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Roof Gardens

Roof Configuration

The most important consideration when choosing which type of roof garden (intensive, semi-intensive, or extensive) will be built is the structural capacity of the deck. Soil, plants, intermediate layers, and people all add to the loads the deck must be able to carry. It must be able to support both dead loads, including of the roofing system, growing media, plants and all intermediate layers as well as the live loads resulting from wind, rain and snow, as well as human traffic whether from people using the roof garden for recreational purposes or from workers maintaining and servicing the roof garden.

The total weight includes not only the maximum water capacity of the soil (saturated weight) but a water level as high as the overflow drainage pipes and scuppers. The roof should always be designed for the worst-case scenario (supersaturation) that would occur if the drains were plugged and the roof drained through the overflow devices.

In new construction, the increased loads from roof gardens can be accommodated in the initial design. In existing construction, the roof structure must be evaluated by a qualified structural engineer to determine whether a roof garden can be built. In some instances, loads can be supported by placing the heaviest components over or near column heads or beams, thereby reducing midspan stresses. In other cases, the load bearing capacity of structure may be inadequate requiring extensive and costly modifications, structural reinforcing and additional bracing. When building an intensive system, it should be remembered that saplings grow into trees and often require anchorage or additional support. In addition, there are safety considerations for the personnel that will maintain and service the roof gardens. Safety harnesses and anchors may be required. Anchorage of trees and shrubs, along with safety anchors should be designed by a professional engineer.

Protected Membrane vs. Compact Assembly

The contribution to the thermal resistance of the roof assembly from the vegetation and soil layer in extensive systems is limited.[1] This is particularly true when the soil is in a saturated state or when excess water is being drained through the drainage layer. During the winter heating season good thermal resistance is essential in limiting heat loss from the building interior. However, during this time the soil is almost always moisture laden, or frozen, contributing little to the overall resistance of the assembly. By example, damp soil with a density of 1281 kg/m^3 (80 lbs/ cu. ft.) has an approximate thermal conductivity (KSI) of 0.5 (k = 3.47) at a mean temperature of 4ºC (40ºF).

A 75 mm layer of this growing medium would, therefore, have a thermal resistance (RSI) of only 0.15 (R = 0.86). It is obvious that in most normal occupancy buildings, insulation will be required in the roof assembly to achieve the necessary thermal resistance. Which insulation is the best suited for use in roof garden assemblies will depend on the physical properties of the insulation. It is also important to determine where the insulation will be placed, below or above the membrane. In the former configuration, commonly referred to as a compact roof, or “warm roof”, the vegetation, soil, drainage

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and filter layers are placed above the waterproofing layer, which in turn, is placed on top of the insulation. In this configuration, any insulation used must have sufficient compressive strength, good impact resistance, good dimensional stability, and be resistant to deterioration from moisture, biological growth and insects. The major drawback of this type of roof garden assembly is that should a breach in the waterproofing layer occur, substantial moisture intrusion and, consequently, damage to the insulation and other below membrane components may occur before the leak is detected or repaired. If this configuration is selected, it is imperative that the waterproofing layer be protected from mechanical damage both during construction and service and be robust to endure the rigors of service over the expected life of the assembly. Remember that it is practically impossible to inspect and service a roof membrane assembly once covered by a layer of vegetation.

The alternative configuration for roof garden assemblies is to construct a modified protected membrane roof (PMR) assembly with a vegetative cover in lieu of ballast or pavers and where the membrane is placed directly on the deck, or, in the case of steel decks, onto a suitable supporting layer and below the insulation. The advantage of the PMR system is that the waterproofing membrane is shielded from the harsh conditions of environmental exposure, from possible mechanical damage, and from large temperature variations. In addition, there is no need to install a separate air/vapour as the waterproofing membrane fulfills this function. A root barrier, where required, should be installed over the waterproofing membrane. Designers should consider the inclusion of a layer of protective material, such as an inorganic protection board, protection mats, or suitable non-woven fabrics to provide added protection against mechanical damage while the roof is under construction and prior to the insulation being installed. Some materials can provide drainage, protection and root repellency in a single layer.

Currently, the only insulation suitable for use in a PMR assembly is the extruded type of closed cell polystyrene. Any insulation used should comply with the requirements for Type 4 insulation in accordance with the latest edition of CAN/ULC-S701, *Thermal Insulation, Polystyrene Boards and Pipe Coverings.* Although this type of insulation does not absorb water readily in the PMR design, it is essential that any excess water be drained away quickly. Extruded polystyrene, if constantly exposed to water over time can absorb as much as 200 to 300% moisture by weight significantly reducing its thermal resistivity.[2] It is imperative that roof decks be adequately sloped with positive drainage to prevent ponding. The minimum recommended slope is 2% (1/4 in. per ft.).

In addition, provision must be made to allow for topside venting of any residual moisture. It is recommended that an aeration layer be located above the insulation allowing water to drain off quickly at the same time facilitating the evaporation of moisture. The aeration layer must be air and vapour permeable. If it is vapour impermeable, such as water saturated felt, a vapour trap will occur. Instead of escaping, the vapour will be driven back into the insulation reducing its effective thermal resistivity. An aeration layer can consist of any number of materials including a layer of pea gravel above a filter fabric, preformed engineered drainage boards, or other permeable products that will provide adequate drainage without impeding open diffusion. Never install a polyester mat, or moisture retention blanket directly on the insulation. Wherever possible, the insulation should be installed in a single layer. If multiple layers are required, the roof should be configured so that a thicker layer is placed under a thinner layer to promote drying.

In many instances, particularly in shallow systems, this aeration layer can also serve as the drainage layer. Alternatively, the roof garden may be designed with a separate drainage layer below the insulation. It has been suggested that a drainage layer below the insulation may reduce the overall thermal resistance of the assembly through convective looping whereby air moving through the drainage medium carries heat energy away. Although the effects of convective looping appear to be relatively insignificant, a designer may wish to compensate for this phenomenon by specifying the thickness of the insulation.

The insulation must have sufficient strength to withstand the loads that will be applied to it in service. It must resist plastic creep (irreversible deformation under continuous loading) and deformation due to point or static loads. Extruded polystyrene is available in compressive strengths ranging from 240 to 690 kPa (35 to 100 PSI). The designer needs to consider the loads to which the insulation will be subjected over the life of the roof including dead loads (soil, plants, aeration layer) and static, or live loads (snow, foot traffic, vehicular traffic) when specifying the insulation.

In a protected membrane roof garden assembly, the layers above the insulation perform the function of the aggregate ballast in a conventional PMR system. The weight of components above the insulation must be sufficient to prevent flotation of the roof boards. As in a conventional PMR assembly, additional ballast is required around all roof penetrations and at the perimeters. The insulation manufacturer should be consulted for specific ballast requirements.

Conclusion

Although it is possible to build a roof garden over a compact roof (insulation below the membrane), building it over a protected membrane system has several advantages. First the membrane is protected from the environment and possible mechanical damage. A roof garden assembly is almost always wet, and by incorporating a moisture resistant insulation, the thermal resistance of the assembly can be maintained. However, it should be remembered that adequate drainage, ballasting, and provisions for topside venting are essential for satisfactory long term performance.

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