

Below-Grade Waterproofing: A Closer Look into Fully Bonded Blindside Systems

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THIS ARTICLE REVIEWS the bonding mechanisms and test methods for fully bonded blindside waterproofing membranes that are permanently bonded to basement and below-grade concrete structures. The described systems are used to waterproof the positive side (the side facing the soil or backfill) of a concrete structure.

Leaks can occur in below-grade concrete structures exposed to groundwater in the surrounding environment. The leaks can originate from a vast variety of issues. Typically, untreated construction joints (cold joints) and penetrations within the concrete structure (such as pipes, pile heads, and so on) are the areas where water travels to the inside of the below-grade space. In addition, cracks in the concrete slabs or walls can pose a pathway for groundwater to cause leaks.

Different waterproofing solutions are used to protect below-grade concrete structures from leaks. The solutions range from waterproofing admixtures to waterproofing membrane systems. In general, waterproofing solutions can be classified as integral waterproofing systems and barrier waterproofing systems. Integral waterproofing systems add the waterproofing performance directly to the concrete mixture design, which is achieved with waterproofing admixtures.

Barrier waterproofing systems create a separation layer between groundwater in the surrounding environments and the inside of a building. Types of barrier waterproofing systems can be categorized as negative-side waterproofing and positive-side waterproofing. Negative-side waterproofing refers to a waterproofing layer that is applied

on the inside of the below-grade concrete structure. It prevents leaks created by groundwater that has penetrated through the entire thickness of a concrete slab or wall. Typical products are cement-based coatings such as waterproofing grout, mortars, and similar materials. Negative-side waterproofing

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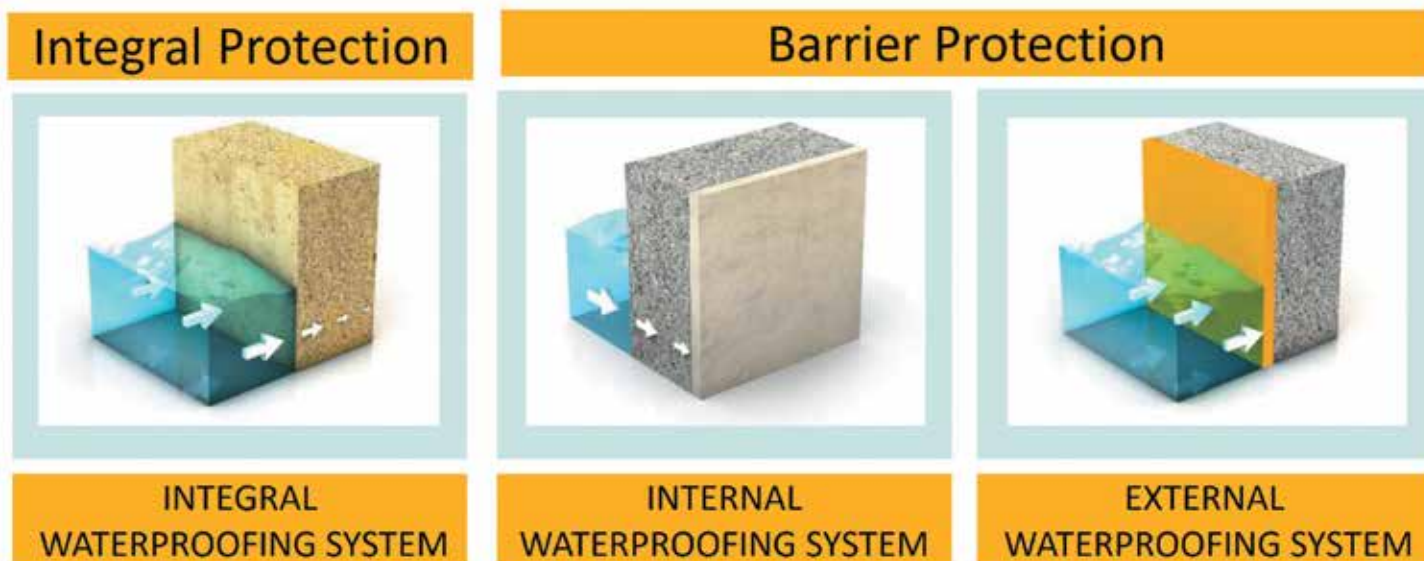


Figure 1. Waterproofing systems can provide integral or barrier protection. Note: Negative-side and positive-side waterproofing systems are shown in the middle and right sections of the figure, respectively.

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is used for repairs of existing concrete structures and can be used in new construction as a last resort. However, negative-side waterproofing leaves the concrete structure exposed to its surrounding environment, whereas positive-side waterproofing creates a barrier between water and the concrete structure.

Products used for positive-side waterproofing include coatings, sheet membranes, liquid-applied membranes, and self-adhesive modified-bituminous sheets, among others. The choice of product depends on the project requirements such as resistance to chemical exposure, resistance to hydrostatic pressure, and material durability. The duration of the warranty may be another consideration when selecting a product. Positive-side waterproofing for new construction on areas where there is no access to the concrete structures once the concrete is poured is called blindside waterproofing. Historically, clay-based systems have been used as blindside waterproofing systems. However, newer polymer-based blindside products have emerged; these are also referred to as fully bonded systems. **Figure 1** shows illustrations for the addition of waterproofing performance to a concrete structure.

BLINDSIDE WATERPROOFING

With the introduction of fully bonded systems (blindside waterproofing systems), manufacturers intended to provide a solution to the lateral water migration that is a significant problem of a system under hydrostatic pressure that is not fully bonded.

All systems that are installed before reinforcement is placed are subjected to

the risk of puncture during the process of reinforcement placement. If reinforcement is dropped or dragged on these systems, that can cause damage and potentially lead to leaks, especially in areas subjected to groundwater and hydrostatic pressure. On residential and commercial concrete structures, vapor barriers with a thickness of 10 mil (0.25 mm) to 15 mil (0.38 mm) are used when there is no hydrostatic pressure against the building. Occasionally, a drainage system is installed in addition to the vapor barrier to divert any potential buildup of hydrostatic pressure. These systems are referred to as loose-laid systems because they are not fully bonded to concrete. The risk of leakage with loose-laid systems arises in situations where the system is damaged and hydrostatic pressure builds up. High-risk scenarios include heavy rainstorms and situations in which the drainage system is blocked. In these types of events, the water level can reach the vapor barrier, bypass the damaged area, and freely move between concrete and the vapor barrier sheet. This effect can also occur with loose-laid systems that are partially fixed but not fully bonded to a vertical concrete substrate. Eventually, the water will be visible in the form of a leak through a crack in the concrete or improperly detailed penetrations. To prevent the described lateral water migration, fully bonded systems have been used for blindside waterproofing, especially for concrete structures in the water table.

Polymer-based fully bonded systems have a general buildup of two layers. The main layer is facing the water and is called the waterproofing layer. This layer resists hydrostatic pressure and general membrane punctures. The second layer,

which is referred to as the bonding layer, creates a bond with fresh concrete during the curing process. Various chemistries and technologies are used within the class of fully bonded systems.

Waterproofing Layer

The most common types of polymers used for the waterproofing layer are high-density polyethylene (HDPE), thermoplastic polyolefin (TPO), and polyvinyl chloride (PVC). The main objective for using a specific polymer and sheet thickness is to achieve the desired physical properties of a fully bonded membrane such as puncture resistance and flexibility (elongation). Puncture resistance is a key factor regarding the waterproofing layer weight, due to the steel reinforcement weight placed on small spacers. When a high load is placed on the small surface of a spacer, a high puncture load is created. Therefore, a fully bonded system must have a high degree of puncture resistance.

Flexibility plays a significant role during the installation of a system. A flexible and pliable system facilitates the installation on site, especially if the geometry of a slab design contains elevation changes and unconventional angles.

Bonding Layer

Fully bonded waterproofing membranes form a bond with the fresh concrete over the entire surface of the bonding layer. The main advantage of this system compared with loose-laid membrane systems is that in the case of a potential damage to the membrane, intruding water will not migrate laterally between the

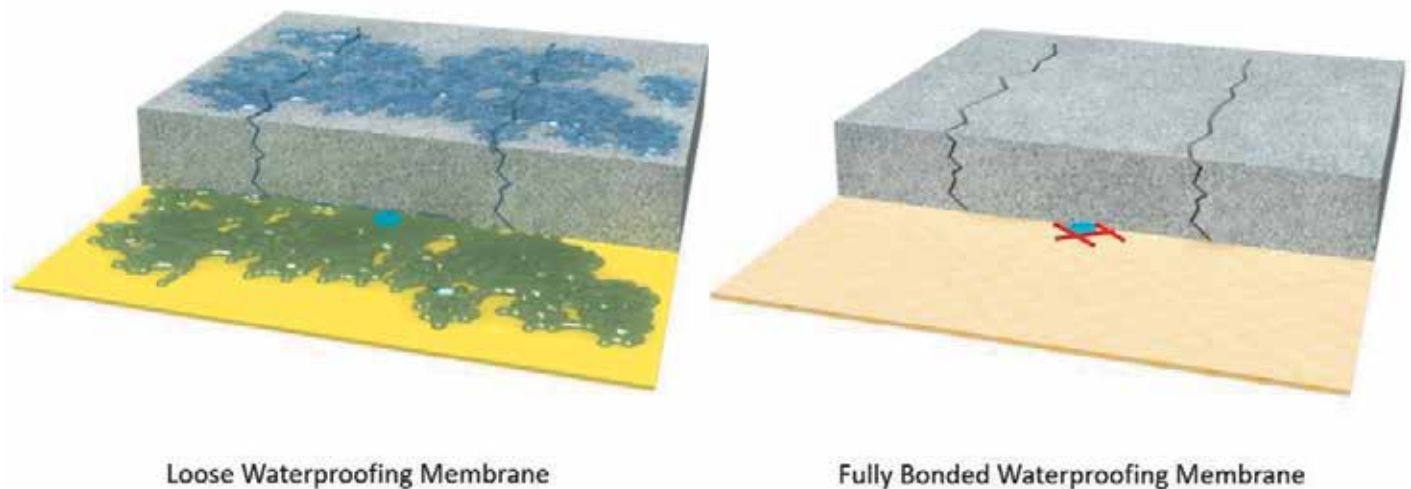


Figure 2. Water migration with loose-laid waterproofing membrane (left) and fully bonded waterproofing membrane (right).



Figure 3. Nonwoven fleece bonding layer.



Figure 4. Bonding layer with sand granules.

concrete and the waterproofing system. Instead, the water will remain contained locally on the damaged area. Thus, the fully bonded system reduces the risk of potential leaks through the concrete structure. In addition, fully bonded systems act as a form of damage control by decreasing how much injection repair is required if a leak occurs. **Figure 2** illustrates the lateral water migration for loose-laid waterproofing membranes and fully bonded waterproofing membranes.¹

In fully bonded systems, the formation of the bond between the bonding layer and the fresh concrete is critical. There is a large variety

of bonding layers on the market. However, the bonding mechanisms can be classified into three categories: mechanical, chemical/adhesive, and dual bond (mechanical and chemical/adhesive). In the following sections, the different bond mechanisms are described in more detail.

Mechanical Bond

Bonding layers with a mechanical bonding mechanism incorporate the effect of friction. Static friction occurs between two motionless objects. The surfaces of objects are generally uneven on an atomic scale. This unevenness results in surface roughness, which creates

static friction that prevents sliding of the objects involved. If a shear force is introduced and becomes larger than the force of the static friction, the object will start to move. The resulting force acting against the shear force is called sliding friction. Generally, the force of sliding friction is less than that of static friction. To take advantage of the effect of friction, mechanical bonding layers contain either nonwoven fleece textile fibers or sand granules (see **Fig. 3** and **4**).

The surface of the mechanical bonding layer is embedded by the cement paste of the fresh concrete during pouring. Once the concrete cures, a boundary layer is formed. The friction present in the boundary layer is called form closure. This kind of friction is achieved when at least two connecting materials (textile fibers/sand granules and concrete) intertwine, thus remaining connected even if the force transfer is lacking.^{2,3}

Chemical/Adhesive Bond

Adhesion generally describes the connection of two surfaces of different materials. Various types of forces are present between the attached particles. Adhesion can occur mechanically through the interlocking of the adhesive material and the surface on which it is applied. This process occurs at a microscopic scale where the adhesive fills in the pores of the surface area. This type of adhesion is a physical connection and does not change the chemical structure of the adhesive or the substrate surface.^{4,5} **Figure 5** illustrates a scheme of a micromechanical adhesion.⁵ **Figure 6** shows a sample of an adhesive bonding layer.

At the molecular level, micromechanical adhesion is created through forces acting between atoms or molecules to form a connection. These intermolecular bonds are influenced by the properties of the atoms or molecules. The types of forces that can form intermolecular bonds can be classified as ion-induced dipole forces, ion-dipole forces, and van-der-Waals forces.

Ion-dipole forces act between an ion and a polar molecule (see **Fig. 7**). The oppositely charged parts of the molecules locate themselves to generate maximum attraction. In an ion-induced dipole force interaction, the charged ion disrupts the arrangement of electrons in an atom or nonpolar molecule and induces a dipole. Hence, a weak bond between the ion and the induced-dipole occurs. The same effect occurs in van-der-Waals forces; however, in van-der-Waals forces, the interaction happens between

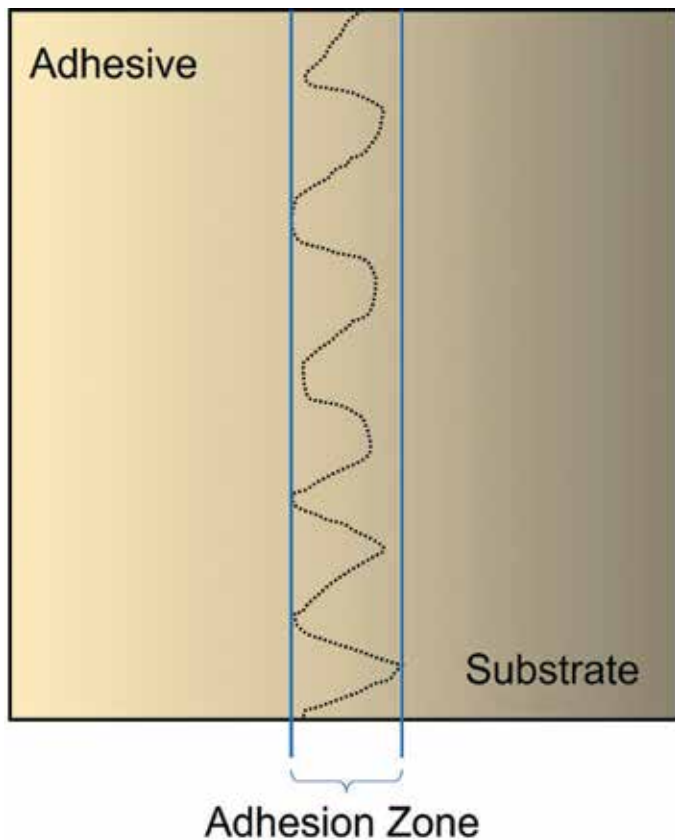


Figure 5. Scheme of micromechanical adhesion.



Figure 6. An adhesive bonding layer.

a polar molecule and either another polar molecule or a nonpolar molecule instead of an ion and another polar molecule or a nonpolar molecule. These interactions are called dipole-dipole and dipole-induced-dipole interactions.⁴

Dual Bond

A new generation of fully bonded systems have been developed to use both mechanical and chemical/adhesive bonding mechanisms. The bonding layer is designed to have a rough or coarse texture so that a mechanical bond is created when fresh concrete encapsulates the layer. In addition, adhesive polymers are added to the bonding layer matrix to provide a chemical/adhesive bond. **Figure 8** shows a cross section of a fully bonded membrane using the dual-bond mechanism. The rough/coarse structure keys into the concrete while an adhesive bond is simultaneously created between the bonding layer and concrete on the entire contact area.

PERFORMANCE TESTING

To test the resistance to lateral water migration between concrete and blindside waterproofing systems, a test method based on ASTM D5385,

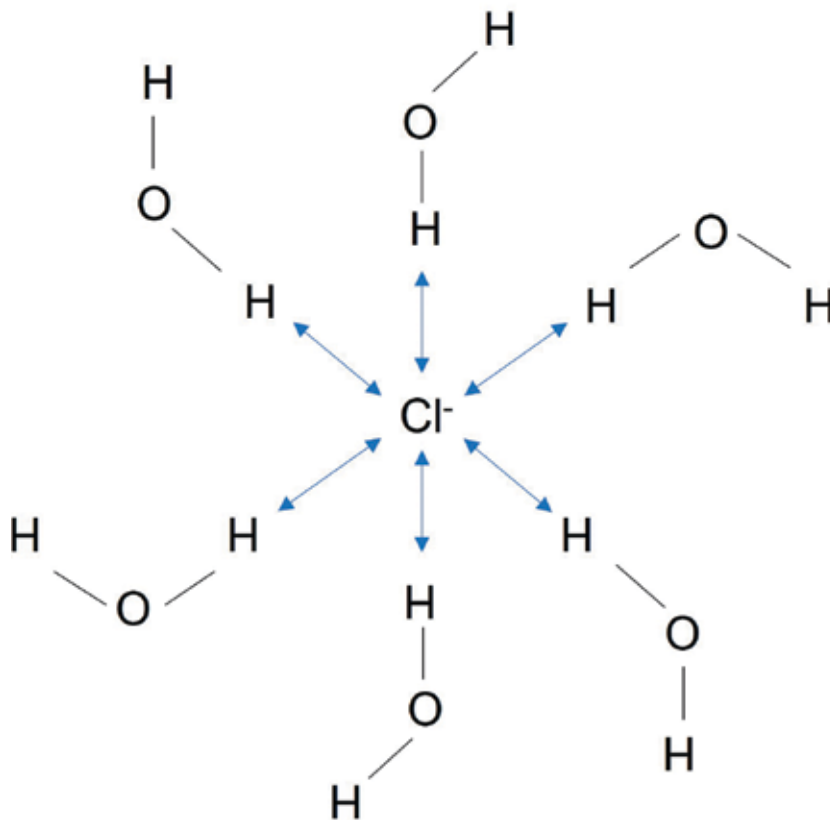


Figure 7. Example of ion-dipole interactions (blue arrows) between a chloride (ion) and water molecules.

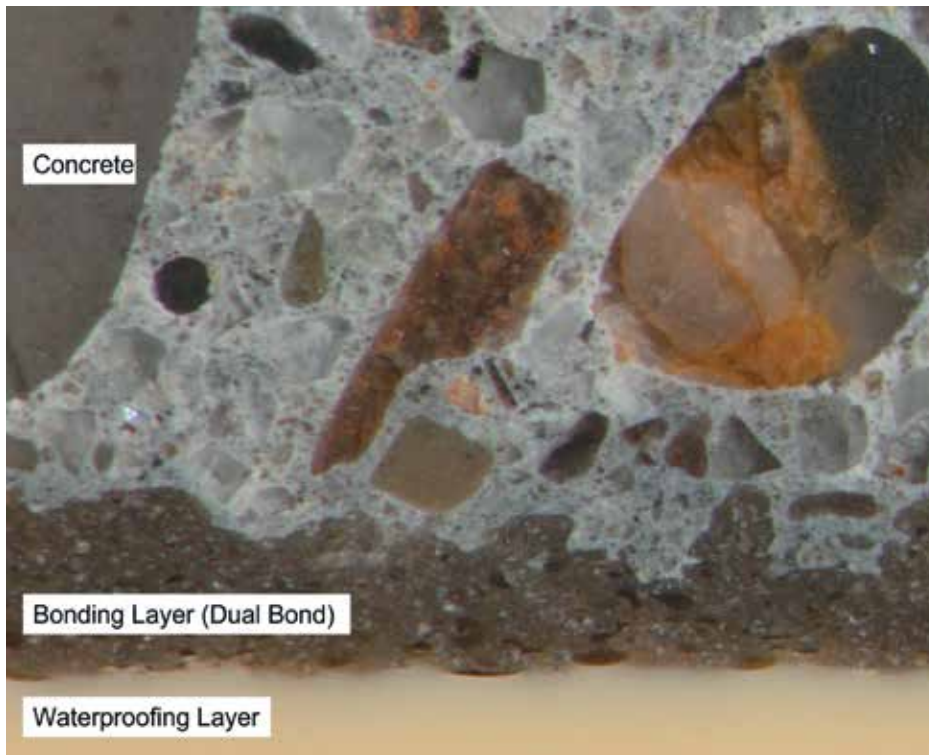


Figure 8. Microscopic image of dual-bond layer bonded with concrete.



Figure 9. Apparatus used for ASTM D5385⁶ testing and the study test method.

Standard Test Method for Hydrostatic Pressure Resistance of Waterproofing Membranes,⁶ was introduced by manufacturers. Product data sheets of blindside waterproofing systems reference the test method as ASTM D5385 Modified (hereafter called “modified test method”). The modified test method uses the

same testing device as ASTM D5385; however, the modified test method is significantly different from ASTM D5385 and thus results from the two methods are not comparable. The following describes both methods in detail for the purpose of understanding the procedural differences.

ASTM D5385

In waterproofing membrane systems, the susceptibility to failure at side laps increases if installation is poorly done and bonding is insufficient. To address this concern and ensure watertightness of the product, manufacturers can use the ASTM D5385⁶ method to test the membranes in the waterproofing system. This test focuses on the crack-bridging capabilities and watertightness of the membrane joints. The testing apparatus has a chamber, gasket, and clamping bracket (see Fig. 9). During testing, the membrane sample and the substrate block are fixed between the gasket and the clamping bracket. The substrate block usually consists of concrete and includes a spacer lengthwise on the opposite side from the membrane. The spacer is triangularly shaped with a width of 125 mils (3.2 mm) and height of 173 mils (4.4 mm). The membrane joint is adhered to the substrate block, where the joint must be perpendicular to the spacer. Subsequently, the substrate block is placed onto the chamber, and the spacer is processed to a crack with a wedge and a hammer. The membrane side of the substrate block is put under water pressure, which is transferred from the chamber (Fig. 10). The pressure is increased by a rate of 15 psi (103 kPa) per hour up to 100 psi (689 kPa). Thus, the overall testing period lasts 7 hours. The watertightness is visually evaluated by the amount of water that has traveled through the crack.

MODIFIED TEST METHOD

In the modified test method, the fully bonded membrane is intentionally damaged to simulate lateral water migration between the concrete and the fully bonded membrane. As shown in Fig. 11, the fully bonded membrane is bonded to the concrete substrate. This sample is created by pouring fresh concrete onto the fully bonded membrane. During the concrete curing process, the bond between the membrane and the concrete is formed. Subsequently, the sample is positioned in the testing apparatus, and hydrostatic pressure is exerted on the membrane side. The sample contains two pipes that are located 4 in. away from the intentionally created damage, and the modified test method uses these pipes to evaluate whether water migrates through the damage between the membrane and the concrete. If the bonding layer fails, water will push through the pipes and make the failure visible as a leak. In contrast, successfully tested fully bonded sheet waterproofing systems do not show any leak (see Fig. 11).⁶ Table 1 summarizes the differences between ASTM D5385 and the modified test method.

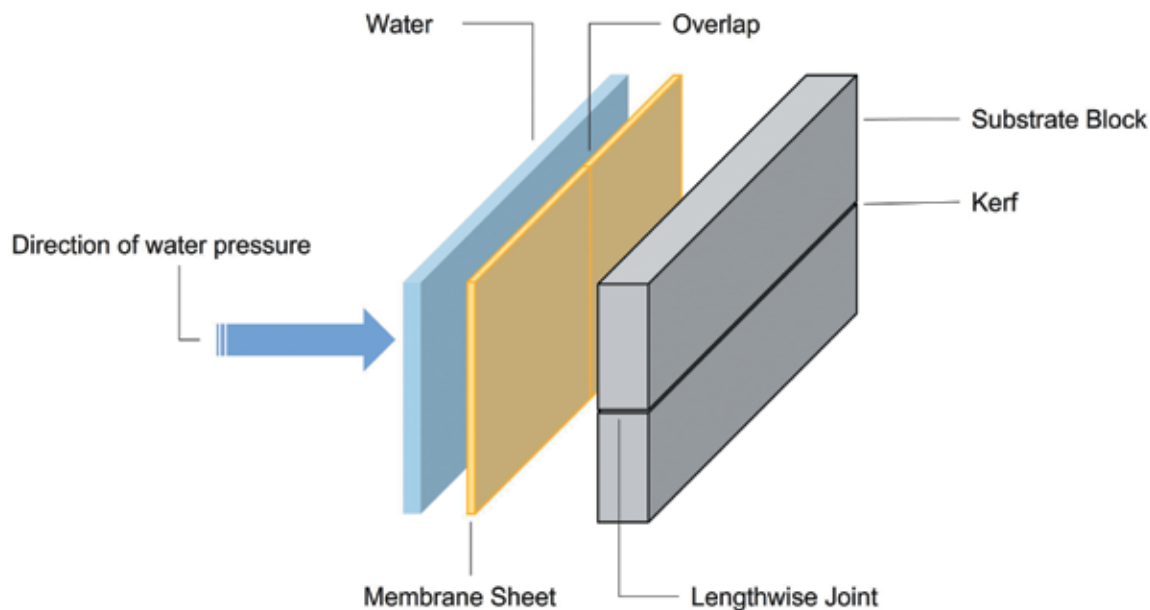


Figure 10. ASTM D5385⁶ test setup.

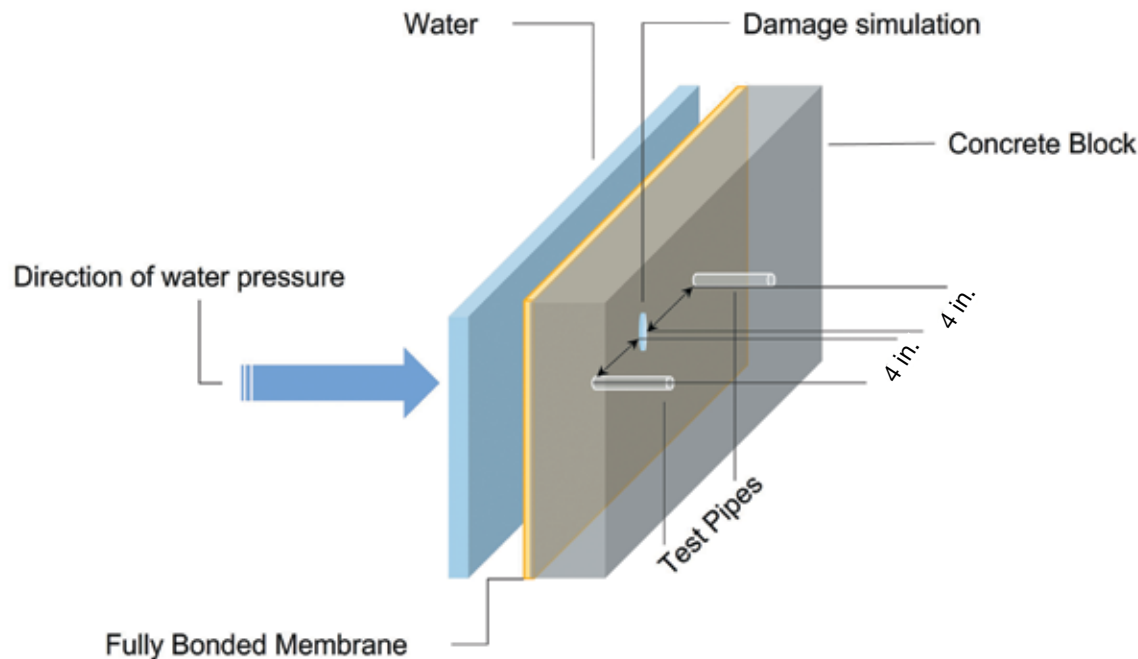


Figure 11. Setup for the modified test method.

CONCLUSION

Fully bonded blindside systems provide a barrier between groundwater and a below-grade concrete structure on its positive side. As reviewed in this article, there are three main methods on how the bond to concrete is achieved.

A mechanical bond is created by a nonwoven fleece/geotextile bonding layer. Alternatively, a bonding layer with sand granules also creates a mechanical bond.

TABLE 1. COMPARISON OF ASTM D5385⁶ AND THE MODIFIED TEST METHOD

Testing criteria	ASTM D5385	Modified test method
Aim	Watertightness of joints/laps	Resistance to lateral water migration
Solution	Water	Water and control tubes
Block preparation	With spacer	Without spacer; with initial damage
Membrane application	Post-applied to substrate block	Pre-applied with fresh concrete
Pressure procedure and duration	15 psi (103 kPa) per hour until 100 psi (689 kPa); 7 hours total	15 psi (103 kPa) per hour until 100 psi (689 kPa); 7 hours total

Bonding layers consisting of an adhesive layer or containing adhesive polymers create an adhesive bond with concrete. A combination of mechanical and adhesive bond is provided by bonding layers that have a rough, textured surface in addition to containing adhesive polymers. This bond method is also referred to as dual bond. The main objective of fully bonded waterproofing systems is the resistance to lateral water migration. This property is tested by a modified test method that utilizes the device referenced in ASTM D5385. The modified test method exerts a hydrostatic pressure at a rate of 15 psi (103 kPa) per hour until 100 psi (689 kPa) resulting in a total test duration of 7 hours.

The fully bonded blindside waterproofing market has adopted the modified test method as the main test method for evaluating the resistance to lateral water migration. For this reason, most manufacturers list the result in the product data sheet of their systems. In the

product data sheets, the modified test method is stated as ASTM D5385 Modified. 

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Nitharsan Kugadas, MSc Chem, CDT, is a product engineer who specializes in sheet waterproofing for below-grade concrete structures. He has vast experience in advising on below-grade waterproofing projects ranging from residential and commercial buildings to tunnel and infrastructure projects in the United States, Europe, and the Middle East. In his previous roles and his background as a chemist, he has been deeply involved in the research and development of below-grade waterproofing solutions.

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Special interest

How to Defeat Workplace Tech-Shaming between Generations

Workplace tech can befuddle older workers—and younger ones.

"Even if you find fax machines or zip files self-explanatory, your younger colleagues may not," wrote Tatum Hunter in the *Washington Post*. To illustrate this point, Hunter shared the story of 22-year-old Erica Lock, an "IT whiz" who couldn't get her printer to work, ruling out one possible problem with the printer after another—until she realized the device was out of paper.

"Age bias affects both sides, as boomers try not to appear out of touch and Gen Z contends with stereotypes that young people are naturally skilled with all forms of tech."

To overcome this communication breakdown, Hunter recommended talking with colleagues about what's not working, then picking one tool to address any breakdowns—for example, use Slack for brainstorming or Google Docs to collaborate in real time. "Then schedule no-shame, question-and-answer sessions to get everyone up to speed. Encourage questions and provide written directions whenever possible."

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