bit unevenly, roof beam elevations vary slightly owing to fabrication and installation tolerances, and beams and decking deflect under load. Also, point loading from HVAC equipment, suspended piping, lights, and such causes some roof structural members to deflect more than others. All these factors may result in the actual roof profile being far from the assumed—with some areas of the roof having no slope at all—and lead to an accumulation of ponded water.

Roofing not designed to be submerged for prolonged periods of time, like some built-up asphalt-based products, may slowly start to disintegrate and eventually leak. Other factors leading to roofing failures include local damage from careless foot traffic or equipment maintenance, clogged roof drains—again resulting in ponding—and poorly protected roof penetrations.

The deterioration often starts at the flashing locations, expansion joints, and improperly fastened gravel guards. Regardless of the origin, roof leakage may result in saturation and ruining of fiberglass insulation, staining of finishes, and corrosion of roof decking. If not addressed promptly, damage can progress to the point of making the roof unrepairable, leaving tear-down and replacement as the only solution.

14.2.2 Reroofing Options

One popular choice for reroofing of conventionally built roofs is the single-ply membrane, especially of the lightweight fully adhered or mechanically fastened varieties. This material is not without drawbacks. To cover an old tar-and-gravel roof with a single-ply membrane, all gravel usually has to be removed. This messy operation, if not handled properly, may result in a badly gouged roof that needs to be overlaid with protection boards or even torn off completely. The roof slope, if previously inadequate, can be changed only with expensive tapered insulation. And, as already mentioned, in sunny locales solar radiation causes the unprotected membranes to fail rather quickly, ruling this system out.

Another increasingly popular option is reroofing with metal. This solution offers numerous advantages. As discussed in Chap. 6, metal roofing comes in a variety of finishes including polyvinylidene-based coatings that are extremely durable and ultraviolet-resistant. Standing-seam roofing with sliding clips can better handle thermal expansion and contraction than membranes. Even with slopes as low as $^1/_4$:12 for structural panels and 3:12 for architectural roofing, water can drain faster than in nearly flat roofs. With steeper slopes, as recommended in Chap. 6, the roofing should perform even better. The required slope can be accomplished by erecting a light-gage framework on the old roof.

The total weight of metal roofing and the new framework usually does not exceed 2 to 4 lb/ft^2, placing this system among the lightest available. Quite often this small additional load can be safely taken by the existing roof structure, while the heavier systems such as built-up roofing would overstress it. If the existing roof structure has no excess capacity at all, a system of beams or trusses spanning between the new stub columns on top of the existing building columns can be erected.

Some experienced architects believe that properly designed and constructed metal roofs will last 40 years.[1] While metal roofs may initially cost more than the competing systems, their exceptional durability combined with ease of maintenance often make metal a winner in life-cycle cost comparisons. Being recyclable, metal roofing wins on an environmental scorecard, too.

Metal roofing is very useful in circumstances requiring a replacement of the existing slate or tile roof supported by an aging, and undersized, roof structure. Such roofs can benefit from a metal Bermuda roofing with the slate, shake, or tile profile, or from a PVDF-covered metal shingle product designed to closely resemble the traditional materials.

14.2.3 Tear off or Re-cover?

A decision on preserving the existing roofing versus removing it often hinges on a level of moisture in the existing roof system. That the previous leaks caused *some* water to get into the roof insulation is clear; the question is only, how much water? Reroofing over existing roofing and moist insulation can invite several problems. In addition to the already mentioned problems of diminished insulation performance and corrosion of the existing decking, entrapped moisture can cause offensive smell and growth of mold and mildew, resulting in serious indoor-air quality problems. Also, retrofit fasteners that penetrate the moist space might eventually corrode and undermine the integrity of a newly constructed roof system.

The degree of water saturation can be determined by a moisture survey performed by the design professional or by a specialized consulting firm. The latter may give more reliable results, because specialized firms are likely to employ such advanced testing methods as infrared thermography, capacitance, and nuclear back scatter.[2] The survey produces a rough outline of the areas containing wet insulation and determines the degree of saturation, which can be confirmed by taking a few insulation cores. Only then can the magnitude of the problem be rationally assessed.

A common solution to the problem of entrapped moisture is to install several "breather" vents and hope that the moisture escapes prior to the final enclosure. This approach works only for very modest moisture levels, however. If the existing roofing and insulation are totally saturated with water from frequent leaks, venting through a few holes might not be adequate, especially when structural decking or a vapor barrier restricts the downward moisture migration.

Studies indicate that it would take 30 to 100 years for the insulation to dry out in such circumstances, even with the vents installed.[2] A better course of action is to remove the roofing and the wet insulation. Tobiasson[3] notes: "In most cases, wet insulation should be viewed as a cancer that should be removed before reroofing." He points out that every inch of saturated insulation can add up to 5 lb/ft^2 to the dead load—a significant amount. A moisture survey that indicates numerous areas of wet insulation is to be taken seriously: a complete tear-off might be the only prudent option left.

A survey of the roof structural decking is also extremely helpful. The persistent leaks might have led to a widespread decking corrosion beyond repair. Similarly, a presence of some potentially corrosive roof components could have degraded the deck. Phenolic-foam roof insulation produced in the late 1980s until 1992 is a case in point. It has been reported that this type of insulation, when wet or damaged, can contribute to corrosion of metal deck, sometimes to the point of making it unsafe to walk on. A replacement of roof decking is a serious matter since it opens the inside of the building to the elements and affects the operations.

There are arguments against a complete roof tear-off, the most obvious being high cost. The bill for a disposal of the removed materials, perhaps containing hazardous waste such as asbestos roofing felts, could also be significant.

The pros and cons of the two approaches require careful consideration. Curiously, the 2 billion ft^2 of reroofing work performed annually in this country are evenly divided between the tear-off and re-covering.[2] Of course, when the local building code prohibits the addition of another roofing layer, the decision on tear-off versus reroof comes easily.

14.2.4 The Issue of Design Responsibility

Who determines whether an existing roof is structurally capable of carrying the extra load, however modest, from reroofing? As we discussed earlier, the manufacturers of metal building systems are unwilling to get involved beyond the design of metal components; they normally disclaim any responsibility for evaluation of the existing roof structure and its capacity to support additional loads. Hire a local structural engineer to analyze the existing roof structure, they suggest.

The problem is, the engineer can readily check only the average *uniform load* capacity of the roof, a computation usable only if the new roofing is simply laid on top of the existing. Any change in slope, however, requires a new ("retrofit") framework supported by some discrete columns that will transmit concentrated, not uniform, loads to the existing structure. At the evaluation stage, the engineer often has no way of knowing which manufacturer will be selected to do the work and what the column spacing will be.

If the manufacturer is already on board, so much the better. If not, the engineers can select one of the popular systems, such as the one described below, base their analysis on that system, and require the contractor to adhere to it. Or, they can assume the worst-case scenario and use a rather