SOLVING DIFFICULT ROOF PROBLEMS

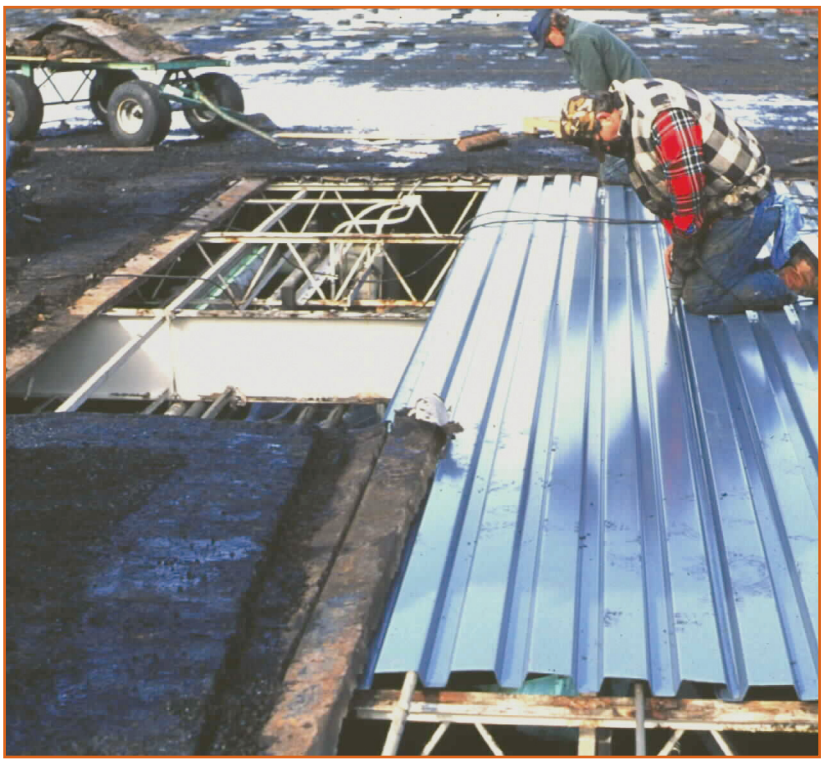
PART I

By Ray Heisey, PE, RRC

On a daily basis, owners contact consultants to seek assistance with both simple and complex roof problems. What moves a problem from the run-of-the-mill category to the very difficult category? Here are some types of problems considered challenging:

- Bad roof decks – steel, concrete, gypsum, structural cement fiber, etc.
- Large quantities of penetrations and/or equipment, piping, etc.
- Multiple, different, adjacent roof elevations
- Curved roofs.
- Drainage issues that require changing the direction of slope.
- Desire to change the look of the building.
- Building additions that conflict with good roofing practices.

This article will explore the problems outlined above and the various solutions used to solve them. *[Editor's Note: The second part of this article, to be published in an upcoming issue of* Interface, *will explore various solutions to the problems outlined herein.]*



Portions of this steel roof deck are being replaced.

ROOF DECKS

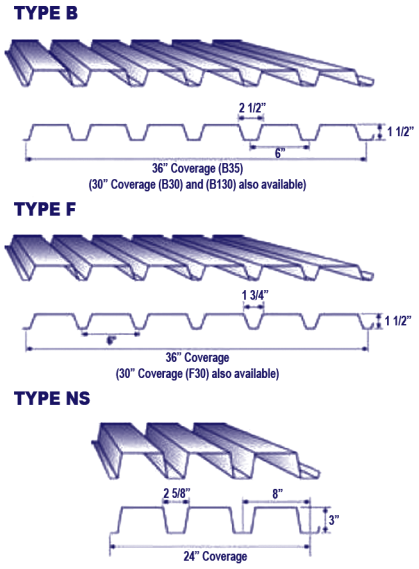
Roof decks provide attachment and support for many types of systems. A structurally suspect deck that is damaged or deteriorated might require expensive repair or even replacement. Disruption and risk to business operations are prime considerations when deck repair or replacement is required. Roof decks come in a multitude of materials and configurations, each with its own features and potential problems.

The criteria for choosing a roof deck can include: structural strength (ability to span distances while carrying load), compatibility with the roof system, building usage, fire rating, acoustics, appearance, and numerous other factors.

Steel Deck

Steel decks are very common in building construction. Galvanized or painted steel coil, typically 22-gage, is rolled into different shapes designated as types B, F, and NS

roof decks. Similar profiles can be made from aluminum or stainless steel. The steel decks are available in several depths, including 1-1/2 or 3 inches deep. Typically, the required span and the applied design loads (dead, live, snow, wind, etc.) determine the depth and gauge of the deck to be used for a particular application. Steel decks are commonly welded to the supporting structural members such as bar joists but can also be attached using screw or powder-actuated fasteners.



Common steel roof deck profiles.

Wood Deck

Wood products such as plywood, OSB (oriented strand board), and planks are used as roof decks. Plywood is manufactured from thin sheets of cross-laminated veneer, bonded under heat and pressure with strong adhesives. OSB is manufactured from waterproof heat-cured adhesives and rectangular shaped wood strands that are arranged in cross-oriented layers. Wood planks are solid lumber units.

Concrete Deck

Concrete is a composite material that consists of a binding medium (Portland hydraulic cement and water) mixed with fine aggregate (typically sand) and coarse aggregate (typically gravel). A concrete deck can be a structural or an insulating assembly screeded to provide slope. Concrete decks can be factory-manufactured (precast planks) or site-manufactured. A site-manufactured concrete deck can be placed into removable or permanently affixed steel or wood forms.

Gypsum Deck

Gypsum (hydrated calcium sulfate) is a common mineral that has excellent fire resistance properties. Gypsum deck is made with a series of steel bulb-tees spaced at 24 to 32 inches on center, between which a formboard is placed. A galvanized steel wire mesh is draped over the bulb-tees. Fast-setting gypsum slurry is then poured on the formboards to a minimum thickness of two inches, entirely covering the bulb-tees.

Cement Wood Fiber Deck

Using aspen wood fibers bonded with inorganic Portland hydraulic cement, planks two to three inches thick and nominally 24, 32, or 48 inches wide are formed. This product, when used as an exposed roof deck, can provide an acoustical-textured interior finish and is commonly used in schools and recreational facilities. The planks can be supported by a series of steel bulb-tees that span between the secondary support structural members, or the planks can be supported by the secondary support structural members and span across those members.

All of these decks are typically used as a structural component of a building system, supporting the roof, carrying the imposed vertical loads, and providing a wind-bracing (shear) diaphragm. When the roof deck deteriorates, this can cause structural

This steel roof deck has numerous holes created by severe corrosion.

problems because the deck is no longer able to carry the intended vertical and diaphragm loads. The majority of roof deck problems are caused by moisture infiltration.

ROOF PENETRATIONS

Roof penetrations can cause installation and weathertightness problems for any type of roof. When penetrations become numerous and close together, it becomes difficult, if not impossible, for even experienced crews to successfully install any roof system. Some industrial plants have equipment, piping, and other obstructions so numerous that proper installation techniques are very difficult to follow.

It logically follows that these same industrial plants with extraordinary quantities of rooftop equipment are the most intolerant to roof leaks. The ongoing challenge is that rooftop equipment, piping, etc., are moved, added, or eliminated frequently.

DIFFERENT ROOF ELEVATIONS

Adjacent roof elevation changes and unusually shaped roofs create areas for snowdrift and water accumulation, difficult roof flashing problems, wall area for moisture infiltration problems, and challenges for maintaining rooftop equipment. Elevation and slope changes not only create a large amount of flashing, but also concentrate movement and stresses in the roof planes at the adjoining slope and elevation changes.

CURVED ROOFS

Curved roofs present a unique challenge. The slope varies from dead flat at the highest point to, in many cases, a very steep slope at the low edge. Few roof materials can be used on non-linear surfaces and both steep and low slopes. Curved roofs can also present appearance issues, which further limits the choice in systems. Multiple, adjacent, curved roofs create large valleys where snow, ice, and water can infiltrate, causing long-term roof, wall, and structural problems. These problems can be expensive to correct and disruptive to occupants.

DRAINAGE ISSUES

In some cases, the original drainage design for a building becomes non-functional, disabled, undesirable, or the cause of roof problems. This could happen for many reasons. A new building on an adjacent property, particularly with a zero lot line setback, can cause an existing property to restrict runoff to that property. Interior drains can become islands as the roof areas around the drains sag, settle, and deflect. Problems with interior drains and plumbing can create a desire to eliminate this type of system. Interior drainage systems in combination with parapet walls can create the potential for structural overload when drains become blocked. Interior drain piping can leak, causing interior finish damage, mold growth, and structural damage.

BUILDING APPEARANCE

Many business owners desire an updated appearance for their place of business to compete with businesses located in new facilities. In some cases, flat roofs are eliminated and a steep-pitched architectural

The roof of a beef processing plant with numerous roof penetrations and obstructions.

Adjacent curved roofs create valleys for moisture infiltration and parapet wall problems.

roof is created. This update serves multiple purposes. The steep roof creates curb appeal for the business and also eliminates a problem low-slope roof with interior drains.

BUILDING ADDITIONS

When building additions are constructed, consideration is rarely given to good drainage or flashing design. Roof problem areas are sometimes created, such as valleys between buildings, steps in elevation, and different adjacent roof materials.

Structural issues can arise due to accumulated snow, ice, and water on roofs. Water weighs 62.4 lbs. per cubic foot or 5.2 lbs. per sq. foot per inch of water. The accumulation of as little as four inches of water adds almost 21 psf of load to a building. Building additions are a primary cause of roof problems

This roof drain is blocked with plant growth and sediment.

Flat roof being retrofitted with a sloped standing seam metal roof.

Below: These multiple adjacent metal buildings created leaking valley problems.

because they create areas for snow, ice, and water accumulation. Underground storm-sewer piping may not be designed to carry added water from a building expansion.

Next month, in Part 2, various solutions to the challenging roof problems reviewed will be presented in the conclusion to "Solving Difficult Roof Problems."

Raymond K. Heisey, Jr., PE, RRC

Raymond K. Heisey, Jr., PE, RRC, is senior sales manager of the Midwest Region for Butler Manufacturing Company. He earned his degree in civil and structural engineering from Lehigh University in 1978 and has worked for Butler Manufacturing Co. for over 26 years. Heisey has a wide variety of experiences encompassing plant engineering, metal building design, computer system development, roof product development, and regional sales and sales management. He has been awarded two U.S. patents and numerous foreign patents on metal roof system components. Heisey is a registered professional engineer in the state of Missouri. He earned his RRC in 1993 and is listed in Who's Who in Science and Engineering and Who's Who in the United States. Heisey won six Butler sales awards in an eight-year period for exceeding goals as a sales manager. He has made various presentations on roof-related subjects.

Paris Airport Failure Investigated

Investigation into the May 23, 2004 fatal roof collapse of the 650-meter-long concourse at Paris Charles de Gaulle Airport has blamed "weaknesses at all stages" of design for the collapse that killed four. The most serious structural flaws were said to be areas of the innovative shell roof at the link to the terminal.

The 34-meter-wide concourse was enclosed by a 30-cm-thick perforated, reinforced, concrete vault. Beams rested on Neoprene bearings atop columns supported by horizontal steel ties. The vault had ten sections of 4-meter-wide abutting rings lightly connected to one another. To stiffen the shallow vault, curved steel girders embraced two sides. At points of failure, external struts punctured the shell, and at one point, the shell edge beam fractured.

During the three-year construction of the $900-million complex, Aeroports de Paris' (AdP) chief architect, Paul Andreu, led the design team. In the normal French way, detail design was done by the contractors and checked by both the Aeroports de Paris (AdP) and Bureau Veritas, an international certification agency.

Investigators note that no full, three-dimensional model was ever made of the entire project. **— ENR**

Roofing Contractor Jailed in Employee's Death

Lee Harper, Cannock, Staffordshire, Scotland, managing director of Harper Building Contractors Ltd., pleaded guilty to manslaughter and breach of Section 2 of the Health and Safety at Work Act 1974 (HSWA) recently and was sentenced to 16 months in jail after the death of a roofer in his employ.

Daryl Arnold, 27, who had never before worked on a roof, was employed by Harper to remove and replace a warehouse roof in Salford. He was wearing no safety equipment and no precautions were in place when he stepped backwards onto a fragile skylight, which gave way. He fell 6.75m to the ground floor below and died as a result of his injuries. A prosecutor noted, "...equipment to prevent people falling through fragile materials is readily available and relatively cheap. A sensible, straightforward approach to health and safety in managing the risks on this job should have prevented this tragic death." **— Roofing**