Architectural Coatings & Concrete Treatments

THE CARBONIZATION OF CONCRETE

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What will we cover?

1. What is concrete carbonization - How does it occur?
2. Concrete shrinkage and its potential consequences to the rate of carbonation.
3. Concrete spalling (role of ferric acid).
4. A coating's role in slowing or halting the carbonation process.
5. Standard acrylic coatings.
6. High build acrylic coatings.
7. Ultra-high build and elastomeric coatings.
8. Two pack acrylic urethanes – anti-graffiti coatings.
9. Silicon resin emulsion paint.
10. Oligomeric siloxanes – what are they; with video
11. Conclusion

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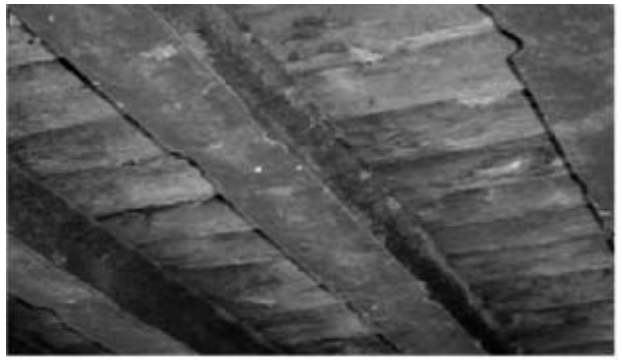
Carbonization of Concrete

- Carbonation is a naturally occurring process in concrete
- The rate of carbonation relates to many factors incl the mix of the concrete (dry or wet mix), CEMENT ratio, MPA, density, concentration of chloride ions and surface finish (FI-6) etc., but as a rule in temperate climates the rate is around 1mm per yr, this rate can double in hotter more humid environments.
- When concrete is new it has a PH of around 12, this alkalinity passivates the steel reinforcing ensuring no corrosion can take place even in the presence of water.
- Over time the concrete starts to carbonate as co2 enters the concrete. If the conditions are right i.e., temp & air humidity which tends to mirrored within the concrete is (>45 <80%) then the co2 can easily diffuse within the water present in the concrete and the alkalinity of the paste is reduced by the conversion of calcium hydroxide to calcium carbonate. When the moisture content of the concrete is lower or higher than these parameters, the pores of the concrete are either too dry or to saturated, effectively reducing vapour pressure and therefore diffusion.



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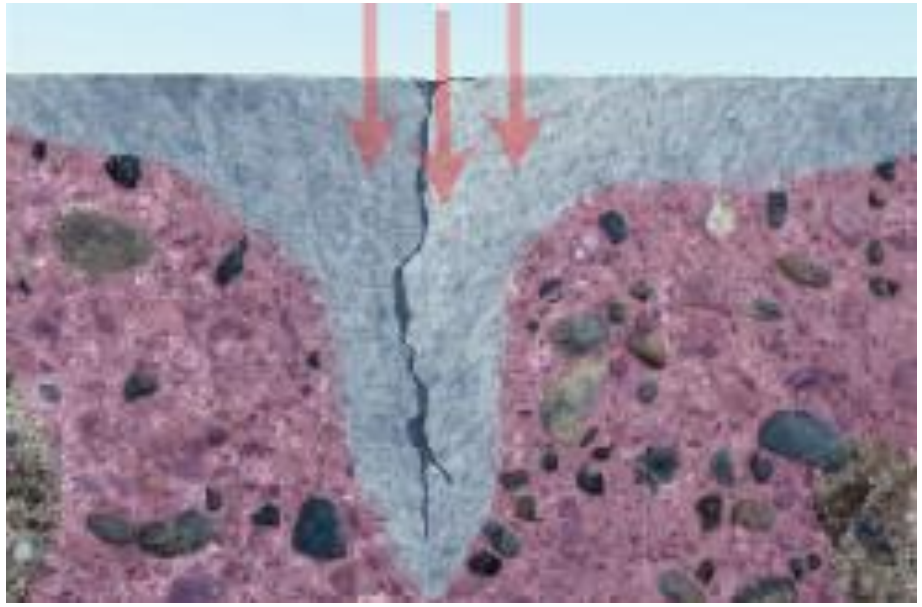
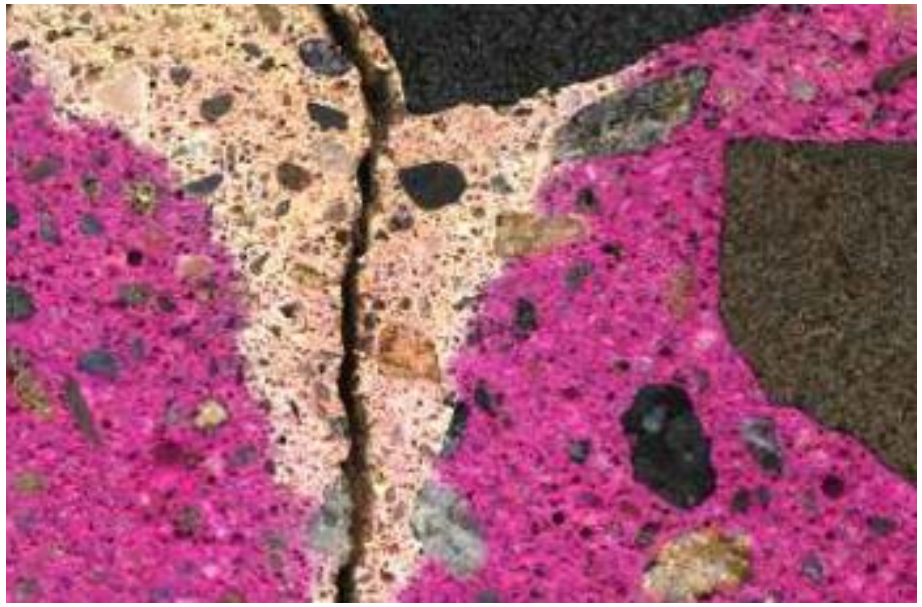
Carbonization close to a crack

- While the carbonization of the concrete increases its compressive strength, a side-effect of this increasing strength is often shrinkage, causing the concrete to crack, allowing easier access of both CO2 and water thus speeding up the carbonization process, and often deeper within the concrete itself. This is obviously not desirable if the concrete is reinforced with steel and has no cathodic protection.
- As evident in this illustration, the presence of cracks can speed up the depth and severity of carbonization.
- A 0.2% solution of phenolphthalein mixed with isopropyl alcohol is used as PH indicator of concrete. The change of colour of concrete to pink indicates that the concrete is in the good health (high PH) , where no changes in colour occurs , it is suggestive the concrete paste has carbonated (refer photo opposite).





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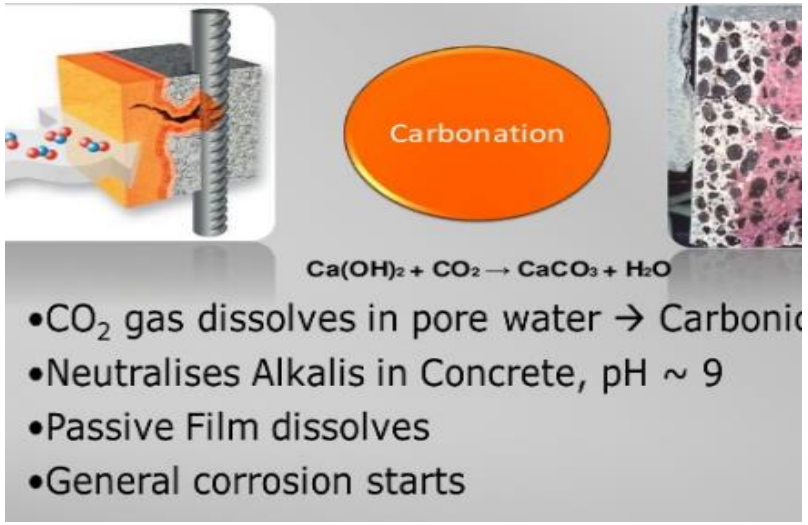
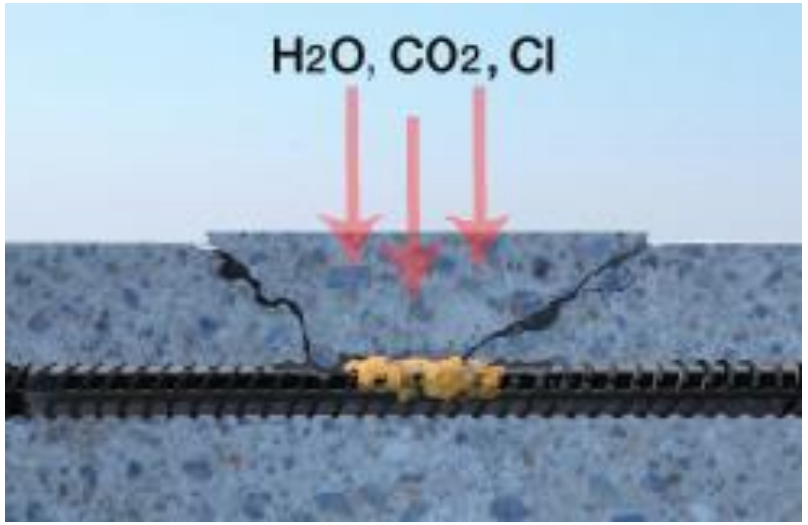
Concrete Spalling

Generally the 50mm cover provided in concrete structures over reinforcing should provide up to 50 years of protection, however as mentioned cracks within the concrete allow the carbonization process to speed up in a localized areas with the concrete losing alkalinity closer to the reinforcing via carbonization process, allowing water to then enter freely, this along with the lowering of the PH level of the concrete paste to <9 (**causing loss of the protective ferric oxide film)** creates the ideal environment for the reinforcing to corrode causing premature spalling.





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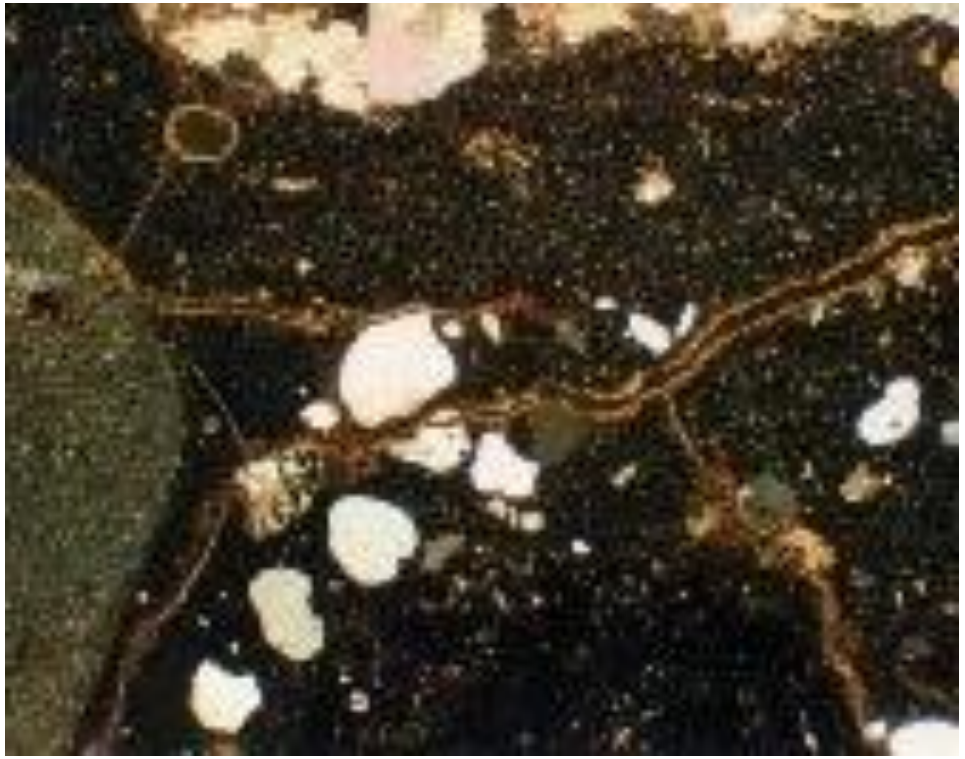
The Role of a Coating
- in Slowing / Halting The Carbonization Process



- If you can keep the concrete relatively dry, that is a moisture content of less than 45% then carbonation process will be stalled or significantly reduced. This can be achieved by various coatings that are impervious to liquid water with differing rates of permeability to gases and or water vapour (i.e., transmission rates) these options are outlined below
- This can be achieved in the following ways:
    - The application of a std acrylic coating
    - The application of a high build acrylic coating
    - The application of an elastomeric coating
    - The application of a two-pack acrylic urethane
    - The application of a silicon resin emulsion paint
    - The application of an oligomeric siloxane

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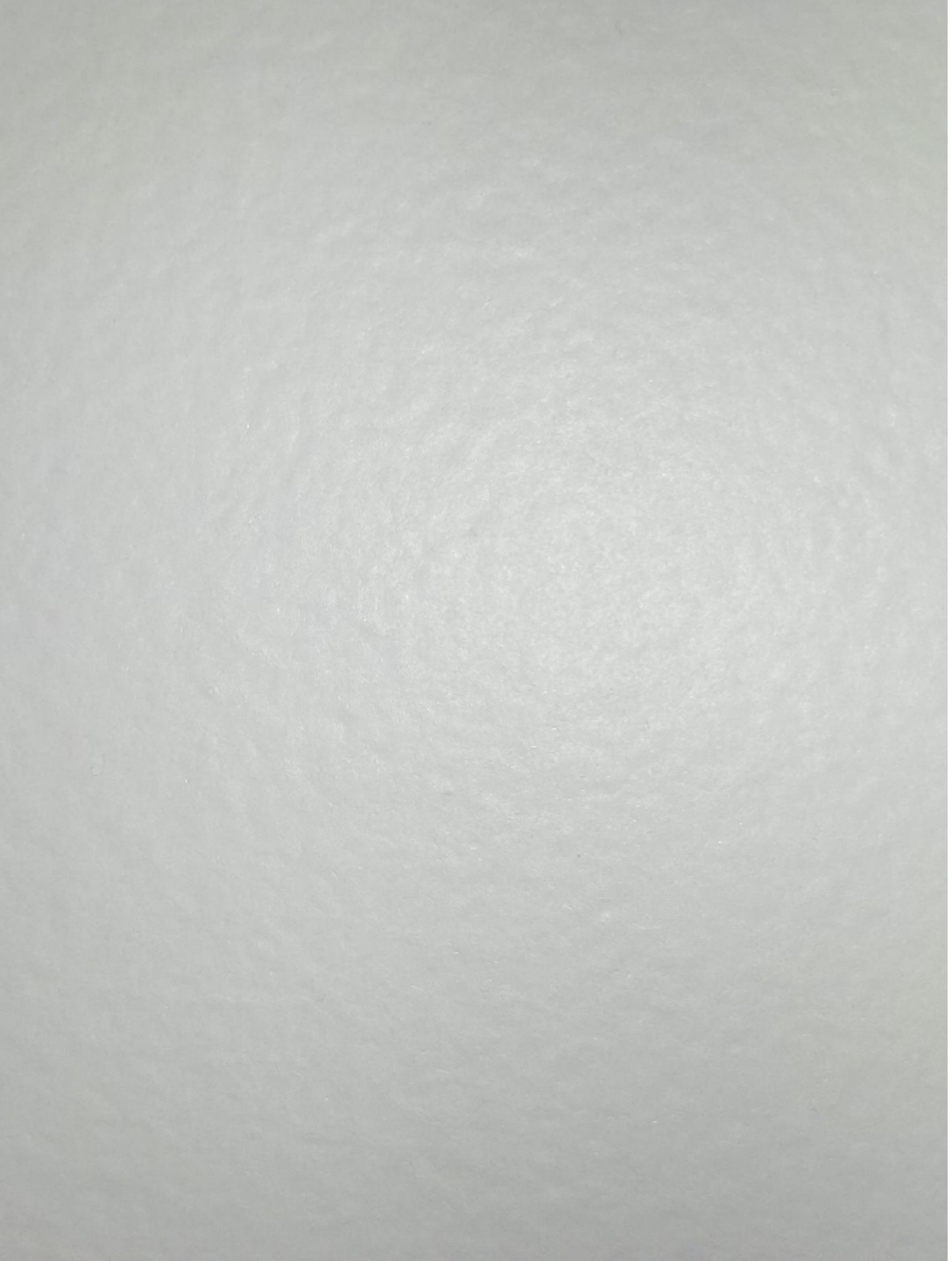

Standard Acrylic Paint (Emulsion)

- Std low build acrylic paints, which may or may not have cross linking (enamel) properties are impervious to liquid water but will allow differing amounts of CO2 gas and or water vapour to pass through at measurable (permeability) rates.
- The addition of a pigmented alkyd (Resene Sureseal) as a primer will significantly improve the anti-carbonation properties of any paint coating system, due to among other things, the tightness and hardness of the film.
- Less expensive than high builds (lower % volume solids) or other specialist coatings.
- Available in various gloss levels and generally all colours.
- Require little skill to apply (d.i.y)

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High Build Acrylic Coatings

- High build coatings like x-200 and x-400 have much lower transmission rates (less permeable) than their low build cousins, e.g., Lumbersider (generally due to the high film builds that can be achieved) these are specialist coatings and are more expensive, due to the very high % of VS within the paint (65%+) and the amount you need to apply to the surface to achieve the required DFT.
- These kind of coatings are excellent at keeping out water in liquid form and minimizing the amount of CO2 and water vapour able to pass through the coating (very low transmission rates). As a rule of thumb, a high build, a high-quality solvent or acrylic coating, which achieves a DFT of around 170 microns, is roughly equivalent to 700mm of concrete, in terms of the relative rate of diffusion.
- However, if water does enter the concrete via cracks or inadequate or poor flashings etc. then it can't easily escape. This can result in water building up behind the coating causing unsightly and large blisters.
- These products require specialist equipment, sleeves to apply and take a little more skill and effort to achieve a good outcome.

Ultra-high build elastomeric paints

- As the name suggests, ultra-high build elastomeric paints can, and must, achieve very high dry film thickness. They need to allow for movement over propagating cracks without themselves cracking.
- It's fair to say all that all acrylic paints have some degree of flexibility, but elastomeric paints have the added advantage of memory and will stretch and return back to its pretension shape without losing its shape (e.g. Rubber band quality).
- Due to their extremely high film builds these kind of paints have very low or nil transmission rates for CO2 etc. and are therefore quite effective in slowing / halting the carbonation process.
- Like a rubber band however, the inherent tackiness of the paint tends to attract and hold dirt. Like its close relative (high build paints) it will hold back any water that gets trapped behind the coating.
- While elastomeric have some applications (bridges etc.) the amount or film thickness that need to be achieved 2 x that of the width of any existing crack (which would be typically around 500-600+ microns) make this an expensive option and one that would have to be persevered with.

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TWO PACK ACRYLIC URETHANES

- Two pack acrylic urethanes (Resene Uracryl) act in many ways like a std acrylic, they are flexible, but achieve a slightly higher DFT per coat and have generally much lower CO2, vapour transmission rates, as they are cross linking (molecules much more tightly bonded) and therefore denser / harder (much less permeable).
- They can also have the added advantage of being inherently anti-graffiti.
- However, if water gets trapped or builds up behind the coating, blisters filled with water can also form behind the coating. The adhesion of these products is generally much greater than a std coating.
- Two pack acrylic urethanes have until very recently been only available in solvent bases, however, Resene have now developed waterborne versions.
- These kind of products require some experience and specialist equipment and care to apply successfully.

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S.R.E.P (Silicon Resin Emulsion Paints)

- SREP paints (Resene AquaShield) occupy a unique space within the paint coatings market.
- While this type of paint is indeed a paint coating (is impervious to water) it is however highly permeable to gases and vapour.
- This very permeable coating allows water vapour that may be otherwise trapped behind any other coating to escape freely in vapour form, as the outside environment (RH) dictates.
- This breathability reduces and virtually eliminates the chances of water getting trapped behind the coating, reducing the likelihood of spalling concrete and helping to keep the concrete drier i.e., Less than 40% within the concrete therefore slowing down or interrupting the ongoing carbonation process.
- This kind of paint also has a flat mineral finish which some people find aesthetical pleasing. It can however mark easily and is not suited in every situation.
- These products are relatively easy to apply.

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Oligomeric siloxanes

- Oligomeric siloxanes (e.g., Resene Aquapel) are something completely different again, it is not a coating but really a concrete treatment that repels water.
- In broad terms, the defining feature of a siloxane is two pairs of silicone centres that are separated by an oxygen atom. An oligomeric siloxane is a hybrid of such a compound.
- Once the surface of the concrete has been saturated, any water hitting the surface simply cannot penetrate and beads off leaving the substrate looking dry. The application of these kinds of treatments is critical; starting from bottom of the wall and working up.
- This treatment is very effective at keeping the concrete dry and allowing any moisture trapped within the substrate to easily escape, thus keeping the concrete relatively dry.
- There are some limitations with this treatment; it has no ability to fill voids or bridge cracks.
- This product is ideally suited to brick and or blockwork, also tilt slab or precast concrete, as the surface is kept dry, moss and mould etc. find it very difficult if not impossible to take hold, unlike acrylic coatings and well all know the tell tale
- It is invisible when it has been applied and dried.
- It comes in both a solvent and waterborne format.

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Resene Aquapel Application Demo

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Conclusion

- There are many obvious benefits that you can derive from painting a building, the most obvious of course is the aesthetics and the role that paint can play in transforming both new and old tired buildings.
- All exterior substrates / materials used to clad buildings can benefit from the various coatings and treatments available, whether steel, timber or concrete.
- While new pre-cast or insitu concrete is often left unpainted, the carbonation process will, over time, leave the structure vulnerable to decay. This occurs as the reinforcing becomes susceptible to corrosion, providing all the necessary conditions are in place.
- There is no one size fits all solution, every building is different in terms of its design, location, method of construction, and its current condition incl the budget the client has to work within.
- A solution can always be tailored to meet these requirements with some thought, good working knowledge of the various options available, and good understanding of the brief.
- The only real risk is doing nothing.

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