BURIED MEMBRANE WATERPROOFING

A Study on the Performance of Today's Technologies

Presented to you by

POLYCOAT PRODUCTS

A Division of American Polymers Corp.

This presentation is an analytical comparison of various types of waterproofing products and systems, such as pre-manufactured membranes, hot and cold fluid applied coatings, expandable waterproofing. It is meant to provide for the specifier a greater understanding of the advancements in today's technologies, best practices, and safety features.

We will discuss:

- Typical Project Conditions
- Compare Properties of Various Products/Systems
- Analyze How the Various Products Function
- Compare Performance
- Compare Ease of Application- Time plus Cost
- Best Practices and Safety in Today's Green Construction Market Place

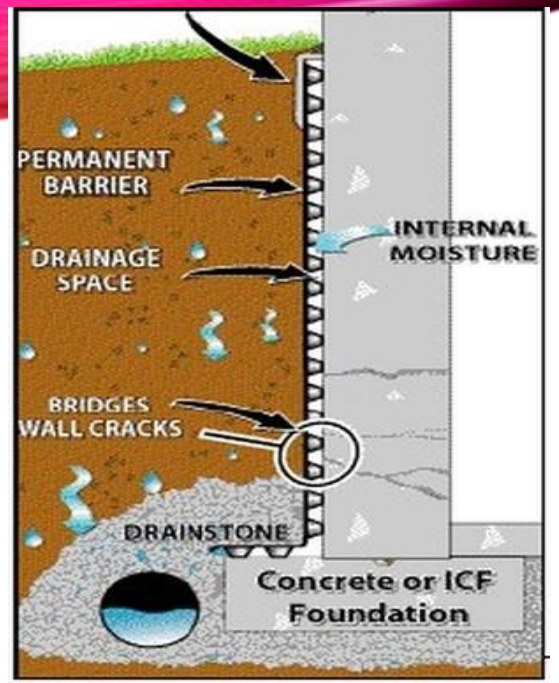
BURIED MEMBRANES

Buried membranes typically require lengthy functional performance. Warranties will vary from 5 to 20 years. Actual functional performance for some systems reach 40+ years. *Unseen and mostly unknown, they protect structures from deterioration.*

Areas of use:

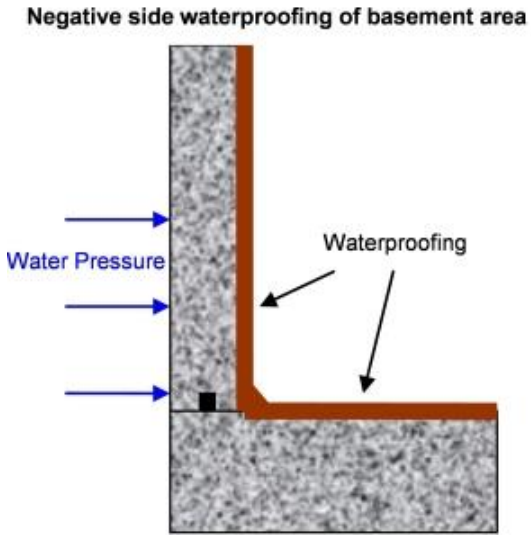
- **Foundation of structures** (i.e., buildings, warehouses, stores, homes)
- **Split-slabs** (i.e., parking garages, walkways, plaza decks)
- **Planters, Elevated Landscapes**
- **Retaining Walls, Elevator Pits**
- **Field Trays** (Stadiums)
- **Tunnels**

UNDERSTANDING THE SELECTION



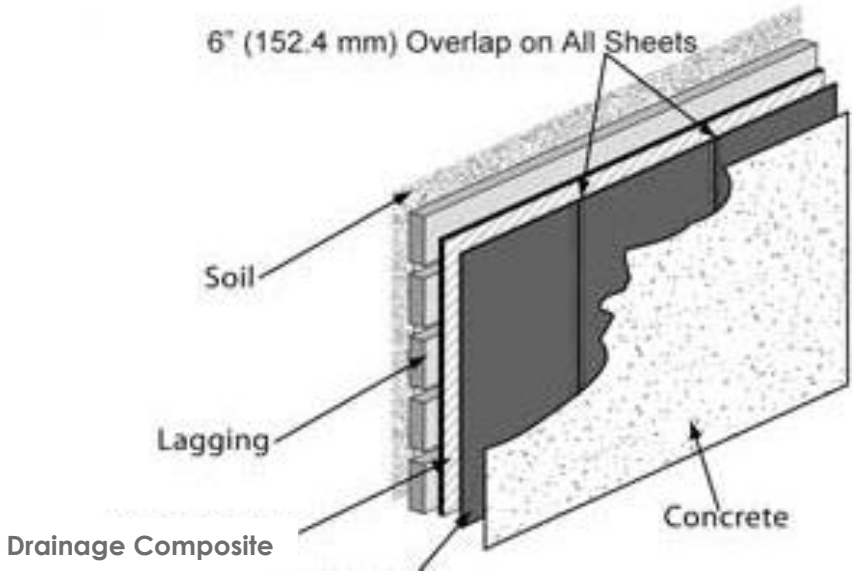
Positive-side Waterproofing

Positive-side waterproofing requires access to the outside face of the structure in new construction or the removal of overburden in an existing structure- whether it is a vertical or horizontal plane. Directly protects the structure from water intrusion and hydrostatic pressure.



Negative-side Waterproofing

Negative-side waterproofing is applied interior to the exposed structure- inside face of the wall—it has no direct exposure to ground water. This option is typically selected when there is no space/or budget to excavate for positive-side waterproofing.



Blind-side Waterproofing

Blind-side waterproofing is affixed to an adjacent structure or soil retention feature- such as a lagging wall- rather than the new structural wall. Typically installed dry, it activates as it becomes wet from either the newly poured in-place concrete, ground water, or water runoff.

DIFFERENT TYPES OF WATERPROOFING MEMBRANES

Peel-n-Stick Membrane

Flexible, preformed waterproof membrane typically combining cross-laminated, semi-flexible, High Density Polyethylene (HDPE) carrier film with a self-adhesive rubber bitumen compound.

Hot Rubberized Asphalt

Hot-applied rubberized asphalt is a blend of asphalts, synthetic rubber polymers, and filler formulated to provide toughness with flexibility and low moisture vapor permeance.

Bitumen modified Polyurethane

Cold fluid applied, single component, bitumen modified, coal tar free, moisture cured non-permeable waterproofing membrane.

Bentonite

Bentonite clay is typically sandwiched between two polyethylene fabrics (woven and non-woven), or laminated to a geotextile core. The bentonite clay activates- and expands- when it becomes wet forcing itself into crevices and sealing them.

PEEL-N-STICK MEMBRANES

- Sheet membranes come in cured forms at a specified thickness. Typically 45-60 mils and are roughly 3-4 feet wide by 60 feet in length.
- A multi-layered product, the self adhered peel-n-stick membranes are made up of either HDPE, bitumen- or both- with a thin film adhesive used to attach the product to the substrate and a release for the adhesive.
- The physical properties of the cured membrane are typically very good. With high puncture resistance and low permeability, the peel-n-stick membrane is attractive.
- Self adhered membranes are not exactly pliable and can be difficult to work with. They do not conform to the irregularities of a raw concrete form, nor to transitions of steel and other building materials. They can not span any type of void. And voids/irregularities are inherent in structures. This creates problematic issues for the product.

THE SCIENCE OF HDPE

- High-density polyethylene (HDPE) is a thermoplastic polymer produced from the monomer ethylene. ... With a high strength-to-density ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping, *drainage boards* and geomembranes.

- HDPE is made under highly regulated controlled conditions by applying intense heat to petroleum. This process, also known as "cracking," helps create ethylene gas. During its production, the gas molecules will attach to form polymers, which then produce polyethylene.

WHAT IS BITUMEN?

- Bitumen is a **semi-solid** hydrocarbon **product** produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process.
- It is produced to meet a variety of specifications based upon physical properties for specific end uses. Its main characteristics as an adhesive, as well as being waterproof, thermoplastic, durable, modifiable and recyclable make it ideal as a construction and engineering material.
- In North America, bitumen is commonly known as "asphalt cement" or "asphalt". But actually, bitumen is a component [of], which holds all of the aggregates together- once cooled.
- Heat causes bitumen to re-emulsify. It stiffens to a semi-solid state as temperatures cool.

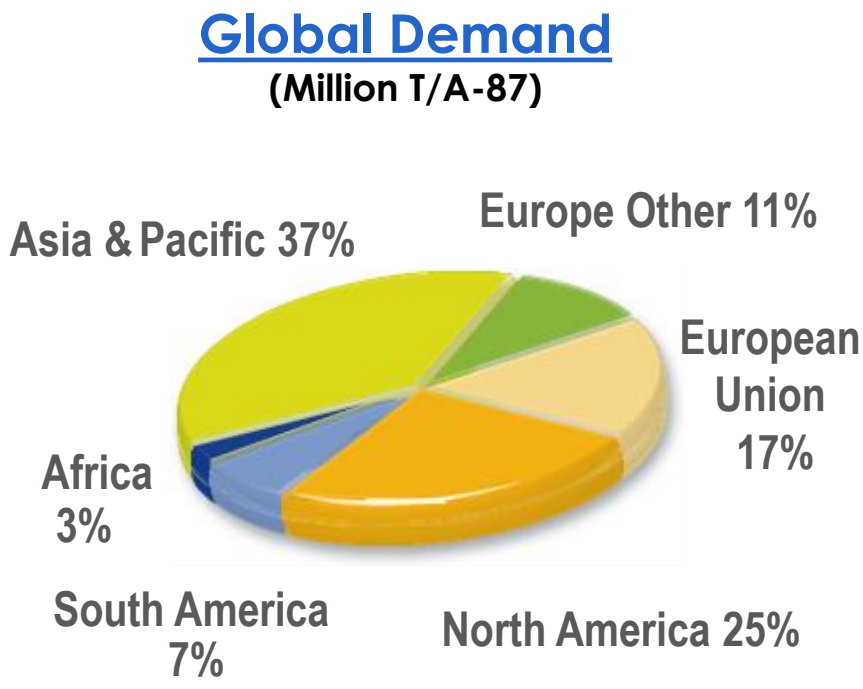
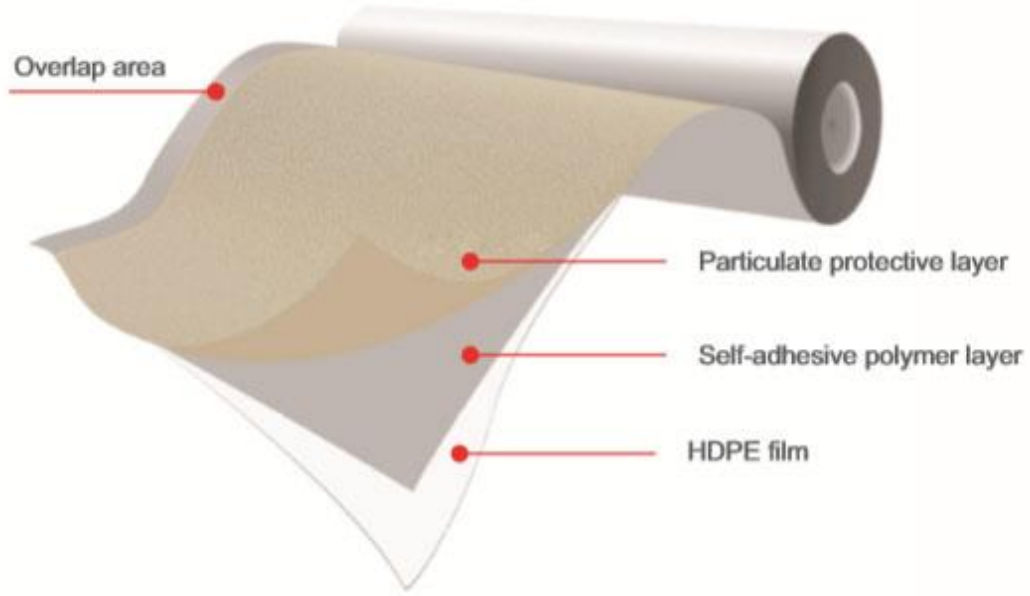


Figure 1. Global bitumen use (Source: Asphalt Institute & Eurobitume)

PEEL-N-STICK MEMBRANES



PEEL-N-STICK MEMBRANE APPLICATION

- Typically requires a primer. Applied at 300 sf per gallon
- The membrane is attached to the substrate utilizing a thin film adhesive. Pockets can be inherent due to its lack of pliability. Performance relies heavily on the product not tearing once the overburden is cast.
- Addressing the inherent seams is also crucial to success.
- Seams are inherent in these types of systems due to the products cured state. Seams are addressed on site by either heat welding, overlapping the rolls in conjunction with the use of additional tapes and double adhesives, mastics, and/or all of the above.

HOT APPLIED RUBBERIZED ASPHALT

(show video)

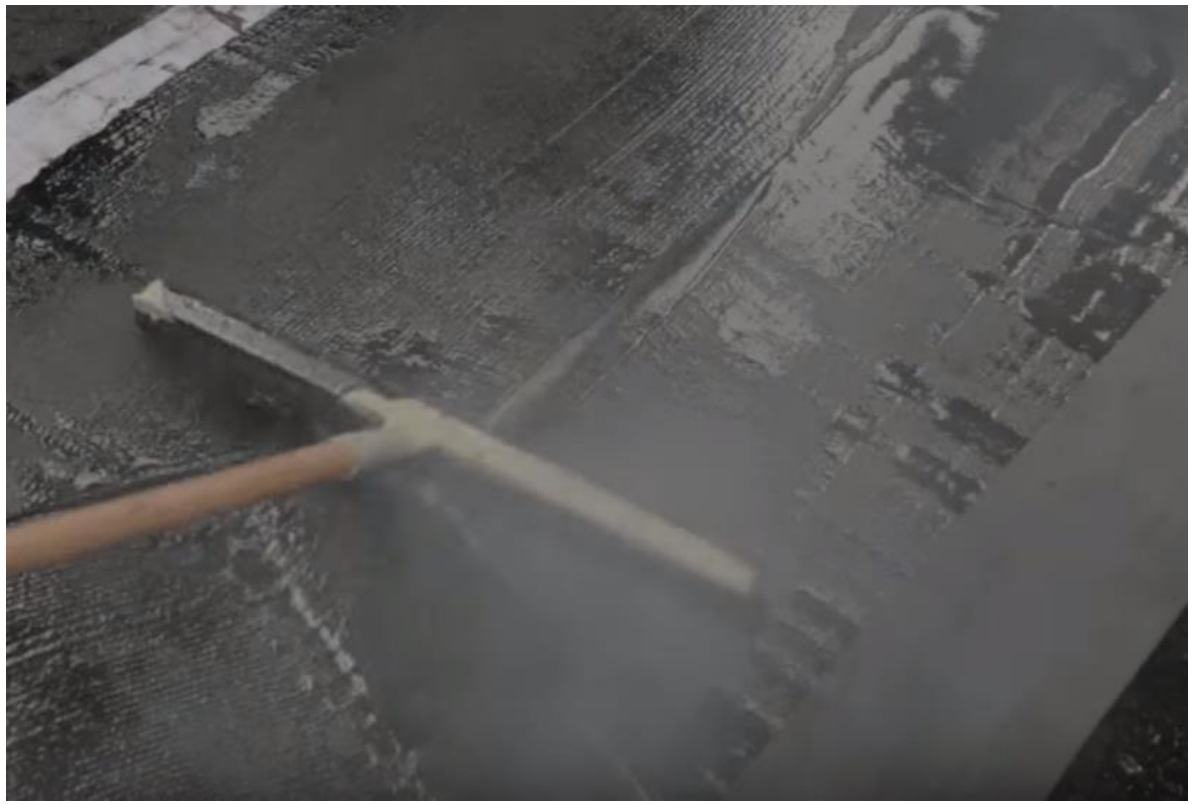
- Hot rubberized asphalt typically goes down in 2 lifts and requires a reinforcing fabric to be embedded into the first application.
- Rubberized asphalt consists of regular asphalt concrete mixed with crumb rubber (15%) made from recycled tires.
- The asphalt is heated to an extreme temperature, agitating the chemical make up of the components, emulsifying- or melting it down- to alter its viscosity on the job site. To accomplish this, both men and women, on the jobsite utilize a double jacketed oil bath kettle. VERY OLD technology. An oil kettle- The kerosene lamp was invented in1854.
- Analysis of the vapors that are released from tires reveals the presence of numerous compounds that constitute the "tire smell." Some of these, mostly those emanating from the hydrocarbon oils, are potentially toxic. Some, like benzopyrene, are carcinogenic. (see, Catherine Hansen on Dangers to Public Health | September 24, 2017 | Energy, Environment, Pollution)
- Is this process the best solution? Specifiers are intellectuals with an inherent responsibility to consider important factors that affect our society and the human experience- from our men and women on the job to the air we breath- all factors. An awesome privilege that impacts the human experience for generations. (**What you specify matters**).
- Melted rubberized asphalt must maintain a temperature of approximately 410° F on site for the entire project, with an oil bath temperature of 550° F. (show pic next slide- FUMES)

HOT RUBBER- APPLICATION

- Surface prep of CSP 3-4 is required
- Detailing and reinforcement of cracks, drains, etc. applies.
- Typically requires a primer. Applied @ 200-350sf per gallon
- The kettle requires warming up 2-3 hours prior to application.
- The first coat is applied at 45 to 95 mils.

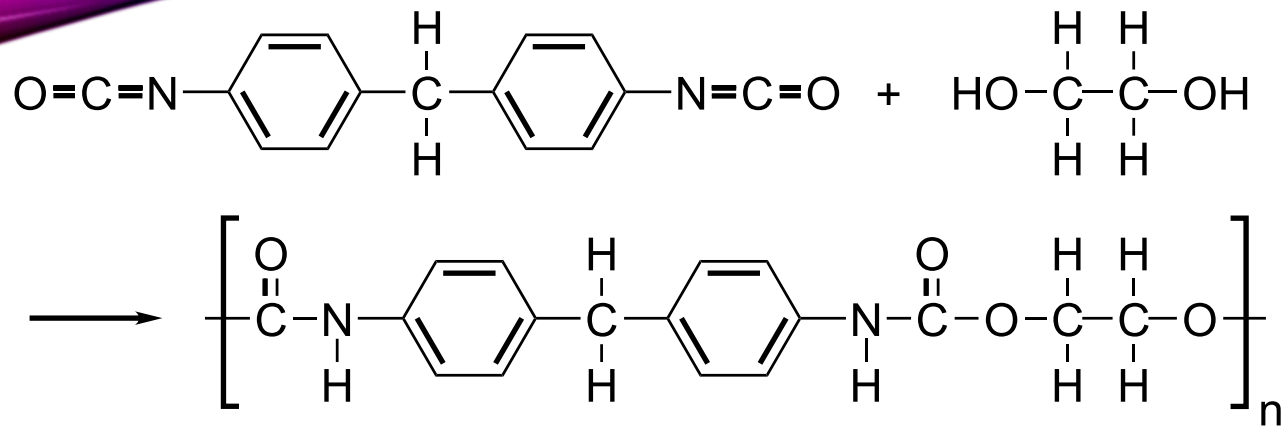
HOT RUBBER- APPLICATION

- Reinforcing fabric is embedded into the first coat while in it is still in an extremely hot and liquid state.
- The second application is applied over the reinforcing fabric at a minimum thickness of 90-115 mils.
- Two-layer drainage mat is required- typically consisting of a ¼ inch polystyrene core with nonwoven, needle-punched polypropylene fabric.



BITUMEN MODIFIED **POLYURETHANE**

- Today's Green bitumen modified polyurethane is coal tar free.
- Cold, fluid applied, polyurethane comes in different viscosities to be applied on both horizontal and vertical planes.
- In can be applied on "Green"/ newly poured concrete after 72 hours of the pour.
- Extremely cost effective.
- Water Catalyzed formulations shorten the cure time to 2-4 hours.
- 2 lifts required for system application
- Field reinforcement not required
- 20 year warranties are available
- LEED Credits applicable



SO WHAT IS POLYURETHANE?

Today, there is a wide variety of Polyurethanes available with different mechanisms for curing, cure rates and viscosities.

Generally speaking, polyurethanes are synthetic elastomeric rubbers produced by reacting compounds containing two or more isocyanate groups per molecule (R−(N=C=O)n[17]) with a polyol containing on average two or more hydroxyl groups per molecule in the presence of a catalyst.

This is performed in a HIGHLY controlled environment..

POLYURETHANES

Polyurethane factories are highly regulated and constantly monitored by U.S. agencies and officials. Systems are required to be in place for safety and environmental protection, such as secondary containments, air suctions and filters, hot rooms, wash areas, and trained emergency team first responders. Compounders and employees of the factory are required to have documented extensive safety training by DOT and the BDG. California implements the strictest/highest standards of regulations in the United States.

On the job

Polyurethane is handled by trained pros.

Water-catalyzed bitumen modified polyurethane is a cold liquid that becomes an inert rubber product in roughly 2 hours.

Can be applied to green concrete after 72 hours.

The product fully conforms to any irregularity of the substrate.

CHEMISTRY IN ACTION

A Covalent Bond is Formed

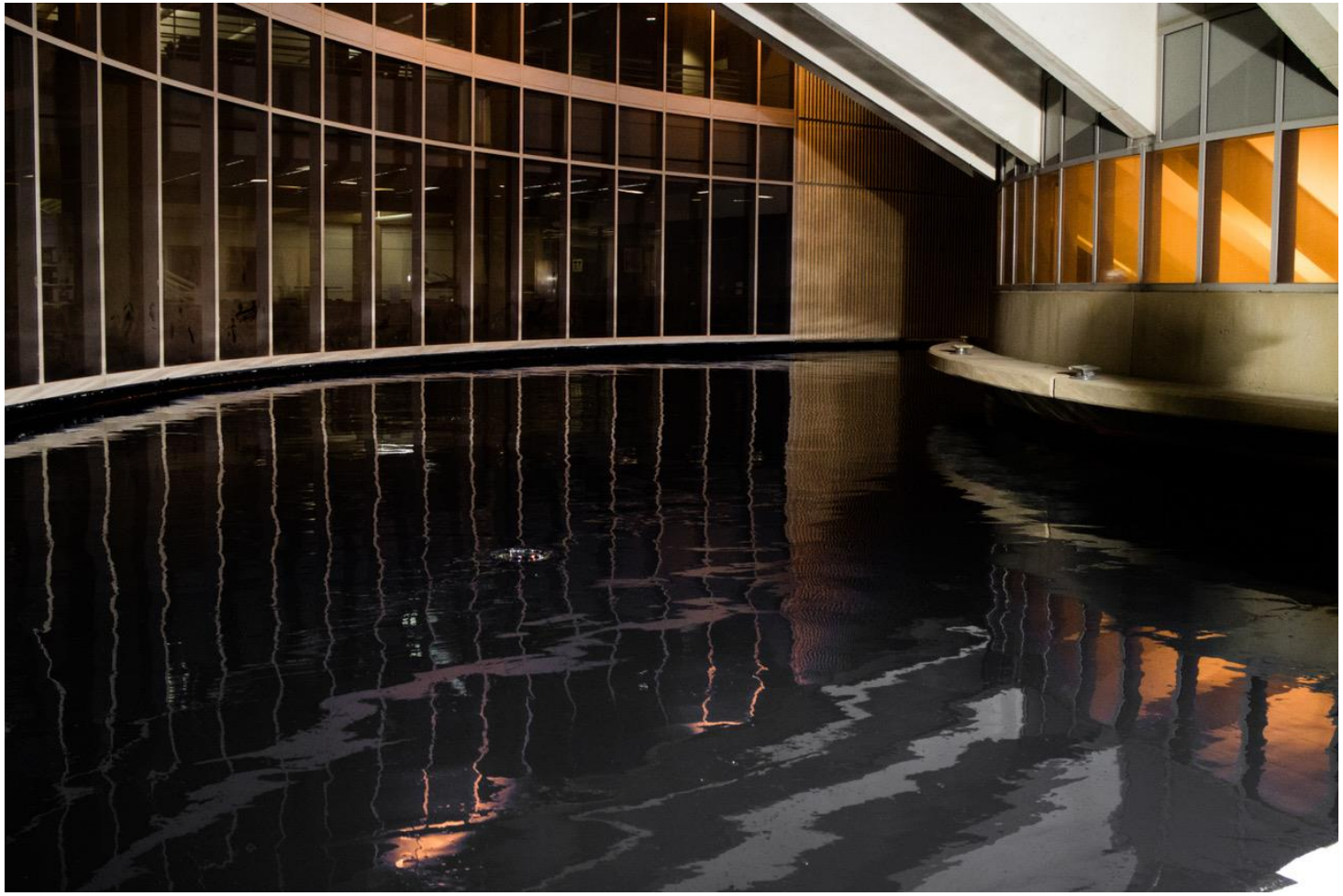
Gravity: A term we use to describe a particular ***Force of Nature***- also called gravitation, in mechanics, is the universal force of attraction acting between all matter..

- The force that attracts a body toward the ***center*** of the earth is called gravity.
- Gravity may not be interrupted except by force.
- Gravity is a law of nature- a phenomenon we can experience and thus describe.

- Covalent bonds are **chemical bonds** between two non-metal atoms. An example is water, where hydrogen (H) and oxygen (O) bond together to make (H2O).
- Also called a molecular bond, a chemical bond involves the sharing of electron pairs between atoms. These ***electron pairs*** are bonding pairs, and the stable balance of **attractive forces** between atoms, *when they share electrons*, is known as a **covalent bond**.
- Adhesion promoters, also known as coupling agents, are bi-functional **reactive additives** designed such that one part of the molecules **forms covalent bonds** with the substrate [and] another part participates in the crosslinking of the binder system of the coating **during** film formation

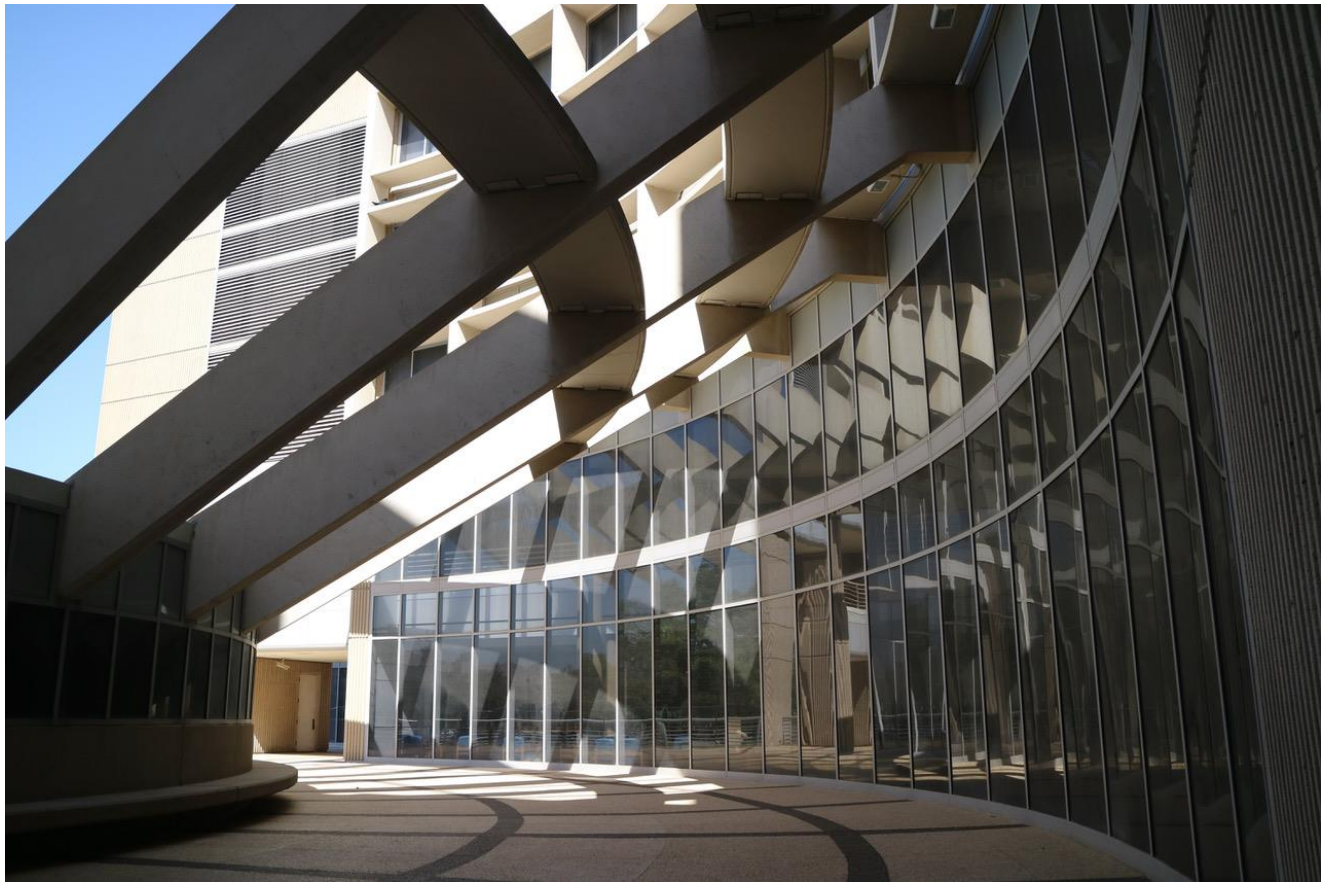
BITUMEN MODIFIED POLYURETHANE

- Surface prep of CSP 2-3 is required
- Detailing and reinforcement of cracks, drains, etc. applies.
- Typically requires a primer. Applied @ 200-350sf per gallon
- The polyurethane is then applied in two coats to reach total system thickness



POLYURETHANE APPLICATION

90 mil application- prior to topping slab overburden



Topping Slab w/ Terrazzo Overburden

POLYURETHANE

Unique characteristics For Below Grade Single Component Membrane

- Seamless, Monolithic
- Product itself- Fully adhered to substrate
- Does not allow water migration, Low Perm
- Superior Chemistry- High Tensile Strength with High Elongation

Hardness, ASTM D-2240	30 ± 5 Shore A	30 ± 5 Shore A	30 ± 5 Shore A	30 ± 5 Shore A
Tear Resistance, Die C, ASTM D-624	70 ± 20 pli 9.3 ± 2.6 kN/m	80 ± 15 pli 14 ± 2.6 kN/m	100 ± 15 pli 17.5 ± 2.6 kN/m	100 ± 20 pli 17.5 ± 2.6 kN/m
Tensile Strength, ASTM D-412	350 ± 50 psi 2.41 ± 0.3 MPa	350 ± 50 psi 2.41 ± 0.3 MPa	350 ± 50 psi 2.41 ± 0.3 MPa	350 ± 50 psi 2.41 ± 0.3 MPa
Ultimate Elongation, ASTM D-412	500 ± 50%	550 ± 50%	550 ± 50%	550 ± 50%
Specific Gravity	1.20 ± 0.3	1.20 ± 0.3	1.19 ± 0.3	1.18 ± 0.3
Total Solids by Weight, ASTM D-2369	95 ± 3%	96 ± 3%	96 ± 3%	89 ± 3%
Total Solids by Volume, ASTM D-2697	94 ± 3%	95 ± 3%	95 ± 3%	88 ± 3%
Viscosity at 80°F (27°C)	3000 ± 1500 cps	3500 ± 1000 cps	30,000 ± 5000 cps	17,000 ± 5000 cps
Volatile Organic Compounds, ASTM D-2369-81	<0.42 lb/gal, <50 gm/liter	<0.42 lb/gal, <50 gm/liter	<0.42 lb/gal, <50 gm/liter	<0.83 lb/gal, <100 gm/liter
Service Temperature	-25°F to 150°F -31.7°C to 65°C	-25°F to 150°F -31.7°C to 65°C	-25°F to 150°F -31.7°C to 65°C	-25°F to 150°F -31.7°C to 65°C

POLYURETHANE

Unique characteristics For Dual Component high Solids Waterproofing Membrane

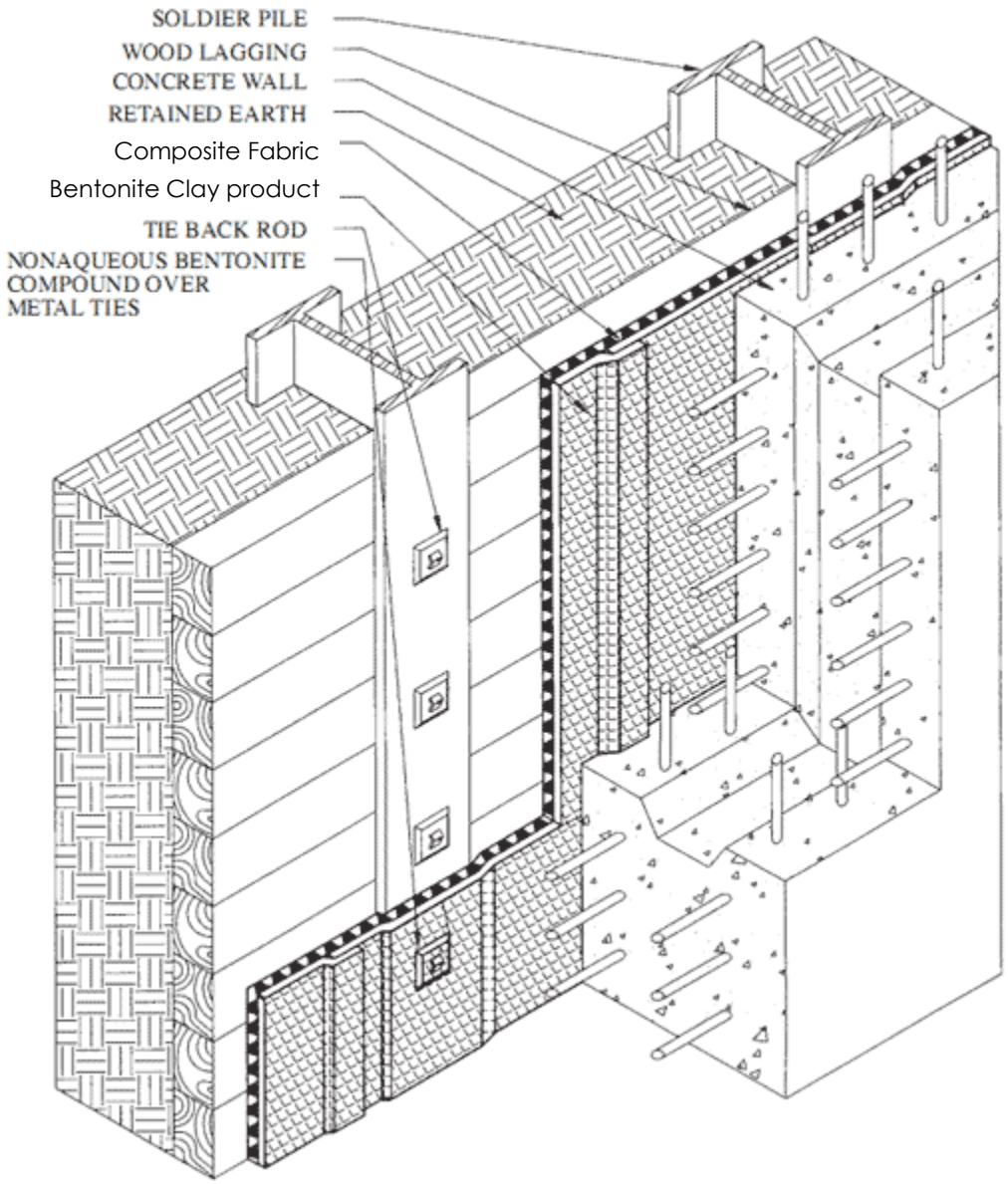
- Seamless, Monolithic
- Product itself- Fully adhered to substrate
- Fast Curing, Low Perm
- Superior Chemistry- High Tensile Strength with High Elongation

ANSI/NSF 61 Approved up to	140°F (60°C)
Elastomeric Waterproofing **ASTM C-836** **ASTM C-957**	 Exceeds Exceeds
Total Solids by Volume, ASTM D-2697	89%
Volatile Organic Compounds, ASTM D-2369-81	87 gm/liter
Mullen Burst Strength, ASTM D-751.50 mil	155 ± 25 psi (no break)
Tear Strength, ASTM D-624 (Die C)	150 ± 50 lbs/in
Tensile Strength, ASTM D-412, 100 mil sheet	900 ± 100 psi
Extension to Break, ASTM D-412	450 ± 100%
Membrane Weight, 60 mils (1.5mmWFT)	approx. 30 lbs/100 sqft 1.5 kg/sqm
Recovery from 100% extension, **After 5 minutes** **After 24 hours**	 98% 100%
Crack Bridging, **10 cycles @ - 15°F** **After Heating Aging**	 > 1/8" (0.325 cm) > 1/4" (065 cm)
Weathering, ASTM D-822	Pass 5000 hrs.
Softening Point, Ring Ball, ASTM D-36	> 400°F (204 °C)
Deflection Temp., ASTM D-648	Pass
Service Temperature	-60 to 200°F (-51.1 to 93.3°C)
Hardness, ASTM D-2240 @ 77°F	50 ± 5 Shore A
Permeability to Water Vapor, **ASTM D-96 method E, 100°F, 100 mil sheet**	0.06 perm
Abrasion Resistance - Wt. Loss Taber Abraser **CS-17Wheel, 1000 gr./1000 rev., ASTM D-4060**	7.2 mg loss
Electrical Resistivity, ASTM D-257, 50% R.H. **23°C, 2" (50mm) disc, 100 mil (2.5mm) thickness**	3.86 x 10E14 ohn.cm
Adhesion to Concrete (dry) Elcometer	350 ± 50 psi
Time to Reach 20 Shore A Hardness, @ 77°F, 200 gram quantity	24 hrs. max
Working Time (Pot Life) @ 77°F	18-20 min
Set Time to Polyurethane Film hours, **ASTM D-164 procedure 5.3.2**	4 hours

BENTONITE CLAY

- Sodium bentonite is one of a family of bentonite clays. It is a chemically inert, organic material that is dug from the earth and supplied in powder form.
- Bentonite clay is an absorbent material that typically forms after volcanic ash ages. This clay has a unique composition. People have been using calcium bentonite clay for centuries- as a way to detoxify the body, improve digestion, improve skin tone, and more.
- ***Sodium bentonite swells many times its mass***, and can form a strong water and chemical proof seal. Easy to install, sodium bentonite is a natural sealant used for sealing recreational ponds, dairy and sewage lagoons, and city landfills.
- In todys's construction, bentonite clay is typically used in blind side waterproofing. The bentonite waterproofing product will typically consist of HDPE (20 mil), sodium bentonite, and a protective layer of a non-woven polypropylene film. The polypropylene fabric protects the bentonite from direct installation of shotcrete.
- When bentonite is installed below grade as a waterproofing membrane, it becomes hydrated with the moisture that is naturally present in the soil- water molecules bond to clay particles, ***the clay expands,*** filling cracks and gaps in the foundation- and forms an impermeable barrier that expels water and most chemicals, such as acids and salts.

BENTONITE CLAY INSTALL



- Wood lagging is installed during the excavation process.
- Bentonite clay is mechanically fastened to the lag wall without regard to puncturing.

BENTONITE CLAY INSTALL

- Bentonite clay products can be installed either vertically or horizontally with the HDPE surface toward the installer. All seams require a lap minimum of 4".
- If installed in the horizontal direction, seams are shingled in a manner to shed water. All seams should be nailed every 2' and a staple placed between the nails. A mastic or caulking is used over all fasteners.
- The concrete form and rebar is then set.
- Concrete is sprayed at high velocity or poured in place.
- Moisture from both the concrete, and soil moisture over time, activates the bentonite clay.
- The bentonite clay expands several times its size to fills voids, capillaries, etc.

Bentonite requires compaction in order to work. Confinement must be effective. A minimum of 24 psf confinement is required.

BENTONITE CLAY

DISADVANTAGES

- Back up wall (lagging) has to be carefully prepared to provide adequate containment. Voids even a ¼ inch will effect **confinement.** Pressure needed to fill capillaries and create impermeability is effected when the proper confinement (24 psf) is not achieved. The system fails.
- **Not an Adhered System**– any water that penetrates through the membrane, for *any reason*, will follow a path of least resistance/travel along the concrete wall with water pressure.
- Any water flow without confinement causes bentonite clay to wash away.
- Requires constant wetness to be effective. Areas where soil wets *and dries* can cause loss of bentonite clay. If Bentonite is unconfined *it can shrink upon drying creating gaps* in the system
- If Tie-backs are not detailed properly, water intrusion typically occurs.

SO WHAT'S GOOD ?

- **Self Adhered Membranes-** Typical properties of the self adhered (peel-n-stick) membrane are very good. Unfortunately, there are still many inherent seams to deal with and the applicator is reduced to heat melting products on-site, using mastics, tapes, etc. as a remedy. In addition, the functional aspects of all of those "great properties" rely on a different product all together (the adhesive) to keep it from failing.
- **Hot Rubber-** Is very old technology. We aim only to provide correct intel so that the specifier can make an informed decision. In our own opinion however, there are several products one may select from that is (1) safer for the installer on the job, (2) better for the environment, (3) less costly, and (4) will provide the same function. Example given: Hot rubber is typically applied at 200 mils reinforced for a 20 year warranty. You can apply bitumen modified polyurethane at 120 mils and get the same 20 year warranty.

- **Bitumen Modified Polyurethane-** Like all polyurethane technology, has advanced tremendously in recent years. It can be applied at virtually any thickness without gassing, cures in 2 hours, has incredible functional properties, will hang vertically **without sagging** at over 90 mils and **is itself entirely adhered to the substrate** which prevents water from migrating **laterally** between the membrane and concrete substrate. It is **seamless** and waterproof. And safe for the environment.

- **Polymer Modified Cement-** Is great for underlayment, and decorative toppings. For below grade applications however, this type of product is the least effective as it is susceptible to cracking- along with the concrete- and notwithstanding its ability to enhance the properties if the concrete itself, will allow moisture and water in through the cracks.
- **Bentonite Clay-** Is highly effective when installed properly. Has no adverse effect on the environment and may in fact be the **best choice for blind side waterproofing**.

SAFETY ON THE JOB

- It is imperative to emphasize safety in all phases of construction. From protective equipment, such as hard hats when in the field, to the careful consideration of products and building materials. What you specify impacts the environment and people more than you know.
- The primary hazard associated with torch down, hot mop, and other hot applied coatings- such as hot rubberized asphalt- comes from the use of fire and/or extreme heat on the job. When these products are specified by the A/E- health, safety, and alternative technologies should be strongly considered.
- Extreme heat and fire cause accidents on the job.
- Continued specification of these types of materials also lead to prolonged exposure for the applicator- who is installing the products you require. Prolonged exposure to fumes of molten asphalt for extended periods and/or consistently, can have negative effects on human health- this *repeated exposure can present a problem later in life.*

THIS CONCLUDES THE PRESENTATION
THANK YOU!