Guide to the Selection and use of Concrete Curing Membranes

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Concrete Curing

- One of the most versatile materials for use in construction is one consisting of naturally occurring products which have been most readily available during the 20th century.
- This material is ultimately flexible in its practical applications. Capable of being formed into many varied shapes, dimensions, surface textures and aesthetic designs.
- This material can be designed to withstand enormous compressive, tensile and flexural loads.
- Durability is also a key feature of this material, and projects with design lives in excess of 140 years have been feasible using adaptations of the general design.
  - The Channel Tunnel
  - The Second Severn Crossing
  - The Stoerbelt Crossing

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Concrete

- In order to achieve these great feats, it is necessary to ensure the component materials are selected for their quality, compatibility, suitability and performance criteria.
- It may be a surprise to realise that the wet grey stuff being churned out of the back of a mixer truck has been subject to all of these careful considerations before being delivered to site.

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Concrete

- So why, after all this careful preparation, do contractors treat concrete with such contempt?
- When a Designer or Engineer states that a concrete of a particular design grade is needed for an application; the concrete supplier has gone through a rigorous test regime to ensure the concrete performs to those exacting requirements and is also able to produce the material consistently; then.

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Concrete

- The vehicle arrives on site carrying, what is largely viewed as a commodity product, a specific grade of concrete selected for its individual capabilities, and the driver is immediately told to change the whole design of his product in order to accommodate the sub-contractors who want to do as little work as possible and therefore want the concrete to place itself and save them the effort. This can be achieved in part by the addition of copious amounts of water.

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Concrete

- The concrete will now flow all the way round the footings of the new office block and find its own level, watched by the sub-contractor without breaking into a sweat. However, it is also without the realisation that he has just compromised the whole design of the multi-million pound office block to be built on those very same footings.

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Concrete

- By adding the water, the concrete will now be subject to greater dimensional instability, lower strength gain potential and decreased overall durability. For this minor crime the overall life expectancy of the structure can be shortened by as much as 30%, a fact that the paying client would be most interested to hear.
- Concrete is a much abused construction material.

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Methods of Curing Concrete

- It's a little appreciated fact that all newly placed concrete should be adequately cured. This includes factory produced items as well as site placed concrete.
- Columns, beams, walls, floors, abutments, decks etc. will all benefit from being subjected to a period / method of curing.

What is Curing?

- Curing is a procedure that is adopted to promote the hardening of concrete under conditions of humidity and temperature which are conducive to the progressive and proper setting of the constituent cement.

Why Should Concrete Be Cured?

- The essential component materials of concrete:-
  - coarse aggregates
  - fine aggregates
  - cements
  - water.
- when mixed together in various proportions will produce a reaction between the cementitious products and the free water within the mix called the hydration process.

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- The reaction allows the formation of a micro-crystalline structure which bonds to the other constituent materials and also binds all the individual particles together to produce a hardened matrix. This reaction produces latent heat and chemical changes within the mix, both of which are important contributors to ensuring the concrete realises its full potential in terms of:-
  - strength gain
  - dimensional stability
  - durability.

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- A concrete mix design has been carefully calculated to produce rigid performance characteristics and therefore the proportions of the constituents must not be changed. Any changes will have detrimental effects upon the concrete design.

Excessive coarse materials	→ Poor finishing characteristics
Excessive fine materials	→ Lower strength development
Insufficient cement	→ High permeability / poor durability
Excessive water content	→ Dimensional instability etc.

- As equally as important as maintaining the proportional balance of the components during mixing, it is essential to ensure the correct amount of moisture remains available throughout the hydration process in order to fully hydrate the cement and not leave un-reacted cement present within the hardened matrix. The latent heat produced in the hydration process is necessary to maintain/accelerate the strength gain development, but also has the undesired effect of dissipating moisture content from the mix.

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- In order for sufficient heat and humidity to be maintained within the mix during hydration, the use of concrete curing media becomes instrumental.
- The methods available for curing are many and varied and although materials have changed through development the basic techniques remain unchanged.
- The essential principle is to restrict the loss of heat and humidity from the mix during the critical early stages. This will generally be achieved by placing physical barriers upon the exposed areas of the concrete surface where moisture and heat are most likely to escape.

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Concrete Curing Techniques

Retaining formwork in-situ	→ Site work; columns, beams, etc.
Constant fog spraying	→ Site/factory; ground slabs, walls
Ponding	→ Site; floor slabs, pavements
Hessian/polythene sheet	→ Site/factory; most units
Steam cure/autoclave	→ Factory; blocks, paviours, etc.
Hydrothermal processes	→ Factory; bed-cast products
Surface applied materials	→ Site; all concrete

- With regard to site practises, virtually all the above techniques require reasonable levels of work (man-hours) to ensure the concrete has been adequately prepared for successful curing.
- The most common alternative to surface applied materials is to cover concrete with wet hessian/polythene.

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Compare the two - wall units

- In both cases the formwork will be removed between 16-36 hours. If stripping takes place at 16-20 hours, the concrete will still be sufficiently ‘green’ to be easily damaged and therefore covering the hessian with secondary sheeting i.e. polythene and then securing the whole structure by taping or banding to prevent both coverings from being displaced may prove a little too intensive to avoid damage to the structure. If these extremely careful labourers manage this process, the structure is then subjected to the actions of the elements. Should the wind find a chink in the curing armour, the protective sheeting will be reversed in its action of preventing heat / moisture loss and may well be turned into a wind tunnel where drying winds may access the hessian and instead of retaining moisture within the structure, will dry-out and draw moisture from the surfaces.

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This will result in:-

- limited hydration
- colour variation (hydration staining)
- surface blemishes
- surface crazing
- plastic shrinkage cracks
- increased permeability
- decreased durability

If a spray-on curing membrane were applied, the labour intensive aspects are immediately dispensed with, as is the accidental damage element. The membrane is applied uniformly over the entire surface and will not be effected by adverse weather conditions. The membrane has the added advantages of remaining intact on the surface for an extended period of cure and not having to be removed at a later stage.

Ground Slabs / Pavement

Once the concrete slab has been placed and finished (tamped, screeded, powerfloated, etc.) the slab may either be left until the initial set has completed and then be subjected to the ponding technique whereby water is constantly applied across the whole surface of the slab to a given depth and for a given period or covered with damp hessian and polythene. The polythene must be secured to ensure the hessian is not allowed to dry out. The complications with these techniques include controlling the depth of water across the entire surface, excessive cooling of the concrete (slowing hydration process and strength gain) controlling duration of curing period and disposing of water. The labour aspects again apply for the hessian technique and again avoiding the reverse effects should the wind access the sheeting. A subsequent sealing coating may be applied later.

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- Should either practice not be carried out precisely the effects may be:
  - surface abrasion
  - exposed aggregate
  - surface crazing
  - plastic shrinkage cracks
  - surface discoloration
  - surface texture disruption
  - increased permeability
  - decreased durability
- If a spray-on curing product were applied, the material may be applied to the surface immediately after finishing, the labour intensive aspects are immediately dispensed with, as is the accidental damage element. The membrane is applied uniformly over the entire surface and will not be effected by adverse weather conditions. The membrane has the added advantages of remaining intact on the surface for an extended period of cure and not having to be removed at a later stage. Particular proprietary grades offer other advantages such as providing combined curing, sealing and hardening properties.

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- The commercial considerations of both comparisons have been disregarded but as a rough guide;

Old technique

Hessian	£0.12/m2
Polythene	£0.18/m2
Labour	£1.56/m2 (2 men)
Total	£1.86m2

Membranes

Curing membrane	£0.20/m2 (£1.00 /Ltr{5m2/Ltr})
Labour	£0.76/m2
Total	£0.96/m2

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Choice of Curing Membrane

- There are a number of proprietary materials on the market which incorporate differing curing systems, these include;

- Ferrous/flouro silicate Solutions (Surecure S, Lithurine)
- Resin / solvent solutions (Masterkure 191, Extracure R)
- Acrylic polymer systems (Masterkure 181, Proseal)
- Wax emulsions (Masterkure 106)
- Bitumen emulsions (A1-40/55 etc)

Metallic Silicate Systems

- These products have been available for many years in varying formats, the most widely recognised being Lithurine. These products are considered as general purpose curing aids.

  The mechanism of curing is as follows:

- The material is ideally sprayed onto the concrete surface whilst still moist. The silicate materials are dispersed across the concrete surface by the water bios, the silicate solids being drawn into the capillaries and pores of the concrete surface matrix.

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- The silicate materials react with the available free lime within the concrete to form a pore blocking micro-crystalline structure which impedes moisture loss. The system is both permanent & integral. These materials generally provide adequate curing to non-critical units, and range in efficiency from 40-50%.

- They do however have an added advantage of imparting surface hardening characteristics to the concrete surface.

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- They also provide a reasonably well sealed surface which does not inhibit the subsequent application of coatings and other treatments. Consideration should be given to the ‘Specification for Highways’- White Book, which states:

‘Should curing membranes be used, they should be of the fully degrading variety’.

- This in theory should preclude the use of integral systems.

Resin / Solvent Systems

- These materials are solvent borne petroleum resin solids. The resin materials are inherently U.V. de-stabilised and are reactive with oxygen.
- The solvent carriers are highly evaporative hydrocarbon materials capable of holding the solids in solution until applied to the concrete surface. Again these products should ideally be sprayed onto the concrete surface where the evaporative carrier will dissipate leaving a uniform thickness film/skin of resin platelets across the entire surface.

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- The film is relatively impermeable and therefore has good moisture retention capabilities usually expressed as an efficiency index in accordance with BS7542 (90% or greater).
- Test method includes perameters for:
  - Curing period
  - Humidity
  - Temperature
  - Water loss
- The ‘Specification for Highways’ refers to this standard.

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- The system is designed to retain it's desired efficiency for at least a 72 hour period. The film will then gradually, but with increasing intensity, start to disintegrate due to the actions of U.V. attack and oxidisation. The integrity of the film is fully compromised within 7 to 14 days and has degraded within 28 days.
- This system is purely designed as a high efficiency curing membrane and does not incorporate other features.
- The quality proprietary systems are suitable for use on concrete structures which are to receive subsequent coatings such as:

  Monomeric alkyl (isobutyl)-trialkoxy-Silane.

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- Paving contracts generally specify the use of 90% efficient aluminised systems. These are the same as the previously discussed products whilst incorporating a highly reflective Aluminium flake which is deposited onto a surface within the resin film. The inclusion of a reflective pigment system is to provide a thermally reflective barrier in order to reduce the internal heat within the concrete slab.

Acrylic Polymer Systems

- Whilst incorporating some of the properties requisite within the solvent/resin systems, and baring descriptive similarities, the two are vastly different.
- The Acrylic Polymer Systems are formulated using Thermoplastic Acrylic resins in solution within a blend of varying property hydrocarbon materials. The Acrylic resins are of increased technology compared with Petroleum resins and in this instance are U.V. stabilised and oxidation resistant.

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They also have the additional features of mechanical stability/flexibility and chemical resistance.

Whilst having the desired curing capabilities, these systems are usually designed to impart other properties to the concrete surface such as:

- Surface hardening
- Sealing
- Dust proofing

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- The Acrylic systems are usually applied by spray equipment to both freshly cast concrete or mature concrete.
- Ideally suited to high specification flooring contracts, where Specialist Contractors lay large areas of quality flooring in short time periods using specialist equipment/techniques such as Laser-screeds.
- The Polymer is deposited across the entire surface of the concrete where it's design enables the resin to penetrate the surface matrix and occupy the void areas within the concrete.
- The resin forms a high strength secondary structure within the capillaries and pores of the concrete where it's impermeable nature inhibits moisture egress. The Polymer, once dry, imparts permanent sealing and surface hardening properties to the concrete surface which are beneficial to the wear resistance and anti-dusting capabilities of the floor.

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- Whilst providing added surface strength to the concrete, these products have the added benefit of flexibility, accommodating the natural movements within the slab, (thermal expansion/contraction).
- The penetrative nature of the Acrylic Polymer System means that the material has a lesser film forming characteristic than the conventional resin system and therefore the BS test method for curing efficiency is not considered as an appropriate measure of the product's capabilities.
- It is therefore generally accepted that the standard test method for these products is the ASTM C309 which dictates an acceptable loss of moisture from a given measure of concrete within a stated period under certain conditions.
- Moisture loss is restricted to not more than 0.55Kg/m3 in 72 hours.

Wax Emulsion Systems

- These systems are formulated using modified crystalline waxes suspended within either a water or solvent bios. The system is designed to deposit a wax film across the concrete surface and thereby preventing moisture loss from the surface.
- These materials are ideally applied by spray equipment but are restricted in use to film forming properties only. Dependant upon the carrying medium, some proprietary products comply with the requirements of BS7542 (90% efficiency).
- The down-side to these materials is that the wax film does not degrade without chemical or mechanical interference. This sometimes precludes their use on structures which are to receive subsequent coatings or treatments.
- If left in place, the wax can also discolour and therefore spoil the aesthetic effect of the structure.

Bitumen Emulsion Systems

- These systems are formulated utilising varying percentages of bitumen solids emulsified within a water bios.
- The designation of the product states the % of solids within the product.

  (A1-40, A1-55, K1-40,K1-60etc.)
- These more popular grades are usually required for the curing of Cement Bound Material used in the construction of road/pavement bases or blinding layers.

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They have a dual purpose in restricting moisture loss from the CRM materials but also providing a tack coat for further Bitumen/Asphalt layers or as a dis-bonding layer if CRCR (continually reinforced concrete roadway) or CRCP (continually reinforced concrete pavement) is to be cast upon the base material.

- These materials are usually applied by trolley spray equipment. They are inherently difficult to handle because of the adhesive nature of the Bitumen and their suitability is limited to specific areas.

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Conclusion

- It is false economy to neglect the correct curing program for all concrete items produced either on site or in factory processes.
- Most pre-cast concrete producers employ some sort of curing system that is appropriate to their production regime.
- Most reinforced concrete constructors pay scant regard to this critical step in realising the full potential of a ‘designed’ concrete and therefore compromise the design of the structure under construction.
- It is a fairly simple exercise to determine the correct selection of curing system needed for a particular application. However, it is a far easier selection to choose to cure a concrete structure or not.

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