Design challenges

Cooler and freezer building designs present unique situations for roof system designers

by Mark S. Graham

Unlike most building types where interior environments are relatively moderate, interior conditions in cooler and freezer buildings often are the same or worse than typical exterior winter conditions. As a result, roof system designers of cooler and freezer buildings are presented with some unique design challenges and decisions.

Sound engineering is necessary when designing cooler and freezer buildings

Design considerations

In addition to typical considerations for conventional buildings, there are at least three fundamental design considerations that need to be resolved when designing buildings for low-temperature operations, such as coolers or freezers:

- Compensating for building thermal movement and avoiding potential damage to the roof system caused by thermal contraction and expansion
- Determining how much thermal insulation (R-value) is needed
- Controlling air and water vapor movement within a roof assembly and deciding whether to use one or more air and vapor retarders

Thermal movement

The conditions under which a cooler and freezer building will be constructed and subsequently operate need to be considered. For example, suppose a freezer building is 100 feet long and 200 feet wide with walls 20 feet high. If the building's structural framework is erected during the summer when the outdoor temperature is 70 F, the building's framework may be square and true.

When the building is put into operation and its interior and structural framework cools to the building's internal operating temperature, which can be about -20 F, the lateral framework may contract about ¾ of an inch because of thermal movement and longitudinal members may contract about 1½ inches. Also, the stresses created by these movements are considerable and typically will be greatest at the building's corners. Thermal movement and stresses also can significantly affect a roof system if not properly addressed.

Sound engineering judgement is necessary when designing the structural framework for cooler and freezer buildings to address thermal movement and stresses. NRCA suggests placing structural expansion joints to divide the building envelope into relatively square (and not rectangular) segments. Also, the design of expansion joints can be critical.

Thermal insulation

Determining how much thermal insulation (R-value) is necessary within a roof system also needs to be closely evaluated. In typical situations, roof surface temperatures during summer months can be as high as 160 F depending on the cooler or freezer building's geographic location and roof color. Interior temperatures on cooler or freezer buildings may be held at -20 F for months, or the space may not be in use and the refrigerating equipment may not be operating. The resulting interior-to-exterior temperature differential through a roof assembly may be as high as 180 F.

Calculating the temperature and vapor pressure gradients across a roof assembly (and wall assembly) may be useful.

When selecting specific insulation types to achieve necessary R-values, designers also need to consider the insulation's in-service temperature within the assembly's temperature gradient. Polyisocyanurate insulation, for example, has a relatively high R-value at 75 F but notably decreased R-values at lower or higher temperatures.

Air and vapor retarders

Also, designers need to consider the placement of a vapor retarder and possibly a separate air retarder.

For cooler and freezer buildings, there is no question the most effective location for a vapor retarder is on the outside of the insulation—a continuous, adhered roof membrane can serve this purpose. The only time there will be a reversal of vapor drive direction is when the exterior temperature drops below the interior temperature; these conditions would need to exist for long time periods before a reverse vapor pressure differential could cause vapor migration damage.

Special consideration also needs to be given to designing roof-to-wall junctures, building expansion joints and any roof system penetrations to ensure air and vapor seals are continuous. The roof system's vapor retarder layer should be made continuous with and be interconnected to the vapor retarder of the wall system.

Failure to provide a continuous vapor barrier and air seal will result in moisture infiltration and accumulation of ice on interior surfaces.

NRCA recommends designers provide detailed specifications and drawings to ensure their design intentions are known to bidders and installers.

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