From ancient times to the modern day, copper and copper alloys have proven to be reliable building materials that can withstand the test of time. European cathedrals and Japanese temples built hundreds of years ago still have their original copper roofs. Even the nearly 200,000-pound copper-cladded Statue of Liberty has remained intact despite over 100 years of corrosive pollution, biting sea winds, driving rains, and beating sun.

Now, the protective living patina is winding its way around the sides of university, medical, government, and residential structures and adding to its robust portfolio. Architects and contractors are selecting copper as a cladding material for its durability, flexibility, and malleability. It is also lightweight, fire-resistant, corrosion-resistant, and available in an array of finishes and colors. These attributes have allowed architectural creativity to flourish beyond the limits of traditional wall cladding systems.

It’s a dramatic movement—one that’s clearly evident in the submissions for the North American Copper in Architecture Award (NACIA) program, hosted annually by the Copper Development Association (CDA) and the Canadian Copper and Brass Development Association (CCBDA). In fact, adoption of copper as a wall cladding material has become so prevalent that it often outnumbers roofing submissions in the annual NACIA awards program.

Why the trend? One reason is increased interest in green building. Not only is copper 100% recyclable, the sheet copper used for wall cladding is often created largely from scrap material, and it can be used over and over with no loss of its engineering properties.

TYPES OF ALLOYS

The various colors, surface textures, and product forms of copper allow architects and contractors to constantly create innovative designs. As with other metals, there are many intermetallic mixtures of copper with other elements. The most common sheet copper wall claddings use only a small number of copper alloys, all of which consist of 99.5% copper (with traces of silver allowed). When considering copper, system designers should specify sheet copper to American Society for Testing and Materials (ASTM) Standard B370. It defines composition, dimensional tolerances, mechanical properties, and characteristics to ensure that the material with the correct properties is specified.

The most popular temper designations for sheet copper for wall cladding are “H00” or “H01” (“cold-rolled” or “¼ to ½ hard”) and “H02” (“½ hard”) if it’s a system where higher tensile strength but less malleability is helpful. It is still common to refer to sheet copper thickness in traditional ounce weight thickness. As an example, 16-oz. copper weighs 16 oz. per square foot, and 20-oz. copper weighs 20 oz. per square foot and is, thus, thicker.

These virtually pure copper alloys are not the only game in town. Think back to high school science or history classes and recall the Bronze Age. Early civilizations discovered a small amount of tin mixed into molten copper creates an exceptionally strong, durable metal: bronze. Although a wide variety of these bronze alloys are still available today, it’s another copper alloy family garnering most of the attention for wall cladding: brass. Brasses are combinations of copper and zinc.

Although common brass alloys do not have the strength of a bronze, they are slightly stronger than the base copper, while retaining considerably more malleability compared to most bronze alloys. Most recognizable for their more golden color that increases with the amount of zinc, the metal has primarily been used architecturally for storefronts, doorways, and interiors. Now, the metal is transitioning into one of the most popular copper alloy cladding materials. Brasses commonly available in sheet form include an increasing amount of zinc, and thus “gold” tone: C22000 “commercial bronze” (10% zinc), C23000 “red brass” (15% zinc), C26000 “cartridge brass” (30% zinc), and C28000 “Muntz metal” (40% zinc). ASTM Standard B36 is the appropriate standard for brass alloys. It is best to refer to brass thickness in decimal inches—
for instance, “.032 in.” or “.040 in.,” selecting a thickness depending on project requirements and availability.

As with any metal (copper or otherwise), it is important to consider the right brass alloy based on service conditions and system design. It is especially important for design professionals and product engineering staff to review product use with alloy-producing technical staff when considering brass alloys over 15% zinc, especially in a salt-spray zone, in a high-pollutant area, or when the product may experience bending or cyclical stresses. There are special processes and alloy formulations, less seen but more appropriate, for extreme conditions (such as naval or admiralty brass, developed for saline conditions.)

PATINATION

Designing with copper often involves designing for the long term, both in relation to appearance and performance. Although it’s possible to paint copper, most prefer the natural weathered appearance. It’s free, gets better with time, and never needs recoating.

The metallic sheen of recently installed bare copper or brass is just a teaser. It may look great, but it’s going to change. Chemicals in the atmosphere cause the metallic surface tone to oxidize, transforming from orange through deepening russet tones, rich browns, to black, and possibly—if there is enough exposure—to a blue-green patina. Hues can vary from panel to panel or perhaps even within the bounds of a panel.

In industrial and seacoast atmospheres, the natural patina generally forms in five to seven years. In rural atmospheres, where the quantity of airborne sulfur dioxide is relatively low, patina formation may not reach a dominant stage for 10 to 14 years. In arid environments, the basic sulfate patina may never form due to the lack of sufficient moisture to carry the chemical conversion process to completion. The protective chemical reaction occurs when a corrosive attack of airborne sulfur compounds leads to a gradual change in the surface color until equilibrium is reached and the change is stabilized.

When exposed to the elements, brasses and bronzes weather, too. Weathering rate depends on exposure, of course, but generally, tones are similar to copper while emerging more slowly. After many years, it is difficult to tell a color difference among weathered brass, bronze, or copper alloys. There are few modern brass alloys containing percentages of aluminum, specially formulated, which retain a golden tone considerably longer.

The Irving Convention Center at Las Colinas, in Irving, Texas, which won a 2015 NACIA award, is covered with a mill-finish copper façade. The raw “red” copper surface is already moving through a long process of patination. Since wall surfaces are vertical and atmospheric conditions in central Texas are more arid than most eastern areas of North America, the wholesale weathering past the deep brown/black hues will be extremely slow.

For centuries, builders have sought to hasten the weathering process by chemical means. Because of the number of variables involved, chemically induced patinas are prone to problems because of lack of adhesion, excessive staining of adjacent materials, and inability to achieve reasonable
color uniformity over large surface areas. Consider these potential shortcomings when specifying such chemical treatments.

Limitations of field-applied chemical treatments prompted copper mills to research and develop prepatinated copper sheet products. Their proprietary methods involve a chemical conversion process to force a chemical patina at the top molecular surface of the copper sheet. Significantly, prepatinated products are created in a controlled factory environment, removing the guesswork involved with field-applied chemical solutions. Product manufacturers supply specifications and samples.

**INSTALLATION**

There are two main types of copper cladding systems: traditional and engineered. Standing-seam, batten-seam, flat-seam, and corrugated panel systems are common forms of traditional installation. Curtain wall and copper screen panels are common forms of engineered installation.

**Traditional**

The most popular methods to adapt sheet copper alloy material to wall cladding utilize the same proven systems developed for roofing, but simply applied to a vertical surface. Both standing-seam and batten-seam systems are common, but the easy-to-install flat-seam copper panels are proving the most popular style. With these traditional systems, concealed cleats attach relatively thin 16-oz. or 20-oz. sheet copper panels to a solid, smooth, nailable substrate. Local contractors often fabricate and install these proven systems, saving an extra layer of shipping-related costs and adding flexibility for customization and adaptation to site-specific conditions.

As with roofing, edge condition and penetration flashing require special design attention and supervision at the job site. Fenestrations are especially critical, but skilled installers make use of copper’s superior formability and its ability to be soldered to create superior joinery to minimize seal-ant use.

**Example:** Harvard University Tozzer Library, Cambridge, Massachusetts, a 2015 NACIA award-winning project (*Photos 1 and 2*)

**Architect**

Kennedy & Violich Architecture Ltd.

Boston, Massachusetts

**Sheet Metal Contractor**

Gilbert & Becker Co., Inc.

Dorchester, Massachusetts

Copper's malleability and workability, combined with adaptability of the traditional standing-seam system, allow unique shape and panel widths, which are difficult to achieve with more common metals. Double-lock, standing-seam copper panels cover both the third- and fourth-floor vertical walls and mansard roof. Standing-seam panel vertical joints line up with the windows on the third floor—a critical requirement of the design. Because it works great for both walls and roofing, a standing-seam system protects the building while providing a consistent look.

Although technically “manufactured systems,” copper shingles and corrugated systems fit into the “traditional” category based on requirements for a solid substrate. Initially intended for roofing, copper shingles see new life as wall cladding, where their distinctive shapes and stiffening properties are particularly advantageous. Although technically “manufactured systems,” copper shingles and corrugated systems fit into the “traditional” category based on requirements for a solid substrate. Initially intended for roofing, copper shingles see new life as wall cladding, where their distinctive shapes and stiffening properties are particularly advantageous.

![Photo 1 – The Harvard Tozzer Library, on the campus of Harvard University in Cambridge, Massachusetts, at dusk. Photo by John Horner.](image)

![Photo 2 – The copper roof of the Tozzer Library. Photo by Alex Alpert.](image)
stampings add extra visual texture. A solid substrate covered with underlayment material provides a secure attachment point. Individual shingles are small in comparison to panel-type systems, like standing-seam; so thermal movement is not as much of a concern as with larger panel systems. Galvanically compatible (such as stainless steel or copper) fasteners penetrate an edge of each shingle. The overlying course of shingles overlaps each row of fasteners, shedding water. There are some variations to this general theme, so check with each shingle manufacturer for exact installation recommendations.

Copper corrugated panel systems are popular, too. These are the same corrugated panels we see (generally in galvanized steel) on industrial or agricultural buildings, but with the distinctive look and long-term performance of copper.

Corrugated copper panels have long been available for roofs and walls, although these systems were never as
common as traditionally seamed panels, such as standing-seam. Special fasteners, designed with a gasket at the base of their heads, help prevent leaks. Proper fastener installation and ultimate replacement schedules are critical. The washboard-like appearance and installation ease inherent to corrugated copper are incomparable.

**Example:** 4143 Buena Vista Project in Dallas, Texas, a 2010 NACIA award-winning project (Photos 3 to 5)

**Architect**
Ryan Wommack
Dallas, Texas

**Sheet Metal Contractor**
Beach Street Metal
Dallas, Texas

Natural-aging, corrugated copper wall cladding assures that these townhomes coordinate with the design aspects found on the popular Katy Trail. Materials are all direct responses to the environment of the trail: vertical corrugated copper, Milsap stone (used in earlier Work Projects Administration projects along the trail), and ipe wood screens provide privacy for the homeowners. Natural materials, such as copper, allow the project to enmesh itself into the world of the trail, as they naturally change over time. Copper’s natural patination lends itself perfectly to integrate with the natural aesthetics along the trails.

**Engineered**
The engineered wall cladding systems’ appearance and capability variations are extreme, from exceptionally smooth, flat systems of thick copper, to composite copper-clad material; through deeply brake-formed, textured systems to perforated copper panels that allow diffused light to reach inhabited areas. Whether the engineered system is attached to an underlying structural grid or hung curtain-wall style off the building, it’s important to coordinate thoroughly with the manufacturer’s engineering staff during design and installation. Credible manufacturers provide considerable technical and design expertise to help achieve a distinctive look and long-term performance. Engineered systems are popular for larger-scale monumental buildings.

**Example:** University Center, The New School, New York, New York, a 2015 NACIA award-winning project (Photos 6 and 7)
Architect
Skidmore, Owings & Merrill LLP
New York, New York

Sheet Metal Contractor
Gamma
Concord, Ontario

Located at the intersection of Fifth Avenue and 14th Street in Manhattan, the University Center reflects and reinforces the experimental nature of The New School and creates a dialogue among the campus community, the local neighborhood, and the city. The 16-story building is enveloped by brass, which helps to mediate between the cast-iron façades of the Ladies’ Mile Historic District to the north and the brownstones of the Greenwich Village Historic District to the south and west. The exterior design of the University Center highlights activity within the building by showcasing the three primary egress and communicating stairs on each of its three main façades. Strong horizontality of the façade echoes the horizontal bands of black and white brick in the New School’s original purpose-built building, designed by Joseph Urban and built in 1931. The façade materials encompass 35% glass and 65% brass, weathered to a golden-brown color by the wall system manufacturer to age in a distinguished way and to grow darker brown over time. Considering the characteristics of the façade’s insulation and the specifications of the glass itself, the thermal envelope is designed to maximize daylight while minimizing heat gain.

Example: Irving Convention Center at Las Colinas in Irving, Texas, a 2015 NACIA award-winning project (Photos 8, 9, and 10)

Architect
Studio Hillier
Princeton, New Jersey

Sheet Metal Contractor
A. Zahner Company
Irving, Texas
The Irving Convention Center is a 100,000-sq.-ft. (9,290 m²) entertainment palace covered in 150 tons (136 tonnes) of milled, perforated copper panels. Copper was chosen for the LEED-certified project’s building façade because it is natural, lightweight, and low-maintenance. At first glance, the material seems impossible. From a medium distance, the metal surface seems to float in space because the circular shapes are pieced together via slight “bridges” or connecting sections of copper. The effect is that from a near distance, the copper circular sections of the perforation appear to float, offering transparency and illusion.

Copper’s natural beauty and self-protective natural finish, performance, durability, long service life, and recyclability make it a superior building material that can be adapted and utilized for a wide variety of contemporary and cutting-edge applications. Traditionally, copper has mainly been utilized for roofing, flashing, and gutter systems. However, these are the qualities that ensure mankind’s oldest metal, copper, remains an important building material.

Finally, a concern we’re hearing over and over again is economy—not just the long-term “life cycle” economy for which copper is known—but installed cost, too. Relatively lightweight copper wall cladding systems often cost less than many masonry options. This calculation involves the cost of the underlying structure, all of the associated component materials, and the installation itself (wall cladding often involves scaffolding or special lift trucks). When all the costs are considered, any upcharge for premium copper material may represent only a fraction of the total installed system. Naturally, calculations are site-specific, so estimators must consider building design and economic conditions on a case-by-case basis. When a building owner considers the overall product installation costs, true potential material life (not manufacturer’s “warranty”), lack of maintenance, and end-of-life recycling value, copper-based systems rise to the top.

As the material of choice for many historic and traditional types of architectural systems and structures—and as evident from the examples profiled herein—copper is increasingly being used for a wide variety of contemporary and exciting new installations. Many of these still rely on the very characteristics that have long made copper the premier material in the architectural metals industry for centuries, and will continue to do so in many new shapes and forms.

For more information about the different types of copper applications, to reference the Copper in Architecture – Design Handbook, and to view past recipients of the NACIA award program, visit CDA’s website at www.copper.org.

Larry Peters is a project manager for the CDA. His responsibilities include providing training and technical assistance to architects, interior designers, contractors, engineers, and others interested in copper and copper alloy material for building construction. A 1987 graduate of West Point, Larry has spent the past 19 years working exclusively with architectural metals. Peters travels extensively for the CDA, educating the industry on the benefits and proper uses of copper in construction.

Stephen Knapp is the program manager of the Sheet, Strip, and Plate Council for the CDA, and the executive director of the Canadian Copper & Brass Development Association (CCBDA), the national trade association in Canada for the copper industry. He is also involved with guiding the market development and promotional efforts for a wide variety of copper and copper alloy applications such as tube and plumbing, electrical, renewable energy systems, and energy-efficiency technologies.

IMMIGRATION SLOW-DOWN FUELS CONSTRUCTION LABOR SHORTAGE

The U.S. construction industry has lost 570,000 experienced Mexican-born workers since 2007, according to a report by homebuilding analyst firm John Burns Real Estate Consulting Inc. Such workers accounted for 1.32 million jobs in 2014—down from 1.89 million seven years earlier. While 40% of roofing contractors report they are having trouble finding enough skilled workers, other construction sectors are faring even worse.

A number of reasons are given, including an improving Mexican economy and better exchange rates, increased e-verification technology, and stepped-up border enforcement and deportation levels. These have combined to produce a 67% decline in immigration from Mexico since 2006.

All of these factors are contributing to increased construction costs due to labor shortages.

— D+D News

FEDERAL CONTRACTORS GET RAISE

The new minimum wage for federal contractors and subcontractors will be $10.15 per hour starting January 1, 2016. The increase does not affect the federal minimum wage, which remains at $7.25/hour. The old contractor rate was only 5 cents lower, at $10.10 per hour. The raise was based on the annual percentage increase in the Consumer Price Index for Urban Wage Earners and Clerical Workers.