STRUCTURAL BASICS - GIRDERS

The distance between two outside walls is usually too great to be spanned by a single joist. A girder is used for intermediate support when two or more joists are needed to cover the span. A girder is a large beam that supports other smaller beams or joists. A girder may be made of timber, steel, reinforced concrete, or a combination of these materials.

Wooden girders are more common than steel in light-frame buildings. Built-up and solid girders should be of seasoned wood. Common types of wood girders include solid, built-up, hollow, and glue-laminated. Hollow beams resemble a box made of 2 x 4s, with plywood webs. They are often called box beams. Built-up girders are usually made of several pieces of framing lumber (Figure 6-10). Built-up girders warp less easily than solid wooden girders and are less likely to decay in the center.

Girders carry a large part of the building weight. They must be rigid and properly supported at the foundation walls and on the columns. They must be installed properly to support joists. The ends of wood girders should bear at least 4 inches on posts.

A girder with a ledger board is used where vertical space is limited. This provides more headroom in basements and crawl spaces. A girder with joist hangers is used where there is little headroom or where the joists must carry an extremely heavy load. These girders are shown in Figure 6-11.

CAUTION Precautions must be taken to avoid or counteract any future settling or shrinking, which would cause distortion of the building.

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SIZE REQUIREMENTS

Carpenters should understand the effect of length, width, and depth on the strength of wood girders before attempting to determine their size.

Principles that govern the size of a girder are the—

• Distance between girder posts.
• Girder load area.
• Total floor load on the girder per square foot.
• Load on the girder per linear foot.
• Total load on the girder.
- Material to be used.
- Wood moisture content and types of wood used, since some woods are stronger than others.

A girder should be just large enough to support an ordinary load. Any size larger than that wastes material. For greater carrying capacity, it is better to increase a girder's depth (within limits) than its width. When the depth of a girder is doubled (the width of lumber, such as 2 x 8 or 2 x 6), the safe load increases four times. For example, a girder 3 inches wide and 12 inches deep will carry four times as much weight as a girder 3 inches wide and 6 inches deep. Table 6-1 gives the sizes of built up wood girders for various loads and spans.
LOAD AREA

A building load is carried by foundation walls and the girder. Because the ends of each joist rest on the girder, there is more weight on the girder than on any of the walls. Before considering the load on the girder, it may be well to consider a single joist.

Example 1. Suppose a 10-foot plank weighing 5 pounds per foot is lifted by two men. If the men were at opposite ends of the plank, they would each support 25 pounds.

Now assume that one of these men lifts the end of another 10-foot plank of the same weight as the first one. A third man lifts the opposite end of that plank. The two men on the outside are each now supporting one-half of the weight of one plank (25 pounds apiece), but the man in the center is supporting one-half of each of the two planks (50 pounds).

The two men on the outside represent the foundation walls. The center man represents the girder. The girder carries one-half of the weight, and the other half is equally divided between the outside walls. However, the girder may not always be located halfway between the outer walls.

Example 2. Imagine the same three men lifting two planks that weigh 5 pounds per foot. One of the planks is 8 feet long and the other is 12 feet long. The total length of these two planks is the same as before. The weight per foot is the same, so the total weight in both cases is 100 pounds.
One of the outside men is supporting one-half of the 8-foot plank) or 20 pounds. The man on the opposite outside end is supporting one-half of the 12-foot plank, or 30 pounds. The man in the center is supporting one-half of each plank (50 pounds). This is the same total weight he was lifting before.

NOTE: To determine the girder load area: a girder will carry the weight of the floor on each side to the midpoint of the joists that rest upon it.

FLOOR LOAD

After the girder load area is known, the total floor load per square foot must be determined, for safety purposes. Both dead and live loads must be considered.

Dead Load

The dead load consists of all building structure weight. The dead load per square foot of floor area is carried directly or indirectly to the girder by bearing partitions. The dead load varies according to the construction method and building height. The structural parts in the dead load are—

- Floor joists for all floor levels.
- Flooring materials, including the attic if it is floored.
- Bearing partitions.
- Attic partitions.
- Attic joists for the top floor.
- Ceiling laths and plaster, including the basement ceiling if it is plastered.

The total dead load for a light-frame building similar to an ordinary frame house is the dead load allowance per square foot of all structural parts added together.

- The allowance for an average subfloor, finish floor, and joists without basement plaster should be 10 pounds per square foot.
- If the basement ceiling is plastered, allow an additional 10 pounds per square foot.
- If the attic is unfloored, make a load allowance of 20 pounds for ceiling plaster and joists when girders or bearing partitions support the first-floor partition.
- If the attic is floored and used for storage, allow an additional 10 pounds per square foot.

Live Load

The live load is the weight of furniture, persons, and other movable loads, not actually a part of the building but still carried by the girder. The live load per square foot will vary according to the building use and local weather conditions. Snow on the roof is also a part of the live load.

- Allowance for the live load on floors used for living purposes is 30 pounds per square foot.
- If the attic is floored and used for light storage, allow an additional 20 pounds per square foot.
- The allowance per square foot for live loads is usually governed by local building specifications and regulations.
The load per linear foot on the girder is easily figured when the total load per square foot of floor area is known.

*Example.* Assume that the girder load area of the building shown in Figure 6-12 is sliced into 1-foot lengths across the girder. Each slice represents the weight supported by 1 foot of the girder. If the slice is divided into 1-foot units, each unit will represent 1 square foot of the total floor area. To determine the load per linear foot of girder, multiply the number of units by the total load per square foot.

Note in Figure 6-12 that the girder is off-center. Remember that half of the load is supported by the girder and half by the foundation walls. Therefore, the joist length to be supported on one side of the girder is 7 feet (one half of 14 feet) and the other side is 5 feet (one half of 10 feet), for a total distance of 12 feet across the load area. Since each slice is 1 foot wide, it has a total floor area of 12 square feet. Assume that the total floor load for each square foot is 70 pounds. Multiply the length times the width to get the total square feet supported by the girder (7 feet x 12 feet = 84 square feet).

84 square feet x 70 pounds per square feet (live and dead load) = 5,880 pounds total load on the girder

**BUILT-UP GIRDERS**

Figure 6-10 shows a *built-up girder.* Notice that the joists rest on top of the girder. This type of girder is commonly used in frame building construction. To make a built-up girder, select lumber that is as free from knots and other defects as possible.

Built-up girders are usually made of three pieces of framing lumber nailed together. (The pieces must be nailed securely to prevent individual buckling.) For proper arrangement of the pieces of lumber, the end grains should match the example in Figure 6-13. The nailing pattern should be square across the ends of the board (1 1/2 inches from each end) and then diagonal every 16 inches as shown in Figure 6-13. This pattern increases the strength of the girder. A typical two- or three piece girder of 2-inch lumber should be nailed on both sides with 16d common nails.
SPLICING

Methods for splicing girders differ according to whether the girder is built-up or solid-beam.

**Built-Up Girders**

The lumber for a built-up girder should be long enough so that no more than one joint will occur over the span between footings. The joints in the beam should be staggered, and the planks must be squared at each joint and butted tightly together.

**Solid-Beam Girders**

To splice solid beams, use halflap joints or butt joints (Figure 6-14.) See Splices on page 6-6.

**Half-Lap.** Sometimes a half-lap joint is used to join solid beams (Figure 6-14). This is done by performing the following steps:

**Step 1.** Place the beam on one edge so that the annual rings run from top to bottom.

**Step 2.** Lay out the lines for the half-lap joint as shown in Figure 6-14.

**Step 3.** Make cuts along these lines, then check with a steel square to ensure a matching joint.

**Step 4.** Repeat the process on the other beam.

**Step 5.** Nail a temporary strap across the joint to hold it tightly together.

**Step 6.** Drill a hole through the joint with a drill bit about 1/16 inch larger than the bolt to be used, and fasten the joint with a bolt, a washer, and a nut.

**Butt Joints.** When a strapped butt joint is used to...
join solid beams (Figure 6-14, page 6-13), the ends of the beams should be cut square. The straps, which are generally 18 inches long, are bolted to each side of the beams.

**GIRDER SUPPORTS**

When building a small frame building, the carpenter should know how to determine the proper size of girder supports (called columns or posts). A column or post is a vertical member that supports the live and dead loads placed upon it. It may be made of wood, metal, or masonry.

- **Wooden columns** may be solid timbers or several pieces of framing lumber nailed together with 16d or 20d common nails.

- **Metal columns** are made of heavy pipe, large steel angles, or I-beams.

A column must have a bearing plate at the top and bottom which distributes the load evenly across the column. Basement posts that support girders should be set on masonry footings. Columns should be securely fastened at the top to the load-bearing member and at the bottom to the footing on which they rest.

Figure 6-15 shows a solid wooden column with a metal bearing cap drilled to permit fastening it to the girder. The bottom of this type of column may be fastened to the masonry footing by a metal dowel. The dowel should be inserted in a hole drilled in the bottom of the column and in the masonry footing. The base is coated with asphalt at the drilling point to prevent rust or rot.

A good arrangement of a girder and supporting columns for a 24- x 40-foot building is shown in Figure 6-16.
• Column B will support one-half of the girder load between wall A and column C.
• Column C will support one-half of the girder load between columns B and D.
• Column D will share equally the girder loads with column C and wall E.

GIRDER FORMS

Forms for making concrete girders and beams are made from 2-inch-thick material dressed on all sides. The bottom piece of material should be constructed in one piece to avoid using cleats. The temporary cleats shown in Figure 6-17 are nailed on to prevent the form from collapsing when handled.

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Editors Note: This article has been unabashedly taken without apology from the US Army Carpentry Manual, FM 5-426.