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CERAMIC TILE and STONE PLAZA / ROOF DECKS

by
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Exterior roof decks that are to be clad with ceramic or stone tile, require special analysis, design and detailing to insure a trouble-free installation. In designing these applications, it is recommended to first start with an understanding of the guidelines of the Tile Council of America's (TCA) Detail F103 for roof decks and F101 & F102-2K for on grade pavements. While this is a good starting point, these details may not recognize new products and developments, therefore it is good practice to also consult installation products manufacturers for new or equivalent products and procedures. One example is that the TCA details, while not expressly prohibiting tile clad roof decks and pavements in freeze-thaw zones, warn that this type of application may not be reliable in freeze-thaw climates. However, these so-called limitations no longer exist with new latex and mortar formulations and installation methods.

FACTORS TO CONSIDER DURING THE PLAZA / ROOF DECK DESIGN STAGE ARE:

1. severity of the installation's exposure to sun (thermal shock and thermal movement) physical impact, water, chemicals, e.g. deicing chemicals, and freeze/thaw conditions.
2. live and dead loads; weight of the tile and deck assembly/ installation system, traffic-pedestrian or vehicular, landscaping features and furniture (water saturated soils can weigh up to 120 lbs. per cubic ft.), snow loads, wind uplift loads (system should have Factory Mutual wind uplift rating or demonstrate adequate ballast to comply with building codes for wind zone)
3. level of control over workmanship caused by demand for faster paced construction and job site conditions

Despite differences in details of plazas and roofs the layered subsystems are somewhat universal. Although the layers are interrelated, it is more convenient to discuss these separate roof deck components consisting of:

1. structural building deck (concrete slab)
2. waterproofing roof membrane (and any required protection board)
3. insulation
4. drainage layer components (drainage mat or gravel, flashing, drains)
5. sloping mortar bed & adhesive mortar bond coat
6. ceramic or stone tile wearing (finish) surfaces

CRITERIA FOR THE PLAZA / ROOF DECK'S UNDERLYING STRUCTURE:

A typical plaza / roof deck concrete structure can be reinforced concrete slabs, post-tensioned slabs, concrete topping over precast units (e.g. planks and tees) or concrete topping over a steel deck. The underlying concrete structure must be:

1. structurally sound, dimensionally stable and properly engineered to receive load impositions
2. surface must be free of surface defects, structural cracking, excessive movement, conform to local building codes and be finished to a broom or light steel trowel finish
3. pitched 1/8" -1/4" in one foot (2% pitch) to drains as recommended to prevent ponding of water; tile over a flat deck may not withstand constant and severe freeze-thaw cycles or be subject to reduced compressive and shear bond strength with resultant premature failure under live load or thermal/moisture movements
4. comply with the requirements established by the manufacturer of the waterproof roof membrane.

A careful concrete installation can produce a nearly watertight deck. The least porous concrete consists of dense, nonporous aggregates, and specification / use of a minimum water to cement ratio.

ROOF DECK INSULATION:

Roof deck insulation may be located above or below the structural deck; location below the deck requires consideration of the deck assembly's internal dew point. Location of insulation above or beneath the waterproofing is also a consideration. A Protected Roof Membrane Assembly (PRMA) places rigid insulation over the membrane in order to reduce thermal stress. Properly specified, rigid insulation with integral drainage channels may also serve a dual purpose as a drainage layer, eliminating the need for a separate drainage medium. Insulation placed below the waterproofing membrane allows the membrane to be subject to thermal cycles. In many cases when the waterproofing membrane is subject to thermal cycles it must be protected by an additional compatible protection layer. Insulation placed above the waterproof membrane can (in some cases) inhibit proper water percolation and drainage. The insulation must be an extruded polystyrene type and have a compressive strength high enough to accommodate live and dead loads, be dimensionally stable, and have low water absorption to be resistant to freeze/thaw cycles and water deterioration.

TYPES OF WATERPROOF MEMBRANES:

Waterproofing can be either loose-laid, mechanically attached or fully adhered to the structural concrete deck Following are several types of available waterproofing suitable for roof deck installations:

Built-up Bitumen Membranes- two or more layers of either paper, felts, glass mats, fabric, etc., are job site assembled with alternating layers of bitumen. Bitumen may be asphalt or coal tar pitch.

Vulcanized or Non-vulcanized Elastomer- sheets of elastomeric membranes spliced at the job site with adhesives that have excellent weathering properties and good puncture resistance. Non-vulcanized sheets are reinforced with a polyester mat laminated between two layers.

Thermoplastics- sheets made of polymers compounded from rigid plastics made flexible by additional plasticizers. Thermoplastic membranes are sometimes reinforced with glass fiber or polyester mats. These large factory fabricated sheets are heat-welded together in the field.

Modified Bitumen- bituminous sheets modified with synthetic rubber to improve their elasticity. This system is fully adhered to the concrete substrate and is comprised of small sheets/ rolls spliced together in the field.

Hot-Applied Rubberized Asphalt Membranes- rubber compound dispersed in asphalt with oil and mineral fillers, melted at the job site in a kettle. The membrane is field fabricated by spreading a continuous layer of liquid over the deck to form a seamless, monolithic membrane.

Cold-Applied Liquid Membranes- adhered liquid polymeric compounds that combine coal tar pitch, modified asphalt and resins. Membrane is field fabricated by spreading liquid over the deck to form a seamless, monolithic skin. During installation, these membranes are sensitive to job site conditions, e.g. deck quality, weather, contaminants and workmanship.

NOTE: Roof deck flashing details are critically important. Lack of flashing or improper flashing design and installation results in many failures (leaks) that occur in roof deck installations.

PLAZA / ROOF DECK DRAINAGE SYSTEMS:

Adequate drainage layer of space that allows an unhindered flow of water- is important for the long-term service of a roof. Each part of the roof deck must facilitate the drainage into drains and conductors. The preferred form of drainage (away from parapets and roof perimeter) is via slope to internal drains. Without proper drainage the roof deck system can be exposed to permanent hydrostatic pressure. A sufficient incline from the sealing level to the drainage points allows water to run off under its gravitational force. This drainage layer can be composed of:

1. crushed stone (1/2" diameter max.) covered by burlap or closely woven cheesecloth
2. (0.4" or 0.8" matting- nylon and carbon black spinerette matting) extruded 630 g/m2 fabric side up. (e.g. Enkadrain)
3. a prefabricated drainage mat with high flow capacity and appropriate compressive strength

Roof drains must provide complete drainage at the waterproof membrane level by use of

weep holes. Roof deck flashing details are critically important. Lack of flashing or improper flashing pitched 1/8"-1/4" in 1' (2% pitch) to drains as recommended to prevent ponding of water. Tile over a flat deck with poor or no drainage will not stand up. in compliance with the requirements established by the manufacturer of the waterproofing or insulation system.

CRITERIA FOR THE FULL MORTAR BED:

The full mortar bed is typically 1-1/4"-2" (30-50mm) minimum thickness at the low point and reinforced with galvanized steel fabric for temperature/shrinkage resistance and increased tensile strength. The wire fabric reinforcing must be located in the upper half of the mortar bed depth in order to function effectively. The addition of a latex additive to the mortar in lieu of water contributes to higher compressive, flexural and adhesive bond strength, reduces water absorption, increases de-icing and other maintenance chemical resistance, increases freeze/thaw cycle resistance, and increases flexibility to accommodate both thermal shock and normal thermal expansion / contraction. When using a latex additive, follow the manufacturer's recommendation for proper usage and exposure. The full mortar bed should be protected for at least 14-28 days before it is exposed to any permanent water conditions. Materials for construction of the mortar bed are as follows:

- Portland cement- ASTM C150 Type 1 (1 part)
- sand- ASTM C-144 (3-5 parts damp sand)
- latex- per manufacturer's recommendation mortar
- reinforcing - 2"x2" W0.3/W0.3 (16 gauge) galvanized welded wire fabric
- expansion joints per TCA method EJ171

NOTE: Expansion joints should extend to the bottom of the mortar bed. The project architect must specify expansion joints and show their locations on drawings. Because expansion joints provide a break where water can penetrate the installation, they should be located in consideration of drainage grades and drain locations. Joints should be located at high points of the drain grading and spaced approximately three times the thickness of the mortar bed in feet (meters), or every 10-12 feet (3-4 meters) for typical plaza deck mortar bed thickness.

CERAMIC TILE or STONE PAVER REQUIREMENTS:

Ideally the roof deck surface should be visually pleasant, durable, functional, easily maintained and able to accommodate all loads and service requirements. It should consist of modular components that facilitate temporary removal for trouble shooting purposes. Unglazed tile has to meet or exceed the following special requirements:

1. must have < 3% water absorption for freeze-thaw resistance (cold climates) and low moisture expansion (humid, rainy climate)

2. must have slip resistance in compliance with ADA requirements (abrasive particles, rough finishes, grooves or patterns fired into the tile and tested coefficient of slip resistance)

3. must have good chemical, stain, abrasion, and thermal shock resistance

The tile manufacturer or stone fabricator should provide a certificate stating the suitability of tile for a particular installation and conformance with recognized test standards of ANSI A137.1 or ISO 10545

GROUT:

When choosing the grout consideration must be given to the physical demands of the installation and the type of tile to be used. Fully filled grout joints protect the mortar bed, insulation waterproof membrane and drainage system from ice melting chemicals, water infiltration, sand, leaf debris, etc. A fully filled grout joint system can also support edges of tile and prevent cracking and chipping, and serve to form an integral locking effect with the adhesive mortar . Site mixed sand-portland cement grout or commercial pre-blended portland cement-sand grout gauged with an appropriate latex admixture is recommended for exterior roof deck installations. Unsanded pure portland cement grout is not recommended for exterior roof deck or pavement installations due to large moisture movements of pure portland cement paste resulting in micro-cracking and ultimate deterioration of the joint. The use of latex grout additives to portland cement grouts help cure the grout to increase compressive strength, and provide flexibility and greater bond strength to dissipate stress from flexural, thermal and moisture movement. Joints should be filled full. Color of grout for exterior applications should ideally be a portland cement gray, dark gray, or brown in order to mask surface dirt and pollutants .

SECONDARY WATERPROOFING MEMBRANE:

Ideally a secondary waterproofing membrane (to protect the full mortar bed from water penetration) can be installed above the full mortar bed. This secondary membrane must allow the thin set installation of paver units and comply with ANSI A118.10 Thin Direct Bond Membranes for Ceramic Tile Installations.

LATEX-PORTLAND CEMENT MORTAR:

Tile can be either thin-set into a pre-floated cured mortar bed, or wet set into a green mortar bed with a slurry bond coat applied to the wet mortar bed and back of the tile. Complete installation specifications for exterior tile applications are listed in ANSI A108.1B for thin set cured mortar bed method, and A108.1A for wet set method.