CONCRETE 101 – BASICS

For centuries, concrete has been used as a durable building material. Since the turn of the century, with the advent of steel reinforcing, concrete has become the most widely used building material in modern society. Durable and corrosion resistant, concrete can resist attack by sunlight, moisture, most microorganisms, and come chemicals. (See attached ACI 515.1R-79, paragraph 2.5.2, Materials that attack concrete). Concrete is capable of achieving compressive strengths of as high as 14,000 P.S.I, and yet has relatively low tensile and flexural strengths. Depending on the availability of raw materials and alternative building products, concrete can be relatively inexpensive to produce and simple to form into complex building shapes.

1.1 WHAT IS CONCRETE

Concrete is comprised of portland cement, fine aggregate, coarse aggregate, water, pozzolans, and air. Portland cement got its name when it was not used in the early nineteenth century in England, because its product resembled building stone from the isle of Portland off the British coast. Portland cement is made by grinding a calcareous material, such as limestone or shell, with an argillaceous (clayish) material such as clay, shale or blast furnace slag. These two finely ground materials are heated in a giant rotary furnace to the point where they begin to fuse. The resulting product is called a clinker. The clinker is cooled and reground to a fine powder to form portland cement. While the clinker is being ground, small amounts of additional ingredients are added to produce the various types of cements. Cements are defined in accordance with ASTM C-150, and are comprised of the following types:

TYPE I	Standard setting
TYPE II	Slow setting (low hi-calcium aluminate) moderate sulfate resistance
TYPE III	Fast setting - High early strength
TYPE IV	Slow setting - Low heat of hydration
TYPE V	High sulfate resistance
TYPE " " a___________________	setting with air entrainment
TYPE " " p___________________	setting with fly ash

When cement is mixed with water the resultant product is referred to as PASTE. This is if substance that binds all other ingredients together.

Aggregates are divided into two categories and are comprised of a large number of naturally occurring and manufactured products. The basic distinction is as follows:

Fine aggregate - #4 sieve to pan (1/4" to powder)
Coarse aggregate – 3/8" to 1-1/2"

The addition of fine aggregate to the PASTE transforms the product to a MORTAR The subsequent addition of coarse aggregate results in CONCRETE.

Pozzolans are defined as anything other than cement, aggregate, and water that are added to the concrete mix. The more common types of pozzolans are:

Fly ash
Slag
Silica fume
Chemical admixtures - ASTM C-494

Type A	Water reducing
Type B	Retarding
Type C	Accelerating
Type D	Water reducing retarding
Type E	Water reducing accelerating
Type F	High range water reducing
Type G	High range water reducing retarding

ASTM C-260 Air entraining
Latex modifiers
Acrylic modifiers

Pozzolans are used for both their cost reducing and performance enhancing properties. The proper engineered use of these materials can greatly enhance workability, setting times, finishing characteristics, density, porosity, durability and strength gain characteristics.

Air voids in concrete are derived from two sources. Air entraining chemical admixtures, that produce uniform microscopic air voids, are used to increase the freeze thaw durability of concrete and have the side benefit of increasing workability and providing an inexpensive volume. Entrapped air is produced during the mixing and placing process. The combination of these two sources can account for 3 to 8 % of the volume of a concrete mix.

All of these ingredients, when minced together, harden to form a near solid mass of concrete. The properties •and quality of concrete caries significantly depending on the type and quality of the above mentioned ingredients and the amount of water used in the mix design in relation to the cement content. This relationship is referred to as the water cement ratio or simply We, and is the fundamental basis for "Abram's Law' ; which states that there is a direct relationship between the strength characteristics of portland cement based concrete and the amount of water used per weight of cement. The lower the w/c ratio the higher the resultant physical properties will be.

1.2 COMPPREHENSIVE vs. TENSILE AND FLEXURAL STRENGTH

The most highly publicized and often misunderstood characteristics of concrete is its compressive strength. While compressive strength is an important structural characteristics, it has less influence on the subsequent application of polymer based coatings and toppings than do the characteristics of tensile and flexural strengths. Generally speaking, the tensile strength of concrete is about 10% of its compressive strength. Unfortunately, the adhesion of polymer products applied to concrete is limited by its weaker tensile strength. This weakness if the primary reason that concrete has the tendency to crack during the drying phase, referred to as drying shrinkage cracks. In additions, the weak flexural strength of concrete makes it more susceptible to cracking with applied Ioads. Refer to General Polymers Brand course Concrete 103 - Crack Behavior and Repair.

Most epoxy based products have very high bond strength capability relative to concrete tensile strength. For example, it is not unusual to achieve 1,200 P.S.I bond strength to steel while the same products applied to standard 3,500 P.S.I. concrete, might only have a bond strength of 350 P.S.I (10% of 3,500). Because of concrete's low flexural strength, cracking often occurs and will almost always transverse through the polymer coating or topping unless preventative measures are taken in the design of the concrete and in the design of the polymer system.

Although no detailed discussion of reinforced concrete is included in this paper, it is important to note that because of concrete's low tensile and flexural strengths, steel reinforced concrete is the most common form of concrete used today. Reinforcing types may be defined by structural use, i.e., temperate steel, tensile steel, and flexural steel. Of less structural significance is fiber reinforcing materials added to the mixed concrete prior to placement. These include fine fiberglass strands a few microns in diameter and 3/4" to 1-1/2" in length and thin hooked metal strands a few millimeters thick and similar in length to the fiberglass. The promoted benefit of this type of internal reinforcing is to marginally increase flexural and tensile strengths, thus reducing concrete's propensity to crack, particularly during drying shrinkage.

1.2 CONCRETE FINISHES

The versatility of concrete is due in part to the variety of finishes attainable. The finishes may be classified as either from finished or mechanically finished. Each presents its own set of challenges associated with the subsequent application of polymer based products.

Form finished concrete will generally have some sort of form release agent on the surface which must be identified and removed Form finished concrete is also notorious for bur holes (small air pockets) at or near the surface, which must be exposed and filled of greater concern to the structural integrity of the concrete is the occurrence of honeycombs (large pockets of voids and coarse aggregate without sufficient mortar). Honeycombs require repair at the direction of the Professional Engineer to insure the structural integrity of the concrete.

Mechanically finished concrete is predominantly horizontal and for the purposes of this discussion, will be limited to concrete floor surfaces. Please refer to the attached ACE 302-1R-89, for a more complete discussion of floor slab classifications and required finishes.

1.3.1 HARD STEEL TROWELED (BURNISHED TROWELED)

This type of floor surface is produced by multiple finishing operations which consolidate and greatly density the top 1/8" of the concrete. The challenge with this type of finish is preparing the surface to the acceptable surface profile for the type of polymer coating or topping being used.

1.3.2 LIGHT STEEL TROWELED

This type of floor surface is produced by minima finishing operations and is the preferred finish for subsequent preparation and application of bonded polymer products.

1.3.3 FLOAT TROWELED

A float finish is produced with the use of magnesium or wood trowel worked over the surface to consolidate and embed both fine and coarse aggregate. Subsequent steel toweling is deferred, leaving the surface with a sand paper texture. Generally speaking, the wood float will leave a rough texture than the magnesium float.

1.3.4 BROOM FINISH

A broom finish is obtained by dragging an industrial broom with medium bristles over the surface of the plastic concrete following the floating operation and just prior to final set. The texture is produced by tearing the surface and dislodging fine aggregate, and is dependent on the mix design, stiffness of the bristles, pressure applied by the installer and the timing of the application. For these reasons, it is not usually desirable to request or require a broom finish.

1.3.5 SPECIAL CONCRETE FINISHES

DRY SHAKE SURFACE HARDENERS - These materials are composed of mineral aggregates or metallic aggregates blended with cements and proprietary ingredients that are broadcast into the surface of plastic concrete during the finishing operations to form an abrasion resistant surface that imparts a density 2 to 3 times that of plain concrete. These materials will range from 1/16" to 1/8" depending on specified rate of application. Because of their density and impact resistance, they possess a particular challenge in surface preparation. Acid etching should never be used with this type of surface.

BONDED TOPPINGS - The materials are composed of similar ingredients to dry-shake hardeners, proportioned as a topping for thickened form 1/2" to 1-1/2". They should be treated with the same caution as stated above.

1.3 CONCRETE CURING

Most technical specifications and most manufacturers' literature, calls for a minimum 28 day curing period prior to the application of polymer based coatings and toppings. The technical basis for this recommendation of the relationship between time and the cement hydration process which is directly related to compressive strength development, and is measurable. Plain concrete is proportioned to develop 80% of its design strength in 7 days and 100% of its design strength in not more than 28 days, (Concrete containing fly ash is 56 days). This measurement tells us that the cement used in mixing the concrete has for the most part completed the hydration process, although, hydration will continue for years to a lesser degree. This measurement does not, however, define for us the relationship of the aged concrete to the remaining excess moisture content.

It is interesting to note that cement requites no more than 22% to 28% of its weight in water to fully hydrate, i.e., a w/c ratio of .22 to .28. With this amount of water, the concrete would be totally unworkable for everything. other than dry-packing. For this reason, additional water is added to the mix to make it more useful. This excess water, is referred to as water workability or water of convenience, A typical 3,500 p.s.i. mix design, with standard air entraining and water reducing admixtures, might have a cement content of 470 lbs. per cubic yard, and a water demand of 188 lbs. or 22.6 gallons (water weighs 8.33 lbs. per gallon), to achieve a required w/c ratio of .40. This mix design would then have an excess w/c ratio in the amount of .15 (.40 - .25). By multiplying the excess ratio (.15) by the weight of cement (470 Ibs.), we arrive at a calculation of 703 lbs. or 8.5 gallons of excess water that will not be consumed by the hydration process. This excess water must be allowed to escape, while maintaining adequate moisture (curing), for the hydration process. Much of the excess water will escape through capillary action i.e., bleeding, while the concrete if in its plastic state during consolidation and finishing operations. These capillary escape routes are the cause of concrete's high porosity and resulting permeability which will be discussed in the next section on concrete vulnerability.

Proper cute of concrete to attain the desired physical properties, requires that moisture in the hardened concrete be maintained for a minimum of 3 to 7 days, depending on temperature of cement, and type of admixtures used. A good rule of thumb is to cure concrete until it has reached 80% of its design strength. There are several acceptable methods of curing concrete and may be referred to in ACI 308-86, and ACE 302.1 R-89. Some of these methods are listed below:

- Ponding water
- Soaker hoses
- Wet Burlap
- Moisture retaining sheet membrane
- Liquid membrane curing compounds

Of greatest interest and concern to our industry is the use of liquid membrane curing compounds, which leave a film and or residue on the surface, which must be removed by mechanical means, i.e., sandblasting, shot blasting, scarification, etc., prior to the application of a bonded system, Please refer to ASTM C-309, for types and uses of liquid membrane curing compounds. The other methods listed above present no particular problem to our industry.

VULNERABILITY OF CONCRETE

Concrete is an alkaline material with a pH of 12-23, and as such is susceptible to attack by chemicals with a pH of less than 7, known as acids. In acidic environments, the degree of degradation and vulnerability of concrete is directly related to permeability (porosity), and reactivity. Reactivity is a dependent variable which affects the degree to which various chemicals attack concrete. The components of reactivity are as follows:

Moisture - Dry chemicals rarely attack dry concrete. Moisture in the concrete or from an outside some, will normally increase the reactivity of chemicals.

Temperatures - A 10°C (18°F) use in temperature doubles the chemical reactivity.

Concentration - As the concentration of a particular chemical increases, its chemical reactivity increases.

Permeability is also a dependent variable. which affects the degree with which chemicals invade or soak into the concrete. Factors contributing to permeability are as follows:

Temperature - Moisture and liquids are attracted to areas of cooler and humidity temperatures.

Concrete Mix Design

WIC — The water cement ratio dictates the excess quantity of water that must be released as explained in Section 1.1 above.

Aggregate Gradation — Though not discussed in great detail in this paper, the proper proportioning of aggregates dictates the size and quantity of voids that must be filled by paste and mortar, Improper proportioning will directly affect the density and therefore the permeability of concrete. For a more complete discussion, refer to ACT 302.1 R-89, and ACT 211.1-81.

Chemical Admixtures — The type and quantify of chemical admixtures used, directly affects the efficiency of the Portland cement hydration process. Increased efficiency results in increased cement crystalline formation which densifies concrete. Properly proportioned and used, chemical admixtures can reduce permeability. Improperly proportioned and used, they can increase permeability. Refer to ASTM C 494, Standard specification for the use of chemical admixtures.

Air Voids — Air voids in concrete that affect permeability come from three distinct sources as listed below:

Entrained air is produced through use of air entraining admixtures. An overdose of air entraining agent can cause abnormally high air content and result in excess permeability.

Entrapped air is produced during the mixing and placing operations. Over mixing and over working the concrete can cause increased entrained air resulting in increase permeability.

For a complete discussion in various chemicals reactivity to concrete, refer to ACE 515.1R-79, paragraph 2.5.5. Materials that attack concrete. For an extensive review of chemical attach refer to General Polymers Brand Chemical Resistance Guide.

The permeability of concrete leads to two very distinct and significant problems for the concrete industry and the polymer coating and topping industry. The first is the passage of water, harmful chemicals and contaminants into the concrete, which spawned the need for protective coatings. The second is the passage of moisture and contaminant out of concrete once protective coatings or toppings are applied. The following discussion will be limited to the latter.

1.5.1 MOISTURE RELATED PROBLEMS

It has been reported that 80-90% of all construction claims involve some form of moisture related damage. Of those figures are tire, it is important that we understand the sources of moisture within our industry.

One obvious source is the presence of visible free moisture on the surface of concrete prior to application of polymer based products. Regardless of whether or not a particular product has the ability to cure in the presence of moisture, the ability to bond to the surface will be impaired relative to the bond strength that could have been achieved on a dry surface. Because of concrete's porosity, penetrating primers are recommended for their ability to soak into the pores filled with the surface area of the bond. Water saturated concrete has its pores filled with water thus the polymers primer must have the ability to displace the water or decrease its ability to penetrate.

Another more subtle source of moisture related problems is that of surface moisture as the result of the dew point. The dew point is the temperature at which moisture will condensate of the surface. When high relative humidity and warm ambient air come in contact with a cooler concrete surface temperature, moisture will collect on the surface of the concrete, and may be difficult to detect until after a problem is experienced. In these conditions, it is always preferable to apply polymer products when the ambient temperatures are falling. (See Dew Point chart below).

DEW POINT CALCULATION CHART (FAHRENHEIT)

% Relative Humidity	AMBIENT AIR TEMPERATURE ºF										
	20	30	40	50	60	70	80	90	100	110	120
90	18	28	37	47	57	67	77	87	97	107	117
85	17	26	36	45	55	65	75	84	95	104	113
80	16	25	34	44	54	63	73	82	93	102	110
75	15	24	33	42	52	62	71	80	91	100	108
70	13	22	31	40	50	60	68	78	88	96	105
65	12	20	29	38	47	57	66	76	85	93	103
60	11	19	27	36	45	55	64	73	83	92	101
55	9	17	25	34	43	53	61	70	80	89	98
50	6	15	23	31	40	50	59	67	77	86	94
45	4	13	21	29	37	47	56	64	73	82	91
40	1	11	18	26	35	43	52	61	69	78	87
35	-2	8	16	23	31	40	48	57	65	74	83
30	-6	4	13	20	28	36	44	52	61	69	77

1.5.1 MOISTURE RELATED PROBLEMS - Moisture related problems with polymers on concrete mat be categorized as follows:

HYDROSTATIC PRESSURE
CAPILLARITY
VAPOR EMISSION
GASSING

HYDROSTATIC PRESSURE - A distinct head of water exerting pressure against a concrete structure. The weight of the water creates the pressure and is dependent on how the height or column depth is.
An example of this would be a below grade structure that experiences moisture intrusion problems during a rain storm. Another example would be a high water table exerting pressure on the underside of a slab on grade.

CAPILLARITY - Moisture pulled through the concrete by the attraction created when a distinct moisture source comes in contact with the fine hair like openings in the porous concrete surface. The action may go up, down, or vertical and is attracted by warmth and dryness.

VAPOR EMISSION - Water in the vapor or gaseous state as the result in natural occurrence, and may not originate from a distinct water source. This is the means by which all concrete breathes and releases moisture.

GASSING - A temporary condition usually occurring during installation of coatings, and usually with urethanes and methacrylate, when components are incompatible with moisture in or on the concrete. A chemical reaction takes place where carbon dioxide is formed in a gaseous state and rises to the top of the uncured liquid resin. A phenomenon often incorrectly referred to as gassing, or out gassing, is the formation of air bubbles in a primer or coating, caused by displacement of air in the concrete or release of entrapped air created during the mixing of the polymer product.

The aforementioned moisture related problems present themselves as blisters in the surface of the coating or topping. If severe enough these blisters may cause delamination of the surface, which is often progressive, and total failure of the system. Chemicals which have penetrated the concrete prior to application may cause adhesion problems immediately or work their way to the surface weeks or months after application.

1.5.2 DETECTING MOISTURE - Detecting the presence excess moisture and harmful chemicals is difficult and certainly not an absolute science. However, there are tools available with which to make some determination.

ASTM D 4263-83 - Indicating moisture in concrete by the plastic sheet method This method tests for the presence of capillary moisture by taping down a sheet of 6 mil or greater visqueen, approximately 18" x 18", to the concrete surface for a period of at least 16 hours. Upon removing the sheet, visually check for the presence of moisture. One test area is required per 500 s.f.

Moisture Test Unit - Developed by the Rubber Manufacturers Association this test uses calcium chloride to make either a quantitive evaluation of vapor emissions from the concrete. On test area is required per 1,000 s. f.

1.5.3 DETECTING CHEMICAL, CONTAMINATION

Detecting .chemical contamination of concrete may be relatively simple task or an expensive complicated task depending **-on** the severity of the contamination and the degree of importance relative to protective coatings or toppings. Some methods of detection are as follows:

LITMUS TEST - Since concrete is known to have a normal pH range of 12 to 13, use of litmus paper applied to a wet concrete surface will determine the pH of the concrete surface in question. A pH value below 10, would indicate acidic chemical contamination. The lower the value the greater the greater the contamination.

TITRATION TEST - This type of test requires the services if an independent testing laboratory to grind portions of the concrete, mix with de-mineralized water and perform laboratory chemical analysis to determine the presence of specific contaminants.

SPECTROGRAPH - The use of spectrographic analysis in the study of concrete can provide the technician not only with precise information on the presence of contaminants, but can be used forensically to determine the components of the original mix design and probable causes of premature failures.

HEAT LAMP - A common household heat lamp can be used to determine the presence of oil based substances at or new the surfaces. The practice is to place a heat lamp focused on the surface of the concrete at a distance of 24" for a period of 8 hours. The presence of these substances on the surface after this time period would indicate contamination.

WATER - As discussed in section 1.5, above, concrete is porous. Application of water to the surface of concrete contaminated with soluble substances would cause the water to puddle or bead up. On uncontaminated surfaces, water would soak in, evidenced by a darkening of the concrete.

1.6 TYPES OF CONCRETE FAILURES

Concrete failures occur for a variety of reasons and as the resile-of a variety of external forces. Some types of failure are more frequently encountered and will be discussed briefly here. A more complete discussion of concrete failures and repair techniques may be found in ACI 302.1R-89, Guide to Concrete Floor and Slab construction, ACI 503 R-89, Use of Epoxy Compounds with Concrete, and various reprints from IACRS, International Association of Concrete Repair Specialists.

1.6.1 CRACKING

Please refer to General Polymers Brand course Concrete 103 - Crack Behavior and Repair.

1.6.2 CRAZING AND MAP CRACKING

Often referred to as alligatoring, this type of cracking rarely presents structural difficulties or bonding difficulties as it does not penetrate more than a few millimeters below the surface. The predominant causes are improper finishing practices and improper curing practices.

1.6.3 LOW RESISTANCE TO WEAR

Simply stated the concrete's mortar at the surface did not gain sufficient strength. Low cement content, high w/c ratio, overworking the surface during finishing, improper curing, carbonation, and freezing prior to sufficient strength development are the primary causes of this type of failure. Subsequent application of polymer coatings and toppings will fail unless the weak surface is removed to sound concrete.

1.6.4 DUSTING

Dusting is a condition resulting from weak mortar at the surface. It presents itself as fine silica powders at the surface which are easily brushed or worn off and become airborne, evidenced by the dust particulates being deposited on surfaces in the general area. The causes of this condition can be attributed to all of the causes stated in section 1.6.3.

1.6.5 SCALING

This is a condition attributed to freezing and thawing of concrete that already suffered from the conditions listed for Iow resistance to wear above. Here the concrete simply delaminates at a depth of about 1/8". The only remedy is to completely remove the top delamination and prepare the surface for application of the desired finish.

1.6.6 POPOUTS

Popouts are cone shaped pits in the surface approximately 3/8" to 2" in diameter, caused by expansion of alkali reactive aggregates and clays, exposed to moisture or chemical attack The repair and subsequent application of polymer coatings and toppings is conducted on a routine basis with the following caution: Popouts may occur for a prolonged period of time and will not be stopped by the application of coatings and toppings,

1.6.7 BLISTERS

Blisters are the result of entrapped air and or free bleed water being trapped beneath the top 1/16" to 1/8" mortar on the surface of the concrete during finishing operations. The primary cause is overworking the surface and attempting to close the surface with a hard steel trowel too early. Application of polymer pm ducts to this type of surface will require breaking the shin of the blisters, making repairs of a coating is to be applied, or simply incorporating the repair into the application of the topping.

1.6.8 SPALLING

Spalling is a term used to describe the breaking away of concrete at joints or steel reinforcing, and nay be structurally significant. It may be caused by moisture attack of the reinforcing steel creating a build up of iron oxide (rust), which exerts pressure on the concrete, causing it to fail in tensile stress. It may also be caused by freeze thaw forces discussed later in 1.6.12. Another mode of failure occurs when inferior concrete is subjected to compression shear or flexural stress at the joints or perimeters. (For additional information regarding jointing refer to General Polymers Brand course, Concrete 102 - Control Joint Protection. Repair of spalled concrete should be undertaken with the advise and council of the professional engineer to insure structural integrity and prevent reoccurrence.

1.6.9 PONDING AND INADEQUATE SLOPE TO DRAIN

The application of polymer coatings and toppings are usually for finished floor surfaces. As such, the required finish conditions of proper slope and the absence of ponding areas, often referred to as bird baths, is the responsibility of the professional applicator. Depending on the relative condition of the concrete, this could present a series of complicated and expensive problems. Inspection of the concrete levelness and or slope prior to acceptance of the surface for application of finishes should be conducted on a routine basis for every project.

1.6.10 CURLING AND WARPING

All concrete goes through a phase of expansion during the plastic state followed by a phase of shrinkage dining the drying state. Unless shrinkage compensating Type cements are used, the shrinkage will always result in a final volume that is less than the original volume. Even with Type 'X" cements, the final volume will be less than the volume of the expansion phase. As concrete dries, it will dry faster and therefore lose volume faster than exposed surfaces. For concrete slabs, this means that the surface is shrinking faster than the under side, and the edges faster that the center. This causes upward curling of the slab at its perimeters and comers, leaving small voids beneath the concrete. Because of concrete's low flexural and tensile strength, when loads are applied to these unsupported edges by forklifts, hand trucks, pallet jacks, etc., they fail by cracking. Proper repair requires providing adequate support and repairing or replacing the affected concrete.

1.6.11 CARBONATION

Carbonation is a process that can cause accelerated corrosion of reinforcing steel. It occurs when carbon dioxide in the air reacts with calcium hydroxide in the concrete to form calcium carbonate. This lowers the pH of concrete and robs it of its protective alkalinity, thus allowing for the corrosive attack of steel. The process of steel corrosion as the result of carbonation is the transformation of steel, water and oxygen into ferrous oxide (rust). Rust has a volume 3 to 4 times that of steel. As the rust builds it creates tremendous pressure on concrete, eventually resulting in spalling of the concrete. In this process, the reaction is dependent on the amount of carbron dioxide in the environment surrounding the concrete and the amount of concrete cover over the steel reinforcement. Carbonation rarely occurs naturally. More often it is the result of improperly vented space heaters used to help decrease the cure time of concrete in cold environments. In this situation, the early formation of calcium carbonate in the uncured concrete surface will result in Iow resistance to wear, (See section 1.6.3 above).

1.6.12 FREEZE / THAW

Because of concrete's porosity, it will absorb water. When water freezes it increases its solid volume by up to 25% of its original volume. When water within concrete freezes it can create fortes strong enough to cause spalling and scaling addressed earlier. Proper use of air entraining admixtures to products microscopic air pockets of proper size, quantity and distribution will prevent this type of damage, by providing room for expansion of moisture. Refer to ACI 211.1R-77, Guide to Durable Concrete, and ACI 306R-88, Cold Weather Concreting.

1.7 SURFACE PREPARATION

Proper surface preparation requires that the following basic needs are addressed:

- Decontamination
- Surface profile
- Surface irregularities

It has been states that 70% of all polymer coating and topping failures are attributable to inadequate surface preparation. If this is tire, it is important that key aspects of surface preparation and strict adherence to manufacturer's recommendations be followed closely.

1.7.1 DECONTAMINATION

In section 1.5, Vulnerability of Concrete, we discussed the mechanism of concrete contamination and detection of contamination. Here we concerned with the tools and methods available to decontaminate the concrete.

Removal of oils, grease and other hydrocarbon base materials mat be accomplished by the use of the following:

Microbial decontamination - The technology for this type of cleanup comes to us from the oil industry, and is available through distributors nationwide. Dormant microorganisms are supplied along with reactive mediums. When the liquid medium and microorganisms are applied to the contaminated concrete, the organisms multiply and flourish devouring hydrocarbons reportedly as deep as 8" below the surface of the concrete. When there are no more hydrocarbons to sustain the colony, they die out.

High pressure water - This technology has been with us for several decades, and is very effective against soluble chemicals such as mold, mildew, dirt, etc. The effectiveness if this method of preparation is completely dependent on solubility and depth into the pores of the concrete thus worsening the original problem by disguising the contamination.

Steam cleaning - Similar to high pressure water but often at lower pressure, this method adds the benefit of higher temperatures in the range of 140°F to 212°F. The benefit is that the higher the temperature increases the solubility of most contaminants making them easier to remove.

Chemical cleaning - The use of detergents, solvents, acidic and alkaline materials in combination with high pressure water and steam cleaning can increase the effectiveness of this economical approach to decontamination. Prior to the use of specialty chemicals, the contaminants should be positively identified and the manufacturer of the chemical cleaner consulted on the correct choice of product to use.

1.7.2 PROFILE

There is an abundant array of technologies, equipment and methodologies to produce a profile on concrete surfaces. Unfortunately, there are no visual standards universally accepted by our industry to act as a guide in defining acceptable surface profile. As we have seen on our discussion of the complexities of concrete thus far, there is an overwhelming variety of conditions and concretes that we may face with each project'. For this reason, there are many ways to approach the task. Regardless of the method employed, we are attempting to provide a surface that will accept the penetration of polymer based products and mechanically bond the polymer securely to the concrete. The type of service the structure will be subjected to, and the type and thickness of polymer coating or topping required, will help to define the degree of profile required.

Surface profile may be defined by considering the view of a cross section through the surface of the concrete. By measuring the average distance from the peaks of the surface to the valleys, we can establish a quantifiable dimension, and call that our surface profile. This dimension can be expressed in terms of is (1/1000th of an inch) in the case of coating applications or fractions of an inch in the case of thicker toppings. Either way, we then have a specific measurable relationship between degree of surface profile and thickness of polymer product application.

It is reasonable to assume, that the monetary constraints and the type of service a particular concrete structure will be subjected to will dictate the type and thickness of protective polymer coating or topping that is to be applied It is also reasonable to assume that the depth of penetration of the polymer into the concrete surface and the degree of surface profile will dictate the strength of the bond and therefore the degree of service it may be subjected to. If we accept this argument, we can then accept the relationship of surface profile to material thickness and establish a conservative rule of thumb.

For a coating application (defined here as up to 40 mils), the surface profile should be not less than 20% of the thickness of the coating or 5 mils, whichever is greater. For a topping application, the surface profile should not be less than 25% of the thickness of the topping or 10 mils, whichever is greater.

Acid Etching - Perhaps the oldest, and unfortunately the most common, form of attaining a surface profile is the use of acids. This method of surface preparation is dependent on the density of the concrete, concentration of the acid and duration of the application. The use of acids is dangerous and requires extreme caution. Today's environmental concerns continue to restrict the use and disposal of chemically contaminated debris, which will increase the expense associated with this method. Neutralization of the acid with alkaline washes and thorough water flushing of the area treated is a mandatory requirement to insure long term bond stability. Free chlorides, produced by the use of hydrochloric acid Hcl), can cause corrosion of imbedded steel and blistering of coatings through the process of osmosis, wherein moisture is drawn through the coating by a physical chemical attraction of water to chloride ions.

Mechanical Abrasion - There are a number of tools and equipment to mechanically abrade and/or drip away the surface of concrete. The range from hand held manually powered tools to electrically or pneumatically driven power tools capable of removing fractions on an inch to inches of a concrete surface. Examples of the common types available are as follows:

Bush Hammer -	Chips away the surface perpendicularly with a single head
Scrabble -	Chips away the surface perpendicularly with multiple heads
Scarifier -	Scrapes or tears the surface from a perpendicular position with star shaped multiple rotary blades
Planer -	Scrapes away the surface from a parallel position
Grinder -	Abrades away the surface in a parallel position
Mechanical Blasting -	Again there are a number of tools and equipment available to perform mechanical blasting of concrete surfaces. This type of surface preparation has become the preferred method for sound uncontaminated surfaces.

	Contaminated surfaces required special attention with regard to the environment in which the basing is taking place, and the proper disposal of contaminated debris created with this method of surface preparation. The choice of equipment used is limited to regulatory requirements, availability and job site conditions. Some types of the equipment available is as follows:
Abrasive blasting -	Various abrasive aggregates propelled at the surface of concrete by air pressure
Wet abrasive blasting -	Same as above with the addition of water high pressure water blasting - With pressure up to 30,000 psi
Shot blasting -	Centrifugal vacuum blasting utilizing recyclable metal shot in a confined vacuum chamber

All of the above mentioned methods of obtaining a surface profile will provide the contractor with varying degrees of texture, varying rates of production and a variety of equipment and power requirements. Consultation with a knowledgeable equipment manufacturers representative prior to selection and use is recommended.

1.7.3 SURFACE IRREGULARITIES

Although no detailed discussion of surface irregularities or concrete repair is presented in this paper, it is important to recognize the types of surface irregularities that require attention and or repair, prior to application of coatings or toppings. In the case of coatings, it is important to provide a continuous surface prior to application. In the case of toppings, it is a general Wile of thumb to fill and or repair surfaces that have irregularities that are greater than twice (2X) the thickness of the topping material, prior to the application of the topping. The choice of repair and or fill material will depend on the product being used, and the polymer product manufacturer's recommendations. Some of the more common irregularities encountered with concrete are listed below:

Bugholes	Blisters	Cracks
Depressions	Honeycombs	Protrusions/fins
Scaling	Spalls	Surface loss

We have seen in this brief discussion of concrete, that concrete is a multi-component, multi-dimensional building material, with a history dating back several centuries. Properly proportioned, mixed, transported, placed, finished, and cured, concrete is a relatively durable, corrosion resistant, and not resistant material, that can provide years of service to many different types of structures. We have also explored some of the weaknesses of concrete and it’s vulnerability to it's varied environment.

The use of polymers products, for the protection, repair, and beautification of concrete, is in it's infancy by comparison, yet the technological advancements in polymer technology over the past 30 years have overshadowed the advancements in concrete technology. As America's Infrastructure and Commercial/ Industrial complexes continue to age, and concern contamination of the environment by seepage of chemical through porous concrete continues to be an issue, the use of polymer products will continue to experience substantial growth. In partnership with the professional contractor, Sherwin-Williams will share in the experience of that growth.