Stainless steel has an excellent resistance to corrosion, although it is not corrosion-proof, as many people believe.

The popular stainless steels of types 302 and 304 contain about 18 percent chromium and 8 percent nickel, the two main ingredients responsible for corrosion resistance. The type 316 stainless offers an even higher degree of corrosion protection at a premium price, because it contains an additional ingredient, molybdenum.

To further increase its resistance to corrosion, stainless steel can be coated with a terne alloy, already mentioned in Sec. 6.1 as a popular material at the turn of the century. While the early terne-and-carbon-steel panels did not last very long, modern terne-coated stainless steel is the most durable roofing material available. Clearly not intended for routine applications because of its cost, terne-coated stainless steel is found on some of the best-known corporate headquarters in America including IBM, Procter & Gamble, and Coca-Cola.

Working with stainless-steel roofing requires some know-how on the part of designers and installers alike. To avoid galvanic action, stainless steel should be physically separated from any mild steel objects, such as purlins, fasteners, and clip angles. This can be accomplished by installation of a moisture barrier, such as 30-lb roofing felt, use of stainless-steel fasteners, and following good industry practices when welding or soldering the material. Some useful information on working with stainless steel can be found in Ref. 29.

Copper roofing, an old and respected material, is still used to reproduce a rich and beautiful look of years past. Apart from renovation of historic structures, copper has its place in new construction of all kinds. The panels, as in Paul Revere's times, are formed on-site. Some of copper's disadvantages, apart from the cost, include problems with the water runoff staining the materials below. Copper in contact with aluminum, stainless steel, or galvanized or plain steel can initiate galvanic action.

Aluminum is the most common of nonferrous metal roofing materials. It offers excellent resistance to corrosion and thus may be appropriate for buildings located near the ocean and in saline environments. Being relatively soft, aluminum is easy to bend and extrude but also easy to damage and dent. For this reason, aluminum roofing is not recommended for areas where hail is common. Another disadvantage of aluminum is its high coefficient of expansion; aluminum roofing will expand approximately twice as much as steel roof.

Again, the question of joining dissimilar metals needs to be carefully addressed. Aluminum roofing should be separated not only from steel purlins, but also from any nonaluminum rooftop framing and conduits. Copper pipes and any water discharging from them should not be in contact with the roofing. The fasteners should be of stainless steel.

Aluminum panels are usually anodized by dipping into a tank with electrolyte. The panel length is limited by the available size of the electrolyte tank. Electric current passing through the tank deposits a layer of aluminum oxide coating that forms a layer of chemically resistant, hard, and durable finish. The panels can be left in a natural color, or a pigment could be added during anodizing to produce a choice of chemically bonded colors, such as bronze and black. The anodized finish retains colors well but is difficult to repair if scratched; it is susceptible to damage by pollutants.

Structural design of aluminum is covered by Aluminum Association (AA) standards[30] and specifications.[31] For stress analysis, structural section properties are computed using the actual dimensions of the cross section. For deflection check, the "effective width" concept is employed. The aluminum alloys used for panels normally conform to ASTM B 209.[32] The panels should be at least 0.032 in (0.8 mm) thick, and for longer spans, 0.04 in (1 mm).

6.9 SITE-FORMED METAL PANELS

Despite the already-mentioned and obvious quality advantages of shop-fabricated metal panels, there are circumstances when roll forming on-site is performed. The panels formed at a job site are not constrained by shipping limits and can extend from ridge to eave, thus eliminating the trouble-prone endlaps. Also, transportation charges are saved, although expensive field labor costs are incurred instead. On balance, site-formed panels are normally less expensive than those supplied by leading metal building manufacturers.

Job-site roll forming was introduced in the 1970s and has been steadily expanding since, paralleling the improved quality of portable roll forming equipment. One of the leaders in the development and utilization of such equipment is Knudson Manufacturing. The company touts its state-of-the-art roll formers with rubberized drive rollers that are said to handle steel, aluminum, and copper coil for damage-free forming of standing-seam roofing. Knudson can reportedly produce continuous panels up to 150 ft long and can form some C, Z, and hat-channel sections on-site. Prefinished curved panels can be site-rolled by Berridge Manufacturing Co. of Houston and by some others.

Despite increasing product quality, job-site roll forming should be approached with some caution, since many site-produced panels still do not come out as good as shop-fabricated panels of major manufacturers, and their installers are not necessarily as experienced. Also, there is still a chance that the coil finish could be damaged during forming; for this reason, galvanized and aluminized steel, as well as anodized aluminum, are not recommended for field forming. Incidentally, metal coil formed during cold weather should be preheated prior to forming, a fact often forgotten at the job site.

6.10 WIND UPLIFT RATINGS OF METAL ROOFS

Pictures of blown-off and damaged roofs often accompany media reports on hurricanes, tornadoes, and tropical storms. Damage to metal roofs from strong winds, which generate high suction forces, can manifest itself as panel buckling, fastener breakage or pullout, seam deformation or opening, and standing-seam clip failure. To ensure specifiers of their products, metal building manufacturers seek to obtain a wind uplift designation from one of the leading testing bodies: Underwriters Laboratories (UL), Factory Mutual (FM), or U.S. Corps of Engineers (Corps). ASTM (formerly American Society for Testing and Materials) is also active in the quest to develop a perfect testing procedure. Unfortunately, as of this writing, no test is able to accurately predict roofing behavior during a "real-world" disaster. A brief explanation of the available procedures will help put roofing salespeople's claims in a proper perspective.

6.10.1 UL 580 Standard for Wind Uplift Testing

The classic UL580 test[33] has been used since 1973. It involves a 10- by 10-ft sample of roofing constructed on a testing platform in accordance with the manufacturer's typical specifications. The edges of the sample are sealed and fixed at the perimeter with closely spaced fasteners (6 in on-center at panel edges). In addition to the supports at the edges, two interior purlin supports spaced 5 ft apart are provided. Panel clips are placed at each line of supports.

The specimen is then subjected to alternating wind pressure and suction. Having safely resisted a 100-mi/h wind for 1 h and 20 min, the specimen earns a class 30 designation. To pass to the next rating level, class 60, the same specimen must withstand a pressure equivalent to a 140-mi/h wind for another 80 min. The highest designation, class 90, can be earned by testing the same specimen a third time for yet another 1 h and 20 min under pressure produced by a wind speed of 170 mi/h.

The panels with a UL 580 class 90 designation have generally performed well—until subjected to a real hurricane. Partial roofing blow-offs and seam separations have been reported to occur at wind speeds producing only about one-fifth of the roof uplift capacity that could be expected from a UL 580 class 90 rating.[34] How could this happen?

The experts point out that the test was developed for evaluations of the adhesive strength of built-up roofs and not for mechanically attached metal roofing. Also, this "static" pass/fail test, conducted at constant pressures, does not account for real-world wind gusts and shifting pressure patterns.[35] Further, the limited specimen size (10 by 10 ft) and the continuous perimeter attachment do not accurately represent the real behavior of metal roofs, especially of the standing-seam type. As already discussed, in these roofs, hurricane failures typically occur at the edges. For all these reasons, the