

Powerful Profile

Lightweight Extrusions Shoulder a Heavy Design Load

Although the extrusion of metals has taken place for almost two centuries—preceding the discovery of the Hall-Heroult process—this essential metal-forming method has come to be identified most closely with aluminum. This is unsurprising, given that extrusion technology takes advantage of aluminum's inherent properties to produce lightweight designs with an unequalled combination of strength-to-weight, ease of joining, corrosion resistance, electrical conductivity, and machineability.

The basic process is a simple one. In the case of direct extrusion—the most commonly employed extrusion method—a heat-softened billet is placed into a hydraulic extrusion press. A ram then pushes a dummy block, forcing the aluminum through a die to produce the desired shape.

The range of shapes created by the extrusion process—sometimes called “profiles” because of their length in relation to their cross-section—is limited only by the imagination of the designer. Such profiles have wide applicability as structural members in building and construction (the focus of this article), as well as in the automotive and durable goods industries.

Putting the Metal Where It Is Needed

It is often said that, compared with alternative materials and forming methods, aluminum extrusions offer parts and product engineers unparalleled design latitude. For starters, almost all aluminum alloys can be extruded—although some are more suited to the extrusion process than others. Second, a wide range of designs are possible—

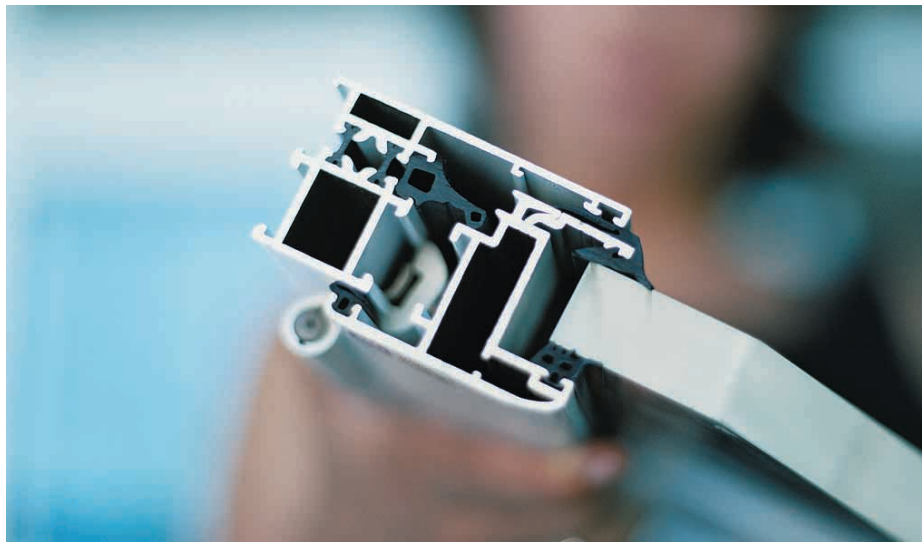


Photo: Norsk Hydro

A key advantage in specifying aluminum extrusions is the ability to create complex shapes—including hollows. This design flexibility is sometimes called “putting the metal where it is needed.”

simple or complex shapes; uniform or multi-thickness walls; parts that interlock, hinge, or self-assemble; and solid, hollow, or semi-hollow shapes.

The design flexibility afforded by extrusions is sometimes referred to as the ability to “put the metal exactly where it is needed.” Thus, a profile can be designed to put aluminum in those places so as to produce the strongest possible piece for a given weight and amount of aluminum used. Similarly, aluminum extrusions can be designed to take metal out of low-stress areas to improve cost-effectiveness.

What's more, aluminum's ability to accommodate a variety of surface treatments adds both to extrusions' appeal and to their usefulness. Anodizing, for example, can add a higher level of corrosion resistance, a decorative finish, improved abrasion-resistance properties, an electrical insulating surface, and/or a more lustrous finish.

Extrusions in Building and Construction

Aluminum extrusions were first used extensively in the building and construction (B&C) market—and that remains their biggest market to this day. Figures recently released by the Aluminum Association and the Aluminum Extruders Council show that, in 2005, 41 percent of the U.S. and Canadian market for extrusions was in B&C applications—including, doors and windows, screens and screen frames, awnings and canopies, siding, soffits and fascia, roofing, sunrooms, patio enclosures, wall panels, partitions, curtainwall and storefronts, gutters and downspouts, shower and tub enclosures, Venetian blinds, and hardware.

The figures also document the continuing growth in the extruded products market. U.S. and Canadian consumption of aluminum extrusions totaled 4.42 billion pounds in 2005—an

increase of 5.7 percent over the previous year. Shipments of aluminum extrusions to the B&C market totaled 1.83 billion pounds—an increase of 4.4 percent over the previous year.

Why their growing popularity? In addition to the flexibility of designs available via the extrusion method, initial costs—such as tooling—and lead times are generally less for aluminum extrusions than for competing forming methods, such as die-casting, impact, stamping, roll forming, and vinyl extrusion.

Finally, because of their low weight and transportability, aluminum extrusions frequently can be easily packed, shipped, and assembled on site. Designed to minimize the need for fabricating operations such as welding, aluminum extrusions can often be assembled with a smaller and less-skilled labor force than that required with other building materials.

Load-Bearing Extrusions

A misconception of aluminum is that it is not strong enough to use in load-bearing structural applications. Perhaps that stems from the ubiquity of the aluminum can and its crushability. In fact, aluminum is probably a “victim of its

own strength” in this respect, as its high strength-to-weight ratio is partly what allows canmakers to use such a thin gauge of aluminum while ensuring product integrity.

As for structural applications in construction, one of the most commonly specified aluminum structural alloys, 6061-T6, boasts a minimum yield strength almost equal to that of A36 steel—which is the standard construction steel used for structural supports in many buildings and bridges.

Aluminum’s light weight and low density, in fact, make it particularly suitable for structural applications where “dead load”—i.e., the weight of the structure itself—is a potential issue, such as roofs and bridges. In such applications, aluminum’s low weight can increase the structure’s “service load”—in the case of a bridge, its traffic-carrying capacity.

Aluminum Deck on Kentucky Highway Bridge

This fall, school buses crossing the Kentucky State Road 974 bridge over Howard Creek in Clark County, Ky., will drive over an extruded aluminum bridge deck. It will be the first alu-

minum bridge deck in Kentucky and one of a handful of load-bearing aluminum transportation structures in the country.

In 2002, the Kentucky Transportation Cabinet (KyTC), Kentucky Transportation Center (KTC), South Eastern Center for Aluminum Technology (Secat), and national representatives of the aluminum industry met to explore the possibility of deploying an aluminum bridge deck as part of the rehabilitation and upgrade of an existing bridge. KyTC submitted a proposal to the Federal Highway Administration’s Innovative Bridge Research and Construction program, which was subsequently awarded in 2003.

The design features 12 deck panels fabricated from extruded profiles welded side by side. The profiles were constructed from 6005-T6 alloy by Bayards Aluminium Constructions B.V., in the Netherlands, in cooperation with KTC and TNO Building and Construction Research.

According to Dr. Issam Harik, of KTC, the three primary advantages of the aluminum deck are:

- Reduced dead load—the aluminum deck weighs approximately 80 percent less than the steel reinforced concrete deck it is replacing, which permits increasing the load limit for trucks crossing the bridge;
- Durability—aluminum is expected to increase the lifespan of the deck many times over that of a conventional reinforced concrete deck; and
- Rapid construction—the aluminum deck can be placed in one day and the bridge opened to traffic later that same day.

Harik says the initial cost is the primary disadvantage of the aluminum deck.

At press time, the construction schedule called for the extruded deck panels to be placed on the bridge on July 18. In lieu of the traditional bolting or welding



Photo: Bayards Aluminium Constructions B.V.

On July 18, twelve aluminum deck panels—fabricated by Bayards Aluminium Constructions B.V. (www.bayards.nl)—were scheduled for installation on this Kentucky bridge to replace the existing steel reinforced concrete deck. The new deck weighs approximately 80 percent less than the old one—thus increasing the load limit for trucks crossing the bridge.

connections, the aluminum panels will be secured to the supporting beam sections and to one another using mechanical clamps. The clamps can be tightened to a desirable pre-tensioning level. Each panel comes with a 20-mm thick protective layer. Upon the completion of the installation process, an additional 80 mm of asphaltic concrete will be added as topping.

"We hope that this new bridge will initiate renewed interest in the use of aluminum in bridge construction in Kentucky and nationwide," says Dr. Subodh Das, president of Secat. "Secat will work with the Aluminum Association, Aluminum Extruders Council, and aluminum producing and fabricating companies along with state and federal transportation departments to promote the expanded use of aluminum in bridge construction."

Nevada Solar One Plant

When the world's third-largest solar power plant fires up next year in the Nevada desert, its nearly 300 acres of solar collectors will be underpinned by extruded aluminum spaceframes. Hydro Aluminum North America will supply almost 3,500 metric tons of extruded tubing for the project.

The plant's solar collectors use parabolic-shaped, mirrored surfaces to concentrate the sun's heat on a thermally efficient receiver running the length of the trough. The largest installation of its



Photo: Solargenix

Collectors at the new Nevada Solar One plant are supported by extruded aluminum spaceframes.

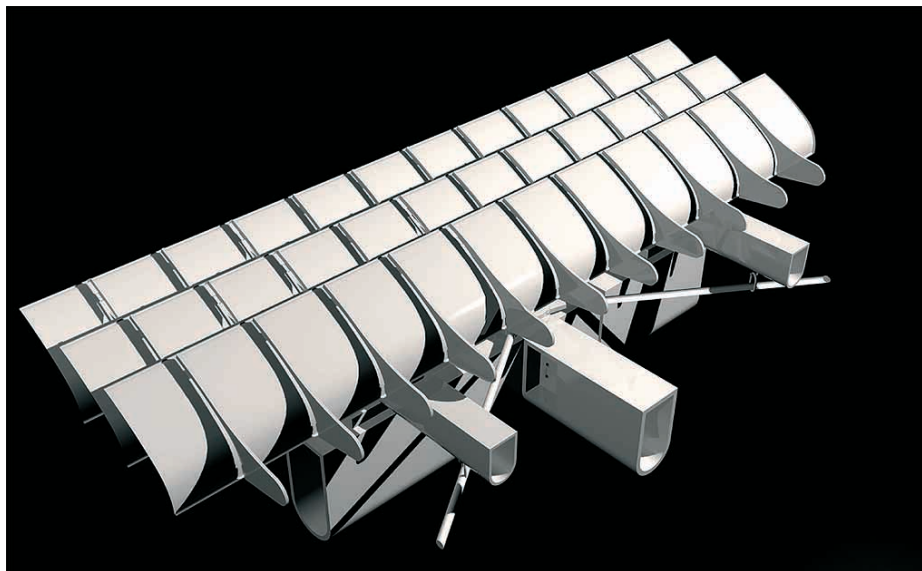


Photo: Renzo Piano Building Workshop

The new wing of the Art Institute of Chicago will be protected by a massive extruded aluminum sunshading device that will float "like an umbrella" over the upper-floor galleries and a garden beneath.

kind built since 1990, the plant will be able to power 40,000 homes once it begins production in 2007.

The collector design uses an innovative new aluminum hubbing system developed in partnership between Solargenix and Gossamer Space Frames (the latter are the creators of the aluminum spaceframe bridge in Long Beach, Calif.) to create a structure 30 percent lighter, with 50 percent fewer pieces, and requiring substantially fewer fasteners than previous designs used by Solargenix. Its structure achieves high resistance to wind loads.

The aluminum spaceframes provide greater corrosion resistance than past designs, and allow the mirrors to be mounted directly to the structure so that no alignment is required in the field. The collectors use a new Schott receiver featuring improvements that increase receiver lifetime and performance. The end result is a system that increases performance by roughly 15 percent, reduces investment costs by 15 percent, and improves component reliability for a net improvement of approximately 35 percent in total cost-effectiveness over previous designs.

The system has been nominated for

an R&D 100 award.

Art Institute's 'Flying Carpet'

Plenty of sunscreens and awnings are fabricated from aluminum extrusions—a result of their high strength-to-weight ratio, corrosion resistance, rigidity, and their imperviousness to temperature change and rot.

Few, if any, are as ambitious or as big—as that proposed for the new wing of the Art Institute of Chicago. Renzo Piano's proposed "Flying Carpet" will measure close to 47,000 square feet when it is eventually hoisted atop the new wing of the building sometime in 2008/09.

Easily the stand-out feature of the Institute's new wing, the massive metallic-covered extruded-aluminum sunscreen will hover over much of the new building, guiding northern light into the third-floor gallery skylights while shading a garden beneath. The extruded aluminum "wings" of the sunscreen were computer modeled specifically for the Art Institute site, and will help to save a reported 20 percent of the building's electrical consumption while providing it ideal lighting conditions during the day.

Aluminum-Grated 'Green Roof' for ASLA

Green roofs are defined as those that are partially or completely covered with vegetation. First pioneered in Germany, and increasingly popular in the United States, green roofs are usually built to decrease the total amount of stormwater runoff and to slow down the rate of runoff flowing from a roof. They also boast insulative and aesthetic value.

Most green roofs are designed to be enjoyed from afar. Not the new roof of the headquarters of the American Society of Landscape Architects (ASLA)—thanks to the extruded aluminum walkway that is incorporated into the roof's design.

"This innovative project breaks the boundaries of typical architecture," said Karl Neifeldt, account manager of Ohio Gratings Inc., which provided the

extruded walkway. "Working side by side with [landscape architect] Michael Van Valkenburgh Associates, we were able to help incorporate a typically industrial material into a non-typical application to allow an expansion of the green roof to maximize the benefits of the project."

The aluminum grating will allow plants to grow beneath it, maximizing the planting area of the roof. "With the unique grating, the roof area can be fully planted and still allow visitors to walk on the space without damaging the sedum," said Nancy Somerville, executive vice president and CEO of ASLA.

The walkway is comprised of Ohio Gratings' standard I-Bar grating—which was selected for its high strength-to-weight ratio, its non-skid properties, non-corrosiveness, its ability to conduct heat, and its recyclability.



Image courtesy of Michael Van Valkenburgh Associates Inc.

The extruded aluminum walkway on the ASLA's new green roof allows visitors to enjoy the roof, while the planting area beneath is maximized.

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