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SPECIAL CONVENTION ISSUE

RECYCLING OF THERMOPLASTIC PVC ROOF MEMBRANES

BY S.P. GRAVELINE

The drive toward ever more sustainable construction practices continues to gain momentum in all segments of the construction industry. Voluntary measures such as Energy Star, LEED, Green Globes, and legislative initiatives such as California's Title 24 energy bill are having a noticeable impact on the way buildings are being constructed. In the roofing industry, efforts to date have been focused on saving energy and reducing the urban heat island effect. The increased use of thermal insulation, air barriers, and highly reflective roofing materials (*Figure 1*) is reducing the ecological impact of roofing systems throughout their life cycles. Many materials used today are durable and can be expected to provide decades of service. A longer life cycle fulfills a key tenet of sustainable design: use materials with a long life expectancy in order to minimize raw material and processing energy consumption.

But not even the best material lasts forever: all products will get to a point where they can no longer effectively perform their intended function of protecting the occupancy from the elements. Eventually, all roofing membranes need to be replaced.

Figure 1 – Energy-efficient roof membrane.

Traditionally, roof replacement has meant massive amounts of material being sent to landfills. In the past, this was viewed as an accepted practice. However, with a growing population generating ever-increasing quantities of garbage and a limited amount of available space to landfill the waste, this practice cannot be sustained. In fact, many larger metropolitan areas have already filled their local landfill sites. Their only short-term solution is to truck, train, or barge their waste long distances to remote disposal areas at great cost, further burdening the environment.

Some major cities, such as Boston and Chicago, in efforts to slow the fill rate of their sites, are enacting legislation to prohibit and/or heavily tax the disposal of construction materials. Currently, such initiatives are aimed at massive, bulky materials like masonry and drywall. It is reasonable to expect that, over time, these measures will be applied to more and more construction materials. Even in areas where there are no formal bans on disposing such products, costs to do so are rising dramatically, particularly in large urban areas. The next frontier on the drive to sustainability is clearly the recycling of construction materials.

Some companies have been recycling thermoplastic membranes for years. For more than a decade, manufacturers have been recycling their production trimmings and scrap into high-value products. One manufacturer, for example, had the material cryogenically pulverized into a powder, which was then used to fabricate injection-molded walkway pads. Over the years, millions of pounds of material were diverted from the waste stream and converted to a top-quality product with a life expectancy equal to that of the roof membrane.

With the newest generations of production equipment, these same scraps, trimmings, etc. can be recycled directly back into new membrane. Typically, the backside of membranes produced on these lines will contain between 5% and 15% of recycled material. The recycled product is only placed into the backside, as significant color variations can occur that would be unacceptable on the exposed surface of the sheet. For example, the backside of one manufacturer's product will vary among shades of grey, with the occasional faint blue or green tint, depending on the color of the recycled membrane. The process is so efficient that the company had to discontinue the production of the walkway pads, as all scrap is now recycled directly back into new membrane. More than three million pounds of materials were recycled in this manner in 2006 alone.

With state-of-the-art grinding equipment, the backing material of felt-backed membranes can be separated, allowing the thermoplastic sheet to be recycled – something that was not possible just a couple of years ago. The equipment is also capable of extracting the encapsulated scrim reinforcement from the polymer matrix. The polyester is subsequently used as a fibrous filler in the fabrication of concrete barriers for roads and highways. Using the most current technology allows for essentially a 100% raw material conversion rate: there is no waste.

Such developments have been tremendous successes. However, the ultimate objective (and the area in which the greatest impact will be achieved) is the recycling of roof membranes at the end of their life expectancy. Even off-spec product from the production of new membrane is clean, relatively homogeneous, and of known composition. In contrast, aged materials are dirty, have been exposed to any number of environmental contaminants, and, after decades of service, have deteriorated to some degree. This presents numerous challenges in recycling the product into new materials.

In the early 1990s, "Arbeitsgemeinschaft fur PVC – Dachbahnen Recycling" (AfDR) was formed by a group consisting of the leading European PVC membrane man-

Figure 2 – Marriott Long Wharf with new roof.

Figure 3 – Roofing membrane under PMR system.

ufacturers. The association funded the construction and operation of a facility in Germany for processing PVC roof membranes at the end of their service lives. Once processed, the materials were returned to the original manufacturer, who then used them in a variety of applications, including as feedstock for producing new membranes. Much in the same manner as is currently done with scrap, the material was integrated into the backside of the sheets, albeit at slightly lower concentrations. The first membranes produced using this recycled material are now more than a decade old, and no differences in performance relative to materials produced exclusively with virgin raw materials have been observed in the field.

The manufacturers' trade association, the European Single Ply Waterproofing Association (ESWA), has taken over the coordination and management of the industry's recycling efforts and AfDR has been disbanded. ESWA is investigating new processes that allow even greater flexibility in the use of the collected materials and potentially higher loadings in finished membranes. They are working with Interseroh, a large European recycler of various goods, on a pan-European collection system to develop an efficient, cost-effective logistics chain for getting the material from a roof to various recycling centers.

Here in America, post consumer recycling of PVC roof membranes started in 1999. A Massachusetts recycling company working with a PVC membrane manufacturer developed a paving repair material using a mixture of old PVC roofing membranes and a variety of other recycled products. Although the product has been a success, the potential consumption of PVC membrane is very modest.

Building upon the experience of its European parent company, one firm has started to recycle old PVC membrane domestically. The company's

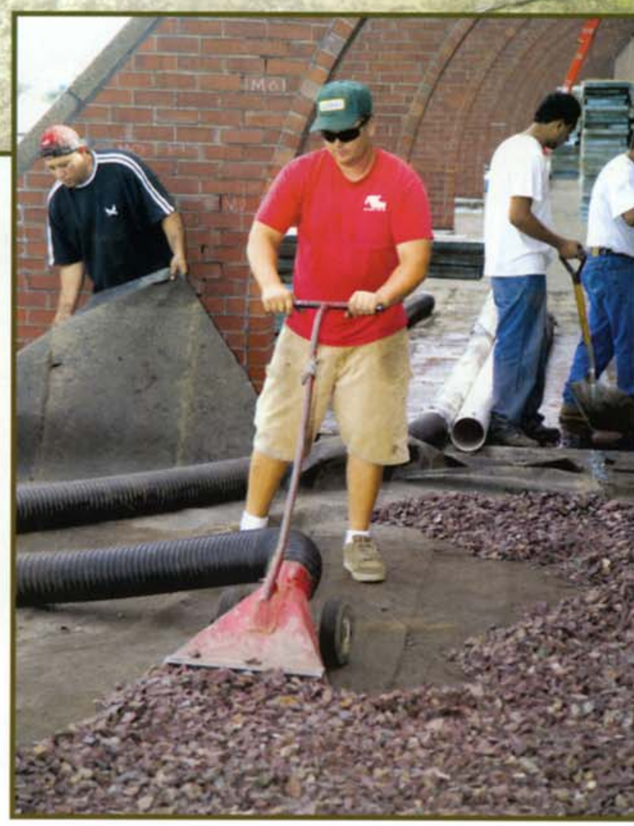

Figure 4 – Ballast being removed for re-use.

Figure 5 – The extruded polystyrene was re-used at other locations.

Figure 6 – Preparing the membrane for shipping.

experience with the Marriott Long Wharf hotel (*Figure 2*) re-roof in Boston best demonstrates the feasibility of the process.

The architecturally striking hotel has long been a Boston landmark. In 1984, the owner commissioned a complete re-roof in an effort to address constant leaking at each of the three tiers of roof surfaces on all sides of the building. Unfortunately, this did not solve the problem, and in 2005, after various attempts at quick fixes, it was decided to address the real issue: a lack of through-wall flashing in the masonry construction. The PVC membrane used (*Figure 3*) in a protected membrane (PMR) configuration on the project was still in excellent condition at 21 years old. Despite the fact that it still retained more than 70% of its original plasticizer content, it was decided that with the scope of work related to the masonry and the magnitude of flashing work to be completed, it would be prudent to replace the roof as well. This would establish a continuum of the building envelope to assure the desired level of performance.

Figure 7 – PVC membrane being ground for recycling.

The roof consultant and the owner were interested in recycling as much of the roof as possible. The project team – consisting of the contractor, the membrane manufacturer, and a local recycling company – developed a strategy to re-use or recycle all components of the existing roof assembly. The ballast (*Figure 4*) was sent to a landscaping company for re-use. The extruded polystyrene (*Figure 5*) was likewise sold for re-use in other applications such as insulating agricultural buildings.

The membrane was cut into nominal three-foot widths, rolled up, and stacked (*Figure 6*). It was sent to the recycling company where it was fed along a conveyor system with powerful magnets that screened for fasteners and other metallic objects. The material was then processed into a fine powder (*Figure 7*).

During trials with this material and feedstock from other projects, the manufacturer was able to successfully integrate very significant amounts of recycled material into thick walkway protection membranes. Subsequent trials have validated the approach.

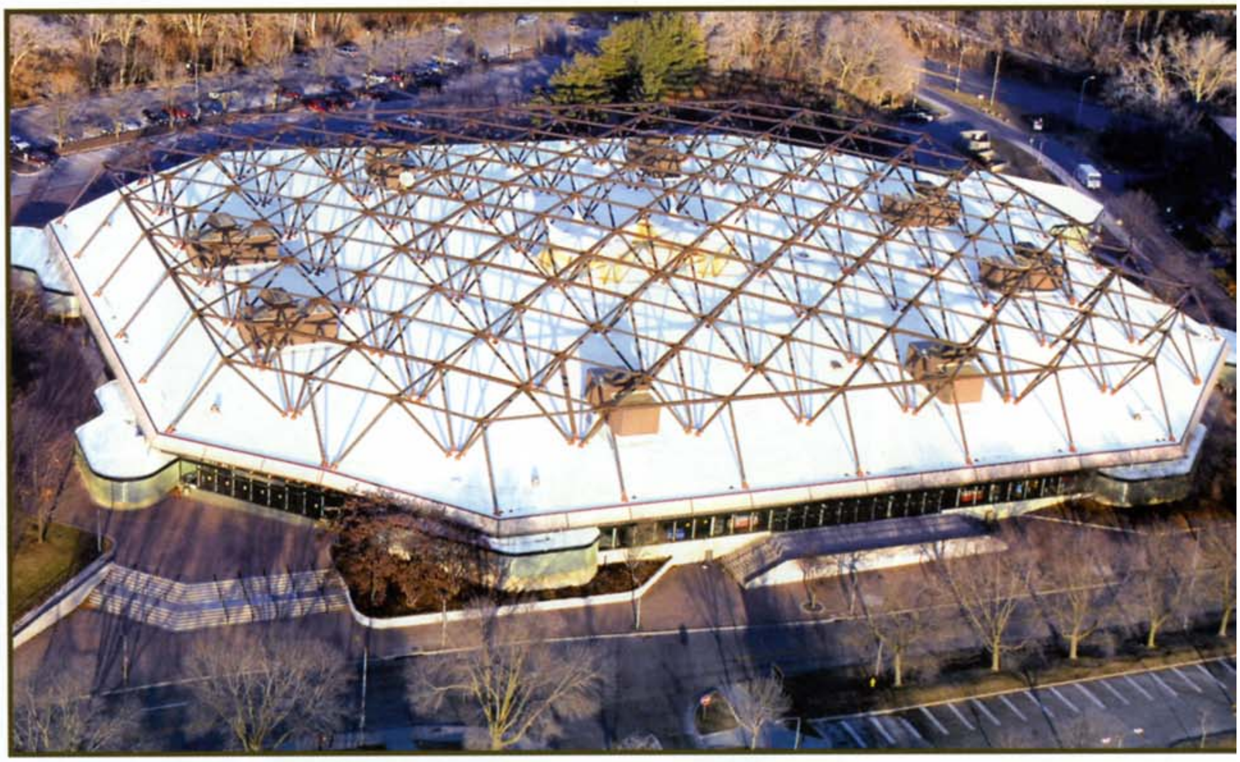

Figure 8 – Carver Hawkeye Arena with new roof.

Having completed a number of projects, the greatest challenge has been found to be the logistics rather than the recycling. Close cooperation is required between all involved parties. Contractors must handle the material a little more than they would normally to segregate it from the other waste and prepare it for shipping. The material must then be shipped to the recycler for the prelimi-

Figure 9 – Old membrane packaged in dumpster for shipment.

nary grinding stages prior to being supplied to the membrane manufacturer.

The experience has, however, been very positive for all parties. On the Marriott project, the contractor estimates that recycling the membrane and the insulation saved approximately 25% of the price it would have cost to dispose of the materials. Although additional handling labor was required, it was minimal relative to the overall savings realized.

Not surprisingly, freight becomes an important factor in the economics of the process as the projects get farther away from the recycling company and the membrane manufacturer.

The most recent recycling project was the University of Iowa's Carver Hawkeye Arena (*Figure 8*). This 158,000-square-foot, mechanically attached PVC roof had been in service for 25 years. This past spring, the campus was struck by a severe storm accompanied by tornados, resulting in damage to the roof covering. The university felt the most prudent course of action was to replace the roof. The campus actively recycles a wide variety of materials, and officials were receptive to the prospect of recycling the large amount of membrane to be removed.

In light of the distance, it was decided to have the membrane ground locally (*Figure 9*), thereby minimizing the volume of the material to be shipped. Doing so saved a significant amount in freight costs. Working in this manner, the concept was found to be economically viable, even at such a great distance between the project and the membrane production facility.

To date, the bulk of the recycled material has gone into the production of protective walkway membranes. The schedule on the Hawkeye project actually allowed for some of the material to be processed into the walkway being installed on the building – the ultimate complete loop. The next phase in scaling up the program is integrating the recycled material into regular roofing membranes. Based on the European experience and the results of the early trials, no significant problems are foreseen. Work has already begun on the next major development effort.

At this time, only loose-laid membranes (mechanically attached, inverted, ballasted) have been processed both here and in Europe. Work is underway to develop a process for working with membranes that are adhered to various substrates. This presents significant technical issues, and a solution will likely take some time to evolve.

These developments bring PVC membranes to a new level of sustainability, one never achieved before in the roofing industry. Decades of proven performance, low maintenance, highly reflective, energy-saving membranes, and the ability to recycle material at the end of its service life provide designers, building owners, and contractors with a powerful combination to meet even their most ambitious sustainability targets.

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