SCC, Form Finishes and Release Agents

Introduction

The main issues that confirmed by the following articles were that to Clean forms extremely well and then Fog on the release agent.

The forms must be kept clean, if they accumulate dust and/or dirt, the concrete surface will appear to want to slough off and not be smooth at all.

The best time to apply the form oil is JUST PRIOR to setting the forms. When applying the form release, the Chapin type sprayer needs to be really pumped up with pressure, and kept that way during the application. You do not want to have the nozzle dribble the material onto the formwork. Remember, the **thinner** or **lighter** the application, the better.

The experience that many contractors have is to use an extremely small tip that FOGS the form release onto the form surface. The less that is used the better. Recommended products from contractors who use Agilia are Dayton Superiors product "Clean Strip Precast Ultra (J-3 PCO) or Cresset, "Crete-Lease 880-VOC" form releases.

Additionally,it has been strongly recommended to use a nozzle made by Spray Systems Co., Cone Jet Nozzle #6x and a Chapin sprayer. (This nozzle will twist onto the applicator wand.)

Joints In the formwork must be caulked or sealed prior to each pour, this includes the form ties. If the ties or the forms leak, the color of the concrete at that location will have the tendency to darken SIGNIFICANTLY.

We do not generally find that integral color was negatively impacted by the use of Agilia SCC.

Agilia SCC has been successfully used in numerous markets throughout the US, North America and around the world for many years. If the steps in this document are followed, the success of the project is greatly increased.

Appearance

The appearance of an element cast with SCC mainly depends on:

- The type of cement and addition used
- The mix composition of the SCC
- The quality of the mould and release agent
- The placing procedure

The appearance is usually better than for normal concrete:

- The color is generally more uniform
- It is easier to avoid defects due to leakage spots at the location of mould joints and around strand or wires exit points
- The edges may be sharp if the mould is well designed and maintained
- Bugholes can still arise, but should be limited in number and size
- Air voids under horizontal parts of the mould can be limited in size and number, when the mould is filled properly.

The following list of defects can be found in all types of concrete but with care, SCC can give an improved finish compared to traditional concrete:

- Bugholes
- Honeycombing
- Vertical stripes and other color variations
- Plastic or drying shrinkage cracking.

A checklist of probable causes of defect causes and prevention is given in Annex C.
Additional information on some defects is given in the following clauses.

Bugholes

Air is introduced into concrete during the mixing process but also during the transportation and casting. The extent to which air is either stabilized within SCC or is lost during placing depends on the cohesion of the mix. A high slump-flow SF3 and low plastic viscosity VS/VF1 are beneficial in helping to achieve perfect surfaces as they make it easier for the air to leave the concrete. A mix that is close to segregation will usually give the best surface.
Blowholes are formed when small air bubbles become trapped or adhere on the formwork surface. In addition to the factors detailed above, blowholes can also be due to the surface quality of the formwork and the type and/or quantity of release agent used. Advice should be sought from both the release agent supplier and the concrete producer.
Air will be released more easily if the rate of rise of the concrete in the formwork is limited and also if it has to move sideways in the mould for several yards.
Pumping from the bottom of the formwork generally produces better surface finish. If this is not possible the casting hose should be kept below the concrete surface at all times. If the concrete is allowed to free-fall, this may increase the number of larger entrapped air voids both on the surface and within the body of the concrete.

Honeycombing

Honeycombing may be due to leakage in the formwork but is more usually caused by poor passing ability resulting in aggregate bridging and voids behind reinforcement.

SCC with poor passing ability is usually due to:

- Slump-flow class too low
- Viscosity too high
- Maximum aggregate size too large
- Insufficient paste or too much coarse aggregate.

If honeycombing occurs and is not due to formwork leakage, the concrete should be checked against the specification. If conformity to the specification is confirmed, consideration should be given to revising the specification.

Color consistency and surface aberrations

Vertical stripes at the SCC surface are rare and usually caused by bleed water. Any bleed water tends to accumulate at the vertical mould surface and flow upwards leaving visible stripes on the hardened concrete surface due to washout and or floatation of the mould oil.
There are several reasons why bleeding may occur:

- High water to powder ratio
- Viscosity too low
- Low temperature
- Retarded set.

Other reasons for color variations are:

- Uneven drying of surface (for example caused by new or dry timber moulds or plastic sheet that touch part of the concrete during the curing period)
- Over application or poor choice of release agent
- Differences in material source between batches of concrete.

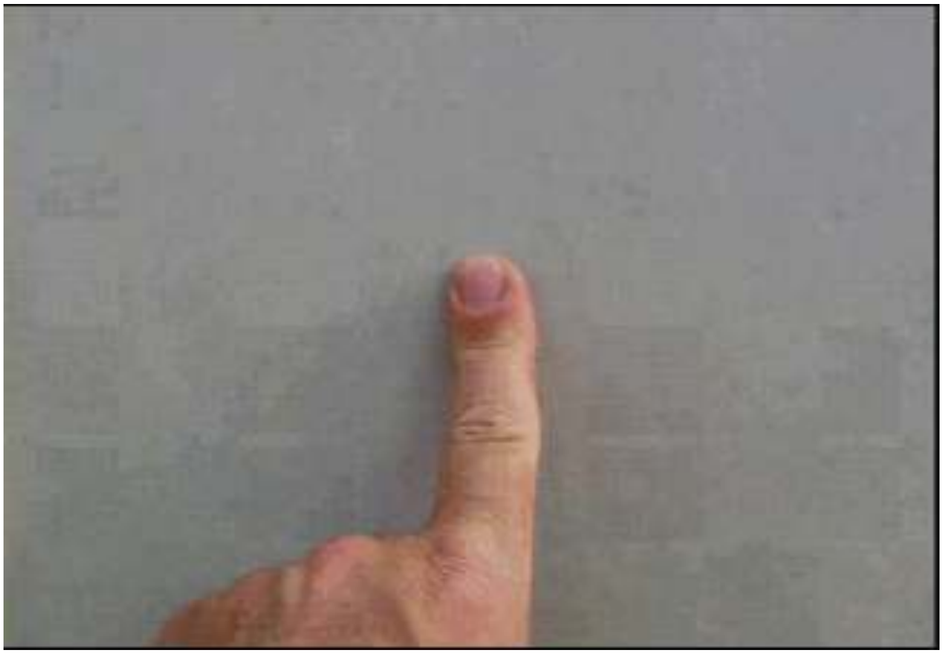
Minimizing surface cracking

SCC is designed to be stable and resistant to segregation but, like traditional vibrated concrete, it may suffer from plastic settlement cracking above reinforcing bars if aggregate settlement does occur. Some SCC mix designs, especially those where a very high-quality finish is required, can be very close to the aggregate segregation point so extra control may be required. The use of a VMA, together with appropriate powder content may help to make the concrete more robust and decrease the risk of plastic settlement and cracking.

Plastic settlement cracks may be wide but normally they are not very deep so trowelling before the concrete sets can often repair the surface.

Because SCC has little or no bleed it can loose surface water, resulting in drying shrinkage cracks if curing is not started at an early age.

Form finishes using SCC:



Random Board form liner and SCC:

Annex C: Improving the finish of SCC

The table below outlines the main defects that may appear during or after the placement of self-compacting concrete. Some of the defects described are also applicable to traditionally vibrated concrete. However, some defects are easier to avoid using SCC due to the nature of the product. It should be noted that surface defects such as blowholes and other surface aberrations affect the appearance of the concrete face, other problems such as honeycombing, joints/layers between batches, scaling, and cracking may impact on concrete integrity.

Type of defect	Primary causes	Practical reasons	How to prevent or correct
Blow holes	entrapped air entrapped water entrapped form oil	• excessive fines/ high specific surface area	• reduce fines
		• heavy or uneven application of mould oil	• minimal application rate applied evenly
		• rough mould surface	• ensure mould surfaces are clean • use of geo-textile form liner will absorb air
		• pouring rate too fast	• ensure steady discharge into forms
		• too long flowing length	• limit flow distance to 5 m
		• too short flowing length	• extend flow distance to 1 m
		• Large free falling distance	• lower free fall to < 1 m • use of soft-walled tremie in deep lifts • pump from bottom up will help to expel air
		• concrete temperature too high	• reduce concrete temperature to below 25°C
		• placing rate too slow	• plan concrete delivery rate and site resources to ensure continuity of pouring
		• settlement of constituents in superplasticiser, particularly defoamer	• concrete producer improve storage, use by date and stock rotation
		• too high viscosity	• reduce dosage of VMA • review mix proportioning
		• unsuitable aggregate grading	• use of VMA or entrained air
		• too long mixing time induces air	• review mixing time
		• admixture/cement interaction	• assess admixtures/cements compatibility prior to production
Physical reasons:	poor filling ability, poor passing ability high viscosity or high yield stress low slump flow and / or long T_{500} time rapid slump-flow reduction		

Type of defect	Primary reasons	Practical reasons	How to prevent or correct
Vertical stripes or water scouring visible on concrete surface	bleeding of water and fines	• too high water to powder ratio • too low viscosity	• use of VMA may assist • increase viscosity through additional fines • use air entrainer to overcome poor particle size distribution
Physical reason: low stability			

Type of defect	Primary reasons	Practical reasons	How to prevent or correct
Colour variations	along the surface differences between batches	• too low temperature	• maintain concrete and/or form temperature during winter conditions
		• too high slump flow, too low viscosity	• increase viscosity by increasing fines or consider using VMA
		• retarding effect of admixture or release agent	• careful selection of admixtures to open-life requirement • reduce water content or reduce plasticiser addition rate • consider using a mild accelerator • use geo-textile form liner
		• changes in rate of pour	• continuous casting
		• plastic curing membrane irregularly in contact with concrete surface	• ensure consistent contact
		• surface-dry timber moulds	• wet mould before casting • preferably use coated form-face
Physical reasons. retarding or staining effect caused by oil, admixture etc. too high plastic viscosity or yield stress			

Type of defect	Primary reasons	Practical reasons	How to prevent or correct
Poor uneven, cast surface	deformation of mould "image-points" from mould to concrete surface	• fast pouring rate or weak form design	• reduce casting speed to reduce hydrostatic head • use VMA to increase viscosity • redesign formwork
		• form face worn-out • adhering residual concrete	• renew formwork • clean face prior to casting
		• unsuitable release agent or method of application	• experiment to establish best release agent • apply at correct rate with proper equipment using right pressure and spray nozzle
		• too high water/powder ratio	• increase superplasticiser addition rate or use VMA
Physical reasons: high formwork pressure too low plastic viscosity			

Type of defect	Primary reasons	Practical reasons	How to prevent or correct
Honeycombing	insufficient paste or fines	• low paste/fines content	• increase fines, use at least 450 kg powder/m³ • add air entrainer
	concrete segregated due to too low plastic viscosity	• unsuitable grading	• continuous grading
		• aggregate size too large compared to free space	• smaller max aggregate size
	concrete not able to fill the part of the mould	• leakage of mould	• check integrity of mould particularly at joints
Physical reasons	incomplete filling ability incomplete passing ability incomplete stability too low slump-flow and / or [illegible] time segregation of course aggregate/paste		

Type of defect	Primary reasons	Practical reasons	How to prevent or correct
Scaling	surface layer contains only fine material and has set too fast	• no curing or limited curing	• ensure proper curing according the ambient conditions
		• segregation and/or bleeding caused by the too low amount of fines	• increase powder content • use of VMA • add air entrainer
Physical reasons	incomplete stability segregation and/or bleeding too fast drying		

Type of defect	Primary reasons	Practical reasons	How to prevent or correct
Visible joint planes between different batches (commonly referred to as "cold joints")	Formation of surface crust prevents monolithic joining of subsequent concrete	• intermittent deliveries of concrete	• continuous casting, no breaks
		• concrete stiffening quickly	• proportioning: not too fast stiffening [illegible]
		• high concrete or air temperature	• lower temperature of concrete than [illegible]
		• segregation of coarse aggregates	• follow mix proportioning • reduce flowing distance
		• too high specific surface of fines	• reduce fine/powder content
Physical reasons:	incomplete filling ability thixotropic setting too fast slump-flow loss too high viscosity admixture - cement interaction		

Type of defect	Primary reasons	Practical reasons	How to prevent or correct
Plastic cracking (early shrinkage and plastic settlement)	too fast drying sedimentation rebar positioning	• poor early age curing regime	• start curing immediately after placing/finishing • proper curing according the ambient conditions
		• segregation and bleeding	• close the plastic cracks prior to concrete setting • increase powder content • use VMA • use air entraining agent
		• extreme ambient conditions (temp, RH, wind etc)	• apply finishing according to prevailing conditions
		• deep lift with rebar close to surface	• rebar cage redesign
Physical reasons: increased plastic drying shrinkage poor stability			

Prepared By:

The European Guidelines for Self-Compacting Concrete
Specification, Production and Use

Promote Communication for Architectural Concrete with CCS...Before You Pour

CCS (Cresset Concrete Standards) is a photographic guide to help you specify high quality architectural concrete surfaces. Using the guide, you choose the concrete surface you want when you're writing contract documents and specifications. The following is a tool to get agreement with all involved in the project...<u>ahead of time</u>. An abbreviated version of the CCS Guide is shown below:

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Forms

Wood forms and metal forms will show significant differences in surface defects. Wood forms tend to produce fewer bug holes than metal because wood forms soak up excess release agent that has been hastily applied. Any small amount of extra oil on a steel form will react with the concrete mix and create small bug holes, perhaps better termed "pinholes." Therefore, proper application is absolutely necessary. Steel forms require more attention to ensure a clean, smooth surface. Any defect on the form will create a blemish on the concrete surface.

A form's cleanliness and smoothness greatly affect the appearance of the concrete surface. This simple, logical truth cannot be overstated when dealing with see.

Forms should be as smooth as possible to allow entrapped air to move easily upward along the form system; they must be kept free of paste buildup and laitance, which prevent air and water pockets from traveling to the concrete surface. In our study, as paste built up on each form with subsequent castings, the concrete surface appeared worse. Scratches or gouges will hold air against the surface of the concrete. Any steel forms pitted with rust will cause blemishes, which at times produce more bug holes than are noticeable with vibrated conventional concrete. We also noticed that when the form skin had a lower temperature than the see, air voids smaller than usual were present. That occurred at approximately a *25°* F temperature difference.

Whenever you grind a "seasoned" steel form, you remove the protective barrier previously produced by the reactive form release agent. Rusted forms have negated the barrier that was in place. Once the form is ground, raw metal is exposed. The reactive portion of the form release agent, typically a fatty acid, has a natural affinity for metal. The fatty acid attacks the raw metal and forms metallic oleate, which acts as a protective coating. Subsequent applications of reactive form release agents are prevented from getting to the metal by the protective layer of metallic oleate, allowing the reactive portion of the form release to be available to react with the free lime on the surface of the concrete. This reaction forms a chemically inert metallic soap, which gives good release and allows free air to rise more easily to the surface on vertical walls. Until the form is seasoned, or the protective barrier is formed, the reactive portion combines with the metal, leaving nothing to react with the free lime. The steel forms used in this study were seasoned after cleaning and before further castings took place. That aided the finish somewhat but the pits left in the forming material by the rusting process trapped air voids, creating bug holes.

Release Agents

Five agents were analyzed in this study. Release agents fall into two primary types, barrier and reactive. Barrier release agents create a physical barrier between the form and the concrete. The barrier agent used here was a plain, low viscosity petroleum oil containing paraffin that acted like a wax, aiding the release of form materials. Reactive release agents contain weak acids derived from vegetable oils or animal fats. They may also include lignosulfates and tall oils (liquid rosin) byproducts from paper manufacture. Reactive agents fall into two primary categories: vegetable oils and petroleum-based. Most reactive release agents on the market today have petroleum-based carrying agents. In this study one vegetable-based and three petroleum- based oils were considered. Vegetable-oil-based agents had two disadvantages. After five to eight castings on a form, a buildup of flaky residue from the agent was noticed. Repeated form cleaning was necessary to maintain a good finish. Also, vegetable oils normally turn rancid when exposed to air and heat. The limited temperature range for product storage poses a problem. The vegetable-and petroleum-based reactive agents were applied to the www.concreteconstruction.net form in a thin mist, as prescribed by
the manufacturers. The barrier type agent allowed the forming material to release from the concrete only when applied heavily. Heavy applications increased the presence of bugholes. The barrier agent also required five times more clean-up time to return the form surface to an acceptable casting condition after each pour. The vegetable-based agent provided the best results when used on new plywood, though only a minor improvement over two other reactive agents in the study. The petroleum based reactive agents produced the best average product appearance when used with steel forms. Not all of the reactive agents gave an acceptable appearance; even in certain reactive form oils various carrying agents can cause flaws in the concrete appearance. The barrier type agent consistently produced a poor finish, even when more labor than usual was put into release agent application.

Conclusion

Any defect in a forming system will become extremely visible in well developed SCC. An overall smooth surface will exaggerate the appearance of marks left on the concrete from scratches in formwork, rust pits, concrete paste buildup, or other defects.

Barrier type release agents should not be used with see when the appearance of the formed finish is important. When barrier agents are applied thinly, the concrete does not release well from the form, and the surface of the concrete "peels." When applied heavily, the barrier agent traps large numbers of air pockets.

When a reactive release agent has been chosen, test specimens should be cast to ensure that the material performs well with the see being used. Not all reactive agents perform equally well with any concrete, though they generally do give a better finish than barrier agents. Reactive agents should always be applied in a thin layer, as prescribed by the manufacturer.

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<u>All of the preceding information was compiled from articles by:</u>

The European Guidelines for Self-Compacting Concrete

Specification, Production and Use
These Guidelines and specifications were prepared by a project group comprising five European Federations dedicated to the promotion of advanced materials, and systems for the supply and use of concrete. The Self-Compacting Concrete European Project Group was founded in January 2004 with representatives from:
BIBM The European Precast Concrete Organization.
CEMBUREAU The European Cement Association.
ERMCO The European Ready-mix Concrete Organization.
EFCA The European Federation of Concrete Admixture Associations.
EFNARC The European Federation of Specialist Construction Chemicals and Concrete Systems.

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