Considering the number of problems ponded water can cause, it should be obvious that the design and construction of all roofs should allow complete drainage of the roof area within 24 hours of a rainfall. Without such positive drainage to reduce the possibility of ponded water, the roof is susceptible to:

- surface and membrane deterioration;
- debris accumulation and vegetation growth;
- deck deflections;
- tensile splitting of water-weakened felts;
- repair difficulties; and
- ice formation.

The dangers of ponded water have been described in some detail by the author C.W. Griffen in the second edition of his *Manual of Built-Up Roof Systems.* Griffen says that membrane imperfections are a much more serious matter on a ponded roof. The standing water has much more time to find its way

into the roof system through fishmouths, splits, cracks, and bare felts when these imperfections are located under a pond. Once inside, this infiltrating moisture can begin to tear the roof apart. When the trapped moisture is heated by the summer sun, it can accelerate the growth of an interply void, forming a blister. If the water freezes, it can delaminate the membrane.

But ponded water can be dangerous even when there are no membrane imperfections present, Griffen says. Water ponded at flashings doesn't need to find a flaw in the membrane to gain easy access into the roof assembly, he says. He also warns that a ponded roof is subjected to greater loads, which can collapse the structure.

Griffen also says that the difference in roof surface temperatures between ponded and dry areas of the roof can create variations in the rates of expansion and contraction within the system. These variations will, in turn, cause the membrane to warp and wrinkle.

And if these problems aren't enough to make you want to avoid ponds at all costs, there may be contractual reasons as well. Evidence of ponded water after a rainfall may nullify the system manufacturer's guarantee.

Making the grade

Each roof's specific drainage requirements must be considered to achieve positive drainage on a project. The designer cannot simply specify a slope of 1/8 inch or 1/4 inch per foot and hope it's sufficient to direct the water into the drains. Other design elements such as the structural framing of the roof, the deck type, the roof membrane specification, roof deflections and the building layout must also be taken into account.

One of the most critically important factors affecting drainage is the deflection of the roof. Drains should be located where the roof will deflect the most, generally at midspan, rather than at a column or bearing wall, where the roof deflection will be minimal.

If drains must be placed at columns or bearing walls, the slope of the roof must be increased to keep the roof's deflection from directing water away from the drains. Once the designer has determined the amount of slope needed to compensate for the roof's deflection, an additional slope of at least 1/8 inch per foot should be added to attain an incline that will positively drain the roof under maximum loading conditions.

The deck type must also be considered when planning for roof slope. The camber that is built into certain decks, such as precast concrete decks or long-span prestressed concrete decks, can affect drainage, and the roof's slope must be designed to compensate for it.

The slope of the roof should continue to the drains themselves. This means that drains must be recessed below the roof surface. At the same time, sufficient insulation must be retained around the drain to prevent condensation. This is accomplished by setting the drain head below the level of the insulation and tapering the insulation down to the drains. NRCA's construction details on roof drains illustrate the correct installation method.

Once positive drainage is achieved, it is important to keep water flowing freely off the roof. Regular maintenance must be performed to prevent debris from clogging drains.