2. The seams of standing-seam roofing form a wavy rather than a straight line when viewed directly upslope. This can make roofing movement difficult and result in panel binding, damage to clips, and eventually leaks.
3. Binding can also occur if the purlin tops do not align with one another, so that the roofing seams look wavy when viewed from the side. True, the proper purlin alignment is the responsibility of the steel erector, not the roofing contractor, but the results affect the roofing and to some degree can be corrected by shimming. The misalignment also occurs when the erector sets some clips too low or too high in relation to the roofing seams.
4. Workers walk carelessly on the roofing, denting the flat areas and squishing the elevated seams, rather than following the manufacturer's instructions, which typically suggest stepping next to but not on the raised seams and using special walk boards.
5. Instead of sheet metal closures (e.g., Fig. 6.26), caulking is used to seal the transitions and penetrations of metal roofing. Also, the penetrations lack flexible boots or flexible flashing for roof movement around them. Roof curbs should be used for large penetrations, as shown in Chap. 10.
6. Roof fasteners are not driven perpendicular to the roofing or are not properly tightened (see Fig. 6.9), wrong fasteners are used, etc.

Occasionally, metal roofing will exhibit waviness (oil-canning). In addition to the obvious design-related reasons for its occurrence, such as using very thin metal without frequent stiffening ribs, there might be others. Some are related directly to the list above. For example, oil-canning can be caused by residual stresses in metal coils, stresses introduced during roll-forming, unevenness of the substrate, misalignment of seams vis-à-vis the clips, damage during construction, and restricted panel movement.[45]

REFERENCES

1. Paul D. Nimtz, "Metal Roofing: Past, Present and Future," *Metal Architecture,* November 1992.
2. "Market Trends/2002," *Metal Construction News,* January 2002.
3. Wayne Tobiasson and James Buska, "Standing-Seam Metal Roofing Systems in Cold Regions," CRREL Misc. Paper 3233, Hanover, NH, 1993.
4. Wayne Tobiasson, "General Considerations for Roofs," CRREL Misc. Paper 3443, Hanover, NH, 1994.
5. Section 07410N, Metal Roof and Wall Panels, *Unified Facilities Guide Specifications,* Huntsville, AL, September 1999.
6. Section 07416A, Structural Standing Seam Metal Roof (SSSMR) System, *Unified Facilities Guide Specifications,* Huntsville, AL, September 1999.
7. "Masterspec-Evaluations," Sec. 07411, American Institute of Architects, Washington, DC, 1990.
8. R. White and C. Salmon (eds.), *Building Structural Design Handbook,* Wiley, New York, 1987, pp. 1048–1050.
9. Y. L. Xu, "Fatigue Performance of Screw-Fastened Light-Gauge-Steel Roofing Sheets," *ASCE Journal of Structural Engineering,* vol. 121, no. 3, March 1995.
10. Brian A. Lynn and Theodore Stathopoulos, "Wind-Induced Fatigue on Low Metal Buildings," *ASCE Journal of Structural Engineering,* vol. 111, no. 4, April 1985, pp. 826–839.
11. Y. L. Xu, "Wind-Induced Fatigue Loading and Damage to Hip and Gable Roof Claddings," *ASCE Journal of Structural Engineering,* vol. 122, no. 12, December 1996.
12. *Metal Building Systems,* 2d ed., Building Systems Institute, Inc., Cleveland, OH, 1990.
13. *Widespan Buildings Erection Information,* Butler Manufacturing Co., Kansas City, MO, 1978.
14. *Metal Roofing Systems Design Manual,* Metal Building Manufacturers Association, Cleveland, OH, 2000.
15. *Product & Procedure Manual,* HCI Steel Building Systems, Arlington, WA, 2001.

16. Tom Hulsey, "Capped Head Self-Drilling Fasteners an Excellent Choice for Corrosion Resistance," *Metal Architecture,* July 1999, p. 61.

17. "Fasteners," An article on the World of Steel Roofing website devoted to Galvalume roofing, www.steel-roofing.com.

18. Paul D. Nimtz, "Metal Roof Systems," *Metal Architecture,* January 1993.

19. Fred Stephenson, "Specifying Standing Seam Roofing Systems for Conventional Buildings," *Roof Design* (now *Exteriors Magazine*), March 1984, as reprinted in *The Construction Specifier,* November 1986.

20. *The NRCA Roofing and Waterproofing Manual,* 5th ed., the National Roofing Contractors Association, Rosemont, IL, 2001.

21. Steve Hardy and Michael J. Crosbie, "Metal Roofing Fundamentals," *Architectural Record,* January 1997, pp. 161–165.

22. ASTM A 653-00, Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM, West Conshohocken, PA, 2000.

23. ASTM A 463-00, Steel Sheet, Aluminum-Coated by the Hot-Dip Process, ASTM, West Conshohocken, PA, 2000.

24. ASTM A 792-99, Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process, ASTM, West Conshohocken, PA, 1999.

25. Spec-Data for Section 07600, Standing Seam Metal Roofing, Galvalume Sheet Producers of North America, Bethlehem, PA, 1995.

26. Angelo Borzillo, "Galvalume Sheet Steel for Versatile Long Lasting Building Panels," *Metal Architecture,* October 1996, p. 10.

27. Bob Fittro, "Industry's Coatings and Substrates Offer Designers Plenty of Options," *Metal Architecture,* June 2001, p. 28.

28. Joan Urbaniak, "Gaining and Understanding of Zincalume-Coated Steel," *Metal Construction News,* November 1996, p. 58.

29. Standard Practices for Stainless Steel Roofing, Flashing, Copings, Stainless Steel Industry of North America, Washington, DC.

30. *Aluminum Standards and Data,* Aluminum Association, New York, 1990.

31. *Aluminum Design Manual,* Sec. 1, *Specifications and Guidelines for Aluminum Structures,* Aluminum Association, New York, 2000.

32. ASTM B 209-00, Aluminum and Aluminum-Alloy Sheet and Plate, ASTM, West Conshohocken, PA, 2000.

33. UL 580, Standard for Tests for Uplift Resistance of Roof Assemblies, Underwriters Laboratories, Inc., Northbrook, IL, 1989.

34. Charles H. Gutberlet, Jr., "Designing against Wind," *The Military Engineer,* September–October 1992.

35. Harold Simpson, "Wind Uplift Tests," *Metal Architecture,* January 1993.

36. ASTM E 330, Test Method for Structural Performance of Exterior Windows, Curtain Walls and Doors by Uniform Static Air Pressure Difference, American Society for Testing and Materials, Philadelphia, PA, 1990.

37. "ASTM's Metal Roofing Standard Intended to Improve Performance," *Metal Architecture,* March 1995.

38. John Gregerson, "Bracing for Wind Uplift," *Building Design & Construction,* September 1990.

39. "MRSA Recommends Wind Uplift Tests for Standing-Seam Roofing," *Metal Architecture,* March 1995.

40. "Technical Bulletin on Wind Uplift Testing…," *Metal Architecture,* May 1995.

41. Richard Coursey, "Keeping Wind from Raising the Roof," *Architecture,* August 1988.

42. Richard Schroter, "Leak Prevention for Metal Roofs," *Architectural Specifier,* November/December 1995.

43. Fred Stephenson, "Design Considerations for Architectural Metal Roofing," *Handbook of Commercial Roofing Systems,* Edgell Communications, Inc., Cleveland, OH, 1989.

44. *Commercial Low-Slope Roofing Materials Guide,* NRCA, Rosemont, IL, 1993.

45. Jeffry J. Ceruti, "Metal Roofing Systems Do's and Don'ts," *The Construction Specifier,* September 1997, p. 64.