

CREATIVE, CUSTOM & CAPABLE: NEW DIRECTIONS IN METAL ARCHITECTURE

Metal building systems offer efficiency, reliability, versatility and sustainability for the broadest range of commercial and institutional facility types ever.



Custom engineered using integrated design and fabrication technologies, metal building systems are increasingly versatile, expressive and cost-effective for a range of architectural styles and building applications. This course describes sustainable directions in the custom-engineered, BIM-driven approaches as they are applied to varied architectural applications, end-uses and design challenges. From structural framing basics and fabrication capabilities to modular and panelized systems, the applications present a wide variety of roof and fenestration options, creative forms, and options for future expansion planning. Typical construction processes and applications are shown to potentially reduce overall building costs, boost construction speed and enhance durability, sustainability and resilience. Case studies in the commercial and institutional sectors provide useful examples of cost-effective and creative solutions with metal architecture.

Architectural innovation often begins with metal building systems and their integrated design and fabrication, and it culminates with a range of project delivery and operations benefits that appeal to the entire building team. For architects and engineers, metal buildings offer cost-effective, proven approaches with a wide expressive

range. Construction teams appreciate the cohesive and functional systems uniting steel erection, metal cladding, fenestration and finish materials. Owners get a building meeting budget and schedule objectives as well as long-range needs for maintenance and sustainability.

Yet there's another elemental draw of metal buildings that transcends these

4 LEARNING OBJECTIVES

At the end of this course, the reader will be able to

- + **EXPLAIN** the use of metal building systems in terms of structural makeup, design complexity, custom steel fabrication capabilities and CAD/BIM integration.
- + **DESCRIBE** how metal architecture can incorporate multiple framing systems, modular designs, mezzanines, panelized wall systems or IMPs, and varied roof and fenestration structures to increase expressive possibilities and allow for facility expansion.
- + **LIST** typical construction and erection methods and how the processes can reduce building structural framing costs, speed and simplify construction sequencing, and enhance durability, sustainability and resilience.
- + **DISCUSS** how metal building systems are developed and employed in various types and applications, including case studies of commercial, institutional, cultural, educational and civic buildings, including multi-story and large-span examples.



Whitcomb Arts Building at Knox College in Galesburg, IL. A dedicated, state-of-the-art facility with studios for painting, printmaking, design, sculpture, ceramics, drawing and digital art, metalworking and wood-working shops, classrooms, faculty offices, dedicated open studio space for faculty and seniors working on capstone projects, and space to display student work.

individual benefits. It speaks to the definition of great architecture as coined by Vitruvius: firmness, commodity and delight. Metal building systems are proven to deliver long-term resiliency, high return on investment (ROI), and – as seen in award-winning works by top-drawer architects – virtually unlimited creative opportunities.

When building teams collaborate in a unified, effective manner, metal building systems are often the linchpin of the project solution. And the results frequently defy commonly held expectations for metal buildings, which have a long and distinguished architectural history in industrial and agricultural typologies and other end-uses driven foremost by functionality. For example, the buildings are taking design honors, such as Knox College’s award-winning Whitcomb Arts Building in Illinois by Lake|Flato Architects. Metal systems also undergird many LEED Platinum projects, such



The Church of St. Francis Xavier in Sallisaw, OK is a metal building system with a 12:12 roof pitch, and additional built out structures in cold-formed steel.



as the Redding School of the Arts in California – also an AIA Design Excellence winner. Just as important, metal building methods can create human-centered, healthy environments for the most challenging occupancies: education, senior care, faith communities, high technology, culture and arts.

The adaptable, design-responsive toolkit of metal building stands behind these architectural successes. “The value from the metal building system is what allowed our project to happen,” says Shelby Navarro of 1Architecture, Tulsa, Okla., describing his firm’s work on a recent house of worship. “If they had tried to deal with glue-lams and custom wood, they wouldn’t have made it there.”

Custom engineered using integrated design and fabrication technologies, metal building systems are increasingly versatile, expressive and cost-effective for a range of architectural styles and building applications.

This course describes sustainable directions in the custom-engineered approaches to the use of metal building systems. Industry trends surrounding metal buildings are first reviewed. Then we look at case studies in the commercial and institutional sectors that illustrate those trends and provide useful examples of cost-effective and creative solutions with metal architecture. Many of the outcomes are very green and design forward, but they are also driven by the particulars of varied architectural applications, end-uses and design challenges.

The overview begins with structural framing basics and fabrication capabilities to modular and panelized systems. A look at the latest range of products and systems is then presented, with examples of innovative new metal building products. Applications present a wide variety of roof and fenestration options, creative forms, and options for clients who require future expansion planning. Exemplary projects also benefit from the use of integrated project delivery (IPD) and building information modeling (BIM), often with manufacturer and fabricator involvement.

Ideal for these architectural solutions, metal building systems also provide for typical construction processes and applications proven to potentially reduce overall building costs, boost construction speed and enhance durability, sustainability and resilience.

FASTER CONSTRUCTION:
Metal buildings cut weeks off of your building construction time, getting you in business sooner!

MONTH

STRENGTH & DURABILITY:
Metal buildings are designed to meet the most stringent building codes and endure the harshest weather conditions and long term effects of the elements.

ENVIRONMENTALLY FRIENDLY:
Star metal buildings are produced with materials that are **99%** recyclable.

DESIGN FLEXIBILITY: Star buildings are designed to meet your individual needs and requirements as you grow. A clear, column-free interior space allows complete flexibility of the interior layout.

LOW MAINTENANCE:
Today's long-life finishes provide years of carefree beauty. Finishes typically last 30+ years with minimal maintenance.

30 years!

IT'S Easy

ENERGY EFFICIENCY:
An insulated Star building can dramatically decrease heating and cooling expenses. Star insulated panel systems, low profile roof options and cool roof colors can also significantly reduce energy costs.

COST SAVINGS:
All these features make a Star building easy on your budget. With fast construction, unmatched durability, carefree maintenance and affordable customization, it's easy to see why a Star building will meet your needs and exceed your expectations. Metal structures can even cost up to 40% less than conventional ones.

UP TO 40% LESS

▲ Define "industrialized construction"

TRENDS BEHIND METAL BUILDINGS

There is a law in construction: What goes around, comes around. Good ideas tend to reappear, and that is the case with metal buildings, as trends in the building industry feed into the use of more metal buildings.

Among the most widespread is a return to what was termed "industrialized construction" in the middle of the last century. Today, these ideas dominate many market sectors thanks to interest among building teams in the benefits of **modular, pre-engineered and prefabricated** building approaches. These systems and products reduce sitework and required laydown space, moving many of the fabrication and subsystem assembly tasks to rigorously controlled manufacturing environments. The systems are also highly cost-effective and resilient.

Today, metal building systems – which are largely prefabricated and modular – bring the benefits of industrialized construction to a range of building types. The newer systems also allow for the integration of **daylighting techniques** as well as solar power, with integrated systems created by manufacturers, says Bryan



Arlington, a former design engineer and now head of operations for metal building maker Star Building Systems.

The most critical trends behind metal buildings, however, are project economics. Approaches including **lean construction**, sustainability and building information modeling (BIM) all favor the use of metal buildings. When the desired outcomes place high value on cost-efficiency (ROI), strength (which includes resiliency), and durability – related to both long-term value (or ROI) and sustainability – metal buildings are comparable to and in many cases preferred over constructing buildings using traditional methods.

Another trend is the use of a conventional steel structure with more **expressive and unexpected profiles** for the metal shapes, massings and panels built out from the underlying structure. Architects and engineers have used the

▲ [Top right] Interior of the Whitcomb Arts Building at Knox College in Galesburg, IL. [Middle] City National Arena is the practice facility and team headquarters of the Vegas Golden Knights of the National Hockey League and is located in the Summerlin suburb of Las Vegas, Nevada.

CITY NATIONAL ARENA, McCLOSKEY COUNTY ADMINISTRATION BUILDING (2/00/2008)



McCluskey Automotive Corporate Headquarters is a 2-story, 46,183 sq.ft. corporate office building combined with a state-of-the-art maintenance and repair shop located on 6.95 acres in the City of Loveland, Ohio. The facility serves as the headquarters for the McCluskey Automotive dealerships as well as the main hub of their “Used Cars” sale operation.



The House of Sports is a hybrid of two types of construction. Previously, there was a warehouse on site. Two of the bays were kept and incorporated in the new facility then new piles were sunk into the ground and the recreational facility was built from the ground up. Cutting the actual build time to 8 months.

systems to achieve creative building profiles while still capitalizing on the cost and construction speed advantages of a metal building system.

Another trend fueling the growth in use of metal building systems has been their compatibility with large-scale glazing, including full-height glass walls, according to experienced general contractors and construction manag-

ers. With increased market demand for more glass exposures and higher window-to-wall ratios (WWRs), architects and owners have adapted metal buildings for greater fenestration needs. For this reason, metal buildings are increasingly used for retail projects, automobile showrooms, restaurants, and athletic fieldhouses, which traditionally require extensive glazing for daylighting or display visibility, or both.

Metal buildings can also deliver successful and adaptable building envelopes with varied architectural finishes: Stone veneer, brick veneer, EIFS, and other cladding types are possible. As metal building makers expanded the finishes available, the design community began adapting

the “metal building look” in many construction applications and types of building projects.

Last, architects, engineers and contractors have seen the benefits of employing fully engineered building systems. “Companies like Star Building Systems have proprietary computer design software programmed with the codes of all 50 states and Canada, speeding up the engineering process for the building as a whole,” says Arlington. “Even in a hybrid structure where only the top floor is a metal building system, that portion of the engineering is handled, shortening design time and allowing the project to move forward more quickly.”

INTEGRATED METAL BUILDING APPLICATIONS

As a starting point or architectural design part for metal building systems, consider the approaches by wHY and K. Norman Berry Associates for the expanded Speed Art Museum in Louisville, or by Studio Ma for their Scottsdale’s Museum of the West. Both are innovative, modern cultural landmarks made possible only by economical, flexible metal building systems. Commercial projects benefit as well: The asymmetrical gabled roof atop Generations Brewing Co. in Freeport, Ill., created by an integrated design-build team of Winter Construction Inc. and Winter Design, Inc., has become an instant landmark in the area. “The brewery’s form recalls the massing of familiar agrarian structures and provides the clear span and height required for the client’s 14-foot-tall fermenting tanks,” says Winter Design’s principal architect, Scott Winter.

From the modern new museums by acclaimed architects like Steven Holl to the thousands of buildings by firms like Winter Design that deliver memorable and high-performance customized solutions, metal building systems are key to meeting high expectations. “Metal has connotations of being a sleek and modern and clean, efficient and rational material,” says Mark Horton, FAIA, principal at Mark Horton Architects, San Francisco.

These are hardly isolated opinions. Recent estimates by the Metal Building Manufacturers Association (MBMA) and the Metal Construction Association (MCA) reveal that, excluding single-family homes and other residential project, at least half of all new low-rise buildings are made with metal building systems. A survey by Metal



Construction News reported increases in use of metal buildings in every U.S. region, and it pegged growth in their average size at about 8 percent annually.

DEFINING THE SYSTEMS

By definition, metal building systems should employ integrated, industrialized building techniques including custom engineering and precision-fabricated components. For years, the terms pre-engineered and prefabricated have been applied to metal building approaches, incorrectly implying that their assemblies are catalogued or limited in expression. In fact, today's approach is more aptly described as a personalized, high-tech craft: Made to suit or mass customized, the just-in-time structures and enclosures are precisely produced per an architect's vision and specifications. They are driven by computer numeric-controlled (CNC) shaping and milling equipment with potential back-end BIM integration. Structures and envelope sections with integral assemblies such as fenestration are assembled off-site in highly controlled production settings, delivered to the project site, and erected quickly and exactly.


Creativity and expression with metal systems, as with any architectural material palette, demands familiarity with its elements and capabilities. Four basic product categories are essential for architects and building teams.

First is the structural framing, the basic metal building structural unit consisting of a system of large steel rafters spanning a bay or the entire structure, supported by steel columns. These are connected with secondary bracing members of purlins connecting the rafters and steel girts spanning from frame to frame along the exterior walls or interstitial vertical elements. Secondary steel framing generally supports wall and roof panels and other cladding and roofing systems. Roof shapes and pitches vary widely, from multiple-sloped forms to single-slope shed roofs to low-slope, modern profiles.

The next building element to consider is the wall panel. A wide range of panelized exteriors, cladding systems and fenestration approaches are used in contemporary metal building compositions. Among the most commonly used are interlocking metal panels, including insulated metal panels (IMPs), which install rapidly and reliably often with self-drilling, self-threading screws directly to secondary steel members.

At the same time, decisions are made about metal roof systems. By definition, metal building systems are topped off by roof assemblies clad in highly resistant, impermeable and durable



 Generations Brewing Company's 8400 sq.-ft. production facility, taproom and beer garden in Freeport, Illinois.



Jones and Company, Ltd. Certified Public Accountants Building located in Jonesboro, AR

alloys of steel, copper, galvanized steel, zinc, or aluminum. Some of the metals are left exposed to develop a patina, while many are treated with architectural coatings or, in some cases, topped with a planted green roof system or solar panels. Similar to the vertical cladding, these roof systems employ interlocking or active fastening, so they can easily meet severe wind and uplift tests including ASTM E1592, UL 580, and UL 1897 and local codes for hurricane-rated approvals such as in Dade County, Florida. In some

cases, reflective finishes or low-emissivity coatings are used to reduce heat gain.

Numerous integral exterior components are then reviewed. Many metal building manufacturers offer these additional pre-engineered components, many of which are typically required in commercial and institutional architecture. Examples include compatible windows to complete an enclosure; matching ventilators, roof jacks and pipe flashings for MEP systems; as well as gutters, roof curb assemblies, and integral downspouts to control bulk water movement as part of a moisture-management system. Glass door assemblies, louver panels, and overhead security

doors kits are also commonly included.

Other cladding systems used in recent architectural applications demonstrate the broad range of finish materials and technical solutions now available. “With decades of track record,



metal building systems have a reputation for solving building owner requirements without compromise,” says Star Building Systems’ Arlington. “Today’s toolkit is sophisticated and can readily incorporate wood, glass, stucco, brick and stone finishes, ideal for the versatile contemporary structures expected by businesses and institutions today.”

INDUSTRY-LEADING PRODUCTS AND SYSTEMS

As these solutions have advanced, a number of innovative products and systems have emerged and become reliable, integral parts of the metal building world. Some of these relate to incremental gains in the performance and life-cycle value of products long involved in the overall building approach. Others reflect the adaptability of metal building systems to new trends, such as the increased use of photovoltaics (PV) and solar power systems. The S-5 clamp, which has long been used for snow retention and utility access, has become a standard component for integrating PV kits with solar mounting assemblies on metal roofs. According to experts, the S-5 clamp reduces installation costs and simplifies the process with module-to-module (bonding) continuity.



Perfect for high-traffic use, DBCI’s heavy-duty, commercial-grade metal roll-up doors are suitable for warehouses, loading docks, terminals and distribution centers.



SA Recycling is a full-service ferrous and non-ferrous metal recycler and processor. Recognized as an industry leader in metal recycling.

by wall systems with factory-assured quality and predictable performance, thanks to frequent inspections throughout their typical manufacturing process. Increasingly sophisticated wall panel designs now incorporate glass, wood, stucco, brick and stone for versatile, expressive structures – some with dramatic effects. Metal panels are lightweight, robust, and relatively easy to install. Sheet steel is bent during manufacturing to achieve architectural patterns engineered to increase overall strength and resistance to wind loads and impact force.

Examples of successful, novel wall panel types include fluted panel products, with a strong and memorable profile delivering aesthetics, economics and function to building façades. Casting deep shadow lines for distinctive architectural impact, the deeply folded panels also provide structural strength and good life-cycle cost.

Metal panels can be mounted quickly and economically to secondary steel members, and leading manufacturers produce panels with self-drilling, self-threading screws and interlocking perimeters. The resulting envelopes resist air and moisture intrusion. Panels are often galvanized to resist corrosion or finished in advanced coatings such as Galvalume or fluoropolymers, and they are available in a wide range of colors. Custom capabilities further expand the aesthetic range.

Depending on interior space needs, wall panels may be backed with insulation and finished with drywall or other interior paneling.

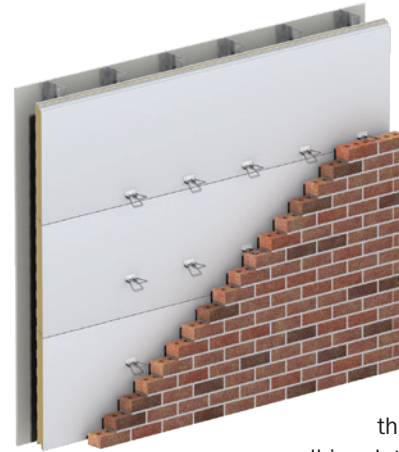
2. Insulated Panels

The increased affinity among architects and building owners to architectural insulated metal panels (IMPs) has expanded their use as cladding and roof systems, adding their resilience and insulating capacity continuously around the envelope. Developed for both new and retrofit construction, these panels employ **foamed-in-place technology**, a manufacturing process developed to ensure a thermally efficient architectural enclosure, placed outboard of the structural supports for a continuous barrier with no areas of compressed insulation or thermal bridging. Most panel profiles allow for both horizontal or vertical application, varying the exterior expression, as well as concealed clips and fasteners in the side joint for a flush appearance. In rare cases, architects choose to articulate the typically hidden attachments.

Advances in this area include a novel backup wall system called the high-performance continuous insulation or HPCI Barrier wall. This IMP serves as an air, water, thermal and vapor barrier panel that can be used behind varied types of façade, seemingly any cladding or rainscreen exterior desired. The HPCI back-up panel is installed in a horizontal orientation completely exterior to the structural frame of the building. This concept eliminates thermal bridging while creating the needed barrier backup wall.



Charleston Southern University's new 8,000 sq. ft. athletic facility combines a 5,000 sq. ft. strength and conditioning center and a 3,000 sq. ft. meeting and office space, essential for recruiting as well as enhancing student-athlete wellness and the competitive experience.



efficiency ability, or a need to meet new wind uplift requirements. This has led to the introduction of specialized **retrofit framing systems**. Created for application to low-slope or “flat” roofs with hydrostatic weatherproofing membranes, which often suffer from water ponding, infiltration and leaks,

the retrofit framing creates a new, well insulated and moisture-resistant roof system above the old membrane roof.

According to Arlington, it is common for a building owner to spend an average of 12 cents per square foot per year on maintenance for membrane roofs, which must be completely replaced every 10 to 20 years. “Compare this to a metal roof that has minimal maintenance requirements and a life expectancy of more than 30 years,” he says. “Due to savings on maintenance expenses and a metal roof’s long life, a retrofit metal roof system will easily pay for itself over time.”

In another roofing related advance, new daylighting products are designed by metal building manufacturers for compatibility and ease of integration into metal roofs. **Daylighting products** are trending today, including light pipes that can bring natural illumination from the roof into lower floors that skylights can’t illuminate. Light pipe products include open tubes with highly reflective interior surfaces, while others comprise bundled fiber-optic strands.

4. Accessories

As shown by the rooftop daylighting products example, metal building manufacturers tend to have extensive catalogs of compatible accessories required for completing a building specification, including **gutters and downspouts**, windows and canopies, as well as ventilators and louvered openings. For the building façades, manufacturers offer overhangs, entry doors, **storefronts**, and thermal windows and insulated glazing units (IGUs). In addition, roll-up doors are available to create larger entries and indoor-outdoor spaces. All of these accessories are designed to match the finishes and styles of the exterior system, providing a useful design palette.



3. Roof Panels

Roof systems integrated into metal buildings have emerged as another area of innovation, with predictable performance, daylighting and solar integration, and extensive development of compatible accessories. These assemblies have earned a reputation for aesthetically pleasing architecture and delivering economy, energy efficiency and consistency of quality.

Among the successful roof panel types are metal **standing-seam roofing** systems attached with concealed, interlocking clips that minimize the need for panel penetrations. Applicable for both new construction as well as retrofit applications on existing structures, the latest generation of the standing-seam roofs offer a high degree of weather tightness, tested by independent laboratories in accordance with ASTM E1680 and E1646, the key standards for protection against air infiltration and water penetration.

The retrofit market for metal roofing has grown steadily over the last several decades, allowing building owners to address such issues as leaks, high maintenance costs, low energy-



Star Building Systems provided three metal building systems to construct The Gathering shopping center in Port Arthur, TX. The 14,004 sq. ft. project includes an entryway, main shopping building and coffee shop. The walls were built with insulated metal panels and, at two corners, horizontal, aluminum accent panels that look like wood.



Built in 2014, Generations Brewing Company resurrected the brewing the industry once located in Stephenson County, Illinois. Three years now in production, they offer artisan ales and lagers in all shapes and sizes, distributed throughout the region. Their beautiful tap room with rollup doors allows patrons to enjoy craft brewing as it was intended, with friends and family whether it be indoors or outdoors.

ARCHITECTURAL ASPECTS OF METAL BUILDING

As seen in the overview and a few varied project examples, metal building systems offer a wide array of expressive and creative capabilities. Yet the use of metal architecture from its earliest beginnings has been driven by efficiency, high strength-to-weight ratios, low costs, and speed of erection. The metal roof, for example, debuted at the 1934 Century of Progress Exposition

CASE STUDY:

STRUCTURAL INNOVATION

As an example of the elements above, consider the recently completed cheese plant for Appel Farms, a family producer based in Ferndale, Wash. The design-build team including contractor Faber Construction employed an exoskeleton structure, with tapered columns pointed outward and walls interior to the columns, and wall expanses clad in vertical and horizontal metal siding, a natural wood cantilever, and a base of manufactured fieldstone. The approach also makes the 12,800 sq. ft. facility efficient and easy to insulate and maintain.

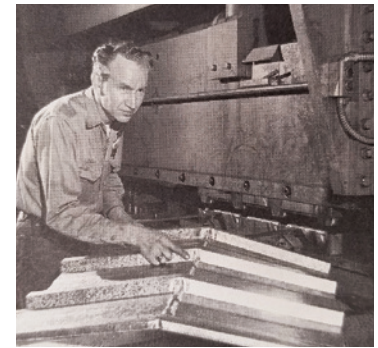
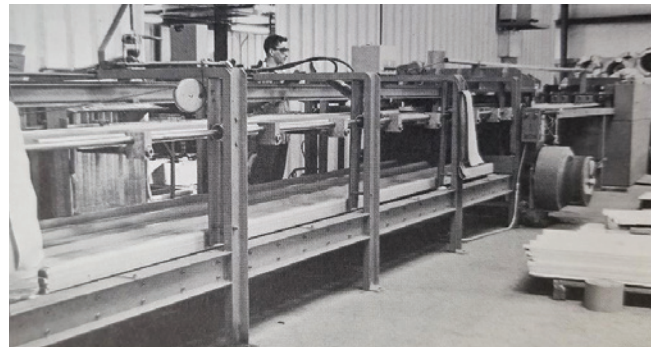
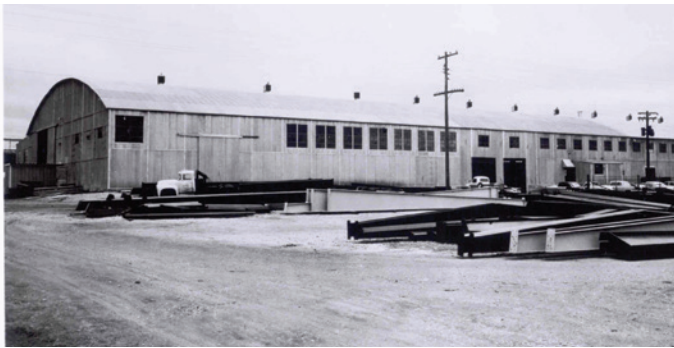
According to the building team, the tapered exterior columns are visually striking but also allow room for more enclosed area, making the building inherently efficient. “The exo-structure design allowed the interior spaces to have seamless uninterrupted wall surface making the space even more efficient,” according to Faber. “Using insulated metal panels, we were able to achieve a food-grade interior surface, get necessary insulation to meet energy codes, and also have exterior skin included in a single installation,” says David Verret, Faber’s pre-construction project manager.

As the Bellingham Herald reported, “When it comes to food production, one of the biggest challenges is keeping a processing facility clean,” and the “local food manufacturer made that easier to do by using a nontraditional building design.”



The Appel Farms cheese plant in Ferndale, WA uses an exo-skeleton structure, with tapered columns pointed outward and walls interior to the columns.





Early Bow Truss Building

in Chicago, and the full metal structure was later popularized during World War II with the evolution of the Quonset hut, introduced at the Davisville Naval Construction Battalion Center at Quonset Point, R.I. The Navy found their all-purpose, lightweight building – easily shipped and quickly assembled – an example of Yankee ingenuity and perhaps a glimpse of a better future for everyday Americans.

Over the following years, metal buildings became a common solution for agricultural and industrial buildings that needed large clear spans, high ceilings, and a low-cost, sole-source procurement approach. As these typologies developed, metal buildings took on new and creative expressions with an expanding palette of integrated systems, materials and finishes. Unique to their structural and architectural approach, metal building systems emerged as the primary option for building teams seeking a custom-engineered yet also “kit-of-parts” systems approach – a very economical and appealing concept.

According to architect and NASA engineer A. Scott Howe, who spoke on principles of “plug-in” or kinematic architecture at the Conference on Construction in the 21st Century in Hong Kong, the kit-of-parts approach describes object-oriented building techniques, relying on predesigned and prefabricated elements for joints, panels and modules in “deployable (time element) construction systems.” These approaches, he says, offer optimal flexibility in assembly and efficiency in manufacture – delivering a focus on end-users with a more environmentally sensitive process.

1. Meeting use-based criteria

In fact, from its premiere in the midcentury, metal buildings have become synonymous with responsive and efficient architecture – an early

advance toward sustainable design. The industrialized approach solved several issues inherent in stick-built frame, unit masonry, and even post-and-beam systems to address the end-user’s specific needs. First is controlled production away from the jobsite: The factory-fabricated steel structure and enclosure could be made in highly automated, precision machinery prior to site assembly with a repetitive process that reduces errors and tolerances. Second is the sizing and shaping of rafters and columns to meet required application end-uses as well as specific engineered criteria for the building loads and live loads – a sharp turn away from designing architectural structures around standard-sized, standard-shaped pieces of steel, such as hot-rolled I-beams.

Third is a transportable, easy-to-erect system of materials and methods that can accommodate varied kinds of construction equipment and crews. The early years of military applications presaged the future of green building, which would seek efficiencies in transporting building systems, optimized and simplified systems that reduce weight and embodied energy, and ultimately products that could be dismantled and recycled.

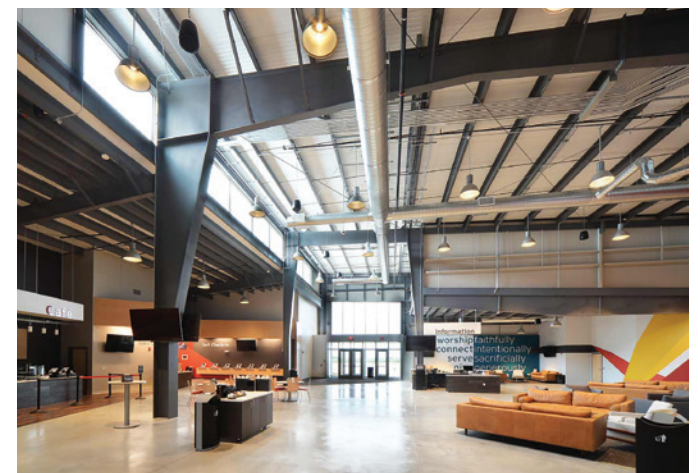
2. Achieving weight savings and cost reductions

Metal building systems are based on the use of custom engineered structural steel, which is optimized prior to being formed into its required shape. This allows the most efficient use of steel, which reduces costs and environmental impact.

Distinct from commodity I-beams, which are continuously hot-rolled into a consistent shape across each member’s length, the web height of primary steel members in metal building systems can be varied as desired. This offers



City National Arena is 142,000 sq. ft. and includes two regulation hockey rinks, a restaurant and bar with a view of both rinks, team corporate offices, a workout facility for the Golden Knights, a gift shop and a skate rental facility.



an opportunity to eliminate the excess weight typical of conventional steel construction. Instead of a beam or column that meets the maximum anticipated load across its length, the metal building manufacturer assembles custom-fabricated steel elements cut from plate steel and precision-welded into specific sizes and shapes determined by the architect's design and engineer's calculations. "The resulting steel members can be sized to the needs of the largest load at one point, and tapered down where the load is smaller," says Allen D. Hurtz, P.E., director of engineering for Oklahoma City-based Star Building Systems, a manufacturer and supplier of metal building systems.

To do so, the maker cuts the plates at angles and shapes it as needed to meet structural load requirements. This decreases steel usage significantly, reducing costs but also weight of

steel produced, transported, and contributing to building static loads. Not only does this allow downsizing of typical framing and foundations, it also improves seismic design and resistance to earthquake damage, says the engineer Hurtz.

3. Improving design efficiency

The tapering of roof joists and columns creates a memorable appearance when left exposed, such as roof rafters with their web depth decreasing from the roof peak to the perimeter, or the dramatic flaring of visible columns as they rise. Even the thickness of the flange steel can be tapered along the same members – a less obvious but essential efficiency. Installed, the members make building more space efficient: the slender foot of tapered column, for example, allows more usable floor area.

As is often seen in architectural solutions, efficient solutions are often elegant, expressive

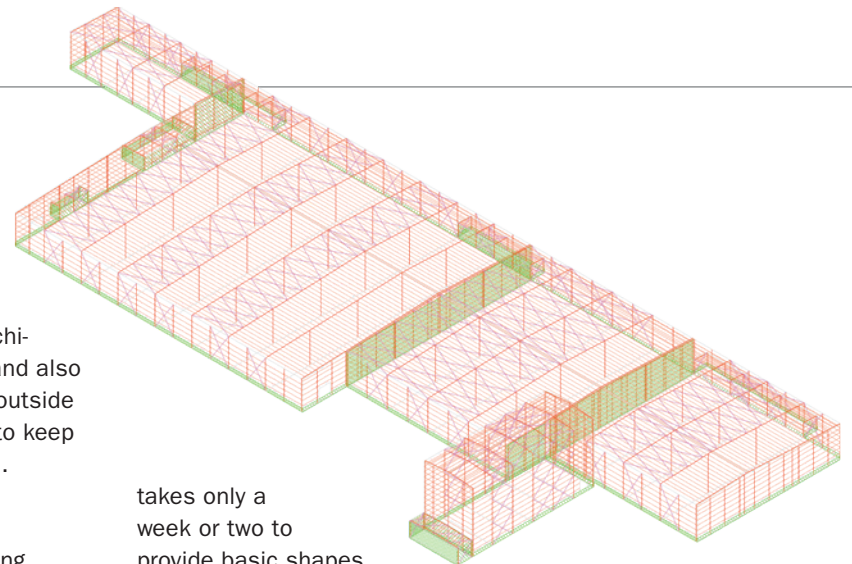
Vale Church's high-performance building envelope features more than 18,000 sq. ft. of Metl-SPAN 3-inch CF Striated insulated metal panels in 24/26 gauge.

ones. Tapered columns suggest a more natural or biomimetic structure – such as the flaring of a tree – and it can form a large, structural arch with the tapered rafters. In the envelope design, architects can have large column-free spans and also position the perimeter column locations outside the exterior walls, so they flare outward, to keep the interior expanses flat and unimpeded.

4. Methods for simplifying construction

With increased complexity of metal building expression and material combinations, they are hardly “pre-engineered” in the sense of the original utilitarian structures created by the Navy and developed worldwide. Structural systems of metal buildings are, in fact, custom engineered and highly efficient. And they consistently deliver substantial savings in time and cost for construction, according to architects and building teams.

The first benefit is BIM and CAD integration. The metal building supplier can take digital drawings and specifications, even early in the design development (DD) phase, to begin creating fully engineered structural drawings for plan approval, and shop drawings used to fabricate the steel. A second benefit is the speed of delivery: Fabricator design for even a highly complex building



takes only a week or two to provide basic shapes and clearances to the architecture and engineering team. Detailing of the metal systems follows, often in parallel, and overlapping this work using integrated project delivery (IPD) such as design-build further telescopes the project schedule. Fabrication and shipment of the finished structural members can take six to eight weeks or more, depending on the project’s footprint and height.

Even greater impact on project delivery is found in the simplified engineering and construction planning processes. Steel is typically fabricated while site work and foundation are underway; when the pre-drilled, detailed steel members arrive, framing is relatively fast. In some cases, the framing is panelized while on the ground, with purlins attached to rafters and



Clear Span is an architectural term to describe the distance between the two inside surfaces of the span supports; the distance that is unsupported. If there is a need in your steel building design for a wide space, like the images above, that is clear of posts and beams, then a clear span design is the choice for you.

girts affixed to column pairs before they are raised. As erection progresses and each building section is completed, exterior cladding and roofing assemblies can be added.

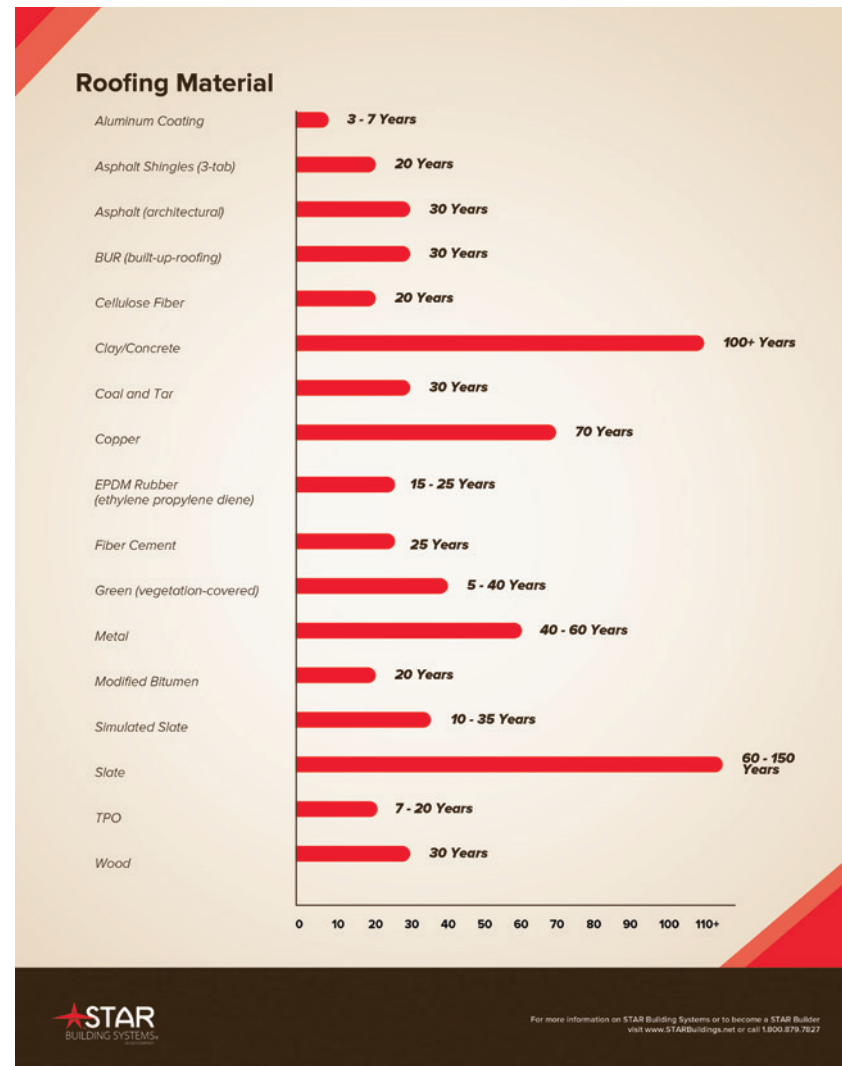
Metal building manufacturers typically have the capacity to deliver entire and completed buildings, so they act as an essential specialty contractor with the mindset of a prime contractor. Moreover, framing designs with metal systems allow for very large, cost-effective clear spans up to 250 feet or more; replicating those frames offers an efficient way to create repetitive bays for whatever building length is needed. Many building owners also use this approach to expand, adding bays as they grow, long after the initial construction, to add more footprint and space.

METAL BUILDING FOR GREENER OUTCOMES

As a primary consideration for system choice, steel is one of the most recycled and recyclable materials in the construction world. Yet metal buildings offer a number of other essential features for green building over the entire life cycle, from efficient manufacture (low embodied energy) prior to construction and to efficient operations and high potential for reuse and reclamation. In this way, metal building systems offer a cradle-to-cradle opportunity with many ecological benefits – an unlimited ability to reutilize the value of the original building project.

Building teams can source structural members with 30% to 50% percent or more postconsumer recycled materials, and many metal roof and wall panels consist of at least 25% postconsumer recycled metals. While the efficient structural members already use an optimized amount of steel, by selecting low-weight, high-strength IMP cladding the structural support needed for the envelope can be further reduced. Metal roofing systems work well for integrated rainwater harvesting strategies, and many are finished with cool-roof coatings, the reflective and emissivity-controlled products that help mitigate urban heat islands and slash energy use.

In the operations phase, metal buildings are resilient, durable, and require less maintenance than many comparable construction types. According to the American Iron and Steel Institute (AISI), metal roofs last between 40 and 60 years



while resisting strong winds and snow loads, fire, and environmental factors such as hail, rainwater, and insect or rodent damage. AISI adds that, at the end of a metal building's useful life, its structural and other metal components "are virtually 100 percent recyclable" while many other conventional building materials head for the landfill. The average recycling rate for steel is about 70%, says AISI, and new steel made with recycled stock may use only 26% percent of the energy required to produce steel from iron and other extracted resources.

While the reuse of building structures is increasing globally, it is still relatively rare. Yet metal building systems interest a number of architects, such as Robin Snell, for their ability to create demountable structures that may be



Aerovista Business Park is a five-building complex located near the San Luis Obispo airport. The project includes 180,000 sq. ft. of corporate and professional office space for multiple tenants. The master plan for the site was designed around an existing rock outcropping and incorporates an entry water feature. Exterior design was created to compliment an airport theme. Steel building systems provided a simple and cost-effective solution for construction.



easily re-assembled or have elements applied to other uses. Distinct from portable or modular systems, these are large-scale reuse opportunities for completely new buildings. The idea is not so futuristic: An early example still standing is the 1925 demountable hangar at the Phoenix-Mesa Gateway Airport in Arizona, a landmark listed on National Register of Historic Places since 1995.

Just as important today for sustainable design are features that boost occupant health, wellness and experience. “The LEEDv4 rating system introduced credits for disclosure of chemicals in the ingredients used for building materials,” according to Scott Kriner of Green Metal Consulting. “The WELL Building Standard is meant to improve health and wellness of building occupants,” he adds, noting how the WELL standard has resulted from “research on the effects of indoor space on people.” The two new developments bode well for the use of metal buildings, which are typically made with benign materials and finishes while

providing a high degree of flexibility for increasing daylight and views. These capabilities, which are tracked for LEED and WELL certifications, improve occupant enjoyment and health.

A final consideration for green building is the ability to procure metal building systems locally. Fortunately, this mature industry offers sources in almost every U.S. market, according to MBMA, with at least 12,000 employees in 65 plant locations globally. This maximizes the amount of material manufactured within a 500-mile radius of U.S. construction sites.

CREATIVITY AND INNOVATION WITH METAL

With these numerous advantages for architects and building teams overall, metal building systems provide a reliable, speedy and flexible solution for varied applications. In this way, they also deliver something every design professional craves: The reassurances that open up time and opportunity to pursue creative, innovative building approaches.

These pioneering architectural approaches have included very large structures, as suggested by the historic airplane hangar. Modern examples range from vast distribution centers for FedEx Ground to multistory structures for schools, office complexes, and residential occupancies. Some are notable for their novel designs – the wood-hued Pacific Commerce Center, for example, with its welcoming entry pergola, or the expressive, wing-shaped cantilevered sections for Aerovista Business Park’s showcase building, a memorable 180,000 sq. ft. designed by Steven D. Pults, AIA & Associates. “The exterior design was created to complement the airport theme, according to the architect. “Steel building systems provided a simple and cost-effective solution for construction. Interior improvements were designed as leasing progressed, providing flexibility and individuality for tenants.”

As seen in examples in this course, a range of buildings designed for visual impact, individuality and brand expression are also possible with today’s metal building systems. Lake|Flato’s art center at Knox College and the Generations Brewing Co. taproom and restaurant are two ideal examples: Both offered low-cost, quickly erected solutions with lasting impact. While cost-effective and resilient, the facilities are also memorable and valuable because of their modern façades, expressive roof profiles and vibrant, double-height interior spaces full of daylight and energy.

Other recent project examples by noted architecture firms include:

1. Campus buildings.

Clad in brick veneer with a light-colored cornice element and with a copper-hued metal awning over its entry, the new Delaware State University dining hall offers an example of how metal building systems complement a campus context. Fitting in with a long-range master plan and flurry of new buildings, many by the firm Ayers Saint Gross, the dining hall is detailed in a way that does not appear to be a classic metal building. A large entry with full-height glass storefront welcomes students into the capacious and comfortable dining facility.

The Delaware State University dining hall, built by Nowland Associates, Inc. in Newark, DE, offers an example of how metal building systems complement a campus context.





The House of Sports is an Olympic-style athletic training facility. Located in Ardsley, NY this 120,000 sq. ft. complex is one of the largest on the East Coast and is the home to the nation's leading lacrosse, basketball and baseball training academies.

2. Large-span venues.

Across the country, metal building systems provide an efficient and budget-wise approach for recreational, sports and entertainment complexes. The House of Sports, for example, is an Olympic-style athletic training facility located in Ardsley, N.Y. Designed by Mann-Hughes Architecture in Doylestown, PA and erected by Thomas Phoenix International the 120,000 sq.ft. complex is one of the largest on the East Coast, serving as home to leading lacrosse, basketball and baseball training academies. To complete the project, the building team added a third floor comprising pre-engineered structures and enclosure onto an existing 40-foot-tall structure. The work earned awards including the MBCEA Building of the Year award.

3. Health and healthcare facilities.

Freestanding clinics, community health centers, medical office parks and other types of buildings are commonly made with metal systems. Among the most creative examples is the Southwest Missouri Humane Society, located in Springfield, Mo., built by Benecorp Contractors as a new, 15,400 sq. ft. veterinary health facility with a fieldstone-look base wrapping the building and an entry portico made with exposed-timber structure. Designed by the award-winning firm Marshall-Waters-Woody Associates, the building reflects the architects' design ethos, "to create structures as unique as the occupants," according to the principals. "Every project is a representation of and adaptation to the personality and lifestyle of the individual client."

4. Schools.

For educational facilities, metal building systems deliver significant value as compared to other construction methods. Adaptable and durable, metal buildings marry reasonable first costs with long-term operational benefits, including cool roofs and continuous exterior insulation to help districts meet low-energy building codes. More examples are seen in recent years around the United States. Located in Lincoln, Ill., for example, the classic brick facades of Lincoln Elementary School wrap the 33,500-sq. ft. structure built by R.J. Hoerr, Inc., conceal a metal building system designed for the educational architecture.



The Southwest Missouri Humane Society's 14,500 sq. ft. facility that will hold up to 400 pets.



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5. Specialty facilities.

Using metal building systems, several framing assemblies can be combined for unique, purpose-built facilities of any kind, from manufacturing and distribution structures to commercial and agricultural locations. For example, the recently built Cobalt Stables in Olathe, Kan., is a combination of three metal building systems: a massive roof structure, an indoor equestrian arena, and the living quarters and stables. The structural approach comprises three framing systems, all arranged in a T-formation. The arena is a clear-span structure and a second, smaller framing system is connected to that. The two-floor living quarters were specified from suitable framing products.

From budget limitations to site conditions and organization goals, the varied projects using metal building systems help illustrate how solutions emerge from this proven and adaptable toolkit. Building teams, starting with their programmers and designers at the front end, have found thousands of ways “to satisfy client needs with functional designs that please aesthetic concerns as well,” according to the firm Marshall-Waters-Woody.

“There are, undoubtedly, many other kinds of building projects that could benefit from the cost savings, rapid construction, and superior performance of metal building systems,” says the engineer and operations director Arlington.



“As architects and design professionals become more aware of the possibilities and benefits of metal building systems, it is likely that even more innovative applications will be found, and that the system will evolve further in versatility and capability.” ■

▲ Cobalt Stables in Olathe, KS, is a combination of three metal building systems. The roof of the largest one, the indoor equestrian arena, is barely visible beyond the living quarters and stables that front the property.