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Roofing Considerations for Controlled Environment Vertical Agriculture Facilities

Driven by the need to supply food to a rapidly growing domestic and global population, modern alternatives like indoor farming are becoming more and more prevalent. Trying to create and maintain a microenvironment inside a building creates many complexities in the structure's design; proper roof system design is crucial to longevity and success.

Called vertical agriculture or controlled environment agriculture (CEA), companies are building new facilities or revamping existing structures to grow hydroponically farmed produce like greens and herbs. *Forbes* reported projected annual vertical farm growth to be 15% per year.

When grown in indoor facilities with durable roofing systems and a tight building enclosure, crops flourish in these highly controlled indoor environments. Immune to the whims of weather, farmers can achieve a substantially higher crop production per unit of land area, year-round production, and capitalize on the highly efficient use of water and fertilizer. It is possible to grow a plant from seed to harvest in half the time of a traditional farm, all without the need for pesticides.

This building's vertical raises the same concerns as roofing over a natatorium (pool).

Infrastructure Requirements

The extensive MEP (mechanical, electrical, and plumbing) systems required to provide a highly controlled environment are typically placed on the roof or hung from the roof structure. This creates a lot of foot traffic to maintain all the HVAC and plumbing. Consequently, the roofing system must be sufficiently robust and durable.

The presence of rooftop equipment also makes it challenging to properly drain the roof, which is very important as pooling water creates additional weight on the roof and accelerates membrane aging.

Strict temperature control makes insulation another primary consideration. There is a significant risk of condensation with fluctuating outdoor temperatures and indoor humidity. If not controlled, this can create mold and a breakdown in the system.

Therefore, vapor barriers or air barriers are essential. Since the interior environmental conditions are so unique (potentially lightly pressurized, warm, humid, or even wet), extensive interior air movement could potentially make the building positively pressurized inside. To best ensure performance, the interior space should be completely divorced from the roofing system. Ensuring no gaps between the building walls and the roof deck will help control airflow. Vapor barriers tied into the perimeter walls essentially makes an air barrier.

Another decision is to build a new facility or retrofit an existing one. Naturally, new construction is much easier as everything can be optimized and purpose-built for agriculture.

In considering a retrofit, numerous aspects must be carefully evaluated to determine if the roofing system can be modified to meet the facility's new requirements without being cost prohibitive. For example, does the existing roof have adequate drainage, and ideally multiple scuppers, gutters, and drains? Does the building have sufficient flashing heights on equipment curbs and walls to accommodate new insulation layers?

Rooftop Systems for Vertical Agriculture and CEA

As noted, rooftop traffic and proper drainage are significant requirements for vertical agriculture facilities. Consequently, thermoplastic PVC and TPO roofing membranes are best suited for these applications.

Selecting thicker sheets with the highest mil thickness, typically 80 mils, will increase the membrane durability and puncture resistance, and is therefore recommended. In addition to the life cycle and sustainability aspects of making this investment with a thicker membrane, a long-lasting roof is key, as replacement is costly due to the complex nature of these facilities.

In addition to thicker membranes, heavy-duty walk pads should be installed at all access points, high-traffic pathways, and around the perimeter of all HVAC and/or mechanical units.

A roofing membrane, insulation, and cover board work together as the system. Polyisocyanurate insulation and HD (high-density) polyiso board are recommended to enhance the roofing system's insulation value and durability. The latter has a coated glass facer, is lightweight, resistant to moisture, and can handle extensive foot traffic. Polyisocyanurate insulation (JM ENRGY3) would be used to build the R-value to create a stable environment inside. Also, by specifying a light-colored reflective membrane, there is the potential to lower the effective heat load and promote more efficient control of the stable internal temperature, which may be particularly desirable in southern locations that require significant cooling.

To enhance drainage with PVC and TPO systems, using polyisocyanurate insulation crickets to create the slope in the valleys is good practice, in addition to crickets on the upslope sides of all curbs to help divert the water around the equipment. While code requires nearly all roofs to utilize ¼ inches per foot slope, agriculture facility designs should consider increasing the slope beyond this to increase drainage speed/efficiency.

If water does start to pool and/or the drainage is not ideal, PVC and TPO are more resistant to the potential ill effects of standing water.

Another requirement is a clear-span structure for column-free interiors in selecting the right roofing system for a vertical agriculture or CEA facility. In addition to providing space for ventilation, lighting, irrigation systems, and water storage, the absence of structural columns creates room for growing tables, crops, and product storage.

PVC and TPO roofs also check the clear-span box for vertical agriculture and CEA facilities. To enable this, a lightweight roof is necessary to support the robust structure required to span this considerable distance without excessive structural steel. TPO and PVC membranes also utilize polyester reinforcement which again has excellent tear strength, an important physical property for resisting excessive movement. Another large clear-span roofing requirement is the ability to support natural expansion and contraction. By utilizing mechanical attachment, the single-ply membrane can move more independently of the structure than a traditional adhered system.

Another consideration is the use of Liquid applied flashings. This product will conform to odd shapes, is maintenance-free, and is covered by the manufacturer's guarantee. Liquid flashings can make a custom, durable seal to just about anything. Both base flashings and pipe boots need a fair amount of height away from the roof level (snow load or heavy rain/flood concern) and must be manually sealed with another product. Liquid flashings are "self-sealing" or self-terminating and can work at lower heights, sometimes occurring with equipment on the rooftop.

Early Engagement

To best ensure the successful performance of these facilities, it is best practice to engage roofing consultants and the manufacturer early in the process. These professionals not only offer advice on the right roofing system for the application, but from a quality control perspective, they can advise on other design considerations like penetrations or conditions that are not quickly detailed. When these experts are consulted early in the process, they can help avoid costly errors.