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CBD 75

Roof Terraces

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G.K. Garden

Please note

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The high cost of land and the trend toward greater population densities in urban areas have increased the demand for multi-use roof areas. With their beauty, interest, and utility through planting, colourful paving designs, fountains and pools, roof gardens and plazas are becoming quite popular; while balconies, sundecks, promenades and roof parking areas are very common. "Roof terrace" is the term used to define any roof designed to meet functional requirements other than the fundamental need to exclude the weather from the space below. Bridge decks, tunnel roofs and other structures in which a waterproofing system is buried are seldom considered as roof terraces, but their design considerations are generally similar.

Too few roof terraces constructed in recent years are performing satisfactorily, and leakage and early deterioration of surfacing materials are common problems. Good performance, however, can be achieved, and a properly designed terrace will not only improve the appearance of a roof, while providing usable space, but should increase its service life.

There are many acceptable materials and many ways in which they can be combined to produce good roof terrace constructions, but each material and system will have some disadvantages that must be determined and allowed for by design. Many of the important considerations in roof terrace design will be discussed in this Digest, but it is important that the reader familiarize himself with the pertinent information presented in several preceding Digests.

General Considerations

A roof terrace must meet all the requirements of a roof in addition to providing for traffic or plant growth. It must furnish the required separation of environments and be structurally sound, aesthetically pleasing, economical to build, and durable throughout. Requirements relating to the separation of environments and the resulting effects are similar to those of other roofs (CBD 67), but there are special moisture, thermal and structural considerations. It should be emphasized that the behaviour and durability of each of the materials interposed between two environments are influenced by the properties and relative positions of all other materials or elements in the construction.

Moisture Considerations

Moisture considerations for roof terraces are generally the same as those for other roofs (**CBD 73**), but the design and protection of the waterproofing element and the drainage of the surfacing materials must receive special attention. The need for relatively flat surfaces normally dictates the use of membrane-type waterproofing systems, most of which can give reasonable service provided the characteristics of the particular membrane selected are duly considered. Few, however, can tolerate traffic and a protective surfacing is normally required.

Built-up membranes (**CBD 24**) of bitumen and felts or fabrics (**CBD 74**) are most commonly used, but since they are buried under a protective surfacing their design and installation should follow only the best practices. Consideration should be given to intermittent bonding of the membrane in order to reduce the risk of high local strains developing as a result of differential movements in the substrate. A bitumen-coated base sheet will resist the wetting of the membrane by moisture from below. Because it is the continuous films of bitumen that provide the waterproofing, the use of a double two-ply membrane system rather than a four-ply system produced by ¾ lapping should also be considered.

Regardless of the membrane system selected, base and counter flashings (**CBD 69**) must be properly designed and carefully installed around the entire perimeter and at all penetrations of the membrane. It should also be recognized that the waterproofing membrane may be exposed to damage during the installation of the terrace surfacing materials and that temporary protection may be required. Plywood sheets may be acceptable in some cases, but mineral surfaced roofing felt, asphalt board, or the material required for free drainage can provide the desired protection and be left in place. The amount of protection required is influenced by the surfacing system, the workmanship to be expected, and the bearing characteristics of the materials below the membrane.

Adequate drainage of roof terraces is of the utmost importance because most terrace surfacing materials can be damaged or displaced by water or frost action. In addition to sloping the membrane, it is necessary to provide a subsurface drainage or percolation layer through which water can run freely. A system of voids, no-fines concrete, fine gravel or clean coarse sand (held on No. 30 sieve) can provide such a layer. A system of open spaces is best, however; dirt is easily washed away and the space in some cases may be large enough to permit some maintenance tasks to be performed without disturbing the surfacing. Ventilation can also accelerate removal of water and drying of surface materials. The subsurface drainage layer immediately above the waterproof membrane should be continuous under planting and paved areas, pools, fountains, stairways and even under garden walls or other nonstructural surface constructions.

Stone or precast surfacing units can be supported by beams, corner posts or sleepers to provide the required space. It is also possible to groove, corrugate or contour the bottom of such units to produce a network of voids. Where the surfacing is not preformed or is made up of small units a no-fines concrete or granular base may have to lie employed. A granular base is normally used under planting areas to provide the required soil drainage.

Roof drains at the subsurface drainage level are essential whether there are openings through the terrace surface or not. Where joints between paving units are closed the terrace surface itself must also be drained. In all cases, catch basins removable for cleaning should be incorporated in the drainage system to intercept dirt that will be washed from the terrace surface.

Thermal Considerations

The thermal considerations in roof terrace design are similar to those for normal roofs (**CBD 70**). The position of the insulation is seldom significant with respect to building heat gain or loss, but it is of great importance with respect to the temperature variation that each element of the construction will experience (**CBD 36**). Actually, the insulation can be placed at any point in the construction provided the adverse thermal effects in all materials have been adequately allowed for. If it is to be located inward of the ether elements in the construction, the designer must recognize that there is risk of condensation, and of cracking of the structure,

interior finishes, walls and the waterproof membrane. If the insulation is placed above the structure but below the waterproofing membrane, it may have to be capable of supporting the terrace surfacing and traffic loads. Here again the risk of condensation and thermal problems must be recognized.

When the structure and waterproof membrane are inward of the materials providing the major thermal resistance of the roof, they are subjected to only a small range of temperature variation. Gravel, coarse sand or soil can provide the required insulation value; one foot of these materials is approximately equivalent to 1/3 inch of insulation material. Where sufficient depth cannot be provided, an insulation that does not soak up water can be placed in or immediately above a well-drained layer of coarse granular material to provide the required thermal resistance in considerably less depth. Granular fill can be covered with soil, paving stones or any other surfacing, and as long as it is well drained will be essentially dry. Insulation in this position, however, must again be capable of sustaining the terrace loading without being compressed to the point where the insulating properties are impaired or unsatisfactory bearing of the surfacing results.

Roof terrace surfacing materials will always tend to change their dimensions under variations of air temperature, solar heating and radiative cooling, and expansion joints at not greater than 10- to 20-foot intervals should be provided. A slip plane between the surfacing materials and the waterproofing membrane may also be required in many systems.

Structural Considerations

The design of a roof terrace structure follows normal design procedures, but the increased load of the surfacing system and traffic effects such as vibration and impact must be recognized. Deflections in spanning members, the position of the structure in the construction and the bearing characteristics of all materials transferring load are frequently not given sufficient consideration in design.

The deflection of spanning members (**CBD 54**) may alter the slope required for drainage, and the difference in deflection between two adjoining members may cause tearing of the waterproof membrane. There are many factors that influence deflections, but the increased permanent load of surfacing materials, trees, sculptures, pools and parked vehicles is of particular importance where the structure is subject to creep. The long-term deflection due to creep in concrete may, in a period of three to five years be approximately three times the elastic deflection under the same load.

The most desirable position for the spanning structure in a roof terrace is influenced by thermal and moisture considerations, the characteristics of all other materials and the loads to result from the intended use. As surface loads must be transferred to the building structure and the bearing strength and compressibility of interposed materials may impose severe limitations in design, the position of the structural deck is of great importance.

Where rolling and point loads will be quite high, it may be best to use the structural deck as the traffic surface, with free drainage through it. The waterproof membrane, insulation and air and vapour barrier in this case are supported on a secondary structure below, but allowance must be made for thermal movements of the deck. Where this is not acceptable, smaller structural surface units can be supported on corner posts or sleepers that bear on the main structure below, but the insulation between the waterproof membrane and support elements may have to be omitted. Actually, it may be best to locate the insulation. directly on the under side of the surface units. In either case the posts will produce a thermal bridge effect (**CBD 44**), which fortunately can be minimized by the use of low-conductivity bearing pads between the posts and the surface units.

When the surfacing materials are supported on no-fines concrete, fine gravel or coarse sand, uniform distribution of the load on the membrane can be achieved. In this case, and provided the traffic loads are not too high, some insulation materials can be used between the

waterproof membrane and structural deck; although again it may be better if the insulation can be positioned directly below the surface units.

Terrace Surfacing

Terrace surfacings must be aesthetically pleasing and capable of tolerating intended traffic while protecting the waterproof membrane from physical damage. They must also be durable in the environment in which they serve, not damage the membrane by their own behaviour and be reasonable in total cost. It is normal to select them for their appearance, their ability to tolerate the intended traffic, and their cost. To obtain the best service life from them the method and pattern of installation must be determined recognizing the properties of the materials selected and the thermal, moisture and structural considerations previously discussed.

Membrane systems designed to carry traffic can provide reasonable service, but because they are exposed to the exterior environment, solar radiation, and direct physical abuse, early local failures may occur. Although repairs may be fairly simple they may seriously detract from the general appearance of the terrace. Built-up membranes surfaced with mastic asphalt normally fall into this category, but it should be pointed out that asphalt paving alone cannot be considered to meet waterproofing requirements.

Small-dimension materials that are not adversely affected by water or wet freezing can be bonded to the surface of many types of waterproof membranes to produce acceptable roof terraces at reasonable cost. It is important, however, that movement resulting from temperature variations be allowed for. All joints between units may be left open or expansion joints at about 10-foot intervals provided. Where heavy or rolling loads are to be allowed on this surfacing it may not be advisable to place insulation between the structural deck and the surfacing. If insulation is located below the structural deck, however, thermal strains or dimensional changes in the total construction must be considered.

Many surfacing materials and systems can be employed when a free draining space or percolation layer is provided at the surface of the waterproof membrane. Wooden duck-board walks have been used for many years and will always warrant consideration where dead loads and cost must be kept to a minimum. Stone and precast concrete surfacings are extensively used, but they must be kept as dry as possible and layers of mortar should be avoided because they may produce frost heaving. It is also imperative that the waterproof membrane be well designed, properly installed and adequately protected during construction since repair is difficult and expensive.

Special Surfacing Considerations

The need for snow removal varies with the intended use of the roof terrace. Power plows can be used on terraces designed for vehicular traffic, whereas small snow blowers may be satisfactory on almost all terraces. The snow itself may be trucked away or pushed into melting pits incorporated in the terrace design, Snow melting systems where the surface material of the terrace is heated can provide good service. It should be noted, however, that rapid temperature variations resulting from intermittent operation can cause rather serious breakup of the heated slab. If a fluid heating system is used, the potential for corrosion of the piping must be recognized; the expansion associated with corrosion can destroy the snow melting slab. It should also be recognized that a heated surface slab will change the thermal behaviour of the total construction.

Landscaping of roof terraces is beyond the scope of this Digest, but the importance of a well drained layer of granular material between the soil and the waterproof membrane cannot be over-emphasized. The need for thermal insulation in landscaped areas is also of interest since it varies with the type of plants to be grown. Bulbs and the roots of herbaceous plants should be kept below a certain maximum temperature during winter, while the roots of ornamental evergreens should have access to moisture in unfrozen ground. Because plant roots may grow into some membrane materials under certain conditions, protection of the membrane should be

considered. This protection may be most cheaply provided by covering the membrane with a polyethylene or polyester film.

Conclusion

The design of a successful roof terrace depends upon the designer's ability to select the most compatible compromises. There are many acceptable materials and many ways of combining them; all have their particular advantages, but allowances for their disadvantages must be made. Surfacing materials, when properly installed, can reduce the range of temperature variation in the waterproof membrane and protect it from solar radiation, physical damage, fire and wind. The longest service life of the surfacing materials will be achieved when their thermal movements have been allowed for and they are kept as dry as possible.