

Lightweight Insulating Concrete As a Choice Reroofing System

By Hubert T. Dudley, Ray Wetherholt, Zen Szewczyk, and Herb Cannon



Lightweight insulating concrete has been used as a roofing substrate for more than 60 years. It is a combination of cement, air, water, and an air-entrained aggregate. The aggregate provides improved surface characteristics, including a smoother finish, and a reduction in cracking. When aggregate is not included, the lightweight insulating concrete is referred to as cellular concrete. Both types—aggregate lightweight insulating concrete and cellular concrete—provide similar solutions to common reroofing problems.

The typical density range for lightweight insulating concrete is 22-38 pcf. (Lightweight insulating concrete should not be confused with lightweight structural concrete, which has a minimum density of 50 pcf.) Table 1 shows the typical range of physical properties for materials used in insulating concrete systems.

cases, a minimum of one inch. This design innovation resulted in a lightweight insulating concrete system that is viable—even advantageous—for use in reroofing applications.

Lightweight insulating concrete systems are placed using mixing and pumping equipment. An average of 8,000 square feet of lightweight can be installed in one day on reroofing projects. A higher coverage rate averaging 15,000 square feet per day can be achieved on new construction projects.

On a typical reroofing application, a lightweight insulating concrete system can be installed directly over the existing roof. Following a structural review and repair of the existing roof and flashing to a watertight condition, the installation of a lightweight insulating concrete system begins with placement of a 1/8-inch minimum slurry coat of lightweight insulating concrete.

The slurry corrects any substrate irregularities or low spots, and bonds the polystyrene to the substrate. Type I expanded polystyrene board, designed with a pattern of holes, is placed into the slurry in a stair-step configuration to create the needed slope-to-drain contour and achieve the required insulation values. A top fill of insulating concrete encapsulates the EPS board, bonding it to the substrate. The pour is screeded to a smooth, planar, monolithic surface suitable for membrane application.

Lightweight insulating concrete systems are used effectively to solve common reroofing and recover problems in applications where bottom side venting is not available, including:

- Providing positive in-place slope-to-drain
- Correcting existing surface irregularities
- Avoiding disruptive tear-off noise and debris
- Avoiding asphalt fumes that accompany hot-mopped, tapered board systems
- Creating potential initial cost savings due to labor savings, and long-term life cycle cost benefits
- Encapsulating/covering roofing membranes that cannot be disturbed

Insulating Concrete Systems
Typical Range of Physical Properties

| Physical Property | Unit | Aggregate | Cellular |
|------------------------------------|-----------------------------------|--------------------|-----------|
| Insulating Concrete | | | |
| Oven Dry Density | (pcf) | 22-38 | 28-38 |
| Placed Density | (pcf) | 55-68 | 34-45 |
| Minimum Thickness | (inch) | 1-0-2.0 | 2.0 |
| Compressive Strength | (psi) | 125-400 | 160-450 |
| R-Value per Inch | (hr ft ² F/BTU) | 0.9-1.5 | 1.0-1.3 |
| Coefficient of Thermal Expansion | (inch/inch X 10 ⁻⁶ /F) | 4.3-7.9 | 5.0-7.0 |
| Curing/Drying Shrinkage @ 180 days | (%) | 0.20-0.45 | 0.30-0.60 |
| Polystyrene Insulation | | | |
| | Unit | Polystyrene | |
| Oven Dry Density (Minimum) | (pcf) | 0.90 | |
| Compressive Strength (Minimum) | (psi) | 10.0 | |
| R-Value per Inch | (hr ft ² F/BTU) | 4.0 | |
| Open Area of Holes in Board | (%) | 3.0 | |
| Water Vapor Permeance 1 Inch Thick | (Max. Perm) | 5.0 | |
| Dimensional Stability (Maximum) | (%) | 2.0 | |

Table 1

Originally, lightweight insulating concrete systems were installed with a varying thickness of concrete to provide slope. In the early 1970s, a constant thickness of polystyrene was incorporated into the system to provide increased insulation. In the late 1970s, the system concept evolved to include stair-stepped thicknesses of polystyrene. This created a slope-to-drain contour that effectively removes water from the roof's surface, reduces weight, and increases insulation values. Additionally, maximizing the use of polystyrene allows a significant reduction in the thickness of lightweight insulating concrete to, in some

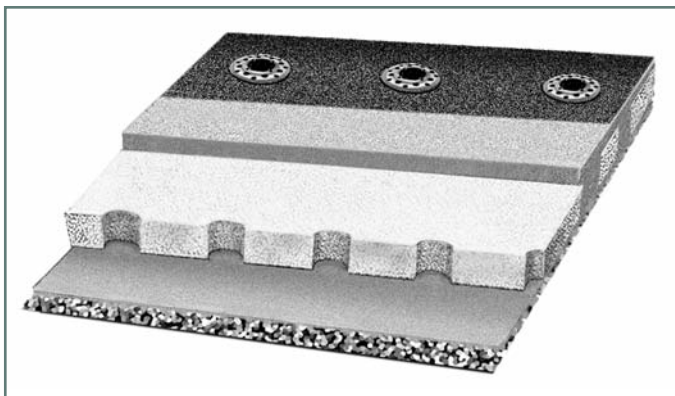


Photo 1—Lightweight Insulating Concrete system cross-section

To illustrate the viability of lightweight insulating concrete systems as a problem-solving tool in such applications, the following case studies of LWIC systems on reroofing and recover projects are provided.

Ray Wetherholt Wetherholt and Associates

Let me start by explaining that, initially, I was not a believer in lightweight insulating concrete, but began using it when I became involved in several projects. In those projects, it was the best option for the architect and construction team to get slope to drain and avoid relocation of drains and complicated tapered system details.

Lightweight insulating concrete can be another tool in the toolbox of the professional roofing consultant.

The three projects I would like to review are located in the Seattle, Washington, metropolitan area. Each was unique and had different requirements. The product used on all three projects was NVS ("Non-vented System," marketed by W.R. Grace) lightweight insulating concrete.

Eastside Hospital with Gravel-Surface, Hot Asphalt Roof

The existing roof of the Eastside Hospital was lightweight insulating concrete over a cast-in-place concrete

deck with a gravel-surfaced, hot asphalt built-up roof that included four plies of 15# asbestos felt. Located in a park-like setting surrounded by tall fir trees, the roof was difficult to access from the sides. The original surface was virtually flat, and the drains were located in a geometry that did not allow a standard tapered system to be economically feasible.

Like most hospitals, Eastside required that the noise and fume smell be minimized. Slope had to be created for drainage, and the hospital wanted a system that would provide increased insulation value, if possible. With lightweight insulating concrete, we could meet all of these objectives.

The old roof was removed down to the existing insulating concrete and allowed to air dry for a few hours. An upside-down cap sheet was nailed down using Zono-tite fasteners and was covered with a heavyweight SBS-modified base sheet torch adhered to the upside-down cap sheet. This provided a temporary roof and allowed for removal of an entire roof area before the lightweight insulating concrete subcontractor performed his portion of the work.

Roof specification and slopes were laid out initially on the design drawings for bidding purposes. Once the contractor was selected, the slopes were reviewed and modified as needed to accommodate doorways and embedded reglet heights.

Overflow scupper openings were too low and had to be modified to allow for placement of the flanged, stainless steel sleeve.

The lightweight insulating concrete subcontractor completed the 20,000 square foot job in a few days. The system was allowed to cure for three to seven days, and an inverted cap sheet and new SBS-modified two-ply system were installed over the lightweight insulating concrete.

The lightweight insulating concrete contractor was able to set up his tractor trailer rig in the parking lot, batch on the ground, and pump the material six stories to the roof. The project required extensive coordination among the hospital staff, facility managers, and the contractor. The project was completed eight years ago, and the roof is still performing well.



Photo 2—Eastside Hospital



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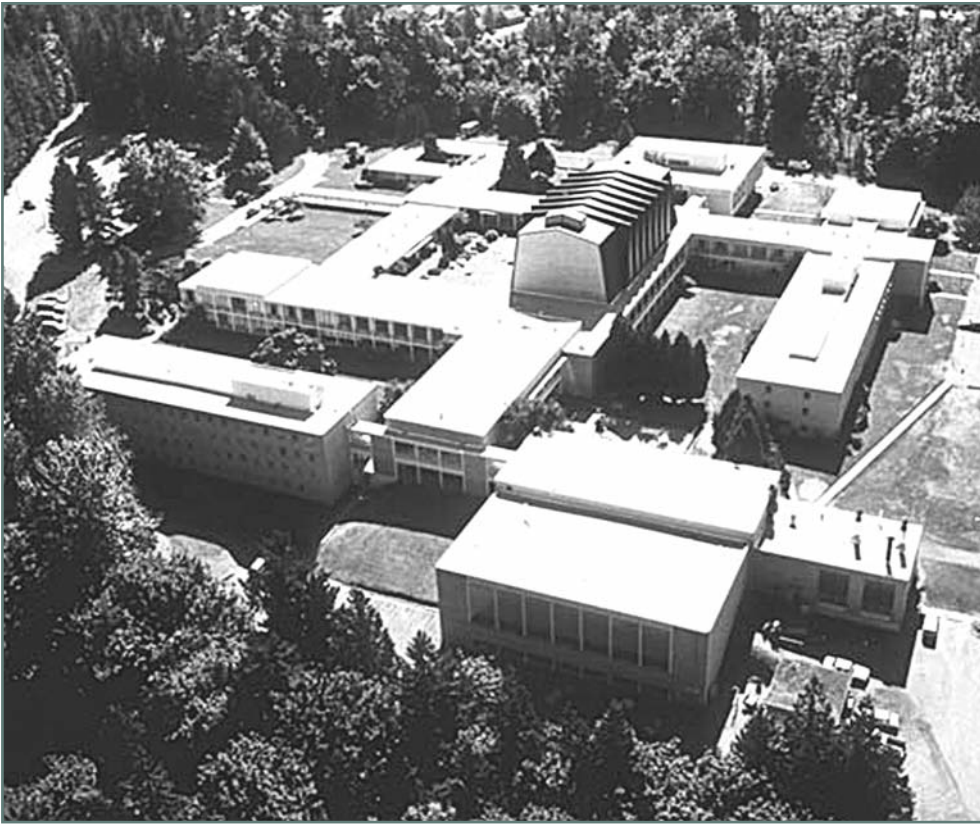


Photo 3—Lutheran Bible Institute

Flat Roof Church with Coal Tar Pitch Roof

The existing roof on this church was flat, gravel-surfaced, and had complicated drainage geometry. Several “consultants” (including church members and roofers) examined the roof and proposed adding drains, recovering the existing roof, and spraying foam and a coating. Contractors were worried that coal tar pitch would be considered hazardous waste and associated disposal costs would be incurred.

The addition of drains through the structural concrete deck was not economically feasible because the underside of the roof deck is exposed to the church interior. The Seattle weather, together with the dearth of qualified SPF contractors, took away the option of SPF, leading us to consider lightweight insulating concrete. A structural engineer was retained to review the building structure. He determined that after the loose gravel from the coal tar roof was removed, lightweight insulating concrete would add a minimal, acceptable amount of weight to the structure.

On this project, the underlying roof was left in place, and lightweight insulating concrete was installed over it. The system included EPS board placed in a stair-step configuration to create an effective slope-to-drain contour. Edges were raised to accommodate the added thickness. In most cases, curbs were raised to accommodate the insulation thickness as needed. On most of the roof, 1/4-inch per foot slope for drainage was obtained. In a few locations, the slope was limited by the chapel’s steep copper roof.

An inverted cap sheet was attached over the lightweight insulating concrete using NVS fasteners, and a torch-grade, heavyweight SBS-modified bitumen membrane was applied. The roof has been performing successfully since the project’s completion in 1997.

Medical Clinic with Old Hot Asphalt Built-up Roof

In 1991, the roof of the medical clinic needed slope for drainage, and the geometry worked for a tapered insulation system over the structural concrete roof deck. The roof was originally designed as a plaza deck area but was never used as such. The bid documents specified a foam adhesive to secure the insulation with an alternate for use of hot asphalt. The roof system specified was polyisocyanurate board over the concrete deck, 3/4-inch perlite, a mopped fiberglass base sheet, and a 2-ply heavyweight SBS-modified bitumen system.

The owner and the low bid con-



Photo 4—Medical clinic.

tractor reviewed the roof system to identify possible cost savings and options to avoid hot asphalt fumes, which would be particularly problematic on a medical facility. The contractor proposed a lightweight insulating concrete system combined with an APP-modified membrane torched down over a nailed base sheet. The system met the owner’s budget requirements and eliminated unacceptable hot asphalt fumes. Later, the owner successfully used the same system on the rest of the building’s 10-story roofs. Examination of the roofs in 1999 found them in good condition.



Photo 5—Eastdale School

Zen Szewczyk IRC

Eastdale School, Ontario, Canada

You would think after performing thousands of condition reports and preparing the same amount of design drawings and specifications, one would rarely come across a situation that presents a unique problem. Well, after 17 years, it happened.

Our firm was called in by a school district to evaluate the extent of deterioration of the roof assembly on a building that was over 30 years old. The roof was the original four-ply asphalt BUR. The owner was not experiencing many leaks. However, due to the age of the roof, the owner thought it might be prudent to perform some preventive maintenance to extend the life of the roof indefinitely. The owner thought it also prudent to retrofit the roof with additional insulation, as it was believed the roof did not have good thermal resistance.

We arrived on site to find the roof completely under water, so our initial investigation was limited to some wading around and interior investigation. One thing we noted was that there were relatively few roof drains. The existing deck varied from area to area and consisted of poured-in-place concrete, metal deck, wood deck, and concrete slab. The underside was plaster ceiling. What little waterstaining existed was limited to around openings. Some time later, when the roof surface was dry, we returned to complete our evaluation. Infrared scans, core-cuts, and probes all indicated saturation above all decks. The continuity of the decks and a good vapor barrier had been hiding a secret for some time. Very little preventive maintenance had ever been performed on this roof.

Roof replacement should be easy! Remove and replace. Drainage calculations showed that the size of the rainwater leaders was adequate to get all the water off the roof; however, they were few and far between. The distance between drains was as much as 125 feet. The idea of adding more drains was thwarted by an inaccessible ceiling space, fire-walls, and a fire-resistant mineral fiber no longer used in building construction.

Random core samples confirmed that the existing poured-in-place concrete deck was very uneven with deviations up to two inches. Introducing rigid tapered insulation would have yielded



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an irregular surface with unsatisfactory results. Furthermore, in order to achieve any success with rigid insulation, it would require a slope of at least 1/4-inch per foot. The insulation thickness would have been from 3 inches at the drain to 19 inches at the high point. The costs were rising.

It didn't take long to conclude that the optimum solution was lightweight insulating concrete. The existing roof was removed to the deck. After deck repairs, a new vapor barrier was mopped to the deck to serve as a temporary roof. Lightweight insulating concrete was pumped onto the roof surface where it would find its level. The stair-stepped polystyrene would be installed at a 1/16-inch per foot slope. The top coat was installed and finished smooth. After four to seven days, fastener withdrawal tests were conducted to determine if the fastener held a minimum 40-pound load. The venting sheet was fastened to the concrete surface and the base sheet was installed. Then a 24-hour rainstorm arrived. To everyone's delight, the water was draining off the roof like never before. Even after the cap sheet was installed, the thickness of the overlaps had little effect on the ability of the roof to shed water. The project was completed to the satisfaction of the manufacturer, contractor, consultant, and the building owner—all within budget.

Herb Cannon The Cannon Group

Terminal Market at Hunts Point

In 1994, the 35-year-old roof of the Terminal Market at Hunts Point, New York, sustained severe damage due to high winds. The roof consisted of a poured gypsum deck, three-ply built-up roof, polyisocyanurate insulation, and a mechanically fastened PVC membrane. An emergency removal of the PVC membrane and polyisocyanurate insulation was necessary. Removal was followed by the installation of an SBS-modified bitumen sheet to secure the interior of the building. Then the building owners, the New York City Economic Development Corporation and the Hunts Point Terminal Produce Cooperative Association, Inc., began considering a full redesign for the facility's 750,000-square foot roof. There were several circumstances unique to Hunts Point that had to be considered when evaluating possible roof systems:

- The location of the facility, on the bay across from LaGuardia Airport, meant that the roof would continually be subjected to high winds.
- The roofs of the 75-foot wide x 200-foot long bays did not have adequate slope.
 - The three-ply, built-up roof contained material that, per New York State regulations, either had to be removed or encapsulated.
 - The market, which sees approximately \$4 billion of produce business per year and operates 24 hours a day, 7 days a week, could not afford to be shut down for reroofing.

Lightweight insulating concrete offered a solution for each of these concerns:

- The finished monolithic deck, with its encapsulated insulation board, is resistant to high winds.
- The lightweight insulating concrete system solved the ponding water problem by creating proper slope-to-drain.
- It was determined in a structural review that the lightweight insulating concrete system could be poured directly over the existing assembly. Pouring over the old built-up roof encapsulated the felts. This was acceptable according to New York State regulations in lieu of abatement.
- By eliminating the need for tear-off, the market was allowed to remain in operation during the entire project. The lightweight insulating concrete pour took an average of three days per bay.

Following the lightweight insulating concrete pour, the project was finished with a base sheet mechanically fastened to an 1-90 wind uplift fastening pattern. A two-ply, torch-applied



Photo 6—Terminal Market at Hunts Point

SBS-modified bitumen roof system completed the roof.

After six years, the roof is performing well, and no wind damage has occurred. The owner is extremely satisfied with the performance of the lightweight insulating concrete system.

Leidy Elementary School (1986/1992)

Philadelphia, Pennsylvania

During the fall of 1992, a nor'easter hit Philadelphia. During this windstorm, a section of edge metal on the Leidy School was dislodged, causing a 200-foot by 75-foot section of the roof to peel back. The original roof, installed in 1986, consisted of a nailed fiberglass base sheet with two layers of torched-down, APP-modified bitumen membrane over lightweight insulating concrete.

When I arrived on the site, the roof was not leaking due to the installation of a two-ply temporary roof below the lightweight pour. All of the roof fasteners held; the fiberglass base sheet tore around the head of each fastener.

Because the roof was not leaking, the Philadelphia School District left it exposed until the spring of 1993. During this time, new plans and specifications were prepared with the options to either keep and reuse the lightweight or to completely remove it and install a new lightweight pour.

At the time the first pull tests were taken, the lightweight was found to be wet. The lightweight was allowed to remain exposed one additional week under a full sun with no rain. The following week, new pull tests indicated that the deck was acceptable, and the new modified bitumen roof assembly was installed. The Leidy Elementary School roof is still functioning.

Bethune Elementary School (1987/1997)

Philadelphia, Pennsylvania

The Bethune School is similar to the Leidy Elementary job. It was roofed in 1987 using a nailed fiberglass base sheet with two plies of MBM (Modified Bitumen Membrane) over a new lightweight concrete pour. Our office was contacted in 1997 to investigate the roof and discovered that the roof had been subjected to a tremendous amount of vandalism. The roof had been cut and punctured in numerous areas. Many of the rooftop HVAC units had been damaged, and hoods had been removed from some units. Core samples revealed standing water between the roof membrane and the lightweight concrete.

Our office recommended the removal of the modified bitumen roof assembly and retaining the existing lightweight concrete. The roof tear-off revealed that the lightweight was sound. Damage to the deck was slight and repairable. A new two-ply modified bitumen system over a nailed base sheet was installed and protected by a flood coat of asphalt and gravel.

Both the Leidy and Bethune projects demonstrate the ability of lightweight concrete to withstand water intrusion abuse and remain reroofable.

Summary Comments

Over the years, lightweight insulating concrete has demonstrated successful performance as a roofing substrate, and its use as a reroofing and recover product has grown. The examples provided herein show why and how lightweight insulating concrete systems are used to solve many reroofing problems, such as providing slope-to-drain, correcting surface irregularities, and avoiding disruptive tear-off and asphalt fumes.

There are other significant characteristics of lightweight insulating concrete that could easily be the subject of another paper. These characteristics include high wind uplift resistance, fire resistant design flexibility, re-roofability, longevity, and the positive impact of lightweight insulating concrete on membrane life.

By offering solutions for chronic roof problems, lightweight insulating concrete represents another time-proven and field-proven tool to deliver significant benefits to building owners.



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Herb Cannon, a registered architect and member of the AIA and RCI, is president of The Cannon Group located in Mt. Laurel, NJ. Cannon has been involved as a roofing consultant since 1982 with the establishment of his own firm and has worked in architectural firms since 1970. His experience with lightweight insulating concrete started in the mid-1970s on new construction projects. Since the early 1980s Cannon has worked on hundreds of reroofing projects, many of which were designed using lightweight insulating concrete. Herb can be contacted at hjcannon@cannon-roof.com.



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