

Addressing the Challenges of Waterproofing with Customized Solutions

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All concrete structures (particularly reinforced concrete structures) are vulnerable if their surfaces are not protected. Concrete is a porous material that allows water and oxygen-containing air to penetrate and corrode or rust the steel reinforcement embedded in it. The environment's carbon dioxide, chlorides, acids, sulfates, and other salts can hasten the deterioration process. When steel reinforcement rusts, it exerts outward pressure on the concrete, causing spalling and cracking. Spalling and cracking in the concrete will eventually jeopardize the structure's integrity.

Waterproofing is a system that uses coatings, membranes, drainage media, perimeter drainage, interior channels, sump pumps, or other elements to insulate and protect a structure from water entry. A quality waterproofing system becomes the only logical, practical, and low-cost way of preserving a structure's integrity and value and protecting its components from adverse conditions by preventing and/or managing water infiltration and leaks, among other complications.

Over the years, many different materials and systems have been tried to waterproof concrete structures. However, field experience shows that most waterproofing systems or treatments, even in the short term, fail to achieve the desired results. The reasons are numerous, but the primary one is a failure to comprehend and address the various challenges associated with developing and implementing an effective and long-lasting waterproofing solution for a given construction project.

A successful and long-lasting waterproofing solution includes four major components: 1) design and material selection, 2) installation; 3) inspection and maintenance; and 4) total cost of ownership (TCO) control. Knowing the most common structure site scenarios and the challenges associated with the project requirements will help us customize an effective and long-lasting waterproofing solution..

The challenges

1) Design and material selection

A waterproofing system's proper design and material selection are critical because remedial waterproofing solutions can be prohibitively expensive, so getting it right the first time is critical. During the design phase of any waterproofing solution project, the following factors must be considered:

External (either positive side or negative side) or Internal:

The external approach employs waterproofing components applied to the concrete's surface (either positive or negative side). Water is prevented from entering the surface by applying positive side waterproofing to the side of applied hydrostatic pressure (e.g., the exterior surface of the concrete). The

negative side waterproofing protects the surface opposite the side of applied hydrostatic pressure (e.g., the interior surface of a concrete wall), directing water after it enters the substrate. Positive side systems are generally preferred over negative side applications due to their effectiveness, but they fall short regarding leak detection and remediation. Traditionally, waterproofing membranes are installed after the concrete has been placed. Blindside waterproofing, or the installation of waterproofing membranes and drainage before the concrete is poured, cannot be inspected once the concrete is poured and poses a significant risk in the membrane installation. Furthermore, highly skilled labour is required to apply the waterproofing membranes after the concrete has cured in dry weather. Surfaces must be prepared appropriately, and the installation must be nearly flawless. Traditional surface-applied waterproofing is susceptible to damage and deteriorates over time, even when installed perfectly. As a result, the waterproofing membrane must be highly resistant to damage and deterioration, including UV resistance, weatherability, fire resistance, and long-term durability.

Internal waterproofing (also known as integral waterproofing or waterproof concrete) is the process of incorporating a waterproofing component (such as admixtures) into the concrete during the batching process. Admixtures reduce the possibility of water ingress by reducing concrete permeability and drying shrinkage. Internal waterproofing has two advantages: low material costs and ease of application. However, it is generally only appropriate for water-retaining structures and less critical locations where soil conditions are not aggressive and the consequences of water entry/flooding are not severe.

Above-grade or below-grade:

Above-grade structures are exposed to atmospheric conditions, and thus their waterproofing can be subjected to hydrostatic pressure caused by wind conditions, as well as UV rays, hot and cold cycles caused by climatic conditions, weathering, and carbonation. Watertight environments for above-grade structures require good waterproofing design and long-lasting materials. A sufficient slope must be designed to allow for water drainage and moisture evaporation. Still, too much slope can cause wrinkling of the waterproofing membrane and break bonds between the components. Poor flashing protocols will often lead to water ingress. Special considerations must be made when using single-ply waterproofing materials. When used for above-grade structures, single-ply waterproofing membranes lack redundancy and are more easily damaged. Specific occupied spaces, such as medical facilities, testing laboratories, book and art storage, and computer rooms, are sensitive to humidity or where water leaks/air intrusion can be detrimental. Positive side waterproofing with a low vapour permeable membrane would be required for proper waterproofing design of these facilities.

On the other hand, protecting below-grade structures is more difficult than protecting above-grade structures due to several additional factors that can degrade the structures. Maintaining below-grade water infiltration can be a more difficult task because water is under pressure below ground and will force its way through even the smallest cracks in the structure. Building foundations built into the groundwater table, in the absence of permanent dewatering, create a condition in which hydrostatic pressure consistently tests the performance of a waterproofing system. Any flaw in the system — or damage to the waterproofing system — will inevitably result in visible water inside the structure. The maximum water table level for the site should be used to design proper waterproofing.

Another feature of today's commercial construction is that many large projects are built on previously occupied real estate, a practice known as brownfield development. Most of these brownfields did not do a good job of containing contaminants and frequently left significant amounts of toxic residues in the

soil. When the soil or groundwater is contaminated with chlorinated solvents, petroleum hydrocarbons, and heavy metals such as benzene, naphthalene, polychlorinated biphenyls, pesticides, and elemental mercury, the waterproofing system must also be resistant to these chemicals to prevent vapour intrusion into the below-grade structure. Concrete is also prone to damage in coastal areas due to sulphate attack and chloride-induced corrosion when exposed to seawater-containing environments. Waterproofing below-grade structures can be made more difficult in harsh climates. In rainy and damp climates, for example, the structures must contend with extreme hydrostatic pressure as well as the ongoing need to divert rainwater away from the foundation.

Furthermore, certain types of below-grade structures may necessitate the most stringent levels of protection: for example, it is prudent to use high-performance waterproofing systems on below-grade structures with deep foundations to combat the high external pressures on the foundation and aggressive soil conditions that can lead to water infiltration and corrosion. Tunnels and below-grade spaces in mass transit systems are subject to intense hydrostatic forces, necessitating the use of a highly durable waterproofing system to prevent lateral water migration, as any moisture or water leaks can result in costly repairs and service disruptions. Obtaining a geotechnical report is an important first step before specifying a below-grade waterproofing system. It contains detailed information about the site's conditions, including the risk of flooding. The report also provides a thorough understanding of soil composition, including whether harmful chemicals in the soil require remediation.

New or restoration/replacement project:

Be aware that complex structures and/or foundations present numerous waterproofing challenges for any new construction waterproofing project. Waterproofing membranes (particularly sheet membranes) can be difficult to conform and bond to structures and/or foundations with non-uniform corners, transitions, or changes in elevation or slope. A dewatering system can be used temporarily during construction or as a permanent component of the waterproofing solution. Water and moisture are allowed to flow through the concrete in the presence of the dewater system, and the system collects and moves the water away from the structure. Permanent dewatering systems can be used for low-risk projects or in conjunction with waterproof concrete or pre-applied waterproof membranes for higher-risk projects. They are not recommended for environments with soil contamination because they do not prevent gas vapours from entering the structure.

Restoration/replacement waterproofing projects can be more difficult due to a variety of structural issues as well as the condition of the substrate and/or previously applied waterproofing systems. Waterproofing is applied to substrate surfaces to protect them from structural deterioration caused by water, chemicals, and soil. The waterproofing material used must also be capable of performing if the substrate becomes unstable or minor imperfections occur. The most difficult task is locating a waterproofing material that is compatible with the existing substrate. Some substrates are naturally prone to imperfection, which should be considered before designing a waterproofing system. Waterproofing membranes applied over substrates prone to cracking from any source must be elastic and resealable. Cracks in masonry or other waterproofed components with multiple construction joints can occur.

Table 1 – Common Waterproofing Materials and Their Advantages and Disadvantages

Material	Description	Advantages	Disadvantages	Applications
Cementitious coating	A form of a powder that consists of sand, organic and inorganic chemicals, and silica-based substances. When the active ingredients are combined with lime, it causes a hydration reaction, creating a waterproof seal.	Ease of application; Readily available; Acrylic additive helps better bonding; Resistant to weathering.	No movement capability. Not resistant to acid rain; Higher water absorption; Not applicable on wood or metal substrate.	The oldest waterproof products. For concrete or masonry.
Bituminous coating membrane	A sticky, highly viscous coating that is made from bitumen-based materials such as asphalt or coal tar and applied in a liquid or semi liquid form. The hydrocarbon bitumen matter is often dissolved in a solution – such as mineral spirits or naphtha.	Inexpensive material; Great weatherproofing; High resistance to mechanical damage; Excellent adhesive properties.	Lifespan decreases significantly when exposed to extreme temperatures and UV radiation; Combustible and releases toxic fumes	Commonly used to waterproof roofs, basements, below-ground structures, bridges and more
Cold fluid-applied membrane	A liquid coating that can be applied by a spray, roller, or trowel, to cure to a solid, seamless, and joint-free membrane. The membrane can be made from numerous compounds such as cement, polyurethanes, and acrylic copolymers.	Versatile application options; Monolithic, no seams, continuous; Full coverage at edge and in corners; High elasticity; Tough and durable.	Risk of air bubbles within the membrane; Risk of membrane blistering over damp/uncured surfaces; Inconsistencies of thickness; Limitation on surface of application.	Can be applied to many structures and different places.
Sheet waterproofing membrane	A membrane (made from PVC, TPO, EPDM, MBR, silicone, etc.) in the form of rolls/sheets, often contains an adhesive and a backing on one side. Applications include torch applied membranes, self-adhesive membranes and membranes that are applied using a liquid adhesive.	High impact resistance, toughness and overall durability; Consistent thickness and exact coverage; Wide application.	Have seams and joints in large areas; Required skilled labors; Comes in fixed size only; Limitation on complex shapes and sealing details.	May need different products for specific substrates.
Composite waterproofing	Textile composite materials consist of a polymeric (thermoplastic or thermoset) coating or film matrix combined with a textile reinforcement.	Enhanced different desired properties; Can offer a true monolithic and durable protection.	Accessibility to materials, price point.	Concrete restoration and high value asset protection.
Admixtures	An integral admixture system which is added at the batching plant or on-site and react chemically within the concrete to turn the concrete itself into a water barrier.	Low material costs; Ease of application and reduce installation time; Will not delaminate, decompose or wear out.	Poor flexibility and movement capability.	Suitable for blindside work, and complex structural designs.
Clay systems (Bentonite)	A thick bentonite forms a hard and waterproof insulation layer.	Self-heal; Non-toxic; Easy application.	Risk of leaks; Weather sensitive; Excavations	A good outside water sealant.

Material selection:

Depending on the identified challenges associated with the site situation and project needs, various waterproofing materials/systems can be used. Table 1 summarizes the most commonly used waterproofing materials on the market, as well as their benefits and drawbacks.

2) Installation

If proper design and material selection are the first steps toward an effective and long-lasting waterproofing solution, then installation quality is the second most important step. Many people overlook installation quality challenges in favour of other project aspects, which increases the likelihood of errors and problems occurring and developing, affecting the installed waterproofing system's ability to function properly.

The challenges in waterproofing installation begin with project specifications and installation details. Most architects, owners, contractors, consultants, or engineers would frequently respond on the general specifications and installation details provided by the waterproofing manufacturer to provide the project waterproofing installation plan. However, those specifics may not fully address site-specific geotechnical conditions, construction sequencing issues, local climate issues, installer skill level, and other project variables. The specifications and details of waterproofing manufacturers are typically validated through ASTM or CAN/CGSB (Canadian General Standards Board) laboratory tests and limited trial installations. They only address the bare minimum of material and application performance properties for the specific waterproofing, such as UV and weathering resistance, as well as hydrostatic pressure, elongation, flexibility, puncture/impact resistance, crack cycling, peel adhesion, and others, the majority of which are obtained under laboratory testing conditions.

Waterproofing manufacturer installation details are limited in scope and depict only the bare minimum of installation requirements for typical conditions. They are difficult to account for due to the wide range of site conditions, structure variations (such as unusual intersections and multiple penetrations), contractor means and methods, and in many cases, they would need to be modified to fit the purpose. It is also important to note that a default waterproofing warranty is not a guarantee of field performance, but rather an outline of what the waterproofing manufacturer is legally obligated to do if their system fails to perform when their standard specification and installation guidelines are followed. Contractors and subcontractors should be encouraged, if not required, to demonstrate their knowledge of the materials, products, and systems to be installed via the submittals process. The risk of system failure increases when people are not properly trained to install a specific assembly.

Every waterproofing project presents its own set of challenges and roadblocks to a successful installation. Waterproofing can be difficult to access during construction and even more so afterward (during the system's service life or during restoration/replacement work). Blindside (or pre-applied before the concrete is poured) waterproofing systems for difficult-to-access areas increase the potential for waterproofing breaches and amplify the consequences if they occur. The type of waterproofing and its installation may be dictated by site conditions, which may necessitate narrow, deep trenches. Careless backfilling is a major cause of waterproofing failure, as is heavy equipment damage. Poor substrate selection may result in dimpling of the waterproofing membrane, resulting in numerous weakened areas that are more vulnerable to puncture failures, and installing waterproofing systems without properly preparing the substrate will result in installation errors. When the substrate to which

they will be applied is combustible, or when nearby structures, openings, or materials present a fire hazard, self-adhering or adhesive-applied materials should be considered as alternatives to torch-applied membranes. As an alternative to open flame protection, a suitable separation or overlay material is suitable.

Other common installation errors that may be observed during construction include, but are not limited to: applying fluid-applied waterproofing products without adhering to its application climate temperature limitations (for example, the feasibility of applying waterproofing coatings below temperatures of 40°F (4°C) is a common question); Incorrectly applying adhesives or primers for self-adhered systems; Applying the self-adhered membrane before the primers being ready; Seams and penetrations that are wholly or improperly sealed; Installing waterproofing systems that are not per the project specifications/details.

Waterproofing restoration and/or replacement installation on a structure due to moisture-related deterioration necessitates the following additional steps to ensure quality: Examine the leak history; Determine the source of the water; Exclude the possibility of ambient moisture. Determine and confirm the leak's location. Repair the leak; Restore the damage. Beyond the original waterproofing design, new corrective actions may be required, such as drainage improvements, resurfacing or injections at interior surfaces to fill cracks, water barriers/sealing at penetrations, concrete patching and/or rehabilitation, mold remediation, and so on.

Finally, a solid waterproofing quality assurance program is required to ensure that the design intent is met and that constructability performance includes approvals and communications. Here are some general guidelines that may help to protect the building from a failed waterproofing system: 1) A pre-construction meeting should be held before the arrival of waterproofing material. 2) Meet with the owner or a representative to discuss typical site/structure conditions and critical waterproofing details. 3) Conduct regular work reviews to ensure all project requirements are met. 4) Examine the storage conditions and specifications. 5) Go over problem-solving techniques and procedures to ensure successful project completion. 6) Schedule and hold regular progress meetings to review the progress of envelope work. 7) Safeguard finished products and limit traffic by different trades that could cause damage. Effective Quality Assurance programs should have different objectives during each phase of the project, but all aim to achieve a single goal: a waterproofing system that performs as expected.

Inspection and Maintenance

Maintaining routine waterproofing inspection and maintenance services is one of the most cost-effective ways to extend the life of a structure/property. A regular inspection, care, and maintenance program are critical to the long-term performance of any waterproofing system, ensuring that the water-resistant system remains intact for as long as possible. The most challenging aspect of a waterproofing inspection and maintenance program is determining which systems, products, and services are most appropriate. Every structure is unique, as are the environmental requirements of each site. A waterproofing services plan that is individually designed and implemented is critical for long-term protection. Waterproofing inspection and maintenance must be customized from above-grade to below-grade, from the roof to the windows and doors to the drainage system, and from exterior to interior. Investing in a professional, customized system, as well as customized inspection and maintenance services, will more than pay for itself.

As a minimum, the routine inspection, care, and maintenance activities and results must be documented on a log. The log must include the following information: 1) the date of inspection (at least twice a year, preferably before and after the winter season); 2) the inspector's record, name, job function/department, and signature; 3) waterproofing conditions, such as record observations of accessible waterproofing membranes and membrane flashings at all edges, terminations, and penetrations. Make a note of any other conditions that may have an impact on the waterproofing system; 4) Leaks: keep track of all waterproofing leaks. If a leak is discovered, contact the waterproofing applicator who installed the waterproofing system right away; and 5) Repairs and alterations: The date of all work, as well as the individual or company who completed work that could affect the waterproofing.

Water ingress and waterproofing failure may cause structural issues in affected concrete buildings and properties over time, such as sagging slabs, cracks, foundation movement, or rusted steel reinforcement, causing concrete cancer. Roof surfaces, drains, plumbing, water irrigation, window/door seals, and so on are the most common and damaging areas for potential waterproofing failures. Blistering or peeling paint, molds, mildews, vegetative growth, rust stains on the concrete façade, odour, efflorescence, cracked walls, and internal and rising dampness are all warning signs. These issues, which can lead to unsafe and unstable conditions, should never be ignored or postponed, no matter how tempting it may be to save money by delaying repair and maintenance work. The first signs of foundation water damage should prompt action. The longer potential harm is ignored, the more severe the consequences can be. A failed system can result in a flooded building in extreme cases.

3) Total cost of ownership (TCO) control

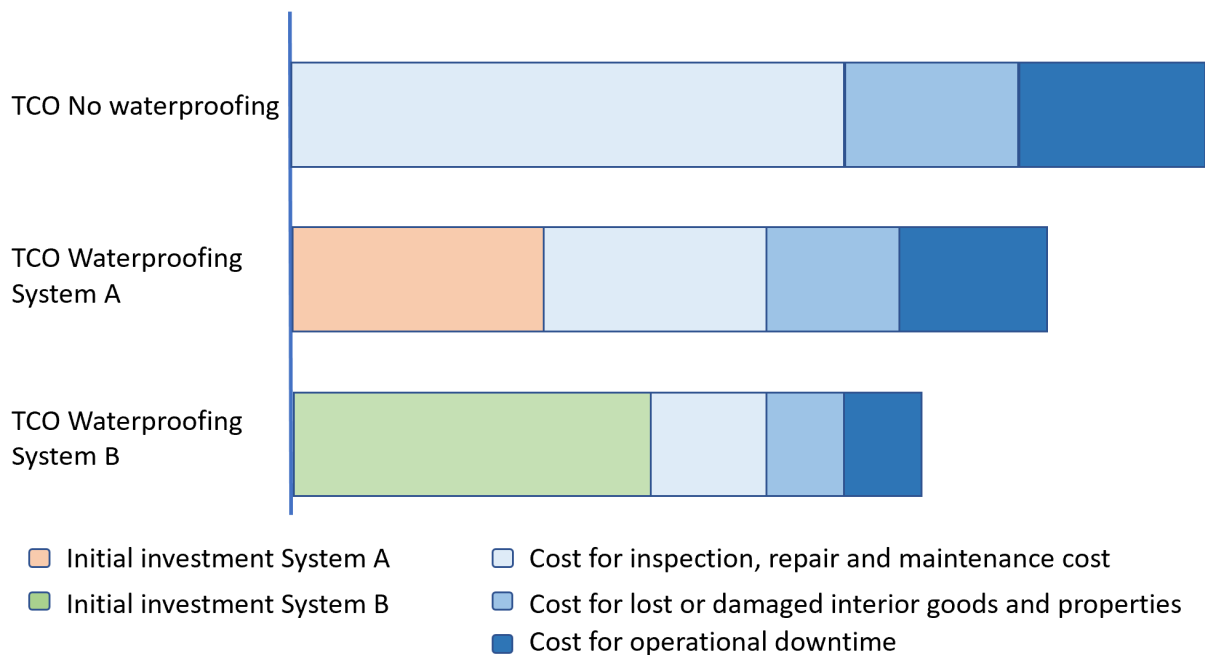


Figure 1 – The total cost of ownership (TCO) concept of waterproofing

It is critical for the structure's owner and investor to understand the importance of considering the total cost of ownership (TCO) of the structure's waterproofing rather than just the cost per kg of waterproofing material and installation. The total cost of ownership (TCO) refers to all the structure's costs over the asset's lifespan, including the initial investment in materials, construction, and installation, the cost of any loss or damage to interior goods and properties due to water ingress, the cost of regular inspection and monitoring, the cost of any repair and maintenance, and the cost of any downtime during such works. Waterproofing will pay dividends in terms of lower TCO of the concrete structure/building. Building waterproofing service issues can result in issues such as a flooded basement or rampant mold growth, as well as damage to interior supports and electronics, which will cost even more to repair. Considering the costs of waterproofing initial investment, associated inspection, maintenance, and repairs is an essential part of controlling TCO among various waterproofing systems (Figure 1).

Hiring an experienced professional firm to assist with any monitoring, inspections, or maintenance when warranted is a wise investment in the longevity of any commercial or industrial building. Building waterproofing services are critical for safeguarding the exterior and interior integrity of any commercial or industrial structure. Make the wise decision today and collaborate with the experts who can effectively maintain a waterproof envelope with professional building maintenance services.

The solutions

Waterproofing systems are primarily used in the building industry. The COVID-19 pandemic has had a significant impact on this industry. Major issues include order shipment delays, supply chain constraints, manpower and equipment shortages, and material shortages. Following the end of the crisis, the construction market is expected to rebound, and demand for waterproofing systems is expected to rise. The pandemic has also increased the demand for construction activities in the healthcare sector. The growing demand for cost-effective and efficient waterproofing systems stems from the growing construction industry, with the hope that these systems can address the various challenges of establishing and implementing an effective and long-lasting waterproofing solution for specific construction projects, as discussed above.

On the other hand, more restraint factors and technological challenges are limiting the growth of the waterproofing system market. The use of waterproofing chemicals or membranes endangers both the environment and human health. Because of the release of toxic fumes, VOCs, and hazardous elements into the atmosphere, the presence of hazardous chemicals, solvents, plasticizers, diluents, and others in waterproofing systems causes some environmental and health safety issues. There is also a growing demand for developing more sustainable, recyclable, or even bio-based waterproofing materials to reduce their carbon footprints and reliance on raw materials derived primarily from traditional petroleum-based sources. New waterproofing systems are also required to meet the needs of sustainable construction projects such as green roofs and green buildings.

Fortunately, waterproofing manufacturers have recognized the challenges above and issues related to the environmental, health and safety, sustainability, and project need aspects of the waterproofing market. They have developed many new products and end-to-end solutions to address these issues. Figure 2 depicts a new trend in the waterproofing solutions offered by manufacturers and distributors.

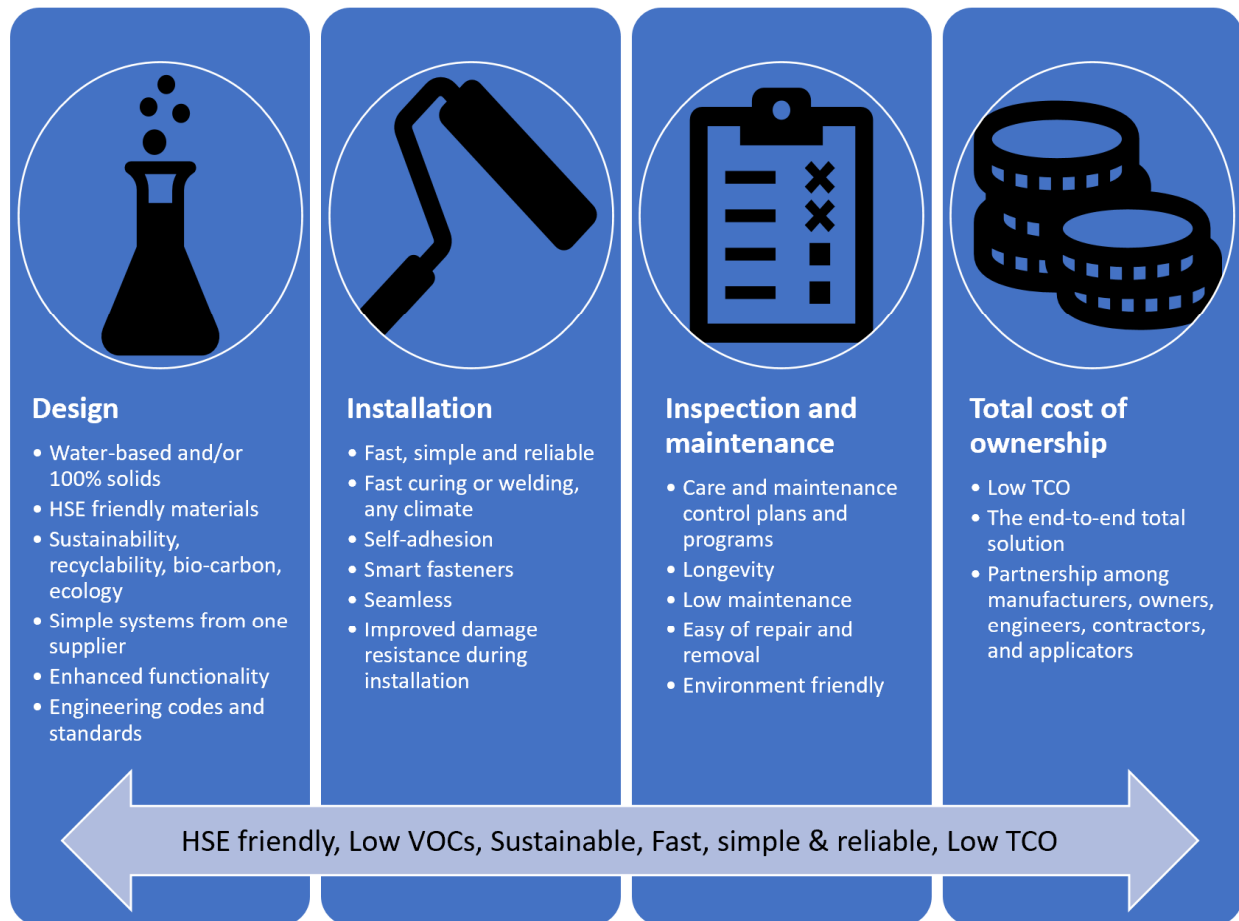


Figure 2 – Trends in Waterproofing Solutions

The two major trends in the waterproofing industry are the development of more sustainable products and the emphasis on improving product durability and functionality. Water-based liquid coatings (rather than traditional bitumen, coal-tar, or petroleum-tar-containing polyurethane coatings), silicones and silanes, polyurea, TPO (rather than traditional EPDM and even PVC membranes), and other more HSE-friendly products are being developed and used in the industry. Water-based coatings are odorless and do not necessitate any special ventilation. Splashes of droplets on the skin are not harmful and can be cleaned with soapy water. There is no need for specialized cleaning agents on the job site or for the equipment. Overspray and spills can be cleaned up with water if done immediately after application.

In terms of enhanced durability and functionality, a puncture/abrasion resistant spray on or peel-and-stick membrane and a seamless, and fastener or penetration free solution, are two topics that are frequently discussed. Peel-and-stick membranes are becoming a popular option for waterproofing in the ICF industry for its fast installation efficiency, but these sheet membranes are not without their challenges, and can be temperamental in less-than-ideal conditions. Poor installation, being left in the elements too long or careless backfilling often results in damages such as punctures, tears or folds that lead to trapped pockets of water unable to escape from behind the membrane. These concerns are not relegated solely to peel-and-stick membranes however and can be a viable problem for most if not all product categories. ICF is an abbreviation for insulated concrete form, which is a hollow stackable block made of rigid foam. Walls are built by stacking blocks, which are then filled with steel-reinforced

concrete. ICF is becoming increasingly popular, particularly for green buildings and insulated basements. Waterproofing can be complex because the membrane must be applied to the foam.

When discussing above-grade water protection in the waterproofing industry, many markets are also looking for added fire protection due to the increase in wildfires and such, and thus a waterproofing product with high fire resistance is also desired. A waterproofing system that combines the class A fire rated coating with E-Glass is a recent development (can endure 600 degrees Celsius and is used to line ovens).

Waterproofing manufacturers are also collaborating closely with distributors, general contractors, and applicators to provide end-to-end total waterproofing solutions, as well as to assist and train in project specifications and engineering details, design and material selection, on-site application training for fast, simple, and reliable installations, and customized care and maintenance programs.

Electronics industry advancements are also having a positive impact on the waterproofing industry. If a problem is detected, sump pumps can automatically contact building management. Rooftop leak detection systems can monitor for leaks continuously and call or sound an alarm if water penetration is detected.

Conclusion

The sophistication of effective and long-lasting waterproofing solutions now available is bringing the waterproofing industry to a new level of performance and productivity. Contractors can tackle more challenging work, take on more work with the same size team, and reduce labour costs with today's technology and new solution developments. Project delays caused by climate change can be avoided or significantly reduced. When owners, designers, and general contractors are concerned about providing environmental friendliness and sustainability, maximum protection with enhanced durability and functionality, and faster turnaround on tighter budgets, solutions are available to meet these demands. These solutions or combinations of a variety of solutions (systems) exist to address various challenges associated with the four elements of waterproofing work for a given construction project in terms of design and material selection, installation, inspection and maintenance, and total cost of ownership (TCO) contingency. The industry would do well to move away from the practice of standardization and lean into the practice of customization when it comes to addressing the unique challenges of waterproofing, given that the demands of any building or geographic region are hardly ever alike.

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