



DENSI-PROOF™ **BENEFITS AGAINST CONCRETE CHEMICAL ATTACK**

THE NAME SAYS IT ALL

The susceptibility of portland cement concrete to attack by chemicals generally results from three of its inherent characteristics: permeability, alkalinity, and reactivity. Permeability factor varies in concrete installations, however, even the most extreme quality installation will have some degree of permeability. Permeability factors are greatly affected by water-cement ratios and whether or not concrete is properly cured, and cure method used.

Penetration of liquids into concrete is often accompanied by chemical reactions with concrete constituents, i.e., cement, aggregates, embedded steel, and etc. Leaching of cement hydration compounds, or deposition of extraneous crystals or crystalline reaction products also degrade appearance, strength, durability and the integrity of the concrete installation.

The inherently alkaline hydrated portland cement binder of the concrete paste reacts strongly with acidic substances. This reaction is usually accompanied by formation and / or removal of soluble reaction products, resulting in concrete integrity disintegration. When the reaction products are insoluble, deposits may be formed on the concrete's surface or on the inside of the concrete causing a reduced reaction rate. Usually the rate and extent of chemical attacks will be increased by increased concentration of aggressive agent(s) in solution. The pH of a solution indicates whether the solution is alkaline, neutral, or acidic. The pH value of a neutral solution is about 6.5-7, an acidic solution has a pH value of less than 6.5, and an alkaline solution will have a pH value of more than 7. Subsequently, as the pH value of a solution decreases to less than 6.5 the solution transforms from neutral to acidic and becomes more acid as the pH value gets even lower becoming increasingly more aggressive in its attack on the concrete.

The physical state of the attacking agent is significant. Dry non-hygroscopic solids do not attack dry concrete. A moist or wet, reactive solid will attack concrete as will aggressive liquids or solutions. Aggressive dry gases can attack concrete internally when coming into contact with sufficient moisture present within the concrete, i.e., carbon dioxide, sulphuric gases, and etc.

Temperature also affects the rate of attack in two different ways. The common affect is that chemical activity usually increases exponentially approximately doubling with each 10°C rise in temperature. Temperature may also affect the rate of chemical attack indirectly since as temperature rises moisture content of affected concrete becomes reduced making it drier and more permeable to additional fluid, due to expansion. On the other hand, as temperature falls, contraction may sometimes cause sufficient shrinkage to create small open cracks allowing greater penetration of liquid into its interior. Furthermore, in addition to measuring the rate of attack it may be desirable to determine how extensive the attack might be, for example, a concrete installation may have been coincidentally placed in an acidic soil, but if the acid source is not somehow replenished the available acid will quickly neutralize with little or no damage to the concrete.

Alternate wetting and drying is harmful mainly due to the fact that alkali aggregate reaction is an increased possibility under such conditions. Also, dissolved substance particles can migrate more readily through the concrete and be deposited and re-crystallize at or near the surface from which evaporation occurs. This effect may be seen in the phenomenon called "efflorescence" sometimes seen on concrete, brick or stone. Salt solutions can also be more disruptive to concrete subjected to freezing and thawing than water alone. This is commonly observed later on by visible and apparent damages following application of deicing salts to pavements.

In addition to individual organic and mineral acids which may attack concrete, acid-containing or acid-producing substances such as acidic industrial wastes, silage, fruit juices, sour milk, salts of weak bases, and some untreated waters may also cause deterioration of concrete integrity. Most ammonium salts are destructive because in the alkaline environment of concrete they release ammonium gas and hydrogen ions. These are replaced by dissolving calcium from the concrete causing a leaching action, much like an acid attack.

Animal wastes contain substances which may oxidize in air to form acids which attack concrete. The saponification between animal fats and the hydration products of portland cement consumes these hydration products, producing salts and alcohols in a reaction analogous to that of acids.

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Concrete attacked by sulphates has a characteristic whitish appearance, damage usually starting at the edges and corners and followed by cracking and spalling of the concrete. The reason for this appearance is that the essence of sulphate attack is the formation of calcium sulphate (gypsum) and calcium sulphoaluminate (ettringite), both products require more space volume than the original compounds that they replace so that internal pressures are subsequently created causing expansion and disruption of hardened concrete, eventually visibly surfacing in the form of delamination, crumbling, cracking, and etc.

Small amounts of gypsum are normally added to portland cement clinker in order to prevent flash setting upon hydration of cement's tricalcium aluminate (C_3A). Gypsum quickly reacts with C_3A (tricalcium aluminate) to produce ettringite which is harmless at this stage because the concrete is in a plastic state so that expansion can be accommodated. However, a similar reaction producing ettringite, may take place when hardened concrete is exposed to sulphates from external sources such as from the soil or the atmosphere, in such an occurrence the hardened concrete cannot accommodate the ettringite causing the concrete to instead crack. A typical sulphate source is from the groundwater of some clays which contain sodium, calcium or magnesium sulphates. The sulphates react with both $Ca(OH)_2$ (calcium hydroxide) and the hydrated C_3A (tricalcium aluminate) to form gypsum and ettringite, respectively.

Magnesium sulphate has a more damaging effect than other sulphates because it leads to the decomposition of the hydrated calcium silicates as well as of $Ca(OH)_2$ (calcium hydroxide) and of hydrated C_3A (tricalcium aluminate): hydrated magnesium silicate is eventually formed possessing no binding properties.

The extent of sulphate attack depends on its concentration and on the permeability of the affected concrete, i.e. the ease with which sulphate can travel through the pore system. If the sulphate contaminated concrete is highly permeable so that water can percolate right through its thickness $Ca(OH)_2$ (calcium hydroxide) will quickly leach out. Evaporation at the 'far' surface of the affected concrete leaves behind deposits of calcium carbonate, formed by reaction of $Ca(OH)_2$ (calcium hydroxide) with carbon dioxide (CO_2): this deposit, of whitish appearance, is also called efflorescence. Efflorescence is not generally harmful. However, extensive leaching of $Ca(OH)_2$ (calcium hydroxide) will increase porosity so that the affected concrete becomes progressively weaker and more prone to chemical attack.

Salts attack concrete only in the presence a liquid (usually water / moisture), and never in solid form. The strength of the liquid is expressed as concentration, for instance, as the number of parts by mass of sulphur trioxide (SO_3) per million parts of water (ppm). A concentration of 1000 ppm is considered to be moderately severe, and 2000 ppm very severe, especially when magnesium sulphate is the predominate constituent.

Many agents attack concrete destructively altering its chemical composition by means of reaction mechanisms which are partially or incompletely understood. Sea water contacting existing concrete, perhaps largely because of its sulphate content, may be destructive to permeable concrete or those made with cement having a high tricalcium aluminate content. Some polyhydroxyl organic compounds such as glycols, glycerol, and sugars can also slowly attack concrete.

PLEASE NOTE: Permeability is the ease with which liquids or gases can travel through concrete. For normal portland cement concrete permeability is governed by the capillary porosity of the cement paste and the aggregates porosity, normal weight aggregates have permeability similar to that of cement paste. Chemical attack by sulphates, acids, sea water, and also by chloride, which induce electrochemical corrosion of steel reinforcement. Since this attack takes place within the concrete mass, the attacking agent must be able to penetrate throughout the concrete, which therefore has to be permeable. Permeability therefore, is of critical importance. Densi-Proof™ has the unique ability to greatly diminish permeability of Portland cement concrete, among other things that are also very beneficial to the installation, therefore cutting off the water / moisture supply to its interior, eliminating formation of acids, because this deteriorating process cannot occur without water, acid production's main constituent. Also if the Densi-Proof™ treated concrete already has acid existing in its interior this acid will be rendered harmless by the presence of Densi-Proof.™

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