INTRODUCTION

Charleston, South Carolina, is known for its inventory of historical buildings, with construction dating from the 1700s to the early 1900s. These buildings are candidates for structural and envelope rehabilitations to preserve the archaic materials while improving building performance commensurate with contemporary building codes. Being based in Charleston, the professionals of our firm regularly investigate and design repairs for these historical buildings. Often the envelope issues stem from fenestrations, wall claddings, and roofs that have deteriorated beyond their useful service lives. Many times, decades’ worth of prior repairs are layered over the top of the original archaic materials, further compounding the effort it will take to restore the envelope’s function. This paper is intended to provide design and construction advice based on our experience in recent years using cold liquid-applied reinforced membranes (hereinafter abbreviated as “LARM”) for roofing rehabilitations to historical buildings (Figure 1).

USE OF LIQUID-APPLIED MEMBRANES

First, liquid-applied membranes are not applicable for every historical building, and the implications of their use on building performance and the historical character must be fully understood on a case-by-case basis. The new membrane should not detract from the original historical appearance and details. Therefore, its use is probably more applicable to surfaces concealed from public visibility. In addition, it should be used in applications where it will not damage intact historical materials. For example, it should not result in the buildup of moisture in moisture-sensitive historical materials, and the substrate preparation should not damage the existing materials. Careful consideration must be given for project applicability and selection of product type. As such, we have considered LARM as a material candidate for roofs and horizontal planes (such as built-in gutters or copings) that are not readily visible from the public right-of-way. Furthermore, we must be confident that the use of an impermeable or semi-impermeable membrane will not be detrimental to the building’s thermal and moisture performance. In limited instances, we will consider LARM for vertical surfaces, such as the inside face of a parapet wall that is integrated with the roof. However, one must always be cognizant of moisture drive (vapor diffusion and humid air transport) through historical wall assemblies, particularly those composed of mass masonry, which are more porous and absorptive than modern wall assemblies.

LARMs are viable material candidates because of their versatility and resilience. They adhere to a wide variety of different materials—both new and old—and can be applied monolithically over any profile or shape (Figure 1). Substrate condition and preparation are critical to achieving proper adhesion, continuity, and durability of LARM. However, proper substrate preparation is a challenging process with historical masonry, clay, terra cotta, and other kinds of archaic cementitious materials. Preservation of the existing materials is usually of importance, and the “gentlest means possible” are prescribed so as not to cause damage to the historical materials (Grimmer, 1979). We recommend that designers and contractors consult the preservation briefs by the National Park Service for basic information on cleaning of historical buildings (Mack, 2000; Grimmer, 1979). Preparation of historical substrates can take on a life of its own during a construction project as compared to preparation of modern material substrates like plywood or new concrete surfaces. At the least,
substrate preparation typically includes the steps of removal of unsound material, cleaning, surface profiling, and control of moisture, all the while ensuring that the archaic substrate is preserved.

On one recent project, we allowed the use of light abrasive grit blasting to remove unsound stucco and masonry material after removal of obsolete coatings was accomplished by hand tools. The blasting consisted of water plus silica at a nozzle pressure starting at 50 pounds per square inch (psi) that was stepped up in small increments to a maximum of 100 psi. After careful observation of several test sections, it was determined that this range of pressure allowed for the removal of spalling and unsound stucco and mortar material without damaging the clay brick units.

It should be noted that this blasting occurred over masonry dating to the early 1900s. We would never permit light abrasive blasting on softer brick masonry from the mid-1800s or earlier. Furthermore, architectural terra cotta can be even more sensitive than historical brick masonry. Preparation of coated architectural terra cotta typically requires time-consuming manual labor using special care with hand tools so as not to damage the glazing shells.

SYSTEM COMPONENTS

A typical LARM system consists of the following components: substrate, primer (if required by the manufacturer), base coat(s) with optional embedded reinforcement, and top coat(s) with or without embedded aggregate. LARM products are packaged in a liquid state and are capable of being applied without heating (ASTM, 2015). They will cure to a solid state due to reaction with a hardener or ambient moisture. Established material classes for LARM include polyurethanes, acrylics, silicones, synthetic rubbers, and cementitious-based products (Mailvaganam, 2004; Farahmandpour, 2001; Parker, 2015).

Many types of nonwoven and woven synthetic textiles are available as reinforcement. Common reinforcing materials for LARM include nonwoven polyester fabric (fleece), nonwoven randomly oriented glass fiber (fiberglass), and woven nylon mesh. The reinforcement improves the membrane’s tensile strength and impact resistance versus an unreinforced membrane. Therefore, we typically prefer reinforced membranes for durability purposes. However, the use of reinforcement will affect the ease and rate of installation in the field, particularly over surface irregularities and changes in plane, so the project team must be prepared to justify the potential additional material and labor costs for the reinforcement.

ASTM STANDARDS

The product manufacturer’s literature should always be consulted for design and installation of a LARM roofing system. In our experience, regular dialogue with the manufacturer’s technical representative—during both design and construction—is important. We typically provide the manufacturer’s guide specifications in the construction documents. Several ASTM standards are also available to assist the designer and contractor on selection, specification, and general installation considerations for cold liquid-applied membranes. Applicable publications are listed in Table 1. It should be noted that ASTM C957 and ASTM C1127 pertain to LARM with an integral wearing surface, whereas ASTM C836 and ASTM C898 pertain to LARM with a separate wearing course.

Furthermore, several standardized test methods are available to field-evaluate adhesion and cohesion of the installed LARM. These test standards are listed in Table 2. In our experience, most manufacturer representatives will conduct some type
of peel testing, sometimes in accordance with ASTM D903, if requested at project initiation.

Our firm regularly conducts pull-off testing per ASTM D7234 or ASTM D4541 during the membrane installation. This type of testing utilizes a portable pull-off testing apparatus that applies a concentric tensile force to the surface of the membrane. The pull-off testing is limited by the strength of the adhesive bond at the test fixture, cohesion strength between membrane layers, and membrane adhesion to the substrate. The results are quantitative and are provided in pounds per square inch (psi). The pass/fail criteria for the pull-off testing is obtained from the manufacturer and typically ranges from 100 psi to 150 psi.

**MOISTURE MITIGATION**

Lastly, moisture mitigation is also one of the most critical steps during substrate preparation and membrane installation. All existing and potential sources of moisture must be identified during the investigation phase, prior to developing the construction documents. We view this step as so important that on one recent project we required the construction of a temporary roof over the existing historical building (Figure 2). This protected the archaic cementitious substrate materials (in this case, mass masonry, terra cotta, and concrete) from precipitation and allowed for drying. Excessive moisture in the substrate will lead to bubbling of the membrane and adhesion failure. Application schedules must always adhere to the minimum cure times provided by the manufacturer’s literature. We often require that the membrane manufacturer provide us with a project-specific letter stating the required cure schedule and maximum permissible substrate moisture content prior to membrane application.

One method for monitoring moisture in cementitious substrates—including masonry, concrete, and stucco—is a handheld electronic moisture meter with a concrete scale. ASTM C1471 supports this method of moisture monitoring, as it states that moisture contents in the range of 3 to 5% are typical for concrete substrates. We have found this range of moisture content to be agreeable with most product literature. Furthermore, the epoxy primer for the LARM can also serve as a moisture indicator, as the epoxy will foam in the presence of excessive moisture.

**CONCLUSION**

The purpose of this paper is to provide design and construction advice based on our experience with LARMs on historical buildings in recent years. The implications of their use on historical buildings must be carefully studied and fully understood on a case-by-case basis. LARMs can be viable system candidates for roofing rehabilitations of buildings with archaic masonry, terra cotta, and cementitious substrates. LARMs form a seamless, monolithic roofing membrane that adheres to a wide array of substrates, surface profiles, and transitions. Careful consideration must be given to selection of product type, substrate preparation, reduction of moisture during application, and control of moisture while in service.

**REFERENCES**


Jason Gregorie and Alan “Al” Schweickhardt are both principal engineers with Applied Building Sciences, Inc. in Charleston, South Carolina. Their practices include consulting, design, and forensic investigations for a range of building projects, including historical structures. They regularly are involved in assessment of historical timber and masonry materials, as well as structural and envelope rehabilitations to existing buildings. Their work often involves high-wind retrofits and mitigation of moisture and bulk water issues in building envelopes.

Photo 2 – System scaffolding temporary roof over the historical structure to reduce moisture exposure during construction and application of the LARM roof.

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