

Effective Installation of Membranes on Parking Garage Decks

by N.P. Mailvaganam and P.G. Collins

This Update discusses how the preparation of the substrate, prevailing ambient conditions and application practices affect the performance of membrane systems installed on concrete decks in parking garages.

The concrete deck in parking garages must be protected against the ingress of water and chloride ions. Ingress can lead to corrosion of reinforcement and eventually to serious degradation of the deck, even structural impairment. The standard protective measure is to install an elastomeric waterproofing membrane system (Figure 1).

The effectiveness of the membrane system in restricting the ingress of water into the concrete deck depends not only on its material properties but also on how well it is installed. Poor on-site practice and an indifference to quality control during installation often produce a final product of dubious performance and durability.

Application problems usually lead to pronounced defects that will act as weak areas during the membrane's service life.^{1,2} Defects can be present in numerous forms: blisters, uneven colouring, craters, surface pinholes, delaminations, and uncured (wet) areas. These defects usually lead to deterioration of the deck.

A typical waterproofing membrane system consists of a series of coats or layers. First, the primer or sealer, which promotes adhesion of the



Figure 1. Application of an elastomeric waterproofing membrane system by spraying and back rolling

membrane to the concrete; next, the waterproof membrane itself, which bridges cracks and prevents the ingress of chloride ions and water; then comes the wear coat, which contains embedded aggregate to provide abrasion resistance and prevent wear of the membrane; and finally, the tie coat, which bonds the aggregate firmly to the wear coat.

The types of coatings used in membrane systems include the following: one-component polyurethane; two-component polyurethane; two-component epoxy-urethane and one-component water-based neoprene.

Variations in chemical composition and mix ratios in the different membrane systems govern the application characteristics and the degree of sensitivity to site factors.

An IRC/industry consortium project conducted in the 1980's found extensive deterioration of concrete decks in parking garages across Canada. The study led to recommendations for the improved design of these garages to provide better protection against moisture and chloride ions.

For an overview of elastomeric membranes, readers can consult the article, "An Elastomeric Membrane System for Parking Decks," Construction Practice (available on the IRC Web site).

Factors Affecting Membrane Systems

The main guide for the proper application of a membrane system is the manufacturer's instructions. Problems arise when these instructions are ignored for the sake of expediency.

The problems that affect the performance of waterproofing membrane systems can be summarized under three categories. These are:

- 1) application factors: mixing of components at cold temperatures, poor mixing of the components, incorrect proportioning of the components, and delayed application of the mixed components;
- 2) substrate conditions: moisture in the substrate and poor surface preparation;
- 3) ambient weather conditions: variations in humidity and temperature.

Figure 2. Effect of temperature on the viscosity of a typical two-component waterproofing membrane system. Viscosity influences the effectiveness of spraying and other key characteristics such as levelling and the sloughing of the material sprayed on vertical surfaces. The drastic effect that low temperature produces is shown in the increased viscosity (cohesion) obtained at 10°C.

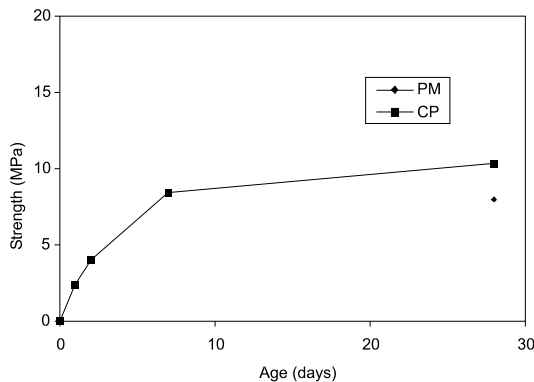
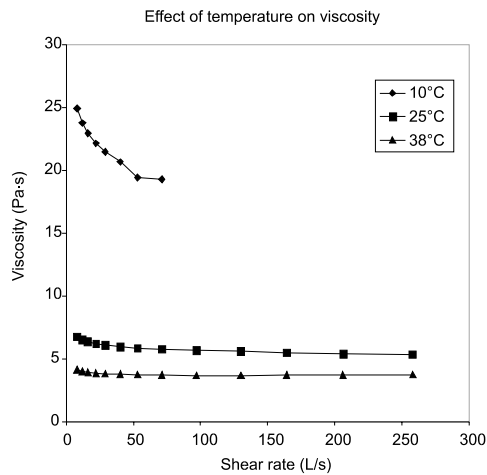


Figure 3. Effect of poor mixing on the tensile strength development of a typical waterproofing membrane system. The effect is illustrated by comparing an extreme case of poor mixing (PM) to that of a correct proportioning (CP) procedure. The cure of the poorly mixed sample was so retarded that the strength value could not be recorded until 28 days had elapsed.

IRC research, consisting of both field investigations and laboratory studies, has led to a new understanding of the effect of the above factors. Some practical guidelines are presented below.

Application Factors

Mixing at cold temperatures. Many applicators store the coating components overnight in trucks and mixing at cold temperatures is not infrequent. Cold temperatures affect membrane installation more than high temperatures. At cold temperatures the increase in viscosity causes improper mixing, making it more difficult to apply the membrane system and to achieve the desired coating thickness for each of the layers; both proper mixing and application are critical to achieving good waterproofing characteristics. The response of coating components to temperature variation is shown by the extent to which the viscosity of the membrane system changes (Figure 2).

Poor mixing. In the field, poor mixing of the components is common. This is often the result of using mixers with poor mixing action. The manufacturer's mixing instructions stipulate that the addition of the resin (polymer) and hardener (the chemical that initiates the polymerization) components should occur at the commencement of the mixing cycle. In practice, however, the hardener component is sometimes added halfway through the mixing cycle. Furthermore, in many instances the manufacturer's stipulated mixing time is not adhered to. Such mistakes increase the permeance of the membrane coat, allowing greater ingress of water and chloride ions.

The effect of poor mixing on the development of early mechanical properties (tensile strength and elongation capability) of some membranes can be drastic: some may not reach the desired tensile strength for 28 days (Figure 3). The membrane system is often subjected to considerable stress from post-installation construction activity of other trades, and if it has not been able to develop any strength because the components are reacting very slowly, serious damage to the membrane system can occur. Foot traffic and the dragging of items across the poorly cured coating, for example, can damage the membrane system, promoting deterioration.³

Incorrect proportioning of the components. Two-component membrane products are formulated with controlled proportions (CP)

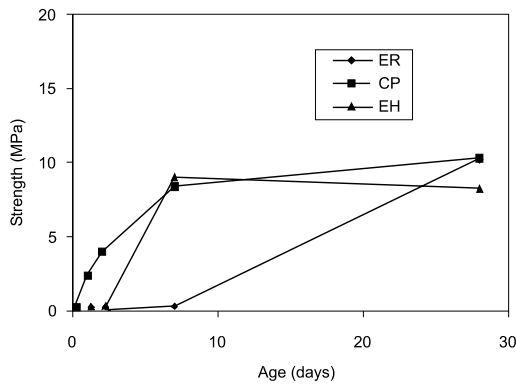


Figure 4. Effect of incorrect proportioning of the resin and hardener components on the tensile strength development of a typical waterproofing membrane. Both excess resin (ER) and excess hardener (EH) retard the development of tensile strength in comparison to that of the sample made with correct proportions (CP).

that govern the development of the designed properties. Incomplete decanting in the field, however, alters these proportions and either an excess of resin or hardener can be present. The presence of excess resin (ER) in the mix has more drastic effects (a greater increase in the permeance of the membrane coat) than the presence of excess hardener (EH). However, increased levels of the hardener component can result in severe retardation of the rate of tensile strength development for some coatings (Figure 4). Post-construction activity on the deck increases the potential for deterioration.

Delayed application. Most membranes are formulated to provide for an application time of up to 60 minutes after mixing. An undue delay between mixing the components and applying the membrane system to the concrete is a concern particularly in summer and when large batches are used. These conditions may shorten the “pot life” of the mix, causing poor sprayability and possibly reduced adhesion to the concrete.⁴

Substrate Condition

Presence of moisture in the surface of the concrete. Excess (>3% by weight) moisture in the concrete will reduce the adhesion of the waterproofing system. Two-component urethane and neoprene emulsion systems appear to be less sensitive to surface moisture than one-component urethane systems. Although in most cases only small decreases in adhesion have been noted, other poor practices may combine with the excess moisture to magnify its deleterious effects.⁵

Type of surface preparation. Different methods of surface preparation produce different surface profiles that affect the adhesion of waterproofing systems to the concrete substrate. Surface profiles should match the recommended thickness for the membrane coating. A mismatch between the surface profile and the required membrane coat thickness affects the coverage rate of the waterproofing system and results in parts of the system being either too thick or too thin. The installed product then has altered waterproofing and durability characteristics.

The best texture for achieving stipulated coating thickness and adhesion to the concrete substrate is produced by sandblasting and waterblasting; the former is restricted to outdoor use, however, because of the dust generated. Shotblasting can leave a fractured surface, which may cause the coating to debond.^{5,6}

Ambient Weather Conditions

Variation in ambient humidity at constant temperature.

Moisture plays a significant role in the curing of one-component urethanes and neoprene emulsions. Since this type of urethane uses moisture as a catalyst in the curing reactions, retarded cure can occur when the relative humidity is below 30%.^{7,8} The curing of the neoprene coating (which depends on evaporation of the water from the emulsion for film formation) is accelerated initially by lower relative humidity levels, but can later produce lower elongation capability.

The effects of varying humidity on the early development of physical and mechanical properties are varied. Those systems that exhibit increases in properties early on rarely see the increases continue over the long term. In the long term, curing at low humidity does not significantly affect the properties of most membrane systems, except for moisture-cured urethane. Curing at high humidity generally leads to a decrease in mechanical properties and adhesion, and an increase in permeance.

Variation in ambient temperature at constant humidity.

The temperature at which the membrane system is placed and cured has a great effect on the development of waterproofing characteristics and mechanical properties, because the rate of reaction (for multi-component systems) or the rate of evaporation of water (for the emulsions) is temperature dependent.

Generally, curing these systems at low temperatures such as 5°C has a greater effect on properties than curing at high temperatures such as 38°C. The retardation of cure at 5°C is so drastic for some systems that they are still liquid after 24 hours. The very slow rate of mechanical property development at early stages therefore leaves membrane systems very susceptible to damage from ongoing construction processes. In the long term, the overall characteristics of the system are not as developed as when cured under standard conditions (22-30°C); permeance is increased, and adhesion to the concrete substrate will be poor.

Practical Recommendations

- Follow the manufacturer's specifications on mixing and application
- Avoid mixing membrane components at low temperatures
- Pay careful attention to the proportioning of components when mixing
- Apply the membrane coat within 30 minutes after mixing
- Avoid excess surface moisture in the concrete before installing the membrane
- Sandblasting and waterblasting produce similar results for substrate preparation
- Shotblasting can leave a fractured surface, which should be removed to prevent debonding of the membrane system
- Consider alternative methods to shotblasting when a very thin membrane is to be installed
- Avoid applications in either high or low temperatures and in high humidity conditions
- Membrane systems should not be applied under low temperature/low humidity conditions, as they create more serious problems than do high temperature/high humidity conditions
- Avoid ambient temperatures outside the 10-28°C range and relative humidities outside the 30-70% range
- Avoid concrete deck temperatures and moisture contents exceeding 30°C and 3% (weight method), respectively
- Avoid a concrete surface profile that significantly exceeds the stipulated membrane coating thickness
- Avoid using low-viscosity materials on vertical surfaces and ramps
- Do not apply a membrane system if there is a prospect of rain occurring within four hours
- Avoid construction traffic on the membrane system, until proper cure is achieved

Summary

Three key elements affect the performance of elastomeric membranes for parking garage decks: application factors, substrate conditions and weather. Careful consideration of these elements is necessary to avoid jeopardizing performance. Adherence to the manufacturer's instructions is paramount.

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