CONSIDERATIONS FOR COPPER ROOF DESIGN

By Lyle D. Hogan, PE, RRC

ABSTRACT

In terms of durability, few offerings in the construction market even approach the service life expectancy of a properly installed
copper roof. Much of this durability is corroborated by the preference for copper as a through-wall flashing for various wall assemblies. Indeed, copper roofing is often the benchmark for life-cycle analysis.

Copper enjoys obvious architectural appeal; however, it is unique among the metals, and its use on any project merits consideration of these attributes and limitations. This article focuses on such aspects, with discussion on avoidance of

Copper is the oldest metal known to man.[1] Few consumers understand the chemistry and physics of copper cladding, but they do seem eager to express opinions regarding how it looks. Copper has low "columnar rigidity." There is nothing particularly wrong with this property, but cautions must be observed to avoid unappealing aesthetics and substandard performance.

Like several other metals, copper is tempered at the mill to increase its hardness and toughness. If the sheet form complies with ASTM B 370, it consists of 99.9 percent copper and is available in six tempers. These are 060 (soft), H00 (cold-rolled, one-eighth hard), H01 (cold-rolled, high yield), H02 (half hard), H03 (three-quarter hard), and H04 (hard). Soft-temper copper is extremely malleable and best suited for applications such as intricate ornamental work. It was historically used in building construction; however, because of its low strength, heavier gauge material was required. Accordingly, soft-temper copper is not recommended for most building applications.

With the development many years ago of cold-rolled copper, the gauge of the material could be lightened without compromising its function. Cold-rolled temper is less malleable than soft temper but is much stronger and is by far the most popular variety of copper now used in construction.

The tempering windows are quite wide, and they overlap. That is, if a particular mill is making half hard at the high end, the product may resemble three-quarter hard in terms of its final engineering properties. Dead-soft tempering is easy to work with, but it literally droops when held.

Figure 1 – Introducing flat pans onto a curved surface can and will produce surface undulations. On curves having a long radius, the susceptibility is lower.

Figure 3 – The author (years ago) atop a curved copper roof having no ridge interruption (the nature of safety gear shown can probably date the image). This roof continues to serve satisfactorily on a corporate headquarters facility.

Figure 2 – Almost any metal roof will exhibit some oil canning in direct angles of sunlight. The displeased party should exercise patience, as the eventual patina will obscure most of the oil canning.

In general, cold-rolled, one-eighth hard copper is recommended for roofing and flashing applications. Soft copper may be used where extreme forming is required, such as in complex through-wall flashings. However, the cold-rolled version offers far more resistance than does soft to the stresses induced by expansion and contraction. Copper sheet of higher temper should be specified only if indicated for specific engineering applications requiring such properties.[2]

Panel width, fluting, swaging, tension-leveling, seam height, and sheet gauge all have bearing on the tendency toward surface distortions, also called "oil canning." Introducing flat pans onto a curved surface can and will produce surface undulations (*Figure 1*). On curves having a long radius, the susceptibility is lower, but almost any metal roof will exhibit some oil canning in direct angles of sunlight. Particularly when pans are new and reflective, these undulations have often prompted disapproval and debate regarding cause.[3] The displeased party should be patient, as the eventual patina will obscure most of the oil canning (*Figure 2*).

The initial bright salmon-pink color is highly reflective but will mature into various shades of brown as oxides and (later) sulfides form on the surface. The very desirable blue-green patina is actually copper sulfate, which is the sole corrosion-resistant agent of copper roofing.[4] This is an oversimplification, since weathering may exhibit a wide spectrum of unusual colors for a number of reasons as set out by Hunt.[5] He postulates that, due to microclimates and other variables, a metal roof may not be weathering as intended, but it is probably weathering normally for its environment.

Copper moves – it is inherent in the chemistry and cannot be dismissed. With long panel runs (40 ft and beyond), the magnitude of movement becomes considerable. Haddock postulates:

> A dark-colored panel with low gloss at right angle to the summer sun can approach temperatures of 200 degrees F. In cold winter nighttime scenarios, the low extremes of surface temperature can actually dip 25 or 30 degrees below ambient air. As a result, the "delta T" figure used in movement calculations can approach 250 degrees in cold northern climates.[6]

Structural metal roofs use large, sturdy clips with considerable freedom of movement. Pitched copper roofing, however, usually has smaller, sheet-metal clips. These may be seamed too tightly, restricting panel movement. At a minimum, oil canning is likely. In extreme instances, fracturing of seams can result. Breaking the work up into shorter segments "manages" the cumulative dimensional change experienced by long individual pans.

Curiously, this movement behavior takes quite a departure on curved surfaces (*Figure 3*). From the previous discussion about columnar rigidity, thermal movement (which cannot be stopped) is accommodated on curved surfaces by slight upward flexure of panels between clips. Accordingly, long panel runs can be used without a ridge detail (appealing to architects who desire the uninterrupted contours of barrel or curved roofs).[7]

The importance of soldering cannot be overstated. Especially for low-slope, flat-seamed copper (*Figure 4*), the time-honored skill of soldering is absolutely central to satisfactory performance. Even where automatic seaming is the predominant method of installation, soldering may be necessary at features such as concealed gutters, which are often problematic in the best of circumstances.

Solder follows heat, and pretinning is crucial for laps and seams that are to perform in a watertight manner.[8] There are four distinct steps to be followed when soldering. They are:

1. Edges that are to be seamed should be cleaned with an acid agent (flux).
2. Using an iron, edges should be

tinned with a thin coat of solder. This should be done immediately, prior to folding or seaming, as the solder oxidizes rapidly.

3. Once nested onto the adjoining piece (and fastened as appropriate), solder is then "sweated" into the seam to completely fill it.
4. A "third" pass is made with additional solder, perpendicular to the seam. This final pass is known as "stitching," and the finished work should barely (if at all) telegraph the edge being closed. (Some highly skilled mechanics maintain that stitching is not needed. Indeed, they argue that any solder flowing into the joint during this step signals deviant work during step number 3. This argument is compelling, but the author has not always enjoyed association with highly skilled mechanics.)

Again, the great preference for this work is by iron, not by open-flame torch, which can destroy the flux; it can also destroy anything under the metal that happens to be flammable.[9] When soldering is rejected (for whatever reason), it may be wise to replace the work rather than to attempt repairs. Adding more heat and solder is not a viable remedy – it will seldom, if ever, rescue substandard workmanship.

Other aspects are worthy of consideration. Though sometimes omitted, underlayments should be used in most (if not all) copper roofs, especially if panels are installed over wood decks. If self-adhering ice-and-water membrane is to be used, softening point of the bitumen must be considered (remember, copper panels can become quite hot during full solar gain).

Condensation can sometimes occur, even below open mansard roofs. Some wood treatments (especially fire retardants) can induce corrosion of any metal roof, including copper.[10] This underscores the need for underlayment. Ventilation of the deck underside is an appealing attribute of virtually all pitched roofing.

Potential for galvanic action will eventually be encountered in copper construction, so precautions are advisable. For instance, steel can drain onto copper, but the reverse should be avoided – copper gutters should be used to drain copper roofs. Beyond this, copper rivets should be used (instead of stainless steel) when crafting gutter joints and end caps. Physical separation should be provided when using stainless steel clips to secure copper panels.

Figure 4 – Especially for low-slope, flat-seamed copper, the time-honored skill of soldering is absolutely central to satisfactory performance. (Photo courtesy of Christopher Waites, ADC Engineering, Inc.)

Over its service life, copper will eventually be subjected to some type of concentrated loading. Minor indentations (such as from hail) do not compromise water-shedding capability or service-life expectancy (*Figure 5*). A number of noteworthy and elaborate copper roofs serve admirably in zones having routine hail exposure. If eventual hail dents will be considered analogous to dents in the fender of an automobile, an alternative covering should be considered.[11]

Pricing of copper has taken on new meaning in recent months. The author has been a direct party to dump truck loads of copper being taken to a landfill. At that time (1982), it was not profitable to clean salvaged metal (remove bituminous contami-

Figure 5 – Minor hail indentations in a copper roof do not compromise water-shedding capability (or service life expectancy). If eventual hail dents in copper cladding will be considered analogous to dents in the fender of an automobile, an alternative covering should be considered.

nants) before its acceptance at a reclamation center. Today, however:

> On three occasions in 2007 (early May, July, and early October), the LME copper price has gone above U.S. $8,000 per tonne before falling back to around U.S. $7,000/t. During 2007, the price didn't surpass the peak level of U.S. $8,500 per tonne that was touched in May 2006. The copper price tumbled to a 9-month low of U.S. $6,330/t in December 2007, but has been climbing again in January 2008, back to U.S. $7,280/t. The lowest level reached in the last 18 months was in early 2007, when the price dropped below U.S. $5,300/t. Even this "low" price is, of course, much higher than the price level that prevailed before copper prices began to rise steeply in 2005.[12]

Yet today, most copper manufactured in the United States is from scrap (recycled) material. Anne Schade reports that a 2006 Copper Development Association (CDA) market study, conducted for a ten-year time frame, suggests that at least 70% of the material used domestically in architectural copper is recycled.[13]

As outlined above, copper enjoys good architectural appeal. If the unique attributes of this material are recognized, its use can bring added value to many projects. With sustainability now being all the rage, copper holds considerable advantage over several alternative roofing types. If examined under a true life-cycle analysis, copper would emerge the victor in many instances.

Footnotes

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Lyle D. Hogan, PE, RRC

Lyle Hogan is owner and principal engineer with Fincastle Engineering, Inc., Swansboro, NC. He is a registered engineer in six states, a Registered Roof Consultant, a Fellow of RCI, and an ICC structural masonry inspector. Lyle has designed and administered roofing projects using a variety of systems across the United States. He is a two-time recipient of RCI's prestigious Richard M. Horowitz Award and chairman of the association's *Interface* Peer Review Committee.