Midwest Roofing Contractors Association, Inc.
4700 W. Lake Avenue, Glenview, IL 60025-1485
Phone: 800/497-6722 • Fax: 847/375-6473 • E-mail: mrca@mrca.org • Web: www.mrca.org

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STRUCTURAL LIGHTWEIGHT CONCRETE ROOF DECKS

Recent new construction involving cast in place concrete floor and roof decks has switched from normal weight aggregate to structural lightweight aggregate. The weight savings is considerable while the structural properties are similar. Normal weight aggregate concrete has a nominal density of 150 pounds per cubic foot while structural lightweight can range from 90 to 120 pounds per cubic foot. Energy savings are achieved by reducing transport costs, handling and weight. All of these features help fulfill the green build initiatives.

Do not confuse structural lightweight concrete with lightweight insulating concrete, which is normally pumped to the roof and placed on an existing structural concrete deck. Lightweight insulating concrete has a density in the 20 – 40 pound per cubic foot range. It is not the subject of this bulletin.

Normal weight structural concrete aggregate does not absorb significant water (<2% by weight); the material is wetted so as the water to cement ratio is not upset by including dry aggregate. The water to cement ratio is the key parameter to insure complete chemical hydration of the Portland cement powder to concrete with full strength.

Lightweight structural concrete aggregate is a porous clinker type material filled with air voids, giving it the lightweight features. Cement paste will not fill the voids, but if the lightweight aggregate is not water soaked, ponded or subjected to a continuous water spray in the bulk pile, the lightweight material will rob free water from the concrete mix, drastically upsetting the handling properties and ultimate compressive strength of the batch. Lightweight aggregate reportedly can absorb anywhere from 5 to 25% of its mass with water.

When structural lightweight concrete is then poured, the aggregate voids are loaded with water. Dry down time for the deck is many months according to Portland Cement Association (PCA) Engineering Bulletin 119, when compared to normal weight structural concrete. Normal weight structural concrete will achieve a 75% internal relative humidity in less than three months according to studies. To achieve the same 75% internal relative humidity, lightweight structural concrete takes twice as long, almost six months according to PCA Engineering Bulletin 119. These tests were run on an 8" slab that had both top and bottom surfaces exposed to air

dry. If a roof is installed over the top surface and the deck was cast into unvented metal form deck, the logical conclusion is that the dry down mechanism is at best severely retarded.

Roof systems installed over structural lightweight concrete in the tight time driven sequence of construction will likely incur a very heavy upward water vapor drive. Heavy moisture vapor accumulating within the roof system leads to problems which could include: loss of insulating value, facer degradation, and physical damage to the insulation, fasteners and adhesives. Roof attachment may be lost locally, depending on system design and materials used. Any organic or water based material or adhesive subjected to moisture condensation will suffer a loss of physical property with the roof system. This damage will occur with single ply, modified bitumen and built up roof systems not using a well designed vapor retarder. A complete vapor retarder seal is needed; the structural lightweight should be poured on vented steel deck to accommodate down venting.

The flooring industry was confronted with this issue some time ago; a moisture probe test was developed; ASTM F2170, "Standard Test Method for Determining Humidity in Concrete Floor Slab Using In-Site Probes" was promulgated in 2002. The probes are sealed in place for 72 hours and read electronically. Acceptable relative humidity levels within the structural lightweight range from 65 – 85% depending on material and flooring manufacturer. The roofing industry has not established any benchmarks or acceptance levels as of this time. Recent F2170 probe tests on 2 year and 7 year old structural lightweight concrete roof decks yielded relative humidity readings in the 90 – 98% range. These roofs used bead adhesives to construct the roof assembly. No vapor retarders were used; a tear off and rebuild is necessary due to heavy moisture intrusion up into the roof insulation.

Contractors are advised not to use the plastic film test on structural lightweight concrete deck to see if condensation forms under the film. This test (ASTM D4263, "Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method") has proven by independent tests to give misleading results and cannot be trusted on structural lightweight concrete decks. This is due to the variation of rooftop temperatures and humidities and/or the possibility that just the very top surface of the concrete is dry.

Course of Action

If you plan to install a new roof over a freshly poured structural lightweight concrete deck, take the following action:

1. Notify the designer of record and general contractor of this bulletin and have them review the American Concrete Institute document ACI 214R-03, "Guide for Structural Lightweight-Aggregate Concrete" and the Portland Cement Association, Engineering Bulletin 119, "Concrete Floors and Moisture (2008).

2. Notify the roof system manufacturer.
3. Determine if vented steel form deck is called for.
4. Plan on incorporating a tight vapor retarder system, including vertically sealing to all perimeter, wall and curb flashings.
5. Consider running the ASTM F2170 probe test. Do not use the plastic film test (ASTM D4263), calcium chloride test (ASTM F1869), or hot asphalt strip mopping as the results are not dependable due to limitations.