

## CONCRETE INDUSTRY INFORMATION – COATINGS FOR CONCRETE

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# ‘SOME IMPORTANT REQUIREMENTS FOR COATINGS INTENDED FOR CONCRETE SURFACES’

BY ROBERT F BARBER

- Surface coatings and paints for concrete should have adequate innate adhesion characteristics and not depend on so-called ‘porosity’ or liquid absorption of concrete to ‘gain adhesion by penetration’.

*curing regime adopted immediately after the finishing operation and having any type of floated finish or degree of smoothness or texture should not be porous enough to allow the penetration and therefore to increase the innate adhesion of any particular coating type.*
- Suitable coatings must feature adequate adhesion to both rough and smooth concrete surfaces – even to say shiny ‘glass-like’ surfaces obtained by pre-casting concrete or mortar against sheet glass.

Adhesion ‘pull off’ tests measured in megapascals, not to be confused with concrete compressive strength, also measured in megapascals is a method of testing the adhesion of coatings.
- Properly designed concrete mixes incorporating sound quality raw materials and supplied in Australia by ethical producers such as the supply members of the pre-mixed concrete division of the Cement Concrete & Aggregates Association of Australia should be supplied for new concrete. *Provided that no extra water is added on site, the concrete is properly placed, compacted to remove air bubbles, subjected to a recognised moist curing procedure and therefore properly site processed according to the Standard AS 3600-2000 ‘Concrete Structures’ it should not be porous in the context of potentially increasing the adhesion of coatings by their penetration. Even the lowest grade of pre-mixed concrete, N20, made and supplied to AS 1379 – 2000 ‘Specification & Supply of Pre-mixed Concrete’, placed at the normally specified semi-liquid consistency of an 80 mm slump and properly processed on site to AS 3600 – including the important adoption of a satisfactory moist*

Although in most cases considered adequate, in the experience of the Perth testing laboratories of international materials technology consultants GHD Pty Ltd (previously Taywood Engineering Limited) and the laboratories of CRL Pty Ltd in Moorabbin, Victoria (Melbourne suburb), it is rare for coating systems applied to properly prepared concrete surfaces (to make them sound, firm and clean) to exceed 1.5 - 2.5 megapascals (MPa) in ‘pull-off’ adhesion tests.

Ability’s quality ‘GEO®’ paint coatings, applied to well prepared existing concrete surfaces, can give highly satisfactory adhesion strengths in excess of 2-3 MPa.

To provide adequate durability, surface coatings for any substrate and particularly for concrete must be applied to result in an adequate total dry film thickness.

- ☑ Ability's 'GEO®' coatings typically have both a wet and dry film thickness of 500µm for two (2) coats.
- ☑ With regard to most paint-type coatings - particularly those that dry by the evaporation of their solvent, this total dry film thickness for satisfactory performance in Australian exposure conditions, is technically considered to be a *minimum* of 200µm. This means that if a coating for concrete has say 25% resin binder solids and 75% solvent that either:

- (a) the wet film thickness (wft), although impractical, must therefore theoretically be 800µm – (preferably applied in a number of thinner coats) to result in 200 µm total dft, **or**
- (b) theoretically four (4) application coats each having a 200µm wet film thickness *must* be applied to conform.

**NB:** The figure of 200µm dft is the *normal* typical dry film thickness applied for many coatings to other substrates in the building industry on a day-to-day basis, eg to parquetry and timber flooring.

#### NOTE:

Any dilution with additional solvent on-site to 'thin out' the coating and theoretically obtain greater penetration into 'porous' concrete and therefore (probably erroneously) greater adhesion *will require even more coats to provide a coating thickness which ensures durability and protection* – proportional to the volume *reduction* amount of the coatings resin binder solids!

For maximum durability and protective qualities of the coating as well as the achievement of sustainability of the environment and the health and well being of applicators using a **minimum** number of coats it pays to use coatings that have high binder solids – preferably 80% plus and therefore proportionally lower VOC's (volatile organic compounds).

Ability's 'GEO®' paints are all 100% solids and have no solvents at all!

For concrete coatings a minimum of two (2) coats - each coat having a dry film thickness (dft) of 100µm, ie a *total* dry film thickness of 200µm is considered essential for an *adequate* period of longevity before the coating starts to disintegrate.

Ability's essentially inorganic 'GEO®' paints have typically at 4m<sup>2</sup>/litre have both a dry and wet film thickness of 500µm for two (2) coats.

- ☑ There are many types of organic resins or polymers used as binders in the manufacture of organic, film forming coatings. Except for Casein, (derived from cows milk), which is stocked by Ability all are derived from crude oil. Some are more suitable than others – especially for exterior concrete. These resins **vary** in their

resistance to UV light, which *sooner or later denudes and destroys all organic substances*. They also vary in their innate adhesive or 'bonding to the surface qualities, hardness to provide wear resistance, resistance to chemicals, as well as skid and slip resistance and other properties.

In addition, all resins shrink. They vary in their shrinkage, abrasion and impact resistance and also their degrees of flexibility or brittleness. They can also vary considerably in their impermeability and resistance to water ingress, various and specific chemicals, paint (and substrate degrading chemical solutions) and to 'chalking'.

Chalking is a phenomenon that occurs upon exterior weathering and is a continuing weakening and dusting of initially the top layer of a coating's dry film due to the forces of weathering, eg all epoxy resins chalk in exterior situations.

- ☑ Some organic resin bound coatings are hardened by means of a co-reactant, ie at least two 'resins' or components (Part A and Part B) are mixed together prior to application. This co-reaction, like the chemical reactions of inorganic cement with water forms a 'glue' or coating with exothermic heat being produced in the chemical cross-linking action.

**Two-pack** epoxy, polyurethane ('urethane' for short), polyester two (2) pack acrylic resin coatings and quality, high performance, polymer modified inorganic 'GEO®' coatings all fall into this category but are quite different in performance and cost.

- ☑ Coloured coatings for exterior concrete that contain a minimum of 5% by weight of ultra fine particle inorganic mineral oxide type colouring pigments (such as those available from Ability's 'abilox®' range are inorganic and not made from crude oil) based on the weight of polymer binder solids are more durable and *last, under the same degrading solar and environmental conditions, approximately four (4) to six (6) times longer* compared with the same clear un-pigmented coating version based on the same resin.
- ☑ Poor quality concrete pavements, suspended slabs, walls, roofs and other concrete structures or units which have loose, soft, weak, and/or dusty surfaces (laitance) usually suffer these deficiencies from the occurrence of:
  - (a) additional water added (in addition to that normally specified) on-site to increase the flowability and consistency of concrete by concreters to wet concrete *supplied to normal specifications* for the particular project by the pre-mixed concrete manufacturer.

(b) poor site processing practices such as:

- (i) no compaction of the plastic concrete by a suitable vibration process to remove all air voids after the concrete is placed, which reduce density of the cement paste and therefore reduce the mechanical strengths and wear resistance of hardened concrete by up to 50%.
- (ii) inadequate or no moist curing procedure provided – especially when the concrete after placing and finishing has been left under adverse windy, low humidity and high evaporation air conditions to ‘look after itself’.

(c) profuse bleeding of water to the surface of freshly placed plastic concrete causing the occurrence of laitance or weak unsound cement ‘scum’ on that surface.

These lacks and failures result in not having a sound, strong enough substrate surface required for any coating to have adequate adhesion, and to ideally accept a coating at all!

- ☑ Laitance on the surface of concrete is ‘bad news’ for the owner of a concrete structure whether it is for instance, an interior floor slab or exterior pavement. Whereas the concrete underneath this weak layer of laitance is usually sound and firm and may be of the pre-mixed concrete strength grade used - for example N32, 32 MPa (megapascals) of compressive strength at 28 days, the laitance layer may typically vary between only 2 and 4 MPa. A bad case of laitance is *dusting* concrete with a surface layer having no compressive strength at all – ie 0 MPa!

Either way, laitance which, without curing (the adoption of an *important* suitable procedure over a period of seven (7) days to a month **to prevent the evaporation of the concrete’s mix water**) can form within five (5) hours of placement. Laitance must be removed before applying any coating to existing concrete.

- ☑ It is worth noting that high quality polymer modified, inorganic ‘GEO®’ paints such as subtly textured, matte ‘the Paint’, the smooth, matte version called X55 HI-SEAL and the ultra-smooth, low sheen finish product called ‘DUROSHEEN®’ coatings for concrete and most other surfaces in comparison to solely organic resin, (polymer) bound coatings:

(a) have 100% of tough, UV resistant, watertight, very long lasting, mineral,

chemically inorganic material forming the coating.

(b) can be more easily applied to give robust, far **thicker**, higher film-build coating results. ‘the Paint’ is five (5) times thicker than most organic resin bound coatings – which apart from any other factor of their durable formulation will impart extra durability.

(c) generally have considerably higher impact and abrasive wear resistance, as well as due to its polymer modification, higher adhesion to concrete than many solely resin bound coatings.

(d) if the total specified low water content used to mix and prepare the liquid coating on site from the powder material as supplied (the water chemically co-reacts to become part of the coating – *permanently*) is reduced in evaporating during its application by applying it to a dampened surface and immediately after its rapid ‘touch drying’ (setting) by means of intermittent water spray curing (up to six (6) separate sprayings over a period of 1 – 2 days), ‘GEO®’ coatings are 100% solids, ie *all* coating – ie no noxious solvent (or its fumes or smell) and therefore no reduction in dry film thickness!

(e) although *not* available in clear transparent versions, ‘GEO®’ coatings are generally for the same dft more moisture impermeable, weather resistant, fire retardant, resistant to chemicals, and considerably more durable than organic resin-based coatings.

(f) Earlier versions have maintained their integrity to last a considerable time, eg the Chapel Street concrete bridge over the Yarra River, and South Eastern Freeway in South Yarra near Melbourne High School in Melbourne, Australia was coated using two (2) coats of a poly vinyl acetate (PVAc) polymer modified (now considered to be inferior to acrylic emulsion polymer modification) white cement-based coating in 1973. This coating, apart from carrying a little dust and dirt is still intact today – in 2008 with no sign of flaking, peeling or other deterioration.

- ☑ Another exceptionally durable film-forming coating type suitable for hardened, partially absorbent, lime/cement bound rendered mortars is the *silicate\** type (also chemically inorganic and

not made from crude oil). This type is available in colours and sometimes as a transparent clear.

☑ Silicate paints chemically bond to lime bound rendered/applied mortar finished surfaces to result in excellent adhesion. They were invented in 1895 by Mr Adolph Keim in Germany, and are highly suitable for concrete substrates. Ability has a product in this class called 'LEVIATHAN®' Matte made from builders' lime to form a long-lasting, non-distressed lime paint made available for large projects in any colour.

☑ Rubber has very high adhesive qualities and typically demonstrates high adhesion relative to other polymeric materials. Suitable synthetic rubbers can be co-polymerised with acrylic monomers to produce in manufacture, acrylic-rubber co-polymer binding resins for coatings.

Acrylic rubber co-polymer resins made available to coatings manufacturers may be used to make excellent high performance clear single pack liquid coatings\*\* for concrete such as 'Duro-Seel' Clear from Ability. This features higher adhesion with similar or often superior durability and wear resistance compared with single pack coatings bound with 'straight' (100%) acrylic or styrene-acrylic co-polymer resins.

☑ Resins used to make paints/surface coatings are supplied in various forms. These include:

(a) Solid form – lumps, beads, prills and 'dust'. Typically in coatings manufacture these are 'dissolved' or 'cut' in a chemical solvent to make the liquid 'binder' for the coating which, after the evaporation of the solvent, holds and binds any colouring pigments used – including any non-colouring filler or extender pigments.

(b) In a liquid form dissolved in chemical (evaporative) solvent for paint and adhesives manufacture. These dry by either the 'pick-up' of oxygen in the air – and are used to make what are called 'convertible coatings' eg alkyd resin (polymer) or linseed/poppy seed drying oil bound coatings such as artists' oil tube colours, or simply by the evaporation of their solvents or both.

**NB** *Convertible coatings are only suitable for existing concrete that is at least three (3) months old, ie has low surface alkalinity – otherwise they will usually saponify (break down chemically) due to freshly hardened, non-carbonated alkaline concrete surfaces having a high pH.*

(c) In a white emulsified liquid form which dry to a clear film. In the USA and Australia, these are called latices (singular 'latex') or

resin (polymer) emulsions. In some countries of Europe, notably Germany, they are called 'polymer dispersions'. These collectively are all emulsified polymer of various types in water which dry to clear films by the water evaporating in a physical process called 'coalescence'.

☑ Chemical solvents – of which there are many, are sometimes made available by coatings manufacturers in either a single generic type or several generic types blended together. These are often referred to as 'thinners'. Many are considered to be toxic and may cause 'painters' syndrome' – a disease of the human brain.

\* Ability offers a clean air, solvent-free, long-life, flat, smooth finish 'GEO®' paint coating available in colours, for lime and/or cement bound rendered and concrete surfaces called **X55 HI-SEAL**. Details can be supplied on request.

\*\* Ability offers its 'Duro-Seel' Clear coating as a **curing compound** for freshly finished concrete **product**.

☑ 'Duro-Seel' Clear forms a low moisture penetrating film to keep the mixing water in cement bound materials to allow it to fully harden.

☑ When 'thinners' are added to a properly prepared and formulated coating usually to assist in its application to make the job easier (such as for reducing the viscosity of a coating to assist in spraying it by an atomisation process) the polymer binder weight and volume solids is reduced to result in a lesser (lower dft thickness) applied amount *per unit area*. Compensation by means of applying *extra* coats should therefore be made to avoid a reduction in durability as a result of the lower dry film thickness (dft) per coat.

☑ Excellent single pack emulsion resin-based coatings\*\*\* in both transparent clear and pigmented coloured versions are available from Ability in Melbourne and elsewhere in Australia, ie, these are mostly easy-to-apply and safe-to-use high performance *water wash-up* acrylic resin (polymer) coatings for concrete which have equal or higher durability potential than non-aqueous acrylic solvent carrying concrete 'sealer' analogues. They may also dry faster in most weather conditions Ability supplies this type under the name '**AQUAdura**' Clear and '**DY-ON-CRETE®** Mark 2 colours.

#### **ADHESION PROMOTERS:**

Acrylic resins used in the manufacture of coatings for concrete – either aqueous or non-aqueous,

available in some of the various supply forms previously mentioned, that do not of their own volition, demonstrate adequate adhesion to sound, firm, strong and clean concrete surfaces, can have their adhesion increased - usually to an acceptable degree by means of a suitable grade of silicone resin – an ‘adhesion-promoting’ additive. However, this increases the cost and therefore the selling price. For residential driveway work, many concreters tend to buy the cheapest clear or coloured ‘sealer’ they can get!

### UV STABILISERS:

Clear concrete pavement ‘sealers’ that are modified and UV ‘stabilised’ with suitable additives, are more resistant to a given degree of UV light and last longer than their unmodified analogues. However, for clear coatings this increase in UV resistance under the relatively high amount of UV light shed daily on Australia, compared to many areas within Europe, USA, and other northern hemisphere locations is likely to be measured only in months or even weeks. This means that ‘glowing’ claims of longevity and durability made by international resins and/or coatings manufactured for various coating systems/binders may not be applicable in Australia’s high UV radiation.

### CONCLUSIONS:

As with most manufactured products, coatings for concrete, viewed from a lasting, durability point of view – “*You only get what you pay for!*”

Coloured coatings or sealers bound with organic resins intended to last for many years (a decade or more) on concrete in Australian exterior locations, should preferably be pigmented with suitable inorganic mineral (metal) oxide type pigments\*\*\*\* such as the ‘abilox®’ range from Ability.

Clear coatings have significantly less durability than pigmented versions. Those coloured with inorganic mineral oxide pigments last up to six (6) times longer than clear products.

**NB** All organic pigments (bright and semi-bright colours) are not fade-free and do not last as long as colourfast inorganic mineral oxide pigments\*\*\*\*\*.

All coatings particularly organic resin-bound coatings should only be applied to *sound, firm, strong* and clean surfaces. This means that with about 80% of all non-weathered concrete pavements and floors existing in Australia, the usually apparent weak layer of laitance *must* be removed with either *minimum* 3000 psi water blasting and for chemical solvent emitting types allowed to dry, grit blasting or acid etching and

allowed to dry, to only reveal *strong, sound, firm* concrete, prior to coating.

Much of the world’s Northern Hemisphere UV light in developed areas is far less intense than that affecting Australia on a day-to-day basis – even in an Australian winter! This means that claims made for the longevity of organic resin-based coatings or resins – particularly in Europe – may not be at all applicable in Australia. However, if they have lasted for a given period in South Africa having a similar climate to Australia, they will usually last for a similar period in Australia.

***It is also worth noting that it appears the general public have far higher expectations of the performance of coatings on concrete than is often actually the case!***

As previously mentioned coatings fail for only two (2) basic reasons.

1. They are of *inadequate* dry film thickness to withstand the environment to which they are subjected for their required or expected design life.
2. They shrink and/or lose adhesion from the substrate.

Most organic resin bound film-forming coatings for concrete applied to less than a total dry film thickness of 200µm cannot be expected to perform well in Australia. It is interesting to note that our own human skin is typically over 800µm thick!

\*\*\* Two (2) Ability brand names for water wash-up emulsion resin bound single pack coatings for concrete of excellent durability are ‘**Dy-On-Crete®** Mark 2 (colours only) and ‘**AQUAdura**’ (transparent/clear only). Details can be supplied on request.

\*\*\*\* Ability offers its ‘**abilox®**’ range of 52 individual UV resistant, inorganic mineral oxide powder pigment colourants – all available immediately ex-stock – for the colouring of pre-mixed concrete, renders, roofing tiles, and other concrete products, surface coatings and adhesives.

\*\*\*\*\* Ability offers its range of 22 ‘**duro®**’ bright and semi-bright organic colouring pigment powders.

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