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Designing for 60 Year EPDM Roof System Service Lives

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ABSTRACT

A common theme of many sustainable building discussions is the achievement of a service life of 60 years. Recent inspections of aged EPDM roof systems over 25 years of age found them to be in excellent condition. Samples of EPDM membrane from several of the oldest EPDM roofs in the United States were taken and tested to determine their current physical characteristics. Test results revealed that nearly all retained performance attributes above and beyond the minimal requirements of today's EPDM membranes. This author's empirical experience has shown that well designed and installed EPDM roof systems can attain service lives of 25 years and more. New innovations and improvements in EPDM membrane and associated components, in combination with superior design, suggest that EPDM roofs can attain supreme long-term service lives. Based on the author's extensive experience with EPDM roof systems over the last 25 years, this paper will demonstrate an approach to achieving 60 year service lives with EPDM roof system, through design, construction, planned assessment and interventions. This paper will review test results of aged in situ EPDM membranes and design considerations to achieve long-term performance. Examples of existing long-term performing EPDM roofs, their design elements, and how they were managed in an attempt to provide extended watertight protection will be reviewed. Examples of current day EPDM roof systems designed for service lives of 60 years will be reviewed as well.

KEYWORDS

Durability, Long-term service life, EPDM.

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1 EMPIRICAL EXPERIENCE

This author, an architect who has chosen to specialize in roof system design, has always been keen on detailing and holds two concepts sacred when roof system design is concerned: 1.) All building elements that impinge on the roof need to be designed into the roof system and detailed accordingly; and 2.) Quality, long-term roof systems, that in time will achieve sustainability, need to be designed as systems and detailed specifically for the project in question. EPDM roof systems designed, detailed and specified under these concepts, designed by the author, and installed over 24 years ago were inspected in the summer of 2009 and found to be in excellent condition and on their way to achieving long-term performance.

Inspection of aged EPDM roof systems over the years has resulted in a common denominator; no matter the design, construction and/or overall condition, the EPDM membrane was found to be in “almost as good as new condition”. These observations were confirmed in research by Dr. Tim Trial [Hutchinson 2005] in which aged in situ EPDM samples were tested for there physical properties and almost without question the physical characteristics of the aged, in situ, climatically exposed EPDM meet or exceed the minimum requirements of new membrane being manufactured today. Another study being undertaken by the author, in which the oldest known EPDM roofs in place, over 30 years old, have had samples taken and the membranes’ physical characteristics tested, which correlated with the Trial research, and confirmed that ageing EPDM membrane holds it physical characteristics.

The SKZ (Süddeutsche Kunststoff Zentrum) in Wuzburg, Germany recently issued a research report (Life Expectancy of EPDM Roofing Membrane Over 50 Years Scientific Approach) on the testing of exposed, in situ ballasted roofs up to 30 years old, all which are watertight and still performing, and concluded that EPDM roofs have a predicted life expectancy of over 50 years.

In the summer of 2009, the EPDM Roofing Association (ERA) embarked on a study of in situ long-term service roof systems; 29 years of age and older. The roofs were located in the Midwest and South Central portions of the United States. The membrane on all the roofs was 45 mil EPDM, the standard membrane at the time of installation. The roof systems were both ballasted and fully adhered. Samples were taken and sent to Momentum Technologies in Union Town, Ohio and their physical properties tested. Results for elongation and tensile reveal that even after 30 years of in field service that the EPDM roofing membrane holds its physical characteristics. These tests confirm empirical experience by this author, that aged in situ EDPM roof membranes continue to perform well into their forth decade.

Roof system designers, architects, building owners and property managers can be assured of EPDM’s long-term, sustainable and environmentally complimentary performance. This author believes that building owners should demand long-term service roof systems and that designers have a fiduciary responsibility to design roofs to achieve this goal.

2 ACHIEVING LONG-TERM PERFORMANCE

Achieving roof system service lives in excess of warranty length involves several phases, the first of which is design.

As roofing professionals have applied the concept of sustainability to their construction and roofing replacement projects, they have come to learn that several key areas provided opportunities for improvement. These areas were identified by the CIB (International Council for Research and Innovation in Building Construction) Working Commission W.83 or RILEM (International Union of Testing and Research Laboratories for Materials and Structures) Technical Committee 166RMS (CIBW.83/RILEM166RMS); of which this author was a co-chairman of.

Three main areas for improvement were identified: 1.) Minimize the burden on the environment by responsible use of materials; 2.) Conserve energy by improving thermal efficiency of roofs; and 3.) Extend roof lifespan by improving long-term performance [Hutchinson 2004].

This paper will focus on the third key item, in particular, how roofing professionals and building owners can extend the lifespan of their roofing systems, specifically EPDM membrane, after installation.

Certainly much can be done to ensure long-term performance prior to bringing in the construction crew. Gaining a consensus among all parties as to the goals and performance expectations is an important step, as are factoring in the budget for the project, the specific characteristics of the building, and its geographic location.

2.1 Material Selection & Design

Choosing the appropriate materials is certainly a major factor in the procurement of a sustainable roofing system. While many products on the market advertise their ability to produce sustainability, only quality materials with proven historical records of long-term performance should be used. Materials and systems which offer the promise of performance without the historical data to support this claim should be avoided. EPDM has over a 40-year history of performance.

While roof system design is worthy of an entire article in itself, this paper will focus on general guidelines and concepts to achieve the intended goals.

The project's roof system designer, a project consultant equal in importance to other project consultants; structural, mechanical, plumbing, etc., should be part of the design process, providing information to the design team so that architecture detrimental to roof system performance can be avoided and/or the costs to protect the roof discussed. Discussion of building and roof use, as well as the anticipated construction process should be undertaken and understood so that the appropriate roof system can be designed and specified.

Roof Membrane: Historical evidence of long-term service life revolves around 45 mil EPDM membranes, as that was the standard 30 years ago. Current architectural standard dictates 60 mil EPDM. This author, who designs roof systems for 40 years or more of planned service life specifies 90 mil EPDM, due to its durability, ease of installation, and of course expected long-term service life performance.

Selecting system components that compliment the EPDM membrane and provide to potentially enhance the materials performance should be reviewed. Substrates of suitable material and compressive strength should be considered. Material attachment methods need to be considered. Protective cover boards often provide a tripartite of benefits: protection from the mechanical fasteners, protection of the insulation boards from compaction or crushing, and protection of the membrane from physical damage due to excessive foot traffic, especially during the construction process.

Incorporating a vapor barrier/temporary roof into the design has many benefits: dries in the building quickly and allows for interior mechanical and architectural work to proceed, provides a work surface for the various trades whose work either impinges upon the roof or requires using the roof as a work surface. The author finds this singular purpose to be an outstanding benefit to the quality of the roof system and to achieving optimal life service. Vapor retarders, depending on the building use (note how important early understanding of the building use can be), are critical in protecting roof systems from the deleterious effects of condensation. Buildings designed under the LEED parameters, with positive building pressure have been found to create damaging effects below mechanically fastened single ply membranes, resulting in their removal and replacement within years of their initial installation, costing millions of dollars.

Redundancies in a roof system are a valuable aspect of achieving long-term service life. EPDM roof systems, by virtue of their seam tape products and ease of adhesive use allow for the quick installation of redundancies. Examples include lap seam cover strips, protective layers of EPDM around roof curbs and areas with a high volume of roof top use, as well as double layers of flashing at penetrations.

A relatively new concept that designers need to come to grips with and design for is the concept of a "Roof as a Platform". The roof has evolved into an important real estate commodity and thus cannot be left abandoned. Roofs are now being asked to perform beyond their principal function of protecting the building from the effects of the climate, to being a platform for garden roof covers, wind powered electrical generation, solar panel support and a new generation of HVAC equipment.

While there are certainly a number of options to consider while compiling a list of materials and design options, focusing on long-term performance should be given priority, whenever possible, over initial costs. Life cycle analyses have been conducted validating the value of focusing on long-term performance, including one written by Jim Hoff [Hoff 2006], former Vice President of Quality, Technology and Product Development, Firestone Building Products. These reports support the proposition advanced by many roofing consultants, including this author, that the investment in enhanced system design can produce relevant economic return to the building owner.

As an example, Hoff, using the Equivalent Uniform Annual Cost (EUAC) calculations, 20-year roofing systems in the study offered long-term costs 10% to 15% lower than their 15-year counterparts. In addition, the EUAC of the single 30-year system studied offers an additional cost savings of 12% beyond a similar 20-year system. It appears that 60-year performance of EPDM roof systems would provide a building owner with substantial economic benefit.

A critical component in achieving roofs with long-term sustainable roof systems is comprehensive construction drawings that appropriately communicate to the bidding contractors both the design intent and scope of work. Simply put, specifications are not enough; the roofing system should be designed and drawn.

No amount of text can properly describe the detailing required in complex situations. Even simple details can become confusing when not properly drawn. Manufacturers' standard details and requests to have contractors basically design the roof with shop drawings are inappropriate for achieving long-term performance. Comprehensive drawings add greater clarity in understanding the project, eliminating many doubts and points of confusion that can lead to mistakes and, in some cases, legal action.

Effective communication has become more important in the past few years, if only because it has become more challenging. Much of today's workforce consists of people for whom English is not a first language, or a language they speak at all. Visual information overcomes any language barrier.

During the roof system process and commitment of the design to graphic representation, the roof system should be in continuous contact with others on the building team, such as the mechanical, plumbing, and structural engineers, as well as the design architect, so that all elements of the building that impinge upon the roof and/or whose installation process has the potential to impinge upon the roof can be discussed and designed for appropriately [Hutchinson 2002].

Prior to releasing the contract documents for bidding, this author recommends pre-qualification of contractors, to confirm their suitability and qualifications for the particular project. Be selective; eliminate the non-qualified early in the process. A poorly qualified contractor can result in less than expected results.

2.2 Construction Administration – An Integral Part of Commissioning

Following the bidding, the emphasis shifts to construction administration and observation. Roof construction and the impact of the construction process, differing trades who impact the roof, and the need to provide a dry interior are all drivers that potentially can derail a roof system's ability to achieve a long-term service life. Oversight in the office, as well as the field, needs to be provided. This activity should be considered an integral component in the roof system's commissioning, as observing the assemble is inherently of more value than a surface inspection.

The oversight commences in the office often months prior to the commencement of the roof construction in the form of shop drawing and submittal review. Shop drawings should be project specific and provide clear evidence of the contractors understanding of the project and impinging factors. Incorrect shop drawings should be rejected and returned for resubmittal. Another often-overlooked responsibility of both the roof contractor and design team is the understanding of and incorporation of equipment and materials that impact the roof, and the need for contractors to communicate amongst themselves so that their respective shop drawings can appropriately reflect the work required. The project design team should also be coordinating the various trade shop drawings and assuring that the various contractors that impact the roof understand the needs of the roofing contractors. Communication, the sharing of information and the submission of shop drawings that complement each other are required. This type of coordination requirement should be specified and followed through. An example of this type of requirement can be seen in the installation of roof top solar arrays, where multiple professional design and trade disciplines meet and interact.

In the field there is an acute need to diligently review the work being performed, to ensure installation complies with the contract documents and lives up to the terms of the contract. An important part of contract administration is answering questions and arriving at decisions when dealing with situations unforeseen at the start of the project.

Additionally, weather issues need to be considered. Installing roofing in inappropriate weather cannot be tolerated. If observed or discovered, it should be rejected. We all have horror stories of a project kept "on schedule" by working through bad weather. The ultimate punishment comes when the roofing system fails to perform as expected because of this push to meet a deadline.

Roofs of inappropriate, non-compliant and unacceptable workmanship, or portions thereof should be rejected and required to be removed and replaced. Empirical experience with attempts to placate contractors only seems to delay and often exacerbate the concern, only to be more costly to correct.

The bottom line is that the maintenance of the installed roofing system and the materials in it are the responsibility of the owner, not the manufacturers. They can only produce a product with the potential for outstanding performance. High quality design and installation are important parameters in the goal of long-term service life achievement, but it is the maintenance of these materials (roof system) that will ultimately determine their performance on a particular roof.

2.3 Roof System Maintenance – Managing the Durability of Your Asset

Most roof system warranties require regular performance of maintenance in order to keep the warranty provisions in place. However, even the specter of keeping your warranty viable doesn't encourage every building owner to implement a maintenance plan. In fact, most would not want to answer the question, "Do you spend as much time maintaining the roof as your other investments?" Building owners who desire attaining roof systems of long-term service lives must commit to a proactive and sustained roof management program, one whose ultimate goal is to keep the roof in a condition where is can continue to perform, year after year.

This author believes the industry standard of a twice-a-year maintenance program is not good enough. While inspection of, and perhaps maintenance of roofs in spring, following winter's storms and then late fall, prior to the onset of winter, as well as following violent storms are good, additional inspections are recommended and required. Proactive building owners and managers are requiring monthly inspections, documentation of corrective action, causes for any concerns and managing who has access to the roof. In addition, particular roof concerns are being addressed accordingly. For instance, roofs with overhanging or adjacent trees, which have a sustained period of leaf loss in the fall, need weekly removal of the leaves from the roof and especially around the drains to prevent drain blockage and resultant ponding, interior moisture intrusion and roof structure overloading, and additional inspections are also required following all HVAC maintenance work.

Visual observation is mandatory; the roofing consultant and/or the owner should walk around the roof and pay careful attention. Has a screw fastener backed out? Did the insulation attached to asphalt or spray foam buckle up? The roof observation walk and subsequent follow-up work should be documented and placed in a historical file.

Roof curbs in particular should be closely observed, as the installation of the roof flashing involves a great deal of handwork. Roof curbs are also often used by crews such as window washers to secure ropes.

In addition to monitoring the roof, track those who access it. A building owner/manager should track activity on the roof by workers sent up to conduct repair or maintenance of HVAC and other equipment on the roof. Accidents may happen and won't be reported. To avoid this, require all appropriate parties to notify you when they access the roof and notify them that you will inspect the roof following their visit. This action commonly increases the level of responsibility of all parties accessing the roof.

This may seem ridiculously obvious, but fix conditions of concern right away. Contact the appropriate manufacturer in writing ASAP so they can document the report and contact a roofing contractor to make the appropriate repairs if warranted, or be held responsible if the repairs don't occur. If the particular item is not covered by the warranty, be sure the owner realizes that they are responsible for payment.

2.4 Planned Assessments and Interventions

There is no low slope roof system, even with excellence in design and construction that can attain a 60-year service life without interventions at some point in the roofs life. Every ten years for the first thirty and every five thereafter a full roof system, membrane and flashing assessment should be undertaken to determine current conditions and prognosis for continued service.

Additionally, there are known vulnerabilities within EPDM roof systems, whose intervention and updating can be anticipated and planned for. Following are some of the interventions that a building owner should consider be undertaken and a suggested year of intervention.

1. Lap Seams: If lap seams have not been overlaid with a cover strip, lap seam inspection, repair and installation of a self-adhering cover strip should be planned for (year 10).
2. Re-flashing of roof curbs and penetrations (year 15, 30 and 45).
3. Re-flashing of roof drains (year 15, 30 and 45).
4. Gravel Ballast: Removal of fractured gravel ballast and installation of new (year 20 and 40).
5. Concrete paver ballast: Removal of fractured concrete paver ballast and installation of new (years 20 and 40).

6. Removal of abandoned and/or obsolete roof top equipment and curbs (ongoing).
7. Removal and replacement of damaged and/or wet insulation (on occurrence).
8. Removal and replacement of backing out fasteners (on occurrence).
9. Application of acrylic roof coatings (every 10 years).

2.4.1 Historical and Modern Day Examples

Waukegan Public School District 60, Waukegan, IL: In 1986, this author designed new 45 mil (60 mil EPDM was not yet available at the time of design and installation) EPDM roof systems for the Waukegan School District No. 60 (Carmen-Buckner Elementary School, Glen Flora Elementary School, North Elementary School, Washington Elementary School, Lincoln Center and Waukegan High School – Washington Campus). Each roof system incorporated tapered thermal insulation to provide positive drainage and roof edges that were raised as required to accommodate the new enhanced insulation heights. Prefinished aluminum fascias and copings were also designed. Cudahy Roofing of Cudahy, Wisconsin was the installing roofing and sheet metal contractor.

The design and detailing were well above what the industry standard at the time. On site observation found excellent workmanship and overall the installation was excellent. 10 warranties were issued.

The roofs were inspected in the summer of 2009 as part of a roof system assessment project and found to range from good to very good, to almost excellent condition. The question often asked is what accounts for this longevity?

The owner, while performing less than desired maintenance inspections, did perform two outstanding roof care items: 1.) They virtually eliminated all but the absolute necessary roof foot traffic; and 2.) They immediately had Cudahy Roofing perform repairs on any noted deficiencies resulting in moisture intrusion.

The roofs, while in good condition, are at the age where the assessment determined minor vulnerabilities that if left unattended could result in the end of the roofs' services lives. Restorative work was completed in the summer of 2010. It is anticipated that following this restoration work another 10 to 15 years of service life can easily be achieved/procured.

Hawthorn School District 73 – Vernon Hills Elementary School, Vernon Hills, IL: In January 1983, this author spent 30 days of full time roof construction observation at the new Vernon Hills Elementary School in Vernon Hills, IL; 25 miles north of Chicago. The roof designed consisted of two layers of rigid insulation on a metal roof deck, structurally sloped to interior roof drains. A 45 mil ballasted EPDM roof system was installed. The perimeter roof edge metal was a gravel stop.

A roof assessment was performed in the spring of 2006, twenty years after installation, for the purpose of assessing the roof systems conditions and estimated remaining service life. While no moisture intrusion was reported, concerns with the uncured membrane over the gravel stop flange end, where splitting was observed and minor bridging at some of the base flashing conditions were noted. Prior to the assessment basic roof maintenance items were performed, but roof top access was closely guarded.

In the summer of 2006, Sullivan Roofing of Schaumburg, IL performed roof restoration services at the gravel stop, lap seam, roof curb, penetrations and lap seam conditions. This intervention cost $52,000.00, over $400,000.00 less than the estimated roof replacement cost. The district hopes for another 10 to 15 years more service life of the roof.

Community Consolidated School District 59 - John Jay Elementary School, Arlington Heights, IL: The school district desired a sustainable long-term solution for this reroofing project, which also came to involve a great deal of HVAC work. Hutchinson Design Group, Ltd. worked with CS2 Design Group, LLC to design and coordinate a new roof system and HVAC roof top unit replacement. The roof system design, to be successful, needed to take into consideration the anticipated construction sequence of related trades such as carpentry, plumbing, sheet metal, pipe fitters, steel erectors, sheet metal duct work, and electricians. Very detailed construction documents coordinated roof and HVAC integration issues such as pre-flashing roof curb extensions, pipe curbs, pipe supports, stairs and walkways were prepared.

The new roof system employed a vapor retarder, temporary roof, which allowed for carpentry, plumbing, HVAC, pipe fitting, new roof hatch, pipe curbs and the raising of roof curbs, rtu curbs and plumbing vents without the potential of damage to the new roof system. A fully adhered EPDM roof system was designed with base and tapered thermal insulation layers, cover board, and fully adhered 90 mil EPDM. Additionally, sheet metal components included metal siding, expansion joint covers, fascias, copings, counter flashings, and metal siding to clad offset roof elevations walls. All roof drains were removed and replaced with the new, and plumbing vents raised. Protective 2” thick rubber walkways were placed, as well as roof top access stairs to provide safe access.

The new roof system was designed for 40+ years of service, and received a 30-year full roof system manufacturer’s warranty.

3 CONCLUSION

The current trend toward increased focus on “green” construction should assist roof system designers in their efforts to promote long-term service sustainability and roof systems that live up to Gro Harlem Brundtland’s words “meeting the needs of the present without compromising the ability of future generations to meet their own needs.”

EPDM roof systems are already achieving 30-year plus service lives with membrane testing showing ‘like new’ characteristics. EPDM roof systems properly designed, installed and managed certainly have the potential of meeting the ‘Holy Grail’ of 60 years of service life.

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