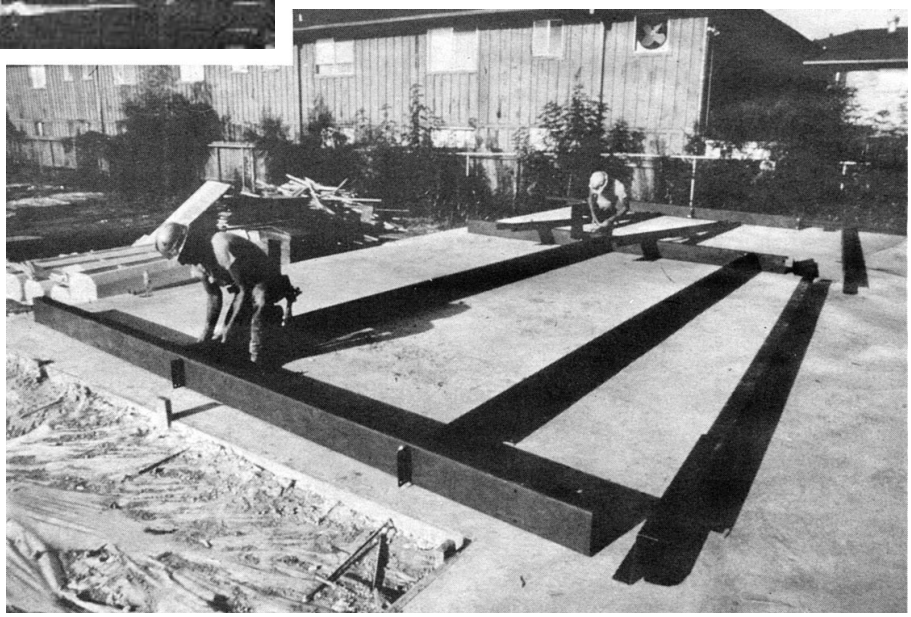
METAL BUILDING BASICS

by Donna Milner

Assembled like a big erector set, metal buildings offer residential builders an easy inroad to commercial construction



Layout and assembly is best done on the ground with this post-and-beam endwall (above). A crane helps erect the pre-assembled components (above left).

The thought of cold-rolled steel construction may not warm your heart, but it might pay to consider it as an alternative to wood-frame, residential building. After all, how many really good clients have you had in the last two years? And how many bad ones, where the last payment was held up because of a nail pop? With metal buildings, you won't have nail pops; you will have clients who want a lot of space in a hurry and are willing to pay for it.

Pre-Engineered Metal Building Types

There are two basic types of pre-engineered metal building: the rigid-frame building, and the metal post-and-beam building.

Rigid-frame buildings. Rigid-frame buildings consist of modular frame sections. These frame sections are designed to provide a clear span without interior columns (Figure 1). In a rigid-frame system, the rafters and columns are rigidly bolted together so that the connections transfer all forces down to the foundation. In this way, they function like a continuous arch.

These heavy and rigid "moment" connections transfer "bending moment" from the rafters to the columns, allowing for a more efficient use of the material. It is important that the contractor and crew take great care to assemble the building properly so connections function as the designer intended.

The rafters and columns in a rigid-frame system are usually tapered, providing the thickest cross section of steel at the places where the load is the greatest (details shown in Figure 1). Because rigid-frame systems are designed for standard clear spans of up to 120 feet (with spans of 300 feet available on special request) they span large, uninterrupted spaces that can be used however the clients wish.

Post-and-beam metal frame buildings. The post-and-beam metal frame works the same way a post-and-beam wood frame does. Roof rafters are supported on columns that transfer the vertical load to the foundation (Figure 2). Some fabricators use horizontal members similar to collar ties, to stiffen the frame sections. Otherwise they must be attached to an adjoining rigid frame.

Post-and-beam frames are less costly than rigid frames, because they use less steel in the rafters and columns. However, they require the use of interior columns, which interfere with the interior space. Consequently, they are used primarily for end walls only (in conjunction with rigid frames).

Unlike rigid frames that are modular and can be expanded at any time by removing the wall panels and adding more bays, post-and-beam end walls are not expandable.

Erecting a Rigid Frame

Since the rigid frame is the most common structural system for pre-engineered metal buildings, we'll focus on that for the rest of the article. First, we will outline the construction sequence.

The foundation. Rigid-frame buildings start with a foundation. Before assembling the building, the contractor must make sure the concrete is sufficiently cured. If not, there is a chance that the anchor bolts may pull loose, the concrete itself may chip and crack,

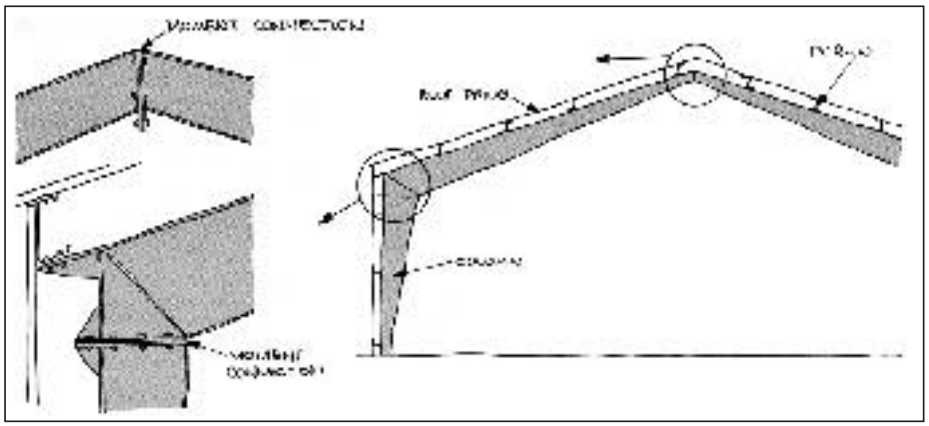


Figure 1. *Rigid-frame metal buildings provide uninterrupted space. The rigid "moment" connections (details enlarged) make the frame function like a continuous arch. Rafters and columns have the largest cross sections where loads are greatest.*

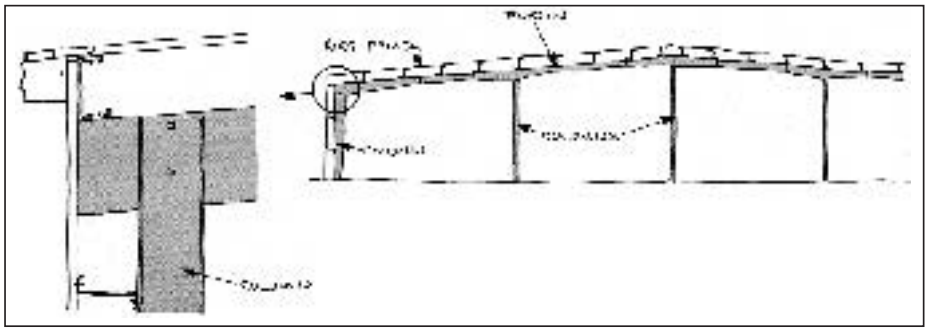


Figure 2. *In post-and-beam buildings, columns transfer the loads to the footings – so less steel is required. The bolt connections (detail enlarged) are simple pinned joints – so bracing is needed for rigidity.*

or heavy equipment used to set up the frame may crack the foundation.

Choosing the right concrete can speed up the completion time. Plain portland-cement concrete takes fourteen days to reach half its final strength, but seven days is often long enough to wait before beginning erection. High early strength concrete can be used in only three days.

> If the concrete is not sufficiently cured, the anchor bolts may pull loose.

Because the frame will require specific tolerances, the contractor should double-check the foundation measurements and the location of anchor bolts. The foundation should be level, square, and the right size.

The braced bay. The need to erect a braced bay is not a concept familiar to stick builders. But is important in this kind of construction. The braced bay serves some of the same functions as diagonal let-ins or as plywood sheathing at the corners of houses. These stiffen the structure against wood and seismic loads.

When erecting a rigid frame for a metal building, erect the braced bay first. Wind load from the end walls is transmitted through the structural members into the braced bay. The braced bay contains brace rods and other diagonal bracing required to withstand these loads (see Figure 3, page 59). It is critical that this by be constructed level and square as all other bays of the building are built off of this one.

There are various ways to erect a braced bay, but one of the most common is to begin with the columns. Column flange braces or clips are attached to the columns first. Then set the columns flat against the foundation and at the proper elevation. After the columns are secured, tie together with horizontal girts and eaves struts to increase their stability (see figure 4, page 59).

Once the columns for the braced bay and adjacent bays have been set, plumb them and tighten all permanent bracing rods. Bracing allows the columns to form a rigid support for the frames when they are raised and set into position.

Assembling rafters. As much assembly as possible is done with the members on the ground. This is because it is easier, safer, and faster to align and tighten bolts on the ground than it is in the air. For bolting structural members, high strength A325 steel bolts are usually used.

First, lay out the members on blocks in their approximate positions and fasten them together. Bolts are tightened either with a torque wrench or by the turn-of-the-nut method, to the tightness required by the manufacturer.

The turn-of-the-nut method is probably unfamiliar to most stick-builders; however, it is commonly used to tighten high strength steel bolts. First, align the holes with spud wrenches and drift pins. Bolts are placed in any holes that do not have drift pins in them, then brought to "snug." ("Snug" is the point at which an impact wrench begins to impact. If a regular wrench is used, snug is as tight as can be turned by a man exerting full effort.)

When all the bolts are snug, all surfaces are drawn into full and complete contact. The drift pins are knocked out and remaining bolts installed. Then tighten all the bolts to a fraction of a turn as specified by the manufacturer.

To maintain the integrity of the moment connections, use caution when reusing A325 bolts. (This might happen if a joint is disassembled and then reassembled.) The threads on these bolts can stretch, so they may be reused only once or twice.

At this time, also install purlins, clips, and flange braces. They are bolted to the structure, but not fully tightened.

Setting rafters. Raising the rafter assemblies is done with extreme caution, even by contractors who are experienced at metal building assembly. Improper rigging can endanger workers as well as damage the structural members. Training manuals provided by the manufacturer describe proper methods of rigging and raising a load.

A crane is used to raise the rafter assembly and guide it into place. When the rafter flanges are lined up with the column flanges, they are bolted, but not fully tightened. The crane boom is then repositioned slightly to allow slack in the rigging, and to allow the roof beam to come under its own dead load. The bolts get a final tightening, then erection cables and brace rods are installed to stabilize the bay.

The second rafter is installed in basically the same way, except that erection cables do not have to be attached. Once the second rafter is bolted in place, install the purlins to provide stability to the structure.

Purlins and Girts

Install purlins at all panel points. A panel point is the point where brace rods intersect the roof beams. Once the purlins are installed at the panel points, the remainder of the purlins are added.

Purlins can be either simple span purlins, which butt together and are installed with clips, or continuous purlins, which overlap and are bolted together.

Like purlins, girts are either simple span or continuous. Simple span girts are bolted directly to the column and terminate at the centerline of the column. Continuous girts are bolted together and to the column.

Brace rods, brace cables (if any), and flange braces complete the construction of the brace bay. Bracing rods and cables are critical to the rigidity of the structure and protect the building against swaying in the wind.

End bays. After the braced bay has been erected and stabilized, the next step is usually the erection of the end walls. The end walls can be one of two types – a lightweight post-and-beam end wall or a rigid-frame end wall. If a rigid-frame end wall is used, the building can be expanded in that direction at any time by simply extending the foundation, removing the wall panels, and adding as many bays as desired.

In the rigid-frame end wall, the intermediate columns carry only wind loads. All of the structural dead load and roof live load is carried by the rigid frame, just as in the other bays. If, on the other hand, a post-and-beam end wall is used, the post-and-beam end wall will have to be replaced if more bays are added at some time in the future.

The intermediate columns in a post-and-beam end wall carry not only the wind load, but also carry a portion of

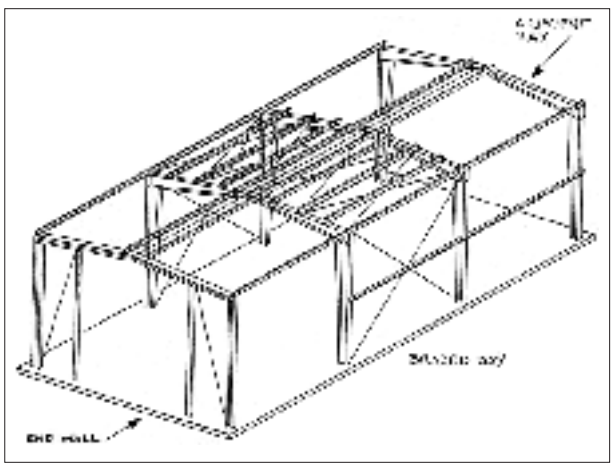


Figure 3. *With no sheathing to provide racking resistance, a braced bay is needed to prevent wind loads from collapsing the building.*

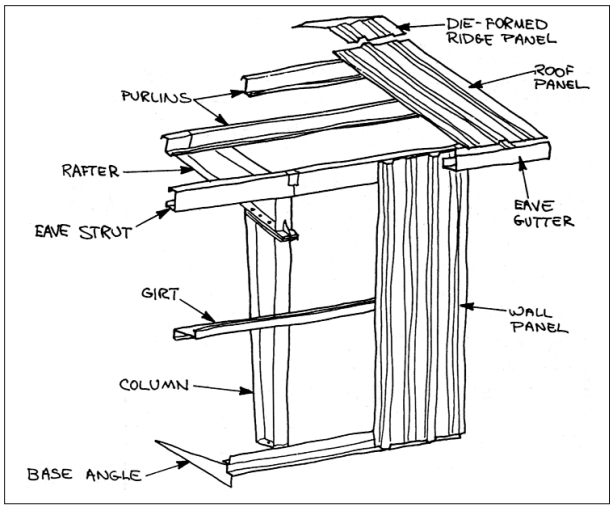


Figure 4. *On a rigid-frame building, girts, eave struts, and purlins tie the individual frames together and provide support for roofing and siding.*

the roof live and dead loads. Lightweight post-and-beam end walls can often be completely assembled on the ground and raised as a unit, unless the span exceeds 60 feet. In this case, the wall is erected similarly to a regular bay. The columns are set in place first; then the rafter is set; and purlins to the braced bay are installed.

Enclosing the Shell

Once the framework is set and squared, you can encase the frame with whatever insulation and wall panels you like. Wall-panel material can be as simple as steel metal sheeting, or as complex as sandwich panels with rigid insulation bonded to a metal facing.

Base angles are used to anchor the wall covering sheets to the foundation. Sometimes anchor bolts are cast into the concrete, but typically base angles are secured with special masonry anchors.

Panels with exposed fasteners. If exposed-fastener wall panels are used, the insulation is usually installed along with the panels. Fiberglass insulation blankets are hung from the eaves strut and dropped to the foundation. Then the panels are installed over the blankets, with fasteners going through the insulation.

Because the panels squeeze the insulation blankets at the points where they are fastened to the girts, there is a loss of R-value at these locations. Some manufacturers have developed thermal blocks that you can install between the frame and the panel to minimize this effect.

Most panel configurations require the use of closure strips. Closure strips are metal, rubber, or foam strips that match the profile of the panel. You insert these strips in the bottom of the panel to prevent dust, rodents, and insects from entering the wall, and to act as a weather seal. If a closure strip is required, it is installed before the panel is fastened to the frame.

When installing the panels, you must line them up with the framing modules. Getting off the module even slightly will create a cumulative error that will cause problems.

Contractors must train and supervise crew members tightening exposed panel-fasteners. Too much tightening is likely to dimple the panel and may form a pocket that can collect water.

Panels with concealed fasteners. Concealed fastener panels use interlocking devices on the panels or specially designed clips. These panels are stronger and are part of the structural system of the building.

The basic installation procedures are similar. However, the insulation may be installed after the panels are installed. In this case, you have a choice of insulating materials including fiberglass blankets or friction fit batts in the cavity.

This eliminates the problem with compressed insulation. It does, however, create an area of thermal bridging where the metal panels are attached to the metal frame with nothing to stop the heat flow.

As an alternative, the contractor can use sandwich panels, with metal and insulation made up as a unit. Sandwich panels are available in thicknesses from 2-5 inches depending on the desired insulation value. The panels can be of either the exposed or concealed fastener type.

Either will solve the thermal bridging problems. The disadvantage is that the openings must be planned before ordering the panels from the manufacturer. While it is possible to job cut sandwich panels by using shears and nibblers to cut the steel, and then sawing the foam, openings are best pre-cut by the manufacturer.

Lining up sandwich panels with the frame is extremely important. Otherwise joints might not fit tightly.

What's In It For You

Because of the precision required, erecting metal buildings can be a challenge. But contractors whose crews know how to use a tape measure, level, and crane should be able to adapt to this type of construction.

A contractor with good general construction knowledge can get training and support from the manufacturer. And once the metal is up, you're home free because interior work can be done with wood. Indeed, metal buildings offer one of the easiest ways to make the shift from residential to commercial/industrial building. ■

Donna Milner is an architect and Research Associate a the Small Homes Council.

THE BUSINESS SIDE OF METAL BUILDING SYSTEMS

By Chuck Stockinger

Manufacturer support makes the contractor's job a lot easier.

Residential construction is a cyclical business that is constantly at the mercy of the market. By diversifying into metal buildings, builders can take advantage of the more steady demand for small commercial buildings. In fact, sales of metal building systems has grown for each of the last five years.

Business Prospects

Because of their low cost, speed of erection, and open space, metal buildings are well suited to the space demands of small businesses, a sector of the economy expected to grow. In fact, four out of ten metal buildings constructed today are built for small clients: stores, banks, car dealerships, and other service businesses. And some 80 percent of building contracts are for structures 15,000 square feet and under.

Panelized components, from fascia to doors and windows, characterize metal buildings.

As their use has increased, so has the range of design. Brick, wood, glass, and concrete are routinely combined with metal building systems. Improvements in metal roof coatings and finishes have helped make them more attractive as well.

Sales and Turnover

The transition from house building to metal buildings is not difficult. Erecting metal buildings requires a different business strategy, however. The metal building industry is heavily oriented toward negotiated design/build contracts. And, the builder must be committed to staffing the company with an effective sales team since so many projects are negotiated directly with a building prospect.

Selling metal building system products has been made easier through the years, thanks to marketing support from manufacturers and to technical improvements in the systems themselves. Also, the prospects for improved cash flow can be attractive. Clayton Richardson, Chairman of the Metal Builders Manufacturers Association (MBMA) says, "You will routinely find metal building contractors completely 10,000-square-foot projects within just 90 days of their groundbreaking. Many ordinary buildings are just coming out of the ground when a metal building contractor is banking his final payment."

Builders Are Trained

The relationship between manufacturer and builder begins with a manufacturer's training school. Typical training schools cover the marketing, selling, pricing, and erection of the manufacturer's product line.

The manufacturer's engineering department is available for consultation should a builder or architect require special design features. However, most metal-building components are off-the-shelf items. The manufacturers provide catalogs with information about the span and load capabilities of various systems.

Today, almost all metal building projects have some features custom-designed for the client. So, many manufacturers provide customized, computerized designs.

Design/Build Popular

Many metal building dealers classify themselves as design-build contractors. They coordinate the entire job for the owner, including the design. So an owner has to deal with only one party.

The design/build contractor will plan the building with the owner, order the building, prepare the site, construct the foundation, erect the building, and install the utilities. Any engineering or architectural work is done by either in-house staff engineers or architects, or by arrangement with outside consultants. The design/build contractor hires all sub-contractors.

The size of an erection crew will vary with the job size. As a general rule of thumb, the work will start with a small crew to lay out structural members. More workers are added as required. The structural steel crew is usually separate from the crew doing the sheeting and flashing.

A small 7,500- to 10,000-square foot building can be erected with one crane and its operator and a five-man crew, consisting of a working supervisor, two lead crew members, and two assistants. Buildings over 10,000 square feet typically will require two more crew members.

Hand Tools Needed

Erection crews should be equipped with a variety of basic hand tools. These include hard hats, bolt bags, "C" clamps, hammers, pliers, pop-rivet guns, wrenches, screwdrivers, and power drills. "Recommended Basic Tool Package for Five-to-Seven-Man Erection Work Crews" is available from MBMA, and is a complete list of the tools needed.

Most contractors use cranes to unload structural materials at the job site. Under the right circumstances, forklifts may be more practical and economical. The spreader bar is essential when unloading sheeting, otherwise the metal can buckle in the lifting process. Chokers, slings, clamps, or shake-out hooks are normally used to unload primary and secondary structural steel.

Sheeting the roof also requires some tools and materials. Tape sealant, tube caulk, and closure stips are critical to preventing roof leaks. Workers use high-torque screw guns primarily for the installation of self-drilling fasteners. Manufacturers of self-drilling fasteners recommend that these guns run between 2,000 and 2,500 rpms and a minimum of 4.5 amps for peak performance in driving self-drillers.

Metal building structural systems can be combined with brick and glass facades.

Low-speed guns of approximately 500 rpms are used with self-tapping screws. Assemblers often use self-tapping sheet-metal screws for making sheet-metal connections. This requires pilot holes. However, special self-drillers can be used to attach panel, trim, and hardware directly to the secondary structural framing, eliminating the need for pilot holes.

Manufacturers review these installation procedures in their training schools. If possible, the instructors take contractors to jobs in progress for a first-hand look at installation.

Marketing Support

Manufacturers also provide a wide range of marketing and promotional support. Many use co-op advertising programs, such as newspapers, television, the Yellow Pages, and Sweet's Catalog.

MBMA offers sales support to manufacturer members as well. The Association has published an extensive library of insurance literature, including a slide presentation. The presentation is designed to help MBMA manufacturers assist their builder networks in selling metal building systems against competing forms of construction.

Interest in metal building systems also has grown among allied construction organizations. Associated Builders and Contractors, Inc., for example, has established a National Metal Building Council for members wishing to learn more about this form of construction.

All forms of construction are vulnerable to economic downturns. But metal building systems can add a profitable new dimension to a home builder's operations. For more information, write to Metal Building Manufacturers Association, 1230 Keith Building, Cleveland, Ohio 44115. ■

Mr. Chuck Stockinger is General Manager of the Metal Building Manufacturers Association.