Choosing support members for wall and deck forms

Careful selection can help ensure proper form alignment and prevent deflection

By Anne Laning

The performance of any form sheathing, whether made of plywood, metal, or fiberglass, is only as good as the performance of its support members. Without adequate support, sheathing can deflect resulting in wavy lines, bulges, and sometimes even cracks in the finished concrete.

Form support is provided by various components (Figure 1). For wall panels, studs supported by cross members called walers provide direct support. Vertical members called strongbacks often are used for secondary support. For horizontal decking, joists give direct support. Secondary support is provided by stringers, which run perpendicular to the joists. To hold support members in place, tension members are used. These include tie rods and bolts for wall forms or compression members, such as shores or posts for deck forms.

Because of their important function, support members must be carefully chosen to coordinate with sheathing selection. Following are descriptions of various types of members available. Each varies in terms of load-carrying capacity, ease of setup and removal, cost, and reusability. When selecting support members, consider how important each of these factors are for a particular project.

Dimensional lumber

The most commonly used support member for formwork is standard dimensional lumber (2x or 4x). Although lumber is typically the least expensive material, reuse is limited because it can warp or split. Care also must be taken to ensure the lumber is straight and structurally sound. If possible, use partially seasoned (dry) stock. Fully dried lumber can swell if it becomes wet, distorting form alignment. Unseasoned (green) lumber can dry and warp during hot weather, also causing distortion.

Allowable stresses for forming lumber vary depending on the type and grade of lumber used. For most applications, use a construction-grade softwood (Douglas fir, southern pine, spruce, or hemlock). Specifications and structural design data for lumber can be found in References 1, 2, and 3.

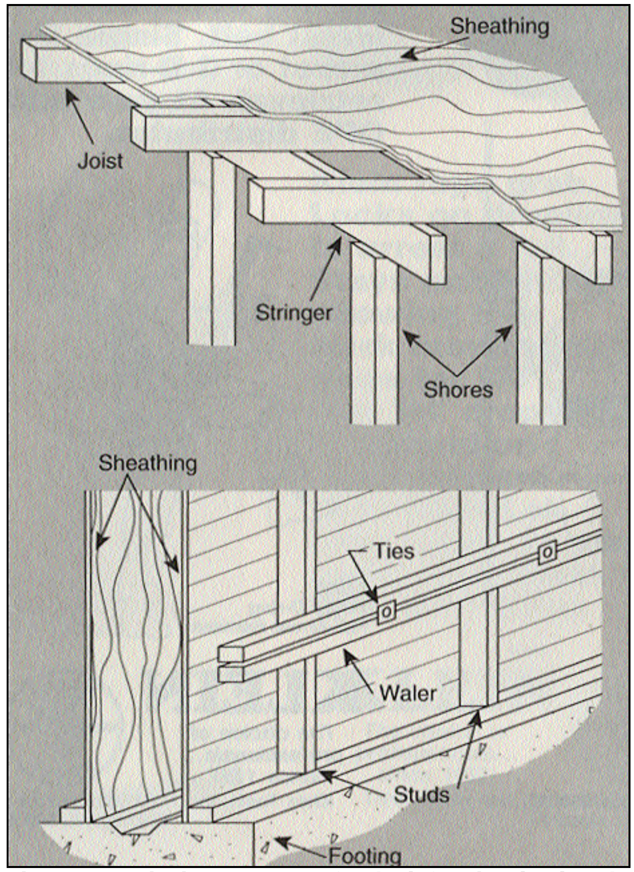

Figure 1. Typical components for deck forming (top) and wall forming (bottom).

Engineered wood

Engineered-wood beam components are an alternative to dimensional lumber and offer several advantages. Because they are factory-produced, their strengths are less variable than solid sawn lumber. Engineered-wood beams also tend to have longer life-spans and greater strengths than standard lumber. During production, engineered wood is sometimes treated to protect it from moisture. And wood's natural defects, such as knots or splits, are controlled, dispersed, or reinforced.

One firm, for example, makes engineered-wood beams from layers of thin, dried wood veneers that are graded to meet stringent standards. The veneers are placed side-by-side with the grain in each sheet parallel

Figure 2. Wood girder has a lattice truss section that adds strength and simplifies waler alignment. Here a preassembled wall form panel using the girders and steel walers is being hoisted into position.

to the next. Waterproof adhesives under heat and pressure permanently bond the veneers together. This process produces laminated beams for wall or deck forming having allowable flexural stresses of 2800 to 3300 psi. The load capacity of a 3 1/2x6 1/2-inch laminated beam at a span of 10 feet is more than 200 pounds per lineal foot, with deflection equal to 1/360 of the beam span (L/360). This is similar to the load capacity of a 6 1/2-inch-deep aluminum joist.

The laminated beam manufacturer offers standard beams in widths of 1 1/2 to 7 1/2 inches, depths up to 24 inches, and lengths up to 60 feet. The beams have a slight edge for easy handling and can be ordered with a protective sealer. The weight of a 3 1/2x3 1/2-inch beam is 3.2 pounds per foot. The same manufacturer also produces I-beams that have top and bottom flanges made from laminated veneers and webs made of 1/2-inch-thick plywood. They come in depths of 10 to 16 inches (in 2-inch increment) and lengths up to 60 feet. The weight of a 12-inch-deep I-beam is about 3 pounds per lineal foot. Load capacity at a span of 10 feet is about 280 pounds per lineal foot.

Another type of engineered-wood support member is a girder made of lumber chords joined to a lattice truss section by mortise-and-tenon connections (Figure 2).

These connections give the girder stability and strength and help prevent the wood from warping and splitting. Steel caps protect chord ends. According to the manufacturer, the average life span of the girder is 8 to 10 years.

Available in two sizes, the girder can be used as studs for wall forms or joists and stringers for deck forms. The smaller size has 2 1/2x3 3/4-inch chords, is 9 1/2 inches deep, and weighs 4 pounds per lineal foot. The larger girder has 2 3/4x3 3/4-inch chords, is 14 inches deep, and weighs 5 1/4 pounds per lineal foot. Both sizes come in 8- to 20-foot lengths. A special extension splice can be used to join two girders for custom lengths. The splice has two components that fit through the latticework and are tightened by two wing nuts.

Using the girders instead of standard dimensional lumber, contractors reportedly can use fewer walers and ties and carry larger spans with fewer intermediate supports. The 14-inch-deep girder carries 235 pounds on a 19-foot span. Maximum bending moment is 11,800 foot-pounds.

For easy passage of tie rods, the girders are designed with ample room between struts. Also, the standard spacing of the lattice joints makes it possible to align walers without measuring. Optional steel walers, in 4- and 8-foot lengths, attach to the girders with quick-connect hooks and are secured with wedge locks. Other optional accessories include articulated couplings for forming angled walls and adjustable steel braces.

Aluminum

Aluminum I-beams are light and durable. They cost more initially than wood but have a longer service life. Their low weight also makes them easy to handle, saving labor. Most lengths can be carried by one worker. One supplier's 10-foot-long, 7 1/4-inch-high aluminum I-beam weighs only 46 pounds.

Aluminum I-beams are primarily used as joists or stringers. Most have 4- or 5-inch-wide flanges, making them less likely to roll over while workers install deck panels. Most also have 2x2-inch nailing strips in the top flange to simplify attachment of plywood. Some systems have accessory clamps for quickly attaching an aluminum stringer to an aluminum joist anywhere along the beam length.

Aluminum I-beams come in lengths from 4 to 30 feet, weights from 3.6 to 5.2 pounds per lineal foot, and heights from 6 1/4 to 7 1/2

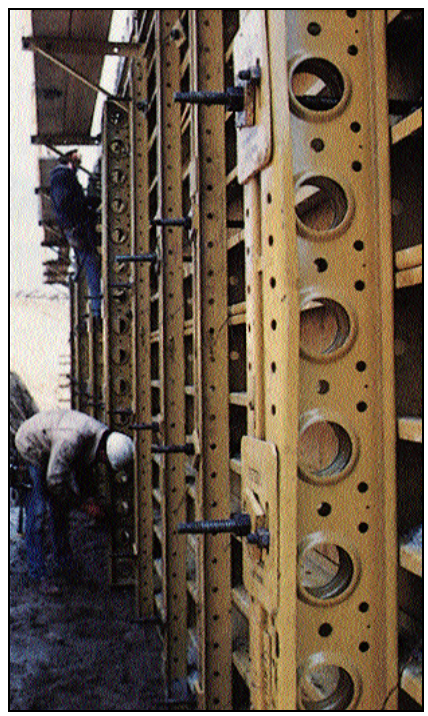

Figure 3. Pre-formed holes in the channel webs and flanges of these steel beams allow easy insertion of bolts, form ties, and other connections.

inches. Load capacities range from 233 pounds to more than 400 pounds per foot on a 10-foot span at L/360. One supplier says its 7 1/2-inch-high, 5.2-pound-per-lineal-foot aluminum beam has a load capacity of 490 pounds per foot on a 10-foot span.

A double-channel aluminum beam offered by one company is especially designed for use as a strongback in wall forming. It also can serve as a joist or stringer for deck forming. The beam's channels have continuous bolt slots on both flanges for easy attachment of tie plates and other wall forming accessories. Weighing 8 pounds per lineal foot and having 6.6-inch-wide flanges, the beam can support 852 pounds per foot on a 10-foot span. It comes in 8 1/2-, 12 1/2-, and 16-foot lengths.

Maximum Lateral Pressure for Design of Wall Forms

Rate of placement (feet per hour)	Maximum lateral pressure (pounds per square foot) for temperature indicated					
	90° F	80° F	70° F	60° F	50° F	40° F
1	600-psf minimum governs					
2						
3					690	825
4			664	750	870	1,050
5	650	712	793	900	1,050	1,275
6	750	825	921	1,050	1,230	1,500
7	850	938	1,050	1,200	1,410	1,725
8	881	973	1,090	1,246	1,466	1,795
9	912	1,008	1,130	1,293	1,522	1,865
10	943	1,043	1,170	1,340	1,578	1,935

Note: Applies only for normal-weight concrete made with Type I cement, no admixtures or pozzolans, and with slumps no more than 4 inches. Vibration depth is limited to 4 feet or less. Do not use design pressures greater than 2,000 psf or greater than 150 times the height of fresh concrete in the forms.

Steel

Probably the strongest of the beam types, steel beams usually support greater spans or heavier loads than either wood or aluminum members. Longer spans save material costs for intermediate supports and the labor needed to install them. Typical steel beams are two to three times heavier than those of wood or aluminum. This makes them harder to transport and install.

Like aluminum beams, steel beams can be reused almost indefinitely and won't warp or split. But they can rust unless specially treated.

One of the most versatile steel beam systems available has members in 1½-, 3-, 6-, and 12-foot lengths that can be bolted end-to-end to form a continuous beam of almost any length (Figure 3). Use the beams as walers, aligners, strongbacks, diagonal form bracing, stringers, joists, and horizontal or vertical shoring. Each 9-inch-wide beam has two channels, 2¼ inches apart, that are welded together at two 1/2-inch-thick end plates and at spacers 3 inches on center. The 2 1/4-inch channel spacing makes it easy to pass large form ties between the channels and symmetrically load the beams.

Each beam also has a network of pre-formed holes in both the channel webs and flanges for easy insertion of bolts, ties, nails, and bracing connections. The largest holes, located in the channel webs, are 4

Patent Scaffolding Co.

Figure 4. Used as joists under plywood sheathing, adjustable horizontal shores can support deck spans as long as 20 feet without intermediate vertical shoring. An I-beam or plate section telescopes to the desired shore length from an outer lattice member or box-beam.

inches in diameter on 9-inch centers. These holes reduce beam weight and facilitate bolt connections. There also are 3/4-inch bolt holes (at 3- and 6-inch spacings) and nail holes for attaching wood strips between beam channels. With wood strips in place, the beams can be used horizontally as joists or stringers. Just lay plywood decking directly on the beams and nail down.

The system's many accessories add to its versatility. These include J-rods that hook steel forms to the beans and hold the form tightly against the beam face, clip angles that connect steel forms to the beams and support vertical form load, reusable taper ties and tie bearing plates, and leveling screws for adjusting panel elevation. When using the beam as a diagonal brace, 45_ intersection adapters are available to connect the brace beam to the strongback beam.

Structurally, the beam compares with double 7- or 8-inch rolled steel channels back-to-back. It weighs 15.1 pounds per lineal foot and can safely support a maximum bending moment of 28,600 foot-pounds.

Adjustable horizontal shores

Made of steel or aluminum, adjustable horizontal shoring beams used as joists under plywood sheathing offer flexibility and high load-carrying capacities. They can support deck spans as long as 20 feet without intermediate vertical shoring. This frees space below the deck for construction activity (Figure 4).

Each shore has an I-beam or plate section that telescopes to the desired length from an outer lattice member or box-beam. Maximum length adjustments range from 3 to 9 feet, depending on the minimum and maximum span of the member used. Spans range from 4 to 20 feet. Built-in camber is designed to produce a level slab as cast when shoring beams are loaded to manufacturer-recommended capacities. Maximum bending moments range from about 1,450 to more than 12,000 foot-pounds, depending on the system used.

Bearing prongs on each end of the shore rest on stringers. Often these prongs are tapered for easy stripping and mated for accurate alignment of adjacent shores on a stringer. To speed erection and disassembly, most systems have hammer-in-place wedge locks that quickly set shore length. One system is available with a fast-attach clip that anchors plywood sheathing to the shore. The clip helps prevent plywood movement and creep. It also keeps the plywood from offsetting at the joints while concrete is poured and vibrated.

Generally, aluminum shoring beams are lighter than those made of steel. One company's horizontal aluminum shore, which telescopes from 5 feet, 9 inches to 9 feet, 9 inches, weighs only 28 pounds. A horizontal steel shore having similar spans weighs about 50 pounds.

Determine loads first

Before selecting forms and form support members, it's important to calculate the loads and pressures to be imposed on them. For deck forms, live and dead loads must be determined. Dead load per square foot equals the weight of concrete in pounds per cubic foot times slab depth in decimal feet. Thus, a 4-inch (0.33-foot) slab of 150-pound-per-cubic-foot concrete would have a dead load of 50 pounds per square foot. Live load is the weight of workers and equipment used to place and finish the slab. ACI 347 recommends a minimum live load of 50 pounds per square foot. Also allow for the estimated weight of the form system. With these loads determined, formwork designers can then (Ref. 4):

- Select the thickness of decking material.
- Calculate size and maximum spacing of joists (for economy, load joists to the maximum safe capacity recommended by the manufacturer).
- Calculate size and maximum ledger or stringer spacing.
- Select shores that will safely support anticipated loads and calculate the best shore spacing.

Before selecting wall forms, the hydrostatic pressure that fluid concrete exerts on the forms must be considered. Two important factors that influence hydrostatic pressure of fresh concrete are the rate of placement, measured in feet of depth per hour, and the ambient temperature. The ambient temperature is important because concrete hardens faster in warm weather than it does in cold. Once hardened, concrete no longer exerts lateral pressure. With information on rate of placement and temperature, calculations can be made to determine the size and spacing of support members whose deflection limit should be the same as that for the forming material (see table).

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