

Elastomeric Membrane Installations in Parking Garages (1992)

INTRODUCTION

The performance of elastomeric membrane systems in protecting parking garage decks from moisture and chloride ion penetration depends on two critical aspects: the material properties of the membrane system used, and the conditions at the time of installation, whether for repairs or new construction.

National Research Council Canada undertook a two-phase project in the early 1990s to develop guidelines to assist designers and specifiers with the process of selecting parking garage membranes, and engineers and others in installing them. Phase I looked at chemical, physical and mechanical factors affecting performance. This highlight summarizes Phase II, which assessed the influence of installation factors on performance.

More specifically, Phase II investigated the effects of different curing humidity and temperature levels; the effects of poor mixing, incorrect proportioning of the components, and mixing and placing at temperatures below that stipulated by the manufacturer; and the effects of surface preparation and the application technique itself.

RESEARCH PROJECT

Field samples were obtained during installations using five of the products tested in Phase I:

1. Urethane—two component, solvent-borne (manufacturer A)
2. Urethane—two component, solvent-borne (manufacturer B)
3. Urethane—one component
4. Epoxy-urethane—two component, solvent-borne
5. Neoprene—one component, water-borne

A literature review, interviews with applicators, manufacturers and owners of parking garages, and site visits by technical staff provided information on installation practices. After collating the key installation parameters that influence membrane performance, the researchers designed an experimental program to verify the effects cited in the literature and observed in the field by technical staff.

In testing the effect of ambient weather conditions, five climatic variations, considered representative of the varying conditions under which membranes are installed, were chosen. Three involved a constant temperature of 22°C with varying relative humidity (RH) at 30 per cent, 50 per cent and 85 per cent. For the other two variations, humidity was kept at 50 per cent RH with temperatures set at 5°C, 22°C and 38°C.

Workmanship factors were investigated by blending the resin and hardener, or catalyst, for one-third of the manufacturer's recommended mixing time. Incorrect proportioning was achieved by preparing samples with 15 per cent more resin, or hardener, over a manufacturer's recommended mixing ratios. Ease of application and the ability to achieve proper membrane thickness was tested by mixing and placing membranes at ambient temperatures of 5°C, 22°C and 38°C.

Water-jet blasting, sandblasting and shotblasting were evaluated to determine the effect of different surface preparations. Water-jet blasting gives the smoothest surface; sandblasting gives a lightly textured surface; and shotblasting gives a coarsely textured surface, resulting in the greatest variation of all three in surface profile. Substrate surface moisture conditions were also investigated. Wet surface conditions were created by saturating concrete slabs in water for 24 hours and then allowing the substrate to achieve a saturated surface dry condition before applying the membrane or primer.

RESULTS

In general, the variation of humidity during curing, with a constant temperature, affected tensile properties (tensile strength, elongation, energy to rupture and modulus of elasticity). These properties changed more with high humidities than low ones. Long-term elongation, however, was found to be insensitive to relative humidity variation.

Ambient temperature variations, with constant relative humidity, affected the rate and extent of membrane curing in the early stages, specifically during the first seven days. Thereafter, for most membranes, little change was observed in tensile properties.

Deviations from manufacturers' stipulated mix proportions also resulted in considerable changes in tensile properties, especially at early ages. Incorrect mixing proportions using excess resin appeared to have no effect on membrane adhesion. However, when excess hardener was used, shotblasted surfaces had lower adhesion values than either sandblasted or water-jet blasted surfaces. Poor mixing of membrane components resulted in effects similar to those for incorrect proportions. Certain membranes, when layered more thickly than recommended, had a tendency to foam. Also, use of very thin membranes with coarsely textured shotblasted surfaces appears inadvisable.

Table 1 Effect of surface condition on adhesion to concrete (MPa)

Membrane	Dry substrate			Wet substrate		
	Shotblast	Sandblast	Water jet	Shotblast	Sandblast	Water jet
Product 1	2.84	3.91	3.50	0.73	0.83	1.54
Product 2	2.78	2.98	2.48	2.20	3.14	3.79
Product 3	2.34	3.83	2.74	1.25	1.99	3.28
Product 4	2.57	3.04	2.73	2.05	2.68	2.87
Product 5	1.94	2.92	3.48	1.58	1.69	3.04

Viscosity values, which are dependent on the application technique, can adversely affect the properties of the finished product and membrane thickness. Low temperatures increase viscosity, and they appeared to have a greater impact than high temperatures on application properties.

The permeance of some membranes, and hence their waterproofing capabilities, were seriously affected by temperature and humidity changes. Permeance increased when curing at high humidity levels, with a standard temperature, and at both low and high temperatures with humidity constant. Permeance only decreased in low humidity conditions.

Table 2 Effect of humidity and temperature levels on permeance

Membrane	Permeance (10 ⁻⁷ g/Pa·s·m)					
	Humidity			Temperature		
	30% RH	50% RH	85% RH	5°C	22°C	38°C
Product 1	2.16	2.17	3.00	3.45	2.17	2.69
Product 2	2.07	2.50	3.11	2.83	2.50	6.15
Product 3	1.70	1.00	3.18	4.00	1.00	2.55
Product 4	1.98	1.43	1.58	1.63	1.43	2.06
Product 5	1.55	3.03	5.81	4.73	3.03	3.21

The interval between mixing and application affects the degree of adhesion to the concrete substrate. The optimal time interval after mixing proved to be less than 30 minutes. After that, large decreases in adhesion were noted. Also, the interval between coat applications can significantly influence intercoat adhesion, with problems arising if the interval is too long.

CONCLUSIONS AND RECOMMENDATIONS

Since elastomeric membranes in parking garages are subject to drastic thermal variations, it is important that the desired properties of the installed product are achieved through proper installation procedures and strict adherence to manufacturers' preparations and installation recommendations. Poor on-site practices and an indifference to quality control during installation will likely result in questionable performance, with premature material deterioration being one of the most frequent and serious problems occurring. Any resulting defects become weak sites in the membrane. Manufacturers' specifications need to be followed to keep defects to a minimum.

Waterproofing membranes must adhere well to concrete. A minimum surface profile of 0.2 to 0.4 mm (8 to 10 mils) is required to remove oil and stubborn surface contamination. Sandblasting is not permitted in many closed areas due to the large amounts of dust generated. Shotblasting creates a fractured surface with a large profile and one which is susceptible to delamination. Use of very thin membranes on shotblasted surfaces requires careful review.

The influence of ambient weather conditions on the application properties of a given membrane should be ascertained in advance of installation. Such properties include viscosity, flow characteristics, pot life, curing, continuity of film formed and coverage per coat.

During application, samples of the film should be made by spraying the film on an appropriate base and taking coupons from it for tensile property tests. The quality of the installed product and the effectiveness of the mixing and spreading can then be assessed.

Previous research shows that the crack bridging test is insufficient in determining a membrane's ability to prevent moisture and chloride ion penetration. Membranes passing this test are still subject to reflective cracking in the field. Such failure is probably due to defects incorporated into the membrane by substrate movement during early curing. When elastomeric membranes are applied in temperatures below those specified by the manufacturers, they are likely to be subjected to movement. Proper application temperatures are imperative for good membrane performance.

Specifications should define the type of membrane required and the quality of the installed system. They should state the thickness of the membrane to suit in-service conditions; limitations and requirements imposed by weather conditions during application; concrete quality and finishes appropriate to the membrane being used; and a requirement for a test area of sufficient size to allow for a valid appraisal of the installation. It should also be stipulated that the garage is not to be subjected to vehicular traffic prior to proper curing of the membrane.

Research Highlight

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