ANATOMY OF A FLOOR FRAME

As discussed in Building Knowledge University: Level 1 Course 2, Lesson 4

A stick-framed floor consists of the sill plate, anchor bolts, joists, rim joist, and sheathing, and it must be framed to adequately distribute loads from the walls that bear on it to the foundation that supports it.

All loads start at the roof, and must transfer on an unbroken path through structural elements to the foundation. Many cracking problems, which are written off as the house "settling," are actually caused by broken load paths. These broken paths result in loads carried by areas that were not designed to carry them.

Sill Plates and Anchor Bolts
The sill plate is the first to go on the foundation, and it must be securely fastened to the foundation with anchor-bolts or strap anchors spaced no more than 6 feet apart.

Most codes call for minimum 1/2-inch-diameter steel J-bolts embedded at least 7 inches in concrete, into CMU mortar joints, or into solid-grouted masonry units. Each section of
sill must have at least two bolts, with one bolt placed within 12 inches from each end.

If there is no band joist or header, solid blocking between the joist ends will be needed to hold them secure and provide a secure path for transferring loads to the foundation. Most codes don’t require additional bridging unless the joist is at least six times as high as it is wide, in which case bridging is needed every 8 feet. However, solid or X-type bridging at mid-span will help stiffen any floor.

**Joists**
The joists themselves should have at least 1-1/2 inches of good bearing on the sill plate, or 3 inches on masonry. If necessary, you can safely notch a joist at its bearing point up to one-sixth the depth of the joist.

Floor joists spread the loads bearing from above, and must be framed adequately to complete the load paths. Ideally, if a load-bearing wall runs parallel to floor joists, then it should sit directly over a beam or a joist supported by a load-bearing wall below.

If the load-bearing wall sits between two joists, the load path must be completed by installing solid blocking between the two joists every 16 inches on-center. If a load-bearing wall runs perpendicular to the joists, it should not be offset from a supporting beam or load-bearing wall below by more
than the depth of the joists.

Non-loadbearing walls that run parallel to the joists don't need to be placed directly over joists. If a wall is not over a joist, however, solid blocking must be installed between the joists to carry the load. If the wall is placed directly over a joist, that joist should be doubled.

A concentrated load, such as a structural post, that bears on a floor system must sit directly over a post (supporting from below) or beam. In addition, solid blocking (with a cross-section at least as large as the post) must carry the load through the floor system to the underlying post or beam. Similarly, where a floor opening is more than 4 feet wide, the joists on the sides (known as the trimmers) and at the ends of the opening (called headers) should be doubled.

Where the joists rest on the foundation or a lower wall, they should have at least 1-1/2 inches of good bearing on wood or metal, or 3 inches on masonry.

**Joist Spans**
The span of the joists is the unsupported distance between bearing points. The thickness and depth of joists are sized according to the distance they must span and the loads they must support.

**Live loads.** A 40-psf live load will meet most codes for residential living spaces (some require only 30 psf in bedrooms).

**Dead loads.** For dead loads, 10 psf is adequate for standard wood-frame construction. If it will carry heavier than normal loads, however, the design load would be increased. For mortar-set ceramic tile floors, for example, the floor framing must be framed for a 20-psf dead load.

**Cantilevers**
Joists can also project out from a wall, supporting a load simply on the bending strength of the material without support from below. This is a called a cantilever.
Where a cantilevered floor supports only a roof load with a total span of 28 feet or less, the joists may cantilever up to one-eighth the length of the lumber span. Where the loads are greater, the cantilever should not exceed the depth of the joists unless the system is engineered. A cantilever that supports a non-loadbearing wall can extend farther, but should not exceed one-fourth the joist span. For non-loadbearing cantilevered decks (floor load only), the maximum overhang is one-third the span.

Cantilevers that exceed these limits should be engineered. Doubling joists or reducing joist spaces, along with upgrading connections, often permit greater overhangs.

**Wood I-joists**

Wood I-joists typically allow for longer spans for a given load and joist depth. However, spans, installation details, and other wood I-joist specifications vary from one manufacturer to the next, so it is important to consult the manufacturer's literature when using these products.

As structural members, wood I-joists tend to behave differently from dimensional joists. In general, the load is carried by the flange, and very little force is resisted by the web. As a result, the top and bottom flange should never be cut.

However, the web can generally support larger holes than comparable dimensional lumber. I-joists are often preferred for floor framing as they allow room for heating and cooling ductwork and plumbing.

Most I-joists require at least 1-3/4 inches of bearing at each end. Unbraced I-joists are flimsy and unstable until they are fully braced and sheathed. It doesn't take much to roll them over and damage them, so it's wise to install all blocking and rim boards as soon as possible. To keep joists from twisting, and to help transfer loads from the wall above to the wall or foundation below, a full-height (band) joist or header, or blocking between the joists, is required. This will necessitate heavy plywood or special rim joist stock to match the height of the joists.
It’s also important not to overload I-joists with heavy construction materials, such as stacks of plywood or pallets of bricks. If such loads are unavoidable, builders should place these directly over load-bearing walls, posts, or other supports.

**Load paths.** As with dimensional joists, load-bearing walls should be stacked over beams or load-bearing walls. But I-joists also require additional support to complete the load path. Standard practice requires the use of "squash blocks" and "web stiffeners" to carry the load through the floor system. These are plywood or lumber blocking cut to fit between the flanges, and they act as a bridge to transfer the load across the relatively lightweight web.

Also, where two or more I-joists serve as a girder, the web area between the two pieces must be filled in with solid blocking of plywood, OSB, or dimensional lumber. The filler will ensure that both members carry the load.

Where a joist or stair stringer attaches to the side of an I-joist, backer blocks will be needed, as well, to provide a nailing surface. Builders should refer to the manufacturer’s literature for details.

**Cantilevers.** Most manufacturers permit non-loadbearing cantilevers up to one-third of the joist span, to a maximum of 4 feet. Load-bearing cantilevers may be up to about 2 feet long. Since a cantilever can easily over-stress an I-joist that's not reinforced, it’s important to strictly follow the manufacturer’s guidelines for allowable spans and required blocking.

**Floor Trusses**
Structurally, an open-web floor truss resembles an I-beam in that it puts most of its material along its top and bottom edges where stresses are greatest. To strengthen a truss, a fabricator may double its top and bottom chords, make side-by-side girder trusses, use larger truss
plates or stronger wood, or use some combination of these techniques.

Floor trusses are usually spaced 24 inches on-center, and are typically lifted by hand, rolled into place, fastened, and braced. Installers must take care to install the trusses right side up, according to the label attached to the truss. Each web member is designed to be in compression or tension, but usually not both.

**Subflooring**
The best quality floor sheathing, or subfloor, consists of tongue-and-groove plywood that's glued and either nailed with rink shank nails or screwed to the joists. T&G subflooring improves the stiffness of the floor and helps prevent squeaks. Subflooring that is not T&G must have solid blocking under all joints.

**Subfloor span.** Although T&G subflooring does not require solid blocking at joints, every sheet must rest on at least two joists. Panels are rated for spans of 16, 20, or 24 inches, depending on thickness and grade. Span information is stamped on individual sheets.

**Plywood vs. OSB.** The strength and nail-holding ability of OSB and plywood are roughly the same for similarly rated panels. However, OSB swells more when wet. Because of this, builders often avoid using OSB for subflooring in kitchens or baths, where exposure to wet conditions is likely. Some flooring contractors will not install hardwood flooring over OSB subflooring either, although tests have shown that it performs the same as plywood.

A piece of wet OSB (right) has increased about 30% in thickness. Although it will dry and retain most of its structural integrity, it will remain thicker than its original size.