SINGLE PLY MEMBRANE ROOF SYSTEM

INTRODUCTION

Since the late 1950s, the roofing industry has experienced a series of changes. With the advent of plastics, the technology for roof coverings has changed from using tar and asphalt-covered felt to using Polyvinylchloride (PVC), Ethylene Propylene Diene Monomer (EPDM), Chlorinated Polyethylene (CPE), or other plastics along with modified bitumen as a covering. A single ply membrane roof system includes deck material, insulation and a single ply membrane. This system can be installed either with the membrane placed over the insulation, barrier board and roof deck, or with the membrane installed between the barrier board and exposed insulation (this method is known as an inverted roof system).

The three methods of securing single ply membrane roof coverings are:

- **Fully Adhered** - An adhesive is applied in strips over the entire top of the insulation board to secure the membrane to the insulation. This method of securing does require some kind of protective coating or additive to protect the membrane from deterioration by the ultraviolet rays of the sun.
- **Mechanically Fastened** - Nails, rivets, screws, and other types of fasteners are used to secure the membrane to the roof deck through the insulation. This method of securing does require some kind of protective coating or additive to protect the membrane from deterioration by the ultraviolet rays of the sun.
- **Loosely-Laid Ballast** - The membrane is secured to the exterior wall, parapet or roof deck around the edges and penetrations, then stones are placed on top of the membrane or insulation to secure them. In most cases, the stones are a major factor in achieving a Class A fire-rating for the roofing. The structural design should take the additional weight into consideration as a dead load and have a factor of safety included to compensate for the scouring (stones blowing away from one area and accumulating in another) in high winds.

The three material types used in a membrane roof are thermoplastics, thermosets and modified-bitumen, each of which have their advantages and disadvantages.

- Thermoplastic membranes will soften and weaken when heated but will harden and regain their strength as they cool. Plasticizers have to be added to PVC to make it pliable. These plasticizers could be degraded by ultraviolet (UV) rays, oils and animal fat, causing the membrane to break down.
- Thermoset membranes will harden when heated and remain hard and rigid even if it is cooled. One of the first types of thermoset plastics used was neoprene. Neoprene resists oils and animal fats but will also be degraded under UV rays and some acids, peroxides and solvents. The most common thermoset plastic used today is EPDM. While UV rays do not affect EPDM,

it is combustible and is susceptible to damage by lighter petroleum products. To reduce the combustibility, it is covered with hypalon (chlorosulfonated polyethylene) and sand, or a halogenated retardant is mixed into the compound during manufacturing.

- Modified-Bitumen (also known as Modified-Asphalts) is an asphalt base modified by additives that make the membrane more elastic, durable and waterproof. The membrane is reinforced with either glass fiber batting or a polyethylene sheet (called a “standard sheet”), or is aluminum-faced. The standard sheet type of membrane requires a covering to protect it from UV rays. This could be accomplished with crushed stone either loosely laid on a glass fiber mat or imbedded in a bituminous asphalt emulsion.

POSITION

General

Use only roof assemblies and components that have been listed by a nationally recognized testing laboratory for internal and external fire exposure and wind uplift. For ballasted roof systems, the listing for uplift can be omitted, provided the ballasting is in accordance with this section.

For fully adhered and mechanically fastened roofs, refer to the manufacturer’s instructions for the spacing or area covered of the fasteners and quantity of adhesives. The instructions will indicate the number of fasteners or amount of adhesive required in the field or main portion of the roof, perimeter and corners.

The perimeter is calculated as 10% of the least roof dimension or 40% of the building height; whichever is smaller, but never less than 4 ft (1.2 m). For example, if the roof is 50 ft × 150 ft (15 m × 45 m), 10% of the least dimension is 50 ft × 0.1 = 5 ft (15 m × 0.1 = 1.5 m). If the building is 30 ft (9 m) high, 40% of the building height is 30 ft × 0.4 = 12 ft (9 m × 0.4 = 3.6 m). The perimeter would then be the area 5 ft (1.5 m) in from the edge. The corner is the area where the two perimeters intersect.

In all cases, secure the first layer of insulation to the roof decking with listed fasteners. For ballasted roof systems, use two or three fasteners per insulation board to keep the board in place in case of excessive scouring. Without the fasteners, the boards may move. If this occurs, the membrane will have to be sliced open, the boards replaced and the membrane patched.

If the membrane is used over an existing asphaltic roof, install a layer of insulation or a barrier under the membrane to avoid chemical interaction between the membrane and asphalt.

Fully Adhered Securing Method

Uniformly spread the adhesive on the surface of the insulation and the bottom of the membrane, or spread it as required by the manufacturer. Adhesives require a cure or set-up time before the membrane is allowed to be rolled out over the roof. Once the membrane is rolled out, remove all folds and wrinkles. Secure the laps with either a solvent or heat weld, depending on the manufacturer’s specifications. Adhere all penetration openings, such as in pipes, equipment supports and drains.

Mechanically Fastened Securing Method

Secure the membrane to the decking with listed mechanical fasteners. Secure the laps and penetration openings with either an adhesive or solvent, or heat welded in accordance with the manufacturer’s specifications.

Loose-Laid Ballasted Method

Secure the perimeter and all penetrations before adding ballast stones. Use only clean, smooth, well-rounded river bottom gravel (no pea stones) of 1 to 2 in. (25 to 50 mm) nominal diameter that meets the graduation requirements of Standard Size No. 3 for Course Aggregate in accordance with ASTM D448-1980. These requirements allow amounts (weight %) listed in Table 1 to pass through the sieve openings.

To determine the amount of ballasting required on a ballasted roof system use the following three steps:

1. Determine the uplift pressure on the roof using the requirements in PRC.2.0.1.1.
2. Determine the group from Table 2 based on the uplift pressure. These groups represent a range of uplift pressures necessary to determine the amount of ballasting necessary to prevent the roofing system from failing. For roof systems with a UL or FM wind uplift rating, the groups can be determined using Table 3.
3. Use the quantity of ballast indicated in Tables 4 through 9 depending upon the ballast materials, deck construction and parapet. Apply the ballast not less than 10 lbs/ft^2 (48 kg/m^2). Paving blocks can be either unsecured or secured to one another. Securing blocks can be accomplished by straps, beveled edges or tongue and groove construction.

Conduct periodic roof inspections to determine if any ballast has been scoured or washed away. If there is any evidence of scouring, redistribute the stones and add additional stones if necessary.

Take extreme care when loading the roof with ballasting stone as not to allow too much stone to accumulate in one area. Too much stone in one area could cause roof collapse. Distribute the stones evenly as they arrive to the roof.

TABLE 1
Standard Size No. 3 Sieve

Sieve Opening in.	Weight %
2½	100
2	90 to 100
1½	35 to 70
1	0 to 15
¾	- - - - - -
½	0 to 5

SI Units: 1 in. = 25.4 mm

TABLE 2
Group Determination Based On Uplift Pressure

Group	Uplift Pressure lb/ft^2
A	<15
A+	15 to 20
B	20 to 25
C	25 to 30
D	30 to 35
E	35 to 45
X	> 45

SI Units: 1 lb/ft^2 = 0.45 kg/m^2

TABLE 3
Group Determination Based On UL or FM Ratings

UL or FM Rating	Group
30	A
60	A+, B,
90	C
120	D, E
150	X

SI Units: 1 lb/ft^2 = 0.45 kg/m^2

TABLE 4
Weight Of Stones Needed With Less Than A 2 ft Parapet

	Ballast Weight lbs/ft^2					
	Insulation & Pre-cast			Cementitious		
Group	Main	Perimeter	Corner	Main	Perimeter	Corner
A & A+	10	12	15	10	10	10
B	12	15	15	10	12	12
C	12	15	18	12	12	15
D		NOT ALLOWED		12	15	18
E		NOT ALLOWED		15	18	21

SI Units: 1 ft = 0.305 m; 1 lb/ft^2 = 0.45 kg/m^2

TABLE 5
Weight Of Stones Needed With Greater Than A 2 ft Parapet

	Ballast Weight lbs/ft^2					
	Insulation & Pre-cast			Cementitious		
Group	Main	Perimeter	Corner	Main	Perimeter	Corner
A & A+	10	10	12	10	10	10
B	12	12	12	10	10	12
C	12	12	15	10	12	12
D	12	15	18	12	12	15
E		NOT ALLOWED		12	15	18

SI Units: 1 ft = 0.305 m; 1 lb/ft^2 = 0.45 kg/m^2

TABLE 6
Paving Blocks With Less Than A 2 ft Parapet, Blocks Not Secured

	Ballast Weight lbs/ft^2					
	Insulation & Pre-cast			Cementitious		
Group	Main	Perimeter	Corner	Main	Perimeter	Corner
A	12	12	15	12	12	12
A+	12	15	20	12	12	15
B	12	18	25	12	15	18
C	15	23	30	12	18	21
D		NOT ALLOWED		15	21	24
E		NOT ALLOWED			NOT ALLOWED	

SI Units: 1 ft = 0.305 m; 1 lb/ft^2 = 0.45 kg/m^2

TABLE 7
Paving Blocks With Greater Than A 2 ft Parapet, Blocks Not Secured

	Ballast Weight lbs/ft^2					
	Insulation & Pre-cast			Cementitious		
Group	Main	Perimeter	Corner	Main	Perimeter	Corner
A	12	12	12	12	12	12
A+	12	12	15	12	12	12
B	12	15	18	12	12	15
C	12	18	21	12	15	18
D		NOT ALLOWED		15	18	21
E		NOT ALLOWED			NOT ALLOWED	

SI Units: 1 ft = 0.305 m; 1 lb/ft^2 = 0.45 kg/m^2

TABLE 8
Paving Blocks With Less Than A 2 ft Parapet, Blocks Secured

	Ballast Weight lbs/ft^2					
	Insulation & Pre-cast			Cementitious		
Group	Main	Perimeter	Corner	Main	Perimeter	Corner
A	12	12	12	12	12	12
A+	12	12	15	12	12	12
B	12	15	15	12	12	12
C	12	15	18	12	12	15
D	15	18	21	12	15	18
E	NOT ALLOWED			12	18	21

SI Units: 1 ft = 0.305 m; 1 lb/ft^2 = 0.45 kg/m^2

TABLE 9
Paving Blocks With Greater Than A 2 ft Parapet, Blocks Secured

	Ballast Weight lbs/ft^2					
	Insulation & Pre-cast			Cementitious		
Group	Main	Perimeter	Corner	Main	Perimeter	Corner
A, A+, B & C	12	12	12	12	12	12
D	12	15	18	12	12	12
E	12	18	21	12	12	12

SI Units: 1 ft = 0.305 m; 1 lb/ft^2 = 0.45 kg/m^2

DISCUSSION

The loosely-laid membrane roofing system is different from the conventional built-up, adhered and fastened systems. The loosely-laid system acts as a single unit since it is essentially secured at the perimeter. As a result, it tends to average out localized areas of concentrated uplift. The uplift is a result of winds crossing over the roof and turbulence creating a low pressure on the top of the roof. Winds that enter the building via cracks, open windows and doors create a high pressure in the building; the pressure then tries to equalize and passes up through the metal deck, creating bubbles in the membrane. If there is a cementitious cover on the metal deck, the force that passes through is low. If there are insulation batts between the metal deck and membrane, the uplift pressure will be greater. As the winds and uplift pressure lift the membrane, the stones will be displaced and collect at the leading edge of the bubble. As the stones collect, the weight will balance the uplift force and the spread of the bubble will stop. A mixture of small and large stones will minimize the extent of scouring and also act as a barrier to protect the membrane from UV rays, and increase the fire-rating of the system.

The membrane is available in widths up to 24 ft (7.3 m). Depending on how it is secured, the membrane is rolled out with a portion overlapping. The laps can be fastened to the roof deck to accomplish a fully fastened roof system, and then seamed together to form a single-ply membrane cover. The seams for the modified-bitumens are sealed with a special joint compound and sealer or the heat from a torch. Caution must be taken to prevent overheating and fires if the torch heating method is used.