Thin vs. Thick & When to PUMA in Underground Parking Structures

By Mohamed Hussein, P.Eng., BSS, Building Science Engineer, Morrison Hershfield Ltd.

The terminology "waterproofing membranes" is common in our industry. There are several types of waterproofing membranes with different physical properties and applications. Today, we're focusing on waterproofing membranes in underground parking garages, specifically on intermediate slabs between floors of a parking garage. Most of these structures are composed of cast-in-place concrete slabs. In these intermediate garage slabs, the waterproofing membrane is exposed to vehicular traffic, hence the term "traffic topping."

PROTECTING THE CONCRETE

The basic function of a waterproofing traffic topping system is to protect the underlying structure from water penetration, which can cause the embedded steel to corrode. Protecting intermediate garage slabs from water ingress is required in order to comply with the relevant standard *CSA S413-14 Parking Structures*. In Canada's cold climate, the traffic topping system serves to protect against water ingress and migration of deicing products. These chemicals typically contain chlorides that are prone to corroding materials. Once this chloride contamination reaches a certain concentration, corrosion can continue to form, even in areas without active water ingress. This ongoing corrosion and subsequent delamination lead to frequent repair programs and reduced structural capacity.

VEHICULAR TRAFFIC TOPPING SYSTEMS

Traffic toppings must withstand physical damage caused by vehicle traffic. It's essential the system has performance characteristics to resist dead loading, shearing forces, and abrasion from vehicles. Vehicular topping systems for suspended concrete slabs found in parking garages come in two basic types:

- **Thin systems:** These are typically elastomeric, cold-applied systems. They are commonly, but not always, made with polyurethanes. They consist of a base layer, which adheres to the concrete surface, and one or more "wear" coats. In these systems, the base coat layer has a minimum thickness, typically between 0.65 millimetres to 1.0 millimetres (25 to 40 mils), and the topcoats are each between 0.3 and 0.4 millimetres (12 to 15 mils) thick, depending on the manufacturer's requirements. Fine aggregates are broadcast into both the wear and top coats to add durability to the membrane and provide a slip-resistant surface. This is applied in 90 per cent of parking garages.
- **Thick systems:** These are the legacy systems initially used for waterproofing. The bottom waterproofing layer is a hot-applied, rubberized asphalt installed in two layers, utilizing a reinforcing polyester fabric or "fleece." The membrane is applied in two lifts, with a total thickness of approximately three millimetres (120 mils). The top traffic layer in this system is typically a hot-applied, mastic asphalt pavement. While hot, it resembles what you could call a "black milkshake." While cold, it resembles typical asphalt pavement without the coarse stone aggregate. It's usually applied in a thickness that ranges between 10 millimetres and 20 millimetres (400 to 800 mils). When finished, this system is up to 20 times thicker than a thin system.

COMPARING THE TWO SYSTEMS

How do these two systems compare when it comes to issues such as bridging cracks, traffic forces, chemical fluid leaks, and cost and maintenance? There are many things to watch for and take into consideration, including:

- Bridging cracks: The loss of moisture from fresh concrete results in a reduction in volume, which leads to drying shrinkage cracks. Water contaminated with salt reaches the reinforcing steel through cracks in the concrete. The waterproofing membrane must be able to bridge the formed cracks. The thick system is generally superior at bridging concrete cracks because of the rubberized membrane thickness. The thin system can effectively bridge minor cracks (less than 1.6 millimetres), but the thinner depth means it doesn't perform as well when dealing with wider cracks or those with active movement.

- Vehicular traffic forces: Withstanding forces exerted by vehicle tires is a key performance criterion for traffic topping systems. Parking garages often have high traffic volumes, sharp turns, and steep ramps; the thin system will wear sooner in these areas. Thick systems don't wear in the same way. Instead, mastic asphalt is susceptible to shearing when wheels are turned as a car stops—the damage occurs when the wheels are turned and the car is stationary. It tends to deform and corrugate.
- Vehicle chemical fluid leaks: Vehicles can be prone to leaking chemicals, like oil, gasoline, and coolant. These chemicals will accumulate, and, in the case of the thick system, will soften the traffic topping. Thin systems tend to have more chemical resistance to oil and chemicals.
- Colour and illumination: The colour of the traffic topping is incredibly important. The black colour of thick systems is light-absorbing and reduces lighting levels. In comparison, elastomeric thin systems are available in lighter colours that better reflect light. I have seen many dark garages where the garage appeared brighter once a lighter traffic topping was applied. In general, thick systems will require a higher lighting density per square foot.
- Cost, maintenance, and repairs: Asphaltic membranes can be more expensive to install than elastomeric systems. It has also become more difficult to find qualified tradespeople to install these products. Both systems require regular maintenance. Thin systems are easy to inspect to identify defective areas. Localized repair is as simple as removing and re-applying a new membrane with minimal tools and equipment. Thick systems also need to be regularly inspected for tire shears and damage from vehicle chemical leaks. The waterproofing membrane is concealed, making it difficult to identify defects or water entry points.

Comprehensive repairs are required for both systems at some point over their lifetime. This is often a good time to switch from thick to thin systems for simplified future maintenance.

CHOOSING THE BETTER SYSTEM

Both systems have pros and cons; however, the industry is moving toward thin systems. Is thin the better choice? Maybe—but this system still has its drawbacks, like durability and curing time. Repairs tend to be required every five years, particularly with high traffic volumes, and it takes the full system three to four days to cure in each area.

HISTORY OF PUMA

Over 30 years ago, methyl methacrylate (MMA) waterproofing was developed in Europe. The rapid curing system wasn't temperature-sensitive and featured extreme durability, tenacious adhesion, and superior abrasion resistance. However, it was too hard and brittle. It lacked the flexibility and elasticity required in parking garage waterproofing applications. From here, the idea of adding polyurethane into the synthetic MMA resin was tested, and the Polyurethane Methacrylate (PUMA) formula was produced. PUMA technology allows the flexibility of polyurethanes in the base layer, while the top-wearing surface boasts the toughness of the MMA resins.

BENEFITS OF PUMA

Thanks to the fast-cure resin, it needs only 45 minutes to an hour to cure between coats. This minimizes disruption and closure times, so building owners and property managers can quickly repair and reopen their parking garages. The combination of polyurethane flexibility with methacrylate toughness means manufacturers can offer up to 20-year warranties, while standard urethanes are typically warrantied at five years.

Primarily, PUMA systems are chemically cured, meaning they are cold-weather-tolerant and can be applied in temperatures as low as -7° C. Additionally, it has high chemical resistance when exposed to petroleum products.

These systems are currently a significant cost premium to standard polyurethane. In some applications, the shorter disruption and reduced labour costs may offset the higher costs. PUMA can be applied at the garage entrance, sharp turns, and high-volume traffic aisles, where a standard polyurethane system would be sufficient at the parking stalls and in low-traffic areas. This way, we get the high-performing system where we need it at a reduced cost.

The inherent qualities of PUMA chemistry make it ideal for projects with tight timeframes and stringent performance requirements. ■

Mohamed Hussein, P.Eng., BSS, is a building science engineer at Morrison Hershfield. He is a licensed engineer in the province of Ontario and a certified Building Science Specialist.