150 pcf	reinforced concrete	
WEIGHTS IN POUNDS PER SQUARE FOOT (psf)		
<i>Ceilings</i>		
0.55 psf	gypsum board (per 1/8 inch)	
<i>Coverings Roof/Wall</i>		
0.40 psf	wood structural panel (per 1/8 inch)	
2 psf	asphalt tile	
16 psf	cement tile	
3 psf	wood shingles	
<i>Floors & Floor Finishes</i>		
16 psf	ceramic tile	
4 psf	wood flooring, 7/8 inch	
<i>Framing</i>		
11 psf	exterior stud walls – 2x4@16”, 5/8” gypsum board, insulated, 7/16” wood structural panel	
12 psf	exterior stud walls – 2x6@16”, 5/8” gypsum board, insulated, 7/16” wood structural panel	
48 psf	exterior stud walls with brick veneer	
8 psf	interior wood studs with 1/2” gypsum board each side	
10 psf	light-frame wood floor assemblies	
15 psf	light-frame wood roof/ceiling assemblies	
8 psf	windows, glass, frame and sash	
<i>Concrete/Masonry</i>		
80 psf	6”-thick concrete walls	
55 psf	8”-thick concrete block walls	
80 psf	clay brick masonry walls	

SOURCE: *Standard Building Code*, 1997 Edition, Table 1604.1 Appendix A.

Footings and Foundations

A firm foundation, including properly installed footings of adequate size to support the structure and prevent excessive settlement, is essential to the satisfactory performance of buildings including raised floor systems.

Foundation systems are often classified as shallow or deep foundations, depending on the depth of the load-transfer member below the super-structure and the type of transfer load mechanism. The required foundation system depends on the strength and compressibility of the site soils, the proposed loading conditions, and the project performance criteria (i.e. total settlement and differential settlement limitations).

Foundation designs are based on the assumed bearing capacity of the soil at the building site (see Table 7 on page 25). In construction sites where settlement is not a problem, shallow foundations provide the most economical foundation systems. Shallow foundation construction is typically utilized for most residential and light commercial raised floor building sites.

Where poor soil conditions are found, deep foundations may be needed to provide the required bearing capacity and to limit settlement. Additionally, structures in coastal high-hazard areas are required to be elevated above the base flood elevation (BFE), commonly on piles. Examples of deep foundation systems include driven piles (e.g. pressure-treated timber piles, concrete, or steel), drilled shafts, or micropiles. See Pile Foundations on page 32.



Storm surge protection in hurricane-prone coastal areas requires an elevated floor system. Wood piles are also an option for this application.

TYPES OF FOOTINGS

Footing requirements are generally covered in the building code and sized in accordance with the bearing capacity of the soil and the weight of the building. In areas subject to seasonal frost, the bottom of the footing must be placed below the frost line to prevent damage to the footing and structure due to frost heave. Typical footing types include:

- spot footings
- continuous spread footing
- grade beam footing

See Figure 9, Typical Footings – Types and Layouts, and Figure 10, Pier or Foundation Wall Options by Footing Type.

SPOT FOOTINGS

A spot or pad footing is used to support a single point of contact, such as under a pier or post. A spot footing is typically a 2' by 2' square pad, 10" to 12" thick, and made with reinforced concrete rated to 3,000 to 5,000 pounds per square inch (psi) in compression.

CONTINUOUS SPREAD FOOTING

A continuous spread footing is commonly used to provide a stable base around the entire perimeter of a structure. Buildings with spread footings often include interior spot footings. A spread footing supports the weight (load) from the exterior or foundation walls. The footing thickness provides the strength needed to support the weight. The wider width of the footing base creates a large area to transfer this weight to the ground and to prevent settlement.

The dimensions of a continuous spread footing vary according to the soil conditions under the building, the load placed on the footing, and the construction style of the structure being supported. It is common practice to make the footing thickness equal to the thickness of the foundation wall, and to provide a footing projection on each side of the foundation wall equal to one-half the foundation wall thickness. Spread footings are frequently 16" to 24" wide, 6" to 16" thick, and made with reinforced concrete rated to 2,000 to 5,000 psi in compression. Table 9 on page 31 lists the minimum footing widths required for a range of allowable bearing capacities and building sizes.

GRADE BEAM FOOTING

A grade beam footing is a continuous reinforced-concrete member used to support loads with minimal bending. Grade beams are capable of spanning across non-load bearing areas, and are commonly supported by soil or pilings. A continuous grade beam is frequently constructed by digging a trench at least 8" wide to the depth needed to span the distance between supports. Grade beam footings differ from continuous spread footings in how they distribute loads. The depth of a grade beam footing is designed to distribute loads to bearing points, while the width of a continuous spread footing is designed to transfer loads to the ground.

Figure 9 Typical Footings – Types and Layouts

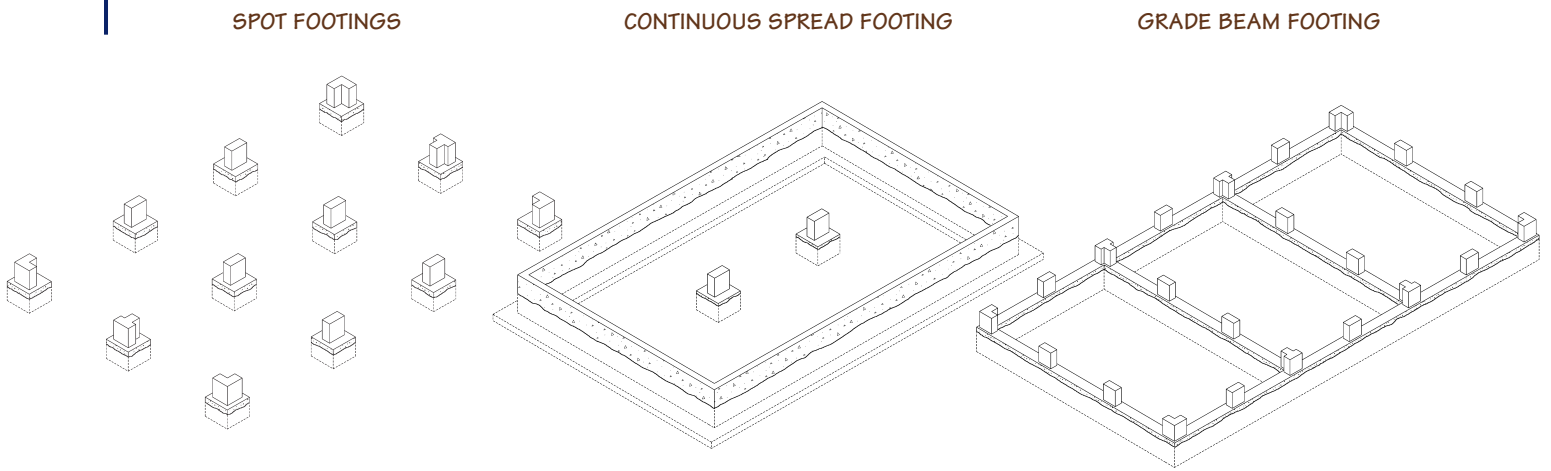
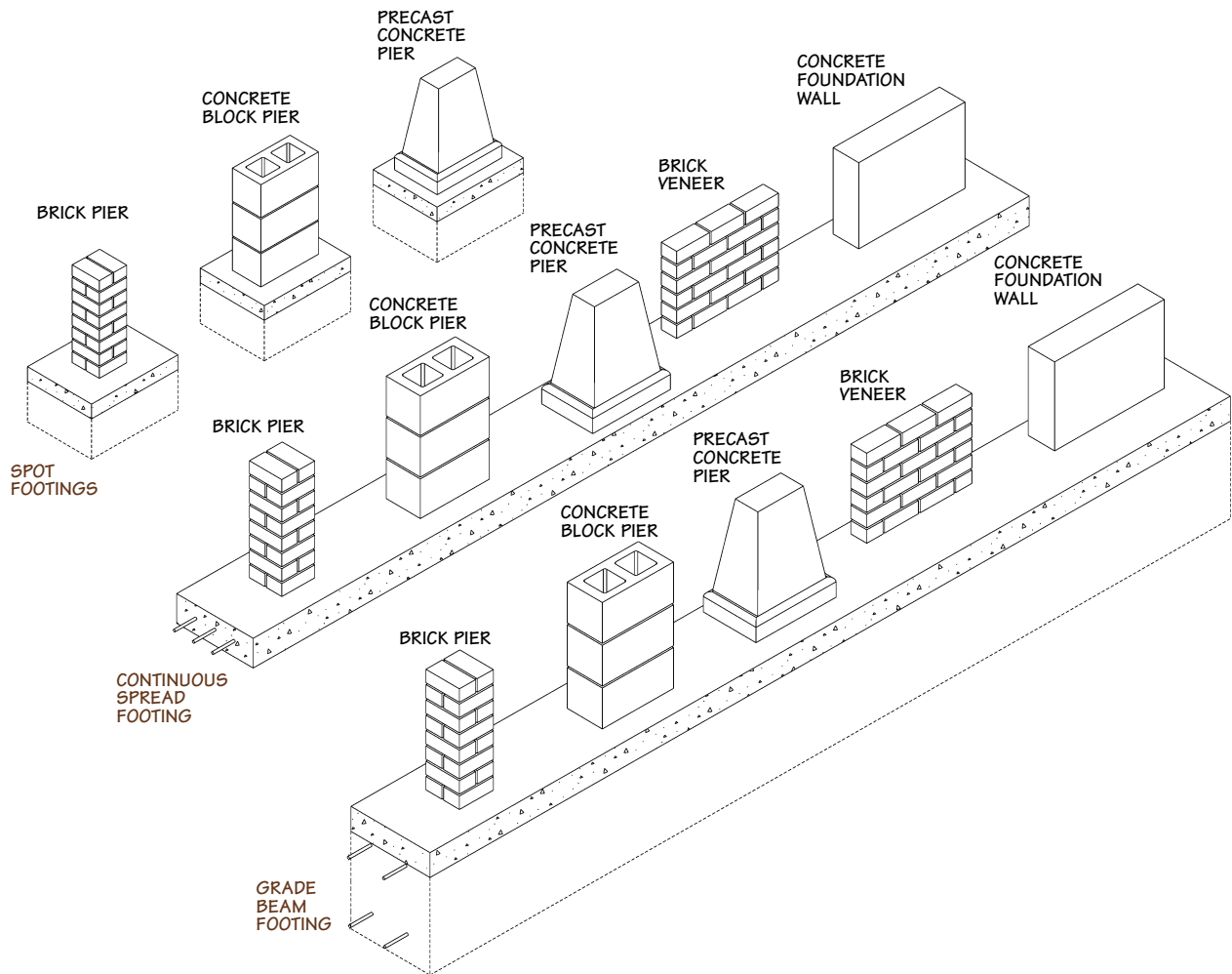


Figure 10 Pier or Foundation Wall Options by Footing Type



NOTE: See additional footing detail for Permanent Wood Foundation (PWF) option, Figure 16, page 32.

TYPES OF FOUNDATIONS

The two most commonly used foundations with raised floor systems are pier-and-beam and stem wall foundations. Regardless of the foundation system used, the foundation and the footings must be of adequate size and strength to support the design loads.

PIER-AND-BEAM FOUNDATIONS

Pier foundations are commonly constructed of reinforced masonry (brick or concrete block) supported by individual, reinforced-concrete pad footings or by continuous, rein-

forced-concrete spread footings. For pier-and-beam foundations, pier spacing will also depend upon arrangement of floor framing, particularly the location of bearing walls and partitions. Spacing of piers in the range of 8' to 12' is common practice. The openness of pier foundations creates natural venting of the crawlspace. Refer to the section on crawlspace ventilation on page 15.

See Figure 11, Interior Pier Detail, Figure 12, Framing Anchorage at Perimeter Pier, and Figure 13, Pier and Beam with Brick Veneer.

Figure 11 Interior Pier Detail

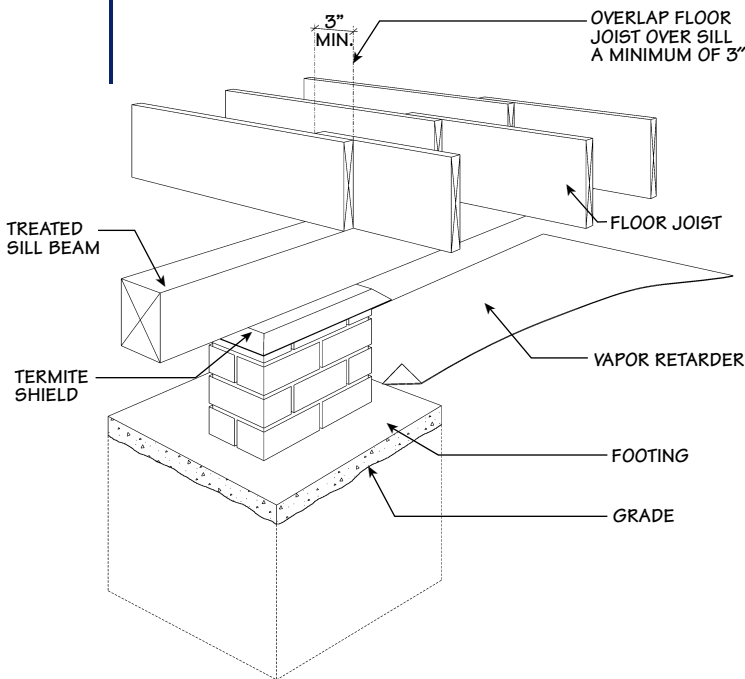


Figure 12 Framing Anchorage at Perimeter Pier

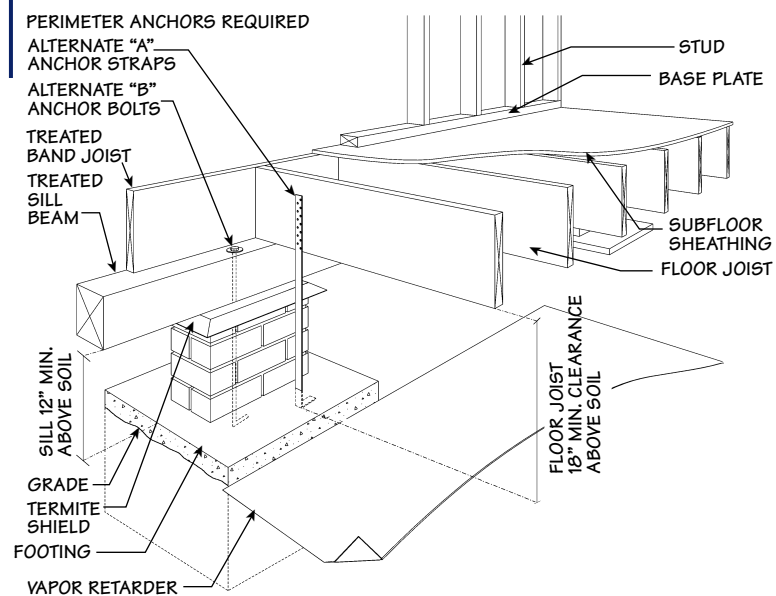
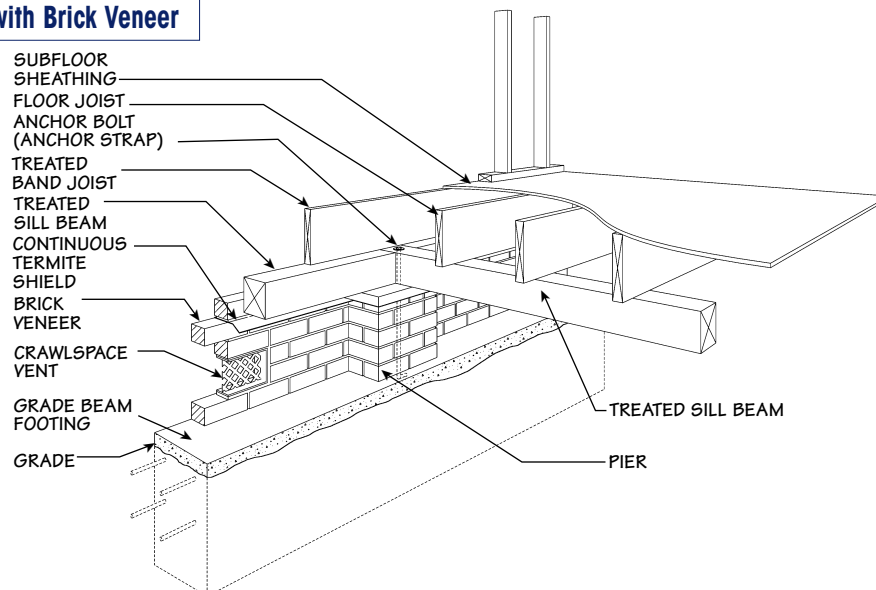


Figure 13 Pier and Beam with Brick Veneer



CONTINUOUS FOUNDATION WALLS (STEM WALL FOUNDATIONS)

Continuous (stem wall) foundations are frequently constructed of reinforced masonry or poured concrete, supported by a continuous, reinforced-concrete spread footing. Refer to Figures 14 and 15 for construction details, and to Table 9 for minimum footing widths. Stem wall foundations may include interior spot piers for support of the raised floor system. Moisture control of the crawlspace created by the stem wall foundation is an important issue. Refer to pages 14 to 16.



Stem wall foundations may also be constructed with pressure-treated wood members, commonly referred to as a Permanent Wood Foundation, or PWF.

Figure 14 Poured Concrete Foundation Wall (Stem Wall)

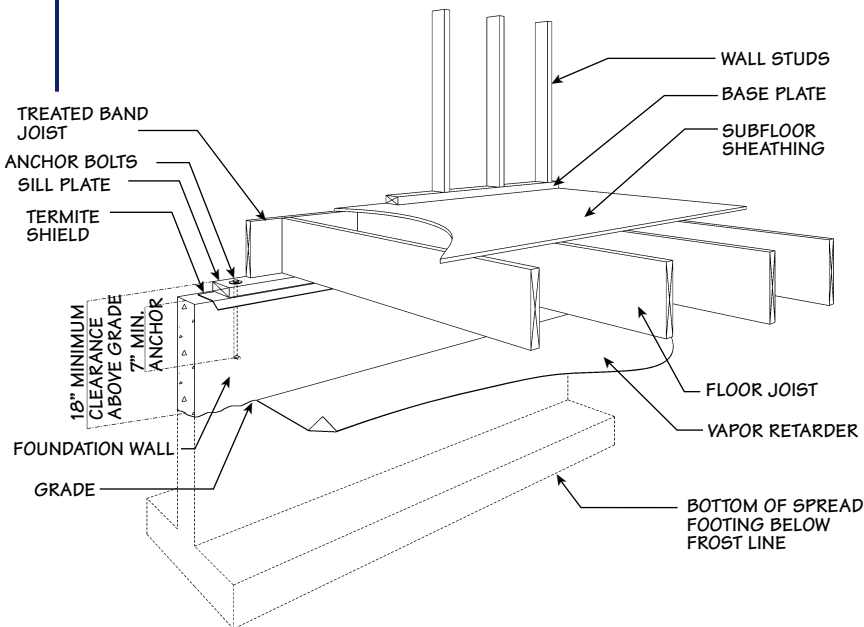


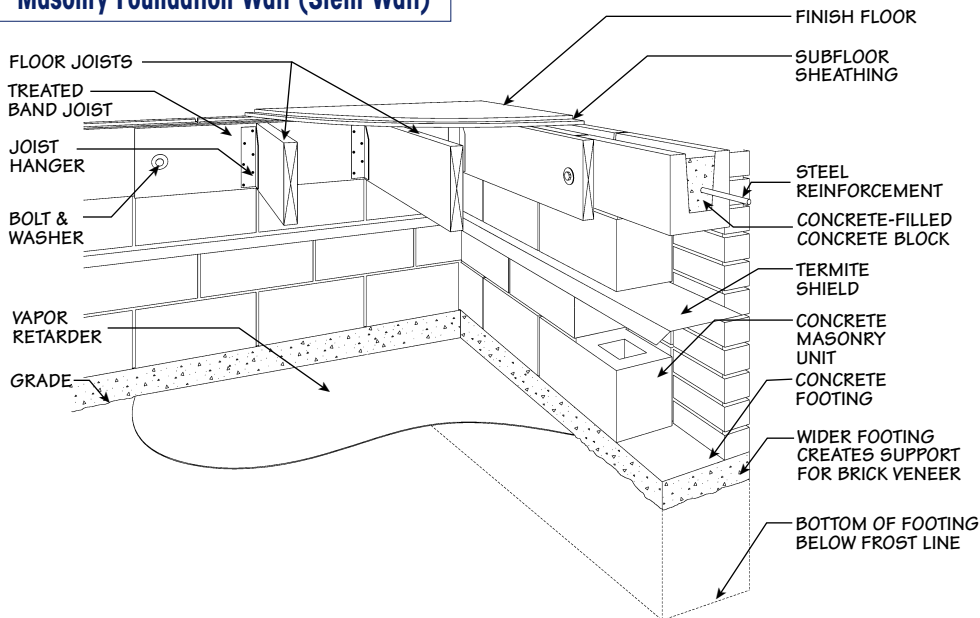
Table 9 Minimum Width of Concrete or Masonry Footings (Inches)¹

	Load-Bearing Value of Soil (psf)			
	1,500	2,000	3,000	≥4,000
CONVENTIONAL LIGHT-FRAME CONSTRUCTION				
1-story	12	12	12	12
2-story	15	12	12	12
3-story	23	17	12	12
4-INCH BRICK VENEER OVER LIGHT FRAME OR 8-INCH HOLLOW CONCRETE MASONRY				
1-story	12	12	12	12
2-story	21	16	12	12
3-story	32	24	16	12
8-INCH SOLID OR FULLY GROUTED MASONRY				
1-story	16	12	12	12
2-story	29	21	14	12
3-story	42	32	21	16

SOURCE: *International Residential Code for One- and Two-Family Dwellings*, Table R403.1 International Code Council (Falls Church, VA, 2003).

¹ Where minimum footing width is 12", a single wythe of solid or fully grouted 12"-nominal concrete masonry units is permitted to be used.
psf = pounds per square foot

Figure 15 Masonry Foundation Wall (Stem Wall)



PILE FOUNDATIONS

Where poor soil conditions are found, foundations may need to be constructed on preservative-treated timber piles capped with wood or concrete sills. In such buildings, support may be provided by the end-bearing capacities of the piles or by friction between the pile and soil. In pile-supported structures where the building support relies upon friction between the pile and soil, two important soil parameters must be known or determined:

- angle of internal friction (for cohesionless soils)
- cohesion value in pounds per square foot (for cohesive soils)

Friction piles may also be required to support standard foundations in unstable soil.

In buildings supported by pile foundations, the layout of the horizontal girders and beams should consider that the final plan locations of the tops of the piles may not be precise. Irregularities in the piles and the soil often prevent the piles from being driven perfectly plumb. The use of thick shims or over notching for alignment at bolted pile-girder connections will adversely affect connection capacity. A rule of thumb regarding notching is to notch no more than 50% of the pile's cross-sectional area. Notching more than 50% will require reinforcing the pile with a steel plate or other suitable material.

Pile foundations are also used in coastal areas where the foundation may be subject to inundation and possible wave action. Elevated wood pile foundations enable buildings to be constructed above the base flood elevation (BFE) as required by the National Flood Insurance Program. For information on coastal construction, consult the FEMA *Coastal Construction Manual*.¹

¹ *Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing and Maintaining Residential Buildings in Coastal Areas*, Federal Emergency Management Agency, www.fema.gov.

For more information on pile foundations, refer to the Timber Piling Council publication *Timber Pile Design and Construction Manual*, at www.preservedwood.com.

Handling Wood Piles

Precautions should be taken when handling and storing pressure-treated wood piles. Piles should not be dragged along the ground or dropped. They should be stored on well-supported skids to ensure air space beneath the piles, and to ensure they are not in standing water. Additional procedures and precautions for pile handling, storage and construction are found in Standard M4 of the American Wood-Preservers' Association *Book of Standards* (www.awpa.com).

PERMANENT WOOD FOUNDATIONS

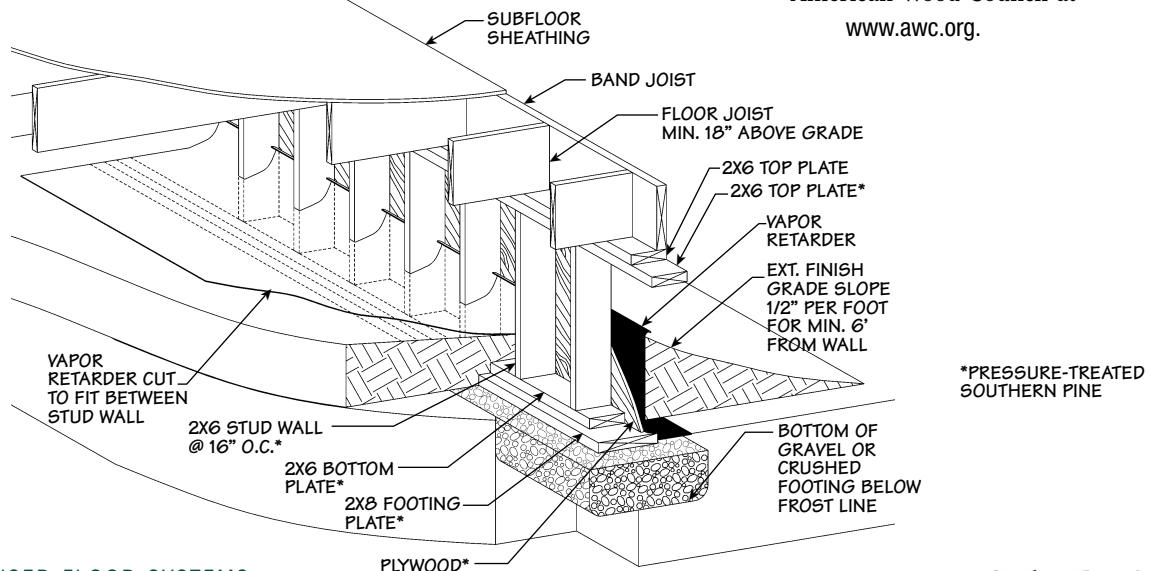
Permanent Wood Foundations (PWFs) are fully engineered systems accepted by all the major building codes, as well as by federal agencies and lending, home warranty and fire insurance institutions. Stem wall foundations constructed in accordance with the system are an increasingly popular option for houses and other wood-frame buildings. Foundation walls are typically load-bearing, lumber-framed walls sheathed with structural plywood panels. All lumber and plywood components in a PWF are pressure treated with a relatively high concentration of a waterborne preservative to withstand decay from moisture and insect damage.

The PWF system can be utilized for both basement and crawlspace (raised floor) foundation systems. Foundation walls are designed to withstand both backfill (lateral) and vertical (axial) loads, and are typically supported by foundation footings of crushed stone. Figure 16 shows a typical PWF wall for crawlspace (raised floor) construction.

For complete design and construction details refer to the SPC publication *Permanent Wood Foundations – Design and Construction Guide* at www.southernpine.com.

Additional technical and design information on the PWF can be obtained from the American Wood Council at www.awc.org.

Figure 16 Typical Permanent Wood Foundation Crawlspace



Floor Framing and Connections

Floor framing consists of a system of sills, beams, girders, joists, and subflooring, all properly sized and connected together. Floor framing provides support for floor loads, and gives lateral support to exterior walls.

FASTENERS AND CONNECTIONS

Proper design, specification and installation of fasteners and connections is crucial to the long-term performance and structural integrity of any structure. Nails, used alone or in combination with metal framing anchors and construction adhesives, are the most common method of fastening framing lumber and sheathing panels. Nail joints provide best performance when loads are applied at right angles to the nails. Nailed joints with the load applied parallel to the nail (in withdrawal) should be avoided.

SILL PLATES ON FOUNDATION WALLS

Sill plates resting on continuous foundation walls (stem walls) are generally of nominal 2x4 or 2x6 pressure-treated lumber. They are anchored to concrete, masonry, or wood walls with steel anchor bolts or proprietary metal anchor straps. The required size and spacing of the bolts or straps is dependent upon the forces acting on the building.

Fasteners for Treated Wood

Metal products in contact with pressure-treated wood must be corrosion resistant. Examples include flashing, termite shields, fasteners (e.g. nails, screws, and bolts), and all connecting hardware (e.g. joist hangers, straps, hinges, post anchors, and truss plates).

Traditionally, the treated wood industry has recommended hot-dip galvanized or stainless steel fasteners and connectors for wood products treated with Chromated Copper Arsenate (CCA). Hot-dip galvanized or stainless steel fasteners and connectors continue to be recommended for use with the new generation of wood preservatives (e.g. Alkaline Copper Quat – ACQ – and Copper Azole), but additional clarification is needed to ensure adequate corrosion protection.

Type 304 and 316 stainless steel should be used when possible; furthermore, stainless steel fasteners are required below grade for permanent wood foundations. Hot-dip galvanized fasteners and connectors are generally acceptable for above-grade applications. Hot-dip galvanized *fasteners* should meet *ASTM A153*. Hot-dip galvanized *connectors* should meet *ASTM A653*, Class G185 sheet with 1.85 ounces of zinc coating per square foot minimum. Fasteners and connectors used together should be of the same type (e.g. hot-dip nails with hot-dip joist hangers).

Do not use standard carbon-steel, aluminum, copper, or copper-based (e.g. brass or bronze) metal products in direct contact with pressure-treated wood. In addition, electroplated galvanized metal products generally have a thinner layer of protection compared to hot-dip galvanized and are not recommended. Refer to preservative or hardware manufacturers for specific corrosion-resistant recommendations for treated wood.

Typically, 1/2"-diameter anchor bolts are placed within 12" from each end of the sill plate and then spaced a maximum of 6' on center. These bolts are usually embedded at least 7" in concrete or masonry (15" in masonry for uplift loads). Proprietary metal anchor straps providing equivalent anchorage may also be used in lieu of anchor bolts. Closer anchor bolt spacing and/or a larger bolt diameter may be required in seismic design categories D1 and D2 and where the design wind speed exceeds 110 mph. Consult the *ANSI/AF&PA Wood Frame Construction Manual* from the American Wood Council at www.awc.org or your local building code official for specific anchorage requirements.

SILL BEAMS ON PIERS OR PILES

Sill beams supported by freestanding piers or piles must be of adequate size to support imposed loads between piers. They must also be adequately attached to the supporting piers. In addition, sill beams must be preservative treated if bearing on concrete or masonry, or if closer than 12" to exposed soil.

Sill beams are generally of solid-sawn lumber (typically 4x6) or timbers (typically 6x6 or 6x8), or glued-laminated timber.

BEAMS AND GIRDERS

Beams and girders are generally of solid-sawn lumber or timbers, glued-laminated timber, or structural composite lumber. They can also be built-up (nail-laminated) with multiple pieces of nominal 2" lumber nailed together with the wide faces vertical. These multiple pieces should be nailed together with two rows of 20d nails – one row near the top edge, and the other near the bottom edge. Nails in each row are spaced 32" apart. End joints of the nailed lumber should occur over the supporting column or pier.

Beams and girders must be adequately attached to supports, and should be tied together across supports if they are not continuous members. Beams and girders must be preservative treated if entering exterior masonry or concrete walls without a minimum 1/2" air space on top, sides and end, or if closer than 12" to exposed soil.

The allowable load tables on page 40 provide maximum pounds per lineal foot (plf) and required bearing lengths for the following Southern Pine beam and girder options:

- Solid-sawn, heavy dimension lumber or timbers (Table 12)
- Glued-laminated timber (Table 13)
- Nail-laminated, built-up lumber (Table 14)

For additional information, refer to the SPC publication, *Southern Pine Headers & Beams* at www.southernpine.com.

FLOOR JOISTS

Floors are commonly framed with solid-sawn lumber, floor trusses, or wood I-joists. Joist end-bearing should not be less than 1 1/2" on wood or metal, or 3" on masonry. Joists are usually attached to sills by toe-nails or by metal framing anchors. Table 10 provides the typical nailing schedule for floor framing, while Figure 17 illustrates floor framing connections. Floor joists must be preservative treated if closer than 18" to exposed soil.

Joists should be placed so the top edges provide an even plane for the subfloor and finish floor. See Tolerances and Techniques for Flat Floors, page 36. Preferably, joists should be attached to the sides of girders as shown in Figures 22, 23 and 25 on page 38. This will reduce the cumulative amount of shrinkage as lumber dries to its in-place moisture content.

Table 10 Nailing Schedule for Floor Framing		
Joint Description	Number and Size of Common Nails	Nail Spacing
Joist to Sill, Top Plate or Girder (toe-nailed)	4- 8d	per joist
Bridging to Joist (toe-nailed)	2- 8d	each end
Blocking to Joist (toe-nailed)	2- 8d	each end
Blocking to Sill or Top Plate (toe-nailed)	3- 16d	each block
Ledger Strip to Beam (face-nailed)	3- 16d	each joist
Joist on Ledger to Beam (toe-nailed)	3- 8d	per joist
Band Joist to Joist (end-nailed)	3- 16d	per joist
Band Joist to Sill or Top Plate (toe-nailed)	2- 16d ¹	per foot

SOURCE: *Wood Frame Construction Manual*, 2001 Edition, American Wood Council (www.awc.org), Table 3.1.

¹ Nailing requirements are based on wall sheathing nailed 6" on-center at the panel edge. If wall sheathing is nailed 3" on-center at the panel edge to obtain higher shear capacities, nailing requirements for structural members shall be doubled, or alternate connectors, such as shear plates, shall be used to maintain the load path.

Proper alignment of the upper edges of floor joists is maintained by adequately nailed subflooring. Nailing the ends of joists to band joists or headers provides additional joist support. These typical construction techniques usually eliminate the need for intermediate bridging. Where the nominal depth-to-thickness ratio of lumber joists exceeds six, intermediate bridging is installed at 8' intervals. Bridging may be accomplished with solid 2" blocking or 1x4 cross braces as illustrated in Figure 17, and helps reduce floor vibration. See *Reducing Floor Vibration*, page 35.

The span tables on page 41 provide maximum allowable spans for the following Southern Pine joist options:

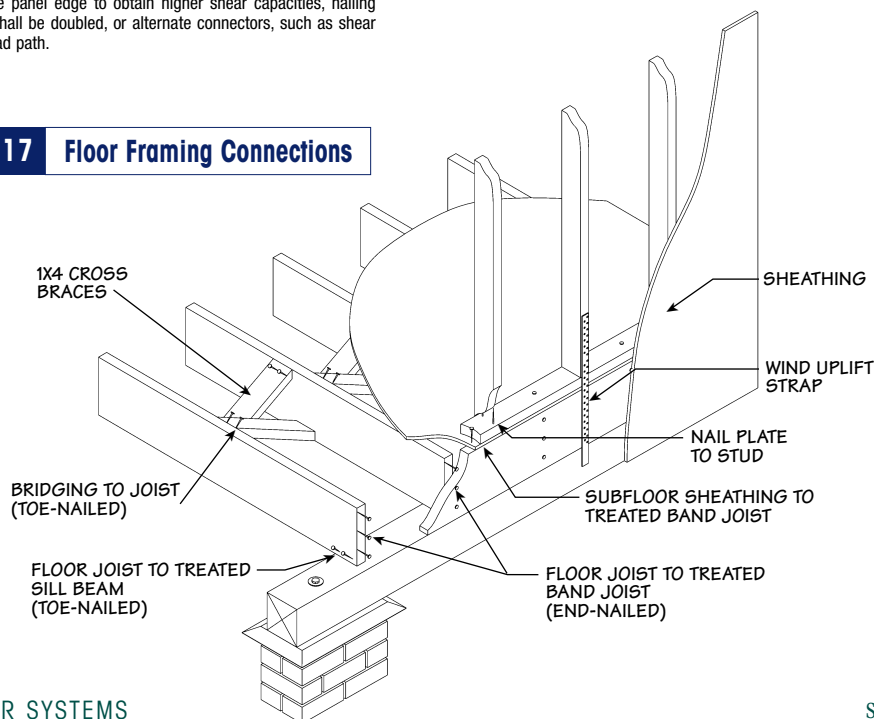
- Solid-sawn lumber (Tables 15 and 16)
- Metal plate connected trusses (Tables 17 and 18)

For additional information, refer to the SPC publication *Maximum Spans for Southern Pine Joists & Rafters* at www.southernpine.com, *Span Tables for Joists and Rafters* from the American Wood Council at www.awc.org, or the *Metal Plate Connected Wood Truss Handbook* from the Wood Truss Council of America at www.woodtruss.com.



Construction adhesive is applied to floor joists before subfloor sheathing is installed. Gluing improves floor stiffness, reduces floor vibration, and helps eliminate squeaks.

Figure 17 Floor Framing Connections



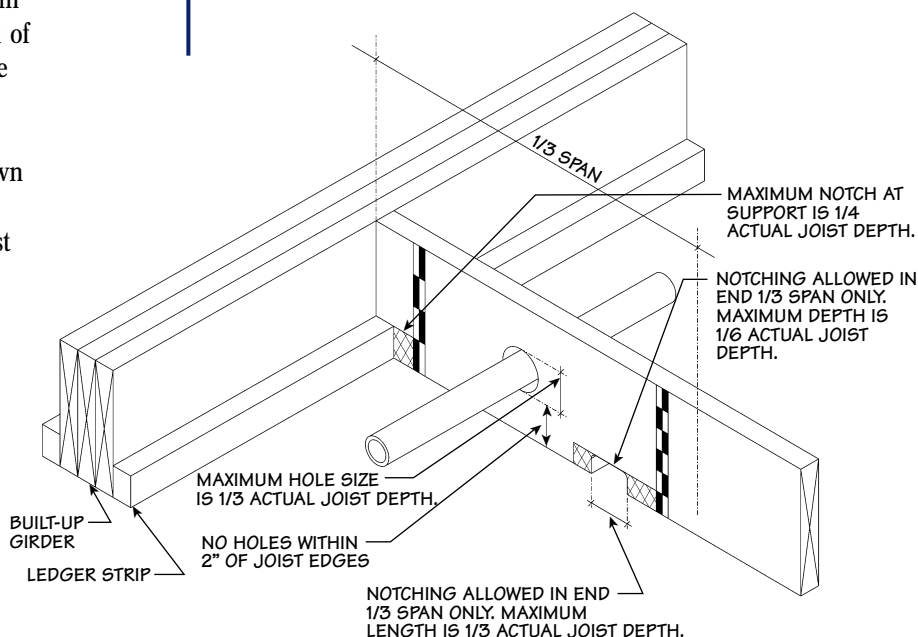
NOTCHING AND BORING OF JOISTS

Figure 18 illustrates joist notching and boring limits for solid-sawn joists. Do not cut notches in the top or bottom edges in the middle one-third of the joist span. Notches in the outer thirds of the span cannot exceed one-sixth the actual joist depth, and cannot be longer than one-third the depth. Notches made at a support, such as shown in Figure 23 on page 38 for joists supported by ledgers, cannot exceed one-fourth the actual joist depth.

Bored holes are limited in diameter to one-third the actual joist depth, and the edge of the hole cannot be closer than 2" to the top or bottom edges of the joist.

No boring, cutting or other modification of wood trusses is allowed. For rules on modification of I-joists, refer to *I-Joists for Residential Floors* at www.apawood.org or to the manufacturer's requirements.

Figure 18 Solid-Sawn Joist Notching & Boring Limits



Reducing Floor Vibration¹

Floor vibration, or bounce, is not a safety issue; it is a performance issue, and one that is likely to be important to homeowners. "Acceptable" floor performance is highly subjective: What's adequate for one homeowner may not be adequate for another. But here are some general rules-of-thumb for reducing bounce that should prevent the majority of complaints.

1 Glue and screw the sheathing. Floor sheathing should always be glued down. Gluing increases floor stiffness and helps eliminate squeaks, floor vibration, bounce and nail-popping. Screws work better than nails for long-term bounce control. See *Steps to Construct a Solid, Squeak-Free Floor System* at www.apawood.org.

2 Shorten the span. In general, shorter spans make for stiffer floors. For example, if the $L/360$ span table tells you a joist of a given size, grade, and species will just barely work for your span, shorten the span by adding a girder near the center of the original span. The resulting floor will vibrate less.

3 Increase the joist depth one size. If the building code requires a 2x8 at 16" on center, then use a 2x10 of the same grade and species. Or use a 14"-deep floor truss when a 12"-deep truss would meet code requirements. This may not be the most cost-effective solution in every case, but it is easy to remember and can save time and worry.

4 Reduce the on-center spacing. For example, if the span table calls for 16" spacing of the floor joists, but this arrangement does not provide the stiffness required, reduce the on-center spacing to 12". This is probably the least efficient and more costly way to improve floor vibration performance, but it can help. The reason is that "bounce" occurs as a result of a foot impacting an individual joist. Joists spaced 16" on center may not be close enough for the shock of a foot to be carried by two joists, so reducing joist spacing to 12" on center can help.

¹ *Reducing Floor Vibration* by Frank Woeste, P.E., and Dan Dolan, P.E., Virginia Tech

ALLERGY-FREE WOOD FLOORS ADD ELEGANCE

Floors are the most heavily used surface in a house. Solid wood flooring is not only durable, but is an elegant way to add value and beauty to your home.

And in five to seven years if the floor needs maintenance, it can be refinished for about \$2 per square foot, roughly the price of replacing carpet or a fraction of the cost of other flooring options. An

added benefit of wood flooring is less allergies because, unlike carpeting, wood does not trap spores and dust that cause many household allergies.

SOURCE: *Home New Home*, Wood Promotion Network at www.beconstructive.com.

Wood flooring naturally complements a wood joist system. Using Southern Pine flooring is ideal. It works with any decor, from country to contemporary. Refer to the SPC publication, *A Guide to Southern Pine Flooring*, at www.southernpine.com.



SUBFLOORING

Subflooring, also commonly called “rough floor”, is the material applied over floor joists to provide a base for the finish floor. The subfloor also works as a horizontal diaphragm in high-wind and seismic areas, transferring lateral loads from the wall system to the foundation below.

Structural wood panels (e.g. plywood, OSB) commonly form the subfloor of a raised floor system. These panels are typically manufactured in 4x8’ sheets. The panels are then applied to the floor joists with 1/8” gaps left between the sheets to allow for expansion and to prevent buckling.



Workers install subfloor sheathing over floor trusses of a 5,000 sq. ft. assembly building. See case study D, page 43.

Table 11 provides a nailing schedule for properly attaching wood structural panel subflooring to the top of the floor joists.

APA-rated Sturd-I-Floor is a combined subfloor-underlayment product designed specifically for single-layer floor construction beneath carpet and pad. When other subfloor products are used, builders often install a separate underlayment grade of plywood over the subfloor to provide a proper base for the finish flooring.

The quality of the subfloor and underlayment layers is fundamental to having a floor that is plumb and stable.

The quality of the subfloor and underlayment layers is fundamental to having a floor that is plumb and stable.

Table 11 Nailing Schedule for Wood Structural Panel Subflooring¹

Panel Span Rating	Panel Thickness (inches)	Maximum Span (inches)	Nail Size and Type ⁴	Supported Panel Edges ⁶ (inches)	Intermediate Supports (inches)
24/16	7/16	16	6d common	6	12
32/16	15/32, 1/2	16	8d common ²	6	12
40/20	19/32, 5/8	20 ³	8d common	6	12
48/24	23/32, 3/4	24	8d common	6	12
60/32 ⁵	7/8	32	8d common	6	12

SOURCE: APA Design Construction Guide – Residential & Commercial; APA – The Engineered Wood Association, (www.apawood.org), Table 11.

1 APA Rated Sturd-I-Floor may be substituted when the Span Rating is equal to or greater than tabulated maximum span.

2 6d common nail permitted if panel is 1/2 inch or thinner.

3 Span may be 24” if a minimum 1-1/2 inches of lightweight concrete is applied over panels.

4 Other code-approved fasteners may be used.

5 Check with supplier for availability.

6 Supported panel joints shall occur approximately along the centerline of framing with a minimum bearing of 1/2”. Fasteners shall be located 3/8 inch from panel edges.

See Tolerances and Techniques for Flat Floors, below. Regardless of the type of flooring used, subfloor and underlayment rules are basically the same. They should be stable, clean, smooth and level. If a subfloor becomes wet during construction, it should be allowed to dry prior to the installation of any finish flooring material.

For more information on subflooring, refer to the *Engineered Wood Construction Guide* available from APA – The Engineered Wood Association at www.apawood.org.

Tolerances and Techniques for Flat Floors

Proper installation of the floor joist system and subfloor will ensure a flat surface ready for the finish floor. Guidelines published by the National Association of Homebuilders (NAHB) and the National Wood Flooring Association (NWFA) suggest minimum tolerances for the builder and finish-floor installer.

The NAHB publication, *Residential Construction Performance Guidelines for Professional Builders and Remodelers*, describes minimum performance criteria to determine whether a floor system is either uneven or out-of-level.

For uneven floors, the NAHB guide states “Floors shall not have more than a 1/4” ridge or depression within any 32” measurement. Allowable floor and ceiling joist deflections are governed by the local approved building codes.”

For out-of-level floors, the NAHB guide states “No point on the surface of a wood floor shall be more than 1/2” higher or lower than any other point on the surface within 20 feet, or proportional multiples of the preceding dimension.”

The NWFA *Hardwood Flooring Installation Guidelines* states “For installations using mechanical fasteners of 1 1/2” and above, the subfloor should be flat to within 1/4” in 10 feet or 3/16” in 6 feet. For gluedown installations and installations using mechanical fasteners of less than 1 1/2”, the subfloor should be flat to within 3/16” in 10 feet or 1/8” in 6 feet.”

Crook is the warping of lumber, causing the edge to become either convex or concave lengthwise. A slight amount of crook is commonly called “crown.” Most lumber naturally has some crown, and should always be positioned in a floor system with the crown on top. Standard carpentry practice is to also sort lumber according to the degree of crown. Lumber with the greatest crown is usually placed in the middle of a room, with lumber of lesser or no crown placed near walls or partitions. Installing the joists according to a sort should mediate differences between the tops of adjacent joists. Installing joists with crowns up will negate deflection of the joists under load and likewise lessen differences in heights of adjacent joists. Lumber with excessive crook should be rejected.

Use of a planer or sander to flatten crowned areas in a joist system should be avoided. Alteration of floor joists in this manner can compromise the strength of the lumber. Instead, where minor differences in crown occur, the subfloor should be renailed and/or shimmed to correct for variations beyond accepted tolerances before installation of the finish floor. Further preparation and flattening of the subfloor may require sanding and/or the application of patching compounds to achieve the desired result.

DO NOT attempt to level a floor after the fact by over-sanding the wood finish floor. Over-sanding will wear down the groove edge of tongue-and-groove flooring, leading to cracks, splits and exposed nails.

FRAMING OF FLOOR OPENINGS

Headers, trimmers and joists form the framing for floor openings. Trimmers and headers are doubled when the header span exceeds four feet. Headers more than six feet in length are supported at the ends by joist hangers or framing anchors unless they are bearing on a partition, beam or wall. Tail joists that exceed 12' in length are supported on framing anchors or on ledger strips not less than 2x2 (nominal).

SUPPORT OF PARTITIONS

Bearing partitions are normally placed over girders or walls that support the floor system. Where floor framing is

adequate to support the added load, bearing partitions may be offset from supporting members by no more than the joist depth, unless floor joists are designed to carry the increased load. Where nonbearing partitions run parallel to floor joists, the joist under the partition is doubled to support increased loads frequently occurring adjacent to the partition.

FRAMING DETAILS

Figures 19, 20 and 21 provide floor framing details. Figures 22, 23, 24 and 25 illustrate various methods for supporting floor joists. Figures 26 and 27 provide stair framing details, with emphasis on floor framing support.

Figure 19 Framing Under Partition

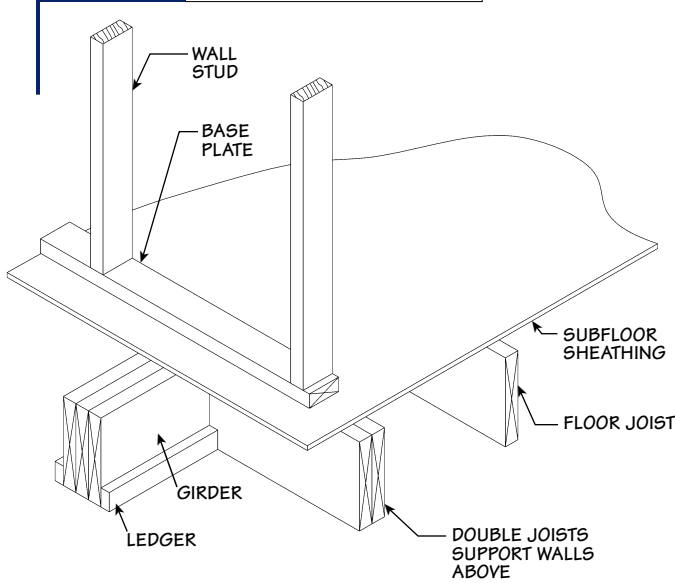


Figure 20 Framing Detail – Plumbing Inside Wall

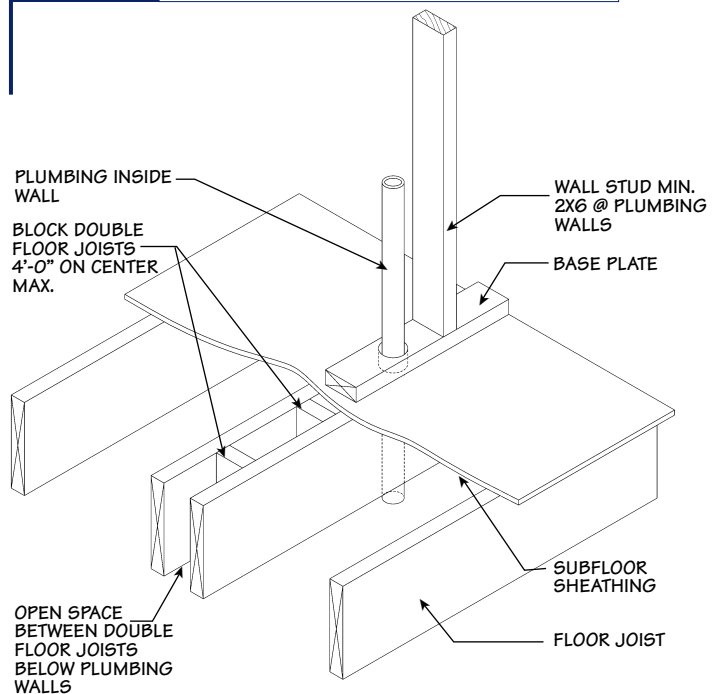


Figure 21 Framing Supporting Bathtub

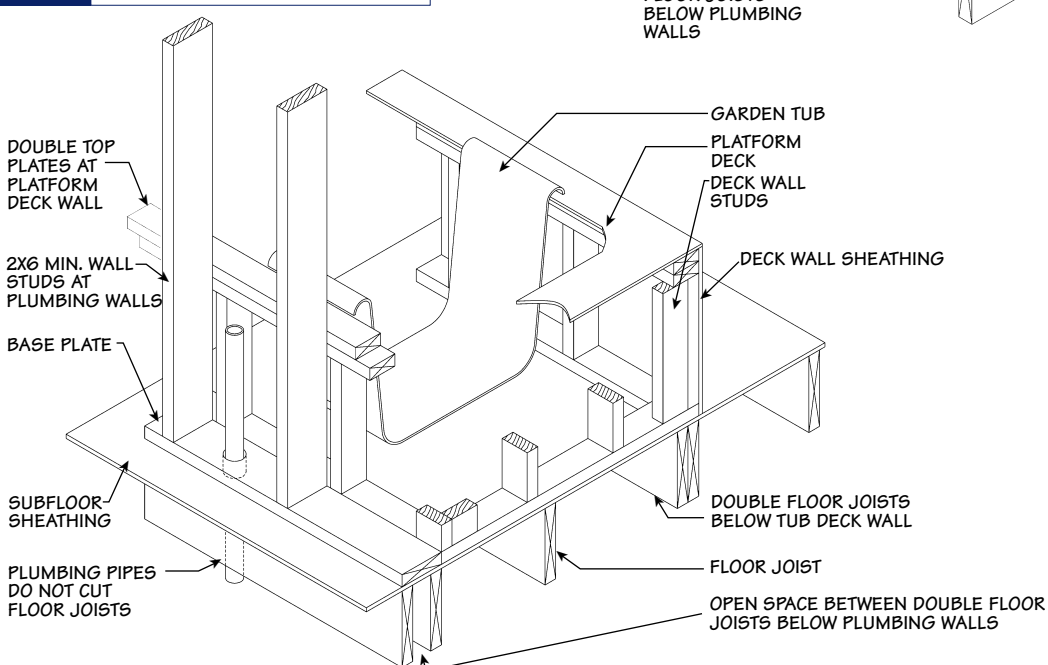


Figure 22 Joists Supported by Ledgers

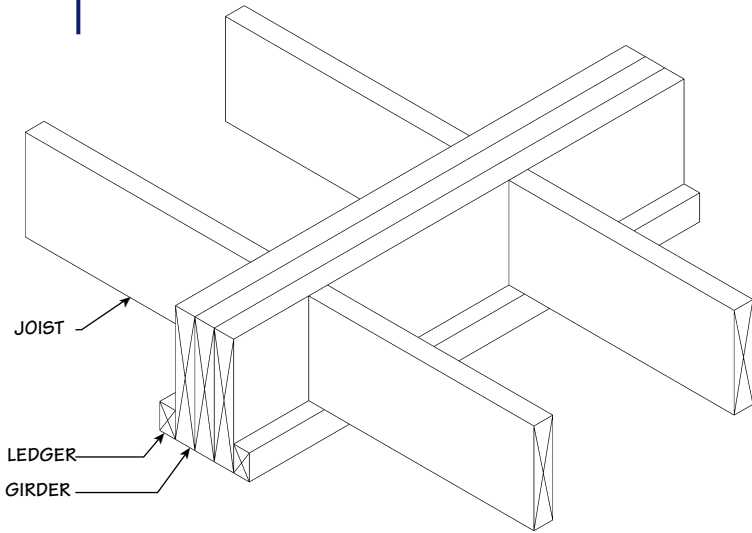


Figure 23 Notched Joists Supported by Ledgers

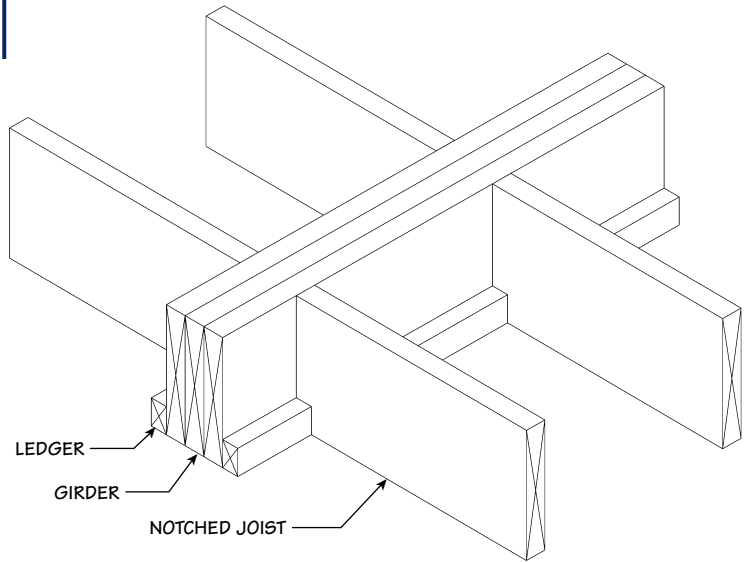


Figure 24 Joists Supported by Girder

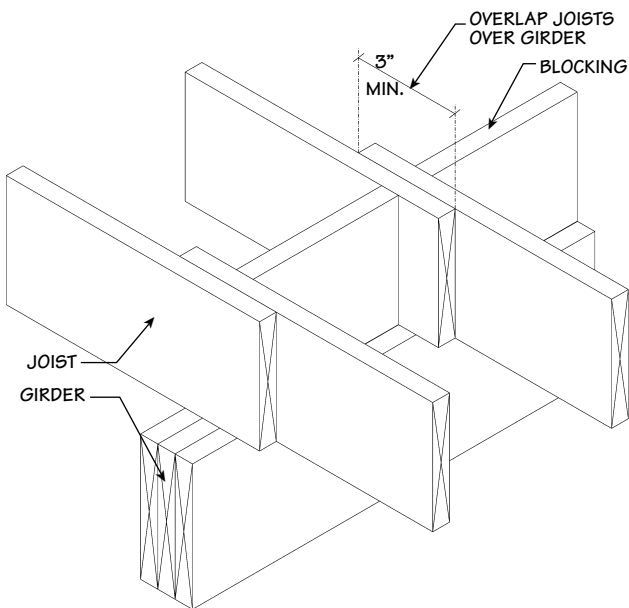


Figure 25 Joists Supported by Joist Hangers

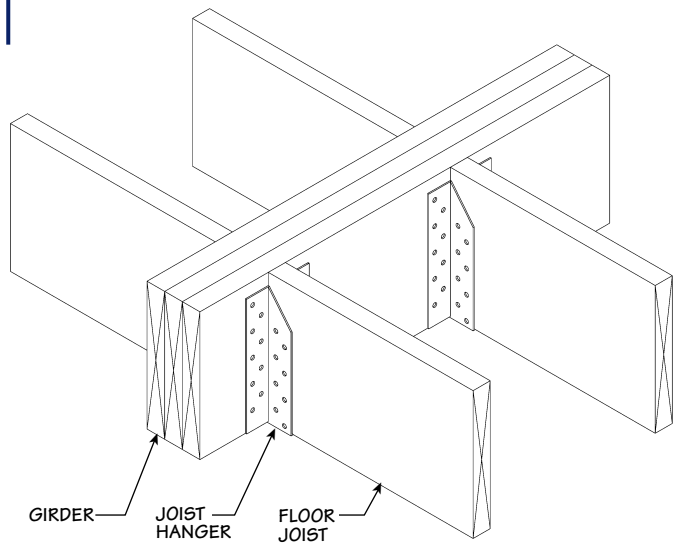


Figure 26 Stairway Framing

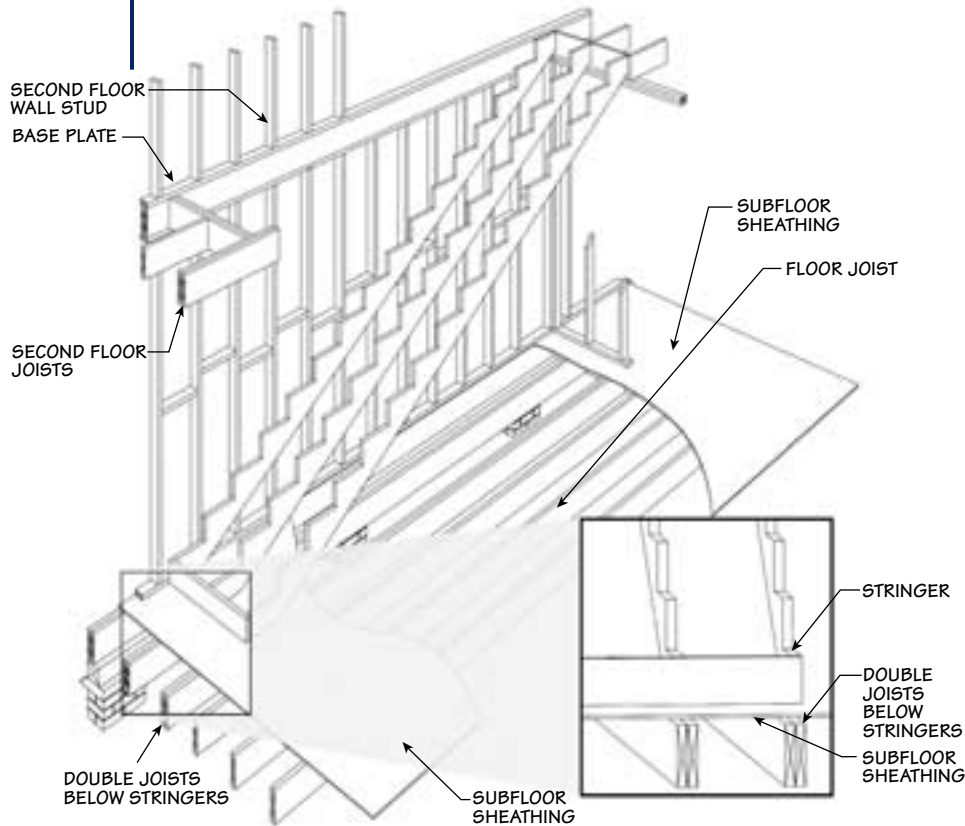
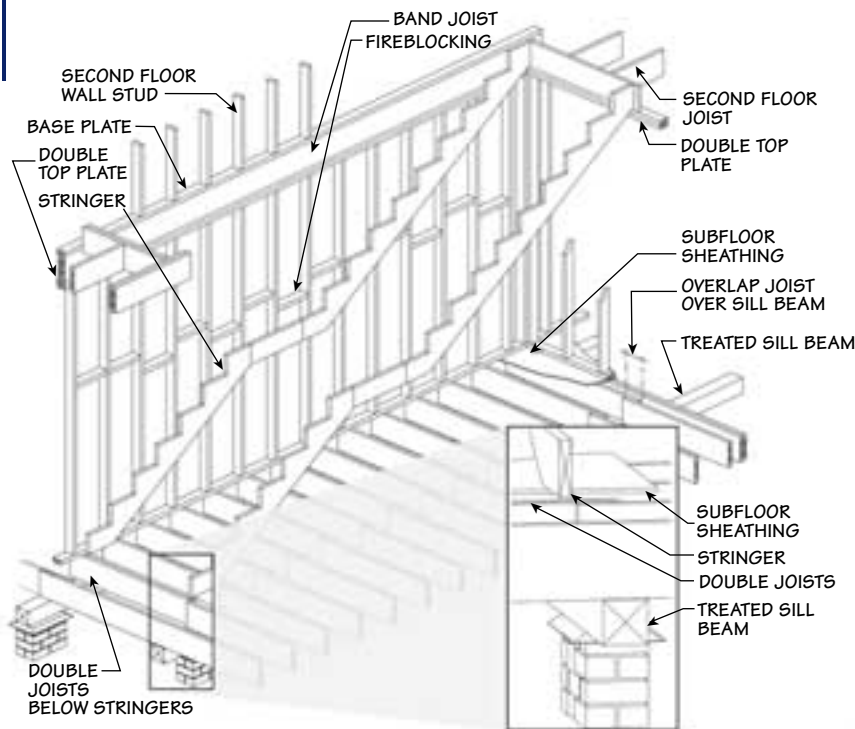


Figure 27 Stairway Framing with Landing



Lumber Storage and Acclimation

Southern Pine lumber 2" and less in thickness must be dried to a maximum moisture content of 19% before it can be grade marked for structural use, so no further seasoning is required prior to installation. For best performance, however, all wood products should be protected from the elements at the job site and properly acclimated if necessary.

In-service Moisture Content.

Wood-frame buildings perform best when the framing lumber at enclosure is as close as possible to the moisture content it will finally reach in service. The final in-service moisture content of lumber in the building varies with the geographic region and with location in the structure. Floor joists over a crawl space may reach seasonal moisture contents in excess of 14%. Roof trusses and rafters, on the other hand, may dry below 6%.

Storage and Protection of Materials.

Wood is a hygroscopic material that absorbs and releases moisture, equalizing itself with surrounding conditions. Wood products should be protected from the weather at the building site. They should be unloaded and stored in a dry place, not in wet or muddy areas. They should be elevated on stringers, not in direct contact with the ground. Wood products stored in an open area should be covered with a material that will give protection from the elements, but be porous enough to allow moisture to escape. Polyethylene or similar nonporous covers may trap moisture.

Acclimation of Finish Materials. Interior finish lumber, such as flooring and paneling, must be protected from moisture and properly acclimated indoors prior to installation. Exterior finish lumber, such as siding and porch flooring, should also be protected from moisture and allowed to properly acclimate outdoors prior to installation.

For more details on lumber seasoning, protection and acclimation, refer to the *Southern Pine Use Guide*, *Guide to Southern Pine Flooring*, and *Guide to Southern Pine Porch Flooring* at www.southernpine.com.

ALLOWABLE LOAD TABLES – BEAMS AND GIRDERS

These allowable load tables (Tables 12, 13 and 14) are intended as guidelines to provide the user with an idea of the maximum loads in pounds per lineal foot (plf) for various wood products with girder spans common in raised floor systems. These allowable loads were determined in accordance with appropriate standards, such as the *National Design Specification® (NDS®) for Wood Construction* published by the American Forest & Paper Association. They are based on uniform, gravity loads only, and assume dry-service conditions. For more complete allowable load table information, refer to www.southernpine.com.



Treated Southern Pine 4x6 sill beams are supported by concrete block piers on a continuous spread footing.

Table 12 Solid-Sawn No. 2 Southern Pine

Span <i>feet</i>	Size (nominal inches)		
	4 x 6	6 x 6	6 x 8
8	223	237	412
	221	237	412
	1.5	1.5	1.5
10	142	149	262
	114	137	262
	1.5	1.5	1.5
12	95	102	179
	66	80	179
	1.5	1.5	1.5

SOURCE: Southern Pine Council (www.southernpine.com). See KEY to table values.

Table 13 24F-V3 Southern Pine Glued Laminated Timber, 3 1/2" Width

Span <i>feet</i>	Depth (inches)						
	8-1/4	9-5/8	11	12-3/8	13-3/4	15-1/8	16-1/2
8	954	1284	1656	2065	2506	2975	—
	813	1268	1656	2065	2506	2975	—
	1.5	3.0	3.0	4.5	4.5	6.0	—
10	615	832	1079	1353	1654	1978	2323
	423	665	980	1353	1654	1978	2323
	1.5	3.0	3.0	3.0	4.5	4.5	6.0
12	365	576	755	950	1165	1400	1651
	248	390	577	813	1102	1400	1651
	1.5	1.5	3.0	3.0	3.0	4.5	4.5

SOURCE: *Southern Pine Headers & Beams*, Southern Pine Council (www.southernpine.com). See KEY to table values.

Table 14 Nail-Laminated No. 2 Southern Pine Lumber

Span <i>feet</i>	2-ply			3-ply			4-ply		
	2 x 8	2 x 10	2 x 12	2 x 8	2 x 10	2 x 12	2 x 8	2 x 10	2 x 12
8	318	451	615	548	776	1057	731	1035	1409
	318	451	615	548	776	1057	731	1035	1409
	1.5	1.5	1.5	1.5	1.5	3.0	1.5	1.5	3.0
10	203	288	395	351	498	681	467	664	908
	203	288	395	333	498	681	444	664	908
	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
12	140	199	274	242	345	473	323	459	630
	129	199	274	194	345	473	258	459	630
	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

SOURCE: *Southern Pine Headers & Beams*, Southern Pine Council (www.southernpine.com). See KEY to table values.

KEY

FOR EACH SPAN, THERE ARE
THREE ROWS OF NUMBERS:

- Row 1:** Maximum total load in pounds per lineal foot with deflection limited to $L/360$
- Row 2:** Maximum live load in pounds per lineal foot with deflection limited to $L/240$
- Row 3:** Required bearing length in 1.5" trimmer thickness increments

It has been determined that Row 1 should read $L/240$ and Row 2 should be $L/360$. We are sorry for this inconvenience, and hope to have a corrected file online soon.

SPAN TABLES – FLOOR JOISTS AND TRUSSES

These span tables (Tables 15, 16, 17 and 18) are intended as guidelines to provide the user with an idea of the maximum spans in feet and inches for various wood products with floor loads common in raised floor systems. These spans were determined in accordance with appropriate standards, such as the *National Design Specification® (NDS®) for Wood Construction* published by the American Forest & Paper Association and the *National Design Specification for Metal Plate Connected Wood Truss Construction* published by the Truss Plate Institute. They are based on uniform, gravity loads only, and assume dry-service conditions. For more complete span table information, refer to www.southernpine.com, www.awc.org, or www.woodtruss.com.

Table 15 Floor Joists – Solid-Sawn Southern Pine Lumber

40 psf live load, 10 psf dead load, ℓ/360 deflection				
Size <i>inches</i>	Spacing <i>inches on center</i>	Grade		
		No.1 <i>feet-inches</i>	No.2 <i>feet-inches</i>	No.3 <i>feet-inches</i>
2 x 8	12	14-5	14-2	11-11
	16	13-1	12-10	10-3
	24	11-5	11-0	8-5
2 x 10	12	18-5	18-0	14-0
	16	16-9	16-1	12-2
	24	14-7	13-1	9-11
2 x 12	12	22-5	21-9	16-8
	16	20-4	18-10	14-6
	24	17-5	15-5	11-10

Table 16 Floor Joists – Solid-Sawn Southern Pine Lumber

50 psf live load, 10 psf dead load, ℓ/360 deflection				
Size <i>inches</i>	Spacing <i>inches on center</i>	Grade		
		No.1 <i>feet-inches</i>	No.2 <i>feet-inches</i>	No.3 <i>feet-inches</i>
2 x 8	12	13-5	13-1	10-10
	16	12-2	11-11	9-5
	24	10-8	10-0	7-8
2 x 10	12	17-1	16-9	12-10
	16	15-6	14-8	11-1
	24	13-4	12-0	9-1
2 x 12	12	20-9	19-10	15-3
	16	18-10	17-2	13-2
	24	15-11	14-0	10-9

SOURCE: *Maximum Spans for Southern Pine Joists & Rafters*, Southern Pine Council (www.southernpine.com). Maximum spans are from inside to inside of bearings.

Table 17 Floor Trusses with Southern Pine Lumber

40 psf live load – Residential				
10 psf dead load top chord, 5 psf dead load bottom chord				
Depth <i>inches</i>	Spacing <i>inches on center</i>	Grade		
		SS/No.1 DNS <i>feet-inches</i>	No.1 <i>feet-inches</i>	No.2 <i>feet-inches</i>
12	24	16-11	16-8	16-1
14	24	19-2	18-11	17-11
16	24	21-6	21-2	19-2

Table 18 Floor Trusses with Southern Pine Lumber

50 psf live load – Commercial				
15 psf dead load top chord, 10 psf dead load bottom chord				
Depth <i>inches</i>	Spacing <i>inches on center</i>	Grade		
		SS <i>feet-inches</i>	No.1 <i>feet-inches</i>	No.2 <i>feet-inches</i>
16	24	24-3	19-1	16-3
18	24	27-0	21-5	17-10
20	24	29-6	23-3	19-8

SOURCE: Wood Truss Council of America (www.woodtruss.com). Assumes bottom-chord bearing. SS = Select Structural. DNS = Dense. Table 19 includes a 20 pound per square foot (psf) partition load and a 2000 pound concentrated load per the *2000 International Building Code*, sections 1607.5 and 1607.1 respectively.

Case Studies

Residential

A Comfort, curb appeal, flood protection, and lasting value are just a few of the reasons the owners of this home near New Orleans chose a raised floor system. Once site preparation was completed, an intersecting grade beam footing was installed. Block piers filled with concrete were then anchored by rebar to the grade beam. Piers support a Southern Pine floor system of pressure-treated 6x6 sill beams and 2x12 floor joists. Hurricane strapping anchors the sill beams and joists to the piers, offering added wind load protection. Subfloor is 3/4" Sturd-I-Floor glued and screwed to the joists. Inside, the finish floor is Southern Pine flooring.

Architect: Kevin Harris, AIA

General Contractor: McMath Construction



Assisted Living Center

B A raised floor system was the answer to this project's success. An addition to this assisted living center in Bay Saint Louis, Mississippi was challenged by a sloping lot and imperfect soil conditions. Concrete block piers bear on a perimeter grade beam footing and interior spot footings. Structural composite lumber beams span the piers and support parallel-chord floor trusses made with Southern Pine lumber. The ventilated crawlspace is protected with a 6-mil polyethylene vapor barrier covered with a layer of pea gravel. The \$1.3 million 16,500 square-foot addition includes 23 spacious private and semi-private living suites, plus a dining room and a therapy treatment unit. This addition also features a covered portico at the center's new entrance.

Architect: Johnny Wynne & Associates

General Contractor: HGM Construction, Inc.



Office Building

The headquarters building of the Southern Forest Products Association is a model of raised floor construction in a nonresidential structure, and a showcase for Southern Pine products. Poor soil conditions required a floor system of glulam beams and double 2x12 Southern Pine joists, anchored atop creosote-treated piling that extend 30' above grade. The raised floor design includes an appealing, centered front porch entry, and a convenient loading dock located at one end of the building. Exterior walls were framed using 2x6 Southern Pine studs 24" on center. Located in suburban New Orleans and dedicated in 1978, the building has 10,700 square feet of office space. Wood flooring and paneling accent the interior décor.

Architect: *J. Buchanan Blich & Associates, Inc.*
General Contractor: *Claiborne Builders, Inc.*



Assembly Building

A raised floor system is just one of many features of the new home for the Marine Corps League's Detachment 708. Located north of Tampa, Florida, in Spring Hill, the 5,000 square-foot building serves a multitude of purposes for members of the detachment, its related women's auxiliary and youth organizations. For the Marine veterans, the raised floor design allows easy renovation or floor plan changes over the life of the building.

"In light commercial construction, raised wood platform foundations can easily accommodate changes," says Bill Tucker, executive director, Florida Building Materials Association. "For example, a change in occupancy from an attorney's office to a doctor's clinic can be easily accomplished. Moving walls and plumbing is simple."

This T-shaped raised floor system started with a concrete-block stem wall. Treated sill



plates of 2x8 pressure-treated Southern Pine were installed atop the entire wall. Inside the stem wall, concrete block piers support glued-laminated beams (5-1/2"x15-7/8") and engineered parallel-chord floor trusses (16" o.c.) for the main room of the building. Trusses span 40 feet; top and bottom chords are 2x4 MSR Southern Pine 2400f-2.0E. Sub-flooring is 3/4" T&G plywood. All wall framing is pressure treated with borates for long-term resistance to decay and termite attack.

Proper connections for high-wind considerations are also incorporated for winds up to 110 miles per hour. Exterior walls use 2x6 material; interior walls are framed with 2x4 lumber. This project was constructed in accordance with the Standard Building Code and is rated for A-2 occupancy.

Project Engineer: *Brian Sterling*
General Contractor: *Shiloh Homes*

Wood: THE RIGHT CHOICE

■ No other material can match wood's unique combination of benefits, including strength, affordability, ease of use, and environmental superiority.

■ Wood-frame construction has a 100-year track record for safety and dependability. That's why some nine out of 10 homes today are built with wood.



■ Building codes require all materials to provide the same degree of protection, even for extreme events such as earthquakes and hurricanes. Wood-frame construction is as safe, sturdy and dependable as any other building material.

■ Wood is the best insulator against heat and cold, which makes it the most energy-efficient material that can help keep energy bills in check. Unlike steel and concrete, wood doesn't conduct heat and cold. Wood is 400 times less heat-conductive than steel, so homes built with wood studs take less energy to heat and cool.



SOURCE: *Why Wood is Good*, Wood Promotion Network at www.beconstructive.com

■ Wood is the most affordable building material. The economy of wood construction is one of the many reasons why wood-frame construction has remained the preferred method for residential construction.

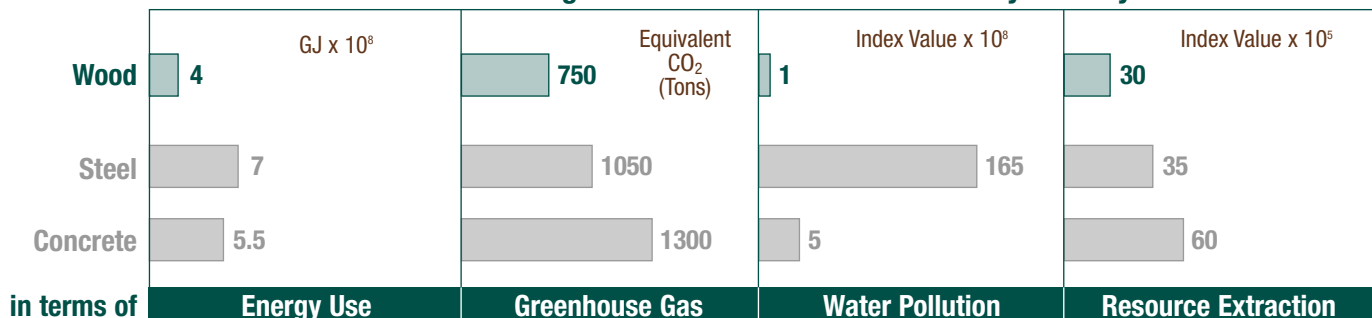


■ Wood is easy to use and widely available. Its practicality and workability make construction simple and efficient for use in residential or commercial applications, including multi-story projects.

■ As the world's only renewable building material, wood can be recycled and regenerated. What's more, trees provide benefits to the environment while they grow, taking in carbon dioxide and releasing oxygen.

■ Wood contributes far fewer greenhouse gases during the manufacturing process than its non-renewable counterparts, steel and concrete. Although wood products make up 47% of all raw materials made in the United States, the share of energy consumed by wood products during production is only 4% of all manufactured materials.

Manufacturing Wood Products is Environmentally Friendly



SOURCE: ATHENA, A Life Cycle Assessment Technology, Forintek Canada Corp., www.athenasmi.ca

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ADDITIONAL INFORMATION

The Southern Pine Council offers a wide variety of other helpful publications. A single copy is free upon request, or can be downloaded from www.southernpine.com. Materials available and the cost per copy for quantities include:

Raised Floor Systems (#410, \$1)

6 pages, benefits, design and construction basics

Southern Pine Use Guide (#200, \$2)

24 pages, grade descriptions, design values, specification guidelines

Southern Pine Maximum Spans for Joists & Rafters (#202, \$2)

36 pages, 48 span tables, design criteria

Southern Pine Headers & Beams (#207, \$2)

36 pages, size selection and allowable load tables for Southern Pine lumber and glued laminated timber

Pressure-Treated Southern Pine (#300, \$2)

20 pages, retentions, standards, proper use and handling

Permanent Wood Foundations:

Design & Construction Guide (#400, \$3)

52 pages, details, illustrations and specifications

A Guide to Southern Pine Flooring (#313, \$2)

20 pages, product description, installation, finishing and maintenance guidelines for interior flooring and exterior porch flooring

For a listing of publications and audio-visual programs available, visit the Southern Pine Council's website: www.southernpine.com, or direct your inquiries to:

SPC Box 641700 Kenner, LA 70064-1700

504/443-4464 Fax 504/443-6612

www.southernpine.com e-mail: info@southernpine.com

On behalf of the Southern Pine Council, SFPA maintains a staff of marketing program directors and overseas consultants. These professionals are available to conduct seminars and to offer technical assistance regarding the specification and use of Southern Pine lumber products. Please contact SFPA for details.

Table 19 Resources

Acronym	Organization	Website – www .
SPC	Southern Pine Council	southernpine.com
AWC	American Wood Council (AF&PA)	awc.org
AITC	American Institute of Timber Construction	aitc-glulam.org
APA	APA – The Engineered Wood Association	apawood.org
AWPA	American Wood-Preservers' Association	awpa.com
WTCA	Wood Truss Council of America	woodtruss.com



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P.O. Box 641700 Kenner, LA 70064-1700
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Southeastern Lumber Manufacturers Association
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www.southernpine.com