PART V. CONCRETING SITE PRACTICES

CONTROL OF SURFACE FINISHES

CEMENT CONCRETE & AGGREGATES AUSTRALIA

CONTENTS

The control of off-form concrete finishes – architectural concrete as it is sometimes known – involves careful planning of all aspects of the work including (a) the form faces and release agents to be employed, (b) the choice of concrete materials and mix proportions, and (c) the techniques used to place, compact and cure the concrete. This section will highlight the factors which influence off-form finishes and ways in which these factors can be controlled.

1. INTRODUCTION

This section deals with the control of surface finishes on off-form or 'architectural' concrete, i.e. concrete which is intended to have a predetermined appearance. Such finishes are produced by combining appropriate formwork with the use of good quality concrete and correct placing, compaction and curing techniques.

Off-form finishes, to be successful, require very high standards of design, specification and construction. Above all, they require good communication between the architect and the contractor and a high degree of knowledge and skill on the part of the workforce. They are not necessarily 'easy' or 'cheap' to produce. This is not to suggest that good quality off-form finishes are beyond the skills of the average contractor but rather to emphasise that such finishes are the result of good planning and execution, i.e. they do not just happen.

2. FACTORS INFLUENCING THE APPEARANCE OF CONCRETE

2.1 GENERAL

Factors which influence the colour and texture of off- form finishes include:

- The nature of the formwork;
- The use of form liners;
- Release agents;
- Concrete materials and mix design;
- The use of pigments;
- Placing and compaction techniques;
- Curing; and
- The protection given to the finished work.

Since many of these factors are both interrelated and inter-reliant, they all need to be considered if visually good quality concrete surfaces are to be achieved.

2.2 FORMWORK

General – The quality of the formwork, and particularly the form faces have a major influence on the appearance of the concrete cast against it. Not only is the off-form finish a direct negative of the form face, it is also affected by formwork characteristics including:

- Stiffness;
- Absorbency; and
- Water-tightness.

If the formwork is not stiff, deflection and movement during concrete placing and compaction may contribute to a number of surface defects such as colour variation and/or a mottled appearance sometimes referred to as ‘aggregate transparency’.

Variable absorbency of the form face will also result in colour variations and possibly even dark staining of the surface. The colour variation is caused by changes in the water/cement ratio of the concrete at the surface (**Figure 16.1**). While this is superficial in one sense, it may occur to a sufficient depth that subsequent tooling of the concrete may not remove the staining. The colour variations are usually most noticeable with changes of absorbency from one panel of timber formwork to the next. It should be noted that the absorbency of 'new' timber forms changes after a number of uses. In addition, the uniformity of the release agent coating can affect the absorbency of the form face.

Figure 16.1 – Hydration Staining and Colour Variation from Concrete placed in Layers

Loss of moisture and/or cement grout through formwork because of lack of watertightness leads to other surface problems, notably honeycombing (**Figure 16.2**). The joints between adjacent planks or formwork sheets should therefore be accurately made and rigidly held together and the joints between elements (e.g. between side wall and soffit formwork for beams) sealed with foamed plastic strips or timber fillets fixed into the joints. Alternatively, a waterproof tape or joint sealant can be applied to the joints. It should be noted that the use of tapes will be reflected on the finished concrete surface.

Figure 16.2 – Honeycombing due to Inadequate Compaction or Grout/mortar Leakage

Formwork Design – All formwork should comply with the provisions of AS 3610. The formwork drawings should show the patterns of the form face (if any) and typical joints between formwork panels. Careful detailing of such joints is critical to the success of off- form finishes (**Figure 16.3**). For example, all control and construction joints on vertical surfaces should be indented or otherwise disguised (**Figure 16.4**).

Form Face Materials – A range of materials can be used to provide the form face against which concrete is cast. Each will give a characteristic texture/finish to the concrete surface. For a given situation (orientation of form face, exposure and desired appearance) some materials will be more suitable than others. For example, smooth faced materials such as plastic-coated plywood and fibreglass should not be used on surfaces that will be viewed close-up (i.e. from closer than three metres). It is difficult to ensure that such (smooth) surfaces are blemish-free and they are very difficult (if not impossible) to repair. However, these smooth materials can be used

where surfaces are visible only from greater distances. Similarly, a board-marked finish will tend to hold dirt on the surface and may harbour fungal growth in tropical climates and thus be unsuitable for external surfaces in certain geographic locations.

Figure 16.3 – Example of Carefully detailed Off-form Concrete

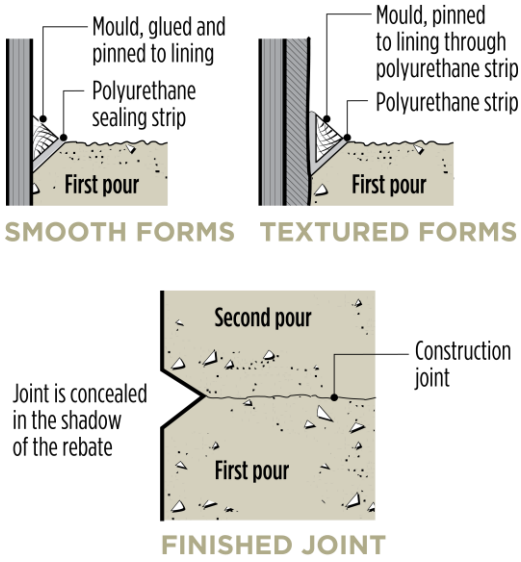

Figure 16.4 – Construction Joint on Vertical Surface

Traditionally, sawn timber has been used extensively as a form face or lining to produce 'board marked finishes'. Oregon boards are preferred – rough sawn or even lightly sand-blasted to bring out the grain. To avoid variable absorbency new boards should be sealed with several applications of a form oil and then 'pickled' by the application of a cement grout or slurry to the surface. The slurry is then allowed to dry before being brushed off. Sawn boards may be used to produce profiled finishes (**Figure 16.5**).

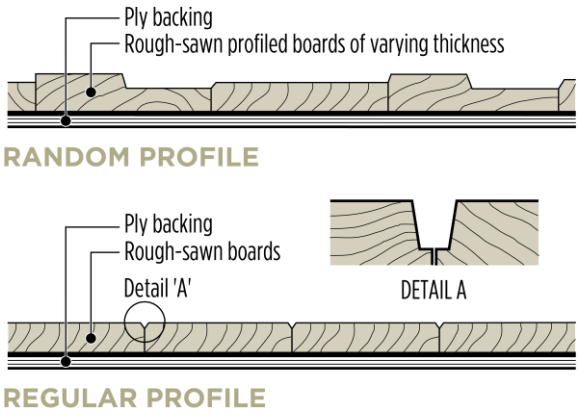

Figure 16.5 – Form Linings for Sawn-timber Finishes

Plastic coated plywood produces a smooth finish. However, as noted above, this formwork type is not recommended for surfaces that are to be viewed at close quarters. A light sanding of the face with fine sandpaper will help improve colour control as will 'pickling' the formwork surface before use.

As with sawn timber, a suitably detailed joint between plastic coated plywood panels is essential. It is almost impossible to disguise the joints between adjoining plywood sheets so, aesthetically, it is best to emphasise them. A rebate at the joint will normally be satisfactory, but in any event, sealing the joint between plywood sheets with a pre-formed foam strip is essential to prevent leakage of moisture and/or cement grout.

Fibreglass forms and form liners are often used for complex shapes and profiles that would be difficult or impossible to achieve by other means. They give a very smooth, mirror finish to the concrete (unless textured) and because of this they should only be used for surfaces that can be viewed from a distance. The joints between adjoining panels or shapes are difficult to disguise and as with other materials, they are best accentuated.

Other materials which have been used to achieve specific effects include (a) rubber and

other forms of plastic form liner, (b) hardboard sheets with the textured side exposed, (c) rope lightly secured to the formwork and then subsequently stripped from the concrete surface, as well as a variety of even more exotic processes. Experimentation and the construction of test panels with these materials is essential to confirm the anticipated texture and appearance as well as ensure satisfactory results for the member and surfaces involved.

2.3 RELEASE AGENTS

Both the type of release agent and the method of application can affect the quality and colour of a surface finish. Whilst it is beyond the scope of this Guide to discuss in detail the wide range of release agents available, it can be noted that chemical release agents are most likely to provide satisfactory results. Water-in-oil emulsions or neat oil with surfactants have also proved satisfactory. Test panels built prior to construction provide the best method for assessing the suitability of a release agent for the given application.

No matter what release agent is used, it is essential that it be applied uniformly and evenly over the form surface at the minimum rate consistent with full coverage. Surplus agent should be removed prior to concreting. Also, if colour control is specified, the same release agent should be used throughout the project.

2.4 CONCRETE MATERIALS AND MIX DESIGN

The requirements for concrete that will give consistent, high quality surface finishes are more demanding than those imposed by the simple strength/durability parameters of structural concrete.

These requirements may be expected to cover such matters as:

- The type of cement and supplementary cementitious materials and their source and relative proportions – to minimise colour variations due to cementitious materials throughout the project;
- The sand, and its source, again to ensure minimal colour variations;
- The coarse aggregates and especially the amount of flat, flaky or elongated particles to be permitted (a minimum practical limit is advisable because of the adverse effect such particles have on the textural quality of off-form finishes); and
- A minimum cement content – The mix design for concrete for high quality finishes will, typically, have a higher cement content and a lower water/cement ratio than may be necessary for the strength/durability requirements of the work. The concrete is sometimes less workable than plain structural concrete and, hence, may create issues with pumping. It may also require more intensive vibration to ensure full compaction.

On many jobs a suitable mix design will be agreed only after adequate field testing has been carried out, using the method of placement intended, and after test panels have been constructed. These may then serve as reference panels as the work proceeds. Sometimes, however, reference can be made to previous projects which are similar in finish and colour to that proposed, thereby reducing the amount of field testing required.

Once chosen, it is essential that the mix remains constant throughout the project. Materials should come from the same sources and their proportions should remain unchanged. The control of the water/cement ratio is particularly crucial. Mixes with a high sand content tend to give better colour control but may result in more blowholes in smooth finishes. Some compromise may therefore be necessary for best overall results. Over-sanded mixes should always be avoided.

Because of these special requirements, concrete for off-form finishes must always be specified as 'Special Class' concrete in terms of AS 1379.

2.5 PLACING AND COMPACTING

While good practice in placing and compacting concrete is always desirable, it is especially necessary to achieve high quality off-form finishes. Appropriate techniques are discussed

in Sections 12 and 13 of this Guide but specific attention is drawn to the following:

- The concrete should be placed at a continuous rate and consistently for each section of the work. In walls, the placing rate should be such that the lateral pressure assumed in the formwork design is not exceeded and the settlement in each layer is substantially complete before the next layer is placed (and no cold joints are formed);
- Placement should occur in uniform horizontal layers, with care being taken that the concrete is not moved horizontally or made to flow by the use of immersion vibrators;
- The concrete should be thoroughly compacted using the techniques described in Section 13 of this Guide. Special care should be taken to avoid touching the form face with immersion vibrators to avoid damaging it, and to avoid the formation of sand streaks on the surface of the concrete (**Figure 16.6**);
- To minimise the formation of blowholes in the top 0.5 m of walls and columns, the concrete should be rodded and/or re-vibrated prior to it stiffening.

Figure 16.6 – Surface Marking due to Immersion Vibrator touching Formwork

2.6 CURING

Curing of concrete is discussed in detail in Section 15. With off-form concrete some special precautions are required to ensure work is not stained or discoloured during the curing process when colour control has been specified (**Figure 16.7**).

(a)

(b)

Figure 16.7 – Surface Appearance affected by Non-Uniform contact with (a) Formwork and (b) Cover

For example, there are special problems associated with the use of formwork to cure concrete. Generally speaking, to ensure adequate curing with formwork it is best to leave it in direct contact with the concrete, thereby preventing air movements which may cause the surface to dry out.

However, with off-form finishes it is often best to ease the form-face from the concrete at an early age to prevent scabbing (see **Table 16.2**). When this is done, it is essential to ensure that all faces are loosened otherwise uneven curing and colour variations may occur.

Other causes of discolouration are more obvious but should always be checked. For example, on vertical surfaces:

- Water curing can cause streakiness and non-uniform dis-colouration, and run-off onto completed work can cause similar problems. Iron salts or similar impurities in water may cause significant colour effects;
- Curing with hessian can cause problems. To overcome such issues it is important that (a) the hessian itself be thoroughly washed before use to ensure it does not stain the surface, and (b) that the hessian is kept uniformly wet to avoid uneven colouration of the cured surfaces;
- Curing with plastic sheets is a satisfactory method – provided the sheets are prevented from making contact with the concrete. Uneven contact can result in dark patches/mottling at the point of contact.

Plastic sheeting has the advantage that it helps protect finished work. A good method of preventing contact is the use of a light plastic or wire mesh stapled to a light timber frame secured to the wall through the tie-bolt holes. This may be left in place to protect the finished work as long as is necessary. Note that some colour variation may occur under the timber frame so its size should be kept to a minimum.

Curing compounds may also be employed to cure off-form concrete. As with other materials, preliminary trials are advisable to ensure there is no permanent staining from their use.

2.7 TREATMENT OF TIE-BOLT HOLES

The treatment of tie-bolt holes is especially important to the overall appearance of off-form concrete. A uniform bolt-hole pattern will enhance the appearance of the surface, while an uneven system will detract from the overall appearance (**Figure 16.8**).

Holes may be made good or filled with either plastic or concrete plugs fixed in position with epoxy mortar. Alternatively, they may be filled with a dry-packed mortar rammed into position.

In either case, the plug or filler should be recessed some 6-10 mm below the surface of the concrete finish.

Figure 16.8 – An Even Tie bolt-hole Arrangement will enhance the Overall Surface Appearance

Where possible, precast concrete plugs should be made with the same concrete as used in the element, to avoid colour contrasts.

If a dry-pack mortar mix is used it should consist of a 1:3 cement:sand mixture employing the cement and sand used in the original concrete – except that about 30-40% of the cement should be replaced with an Off-White cement to lighten the colour of the mortar. This compensates for the generally darker colour of small patches which in this case may be accentuated by the shadow effect of the recessed surface or plug.

To reduce shrinkage and the possibility of a more fluid material staining the surface of the finished work, the mortar should be an earth-damp mix which is compacted by ramming.

2.8 PROTECTION OF FINISHED WORK

Finished work should be protected from both accidental damage and staining.

Accidental damage can be caused in a number of ways, but normal care should suffice to minimise the occurrence of such issues. One problem not always guarded against, however, is the accidental splashing of finished work

either with fresh concrete or mortar or staining by grout lost from subsequent lifts.

Protection of finished work should therefore commence immediately after completion, i.e. as soon as the formwork has been stripped. As has been noted, one means of providing protection is to wrap the element in polythene film, taking care to ensure that it does not contact the fresh concrete surfaces. Surfaces which have been cured and allowed to dry out will not be harmed by wrapping them in polythene.

Work should also be protected from rust washed onto it from projecting (and unprotected) reinforcement; from formwork and screens on upper lifts; and from props or from other steel products used in subsequent lifts. Reinforcement may be protected by painting it with a cement slurry or wrapping it in plastic (though this is not recommended in areas of high humidity) (**Figure 16.9**). Other staining may be prevented by ensuring that materials used above completed work are clean and free from rust.

Figure 16.9 – Completed Work and Reinforcement protected by Wrapping

Another cause sometimes neglected is the staining of work at ground level by mud or soil 'splashed' onto it during rain or from passing vehicles. Protection of the concrete and good site management are obvious precautions against these sources of staining.

3. THE SPECIFICATION OF SURFACE FINISHES

3.1 GENERAL

There are three broad approaches to the specification of surface finishes, viz:

- By performance;
- By method; and
- By a combination of performance and method.

Performance specifications may be based on the provisions of AS 3610 and Supplement 1 to that Standard. Section 3 of AS 3610 deals with surface finish and details five classes of finish by their visual characteristics and suitability for use in different situations (**Table 16.1**). Supplement 1 provides a series of photographs which may be used to evaluate the occurrence of blowholes in smooth finishes and a series of colour charts which may be used to evaluate colour consistency or control in finished work.

The Standard also provides details of the documentation required for each class of finish, tolerances for both linear and angular dimensions, and guidance on acceptable variations in colour.

Method specifications describe the method or technique which is to be used to achieve the required finish. Such specifications need to be complete and unambiguous if satisfactory results are to be obtained.

A combination of method and performance in the one specification is the least satisfactory system although it can be made to work if there is some objective standard (such as a test panel) against which to assess performance.

3.2 TEST PANELS

Test panels (**Figure 16.10**) arguably comprise the single most useful tool for determining compliance with a specification as they demonstrate the acceptability of the

combination of both materials and techniques. AS 3610 requires test panels to be provided for:

- Class 1 and Class 2 untreated surfaces;
- Colour control of surfaces; and
- Surface treatments.

Figure 16.10 – Test Panels should reflect all Aspects of the Proposed Structure

Test panels should be constructed on site using the materials, formwork and formwork details, release agents etc to be used in the actual work. This implies that they need to be of a size similar to that of the actual construction. Small sample panels, especially panels produced in a laboratory, will not properly reflect the ability of on-site construction techniques to produce the desired finish. Where surface treatments such as bush-hammering are to be applied a separate panel should be produced – and this panel may later be placed alongside the completed work for comparison.

Test panels may also be used to assess the acceptability of repair techniques should these be required at a later date.

4 DEFECTS IN OFF-FORM CONCRETE

The production of good quality off-form concrete depends, to a large extent, on recognising the factors which cause defects in it and how these effects might be minimised or even eliminated.

Tables 16.2 and **16.3** set out some of the more common (and some less common) defects which may be encountered in off-form concrete, and their probable causes. Once the causes have been identified, action can usually be taken to eliminate them.

5 REPAIRS AND REMEDIAL WORK

Repairs and remedial work to off-form concrete are undesirable because of the difficulty of achieving visually satisfactory results. AS 3610 gives the specifier the option of not allowing repairs to elements with Class 1 finishes. When necessary, the following precautions and procedures will assist in securing the best possible results:

- As far as is practicable, repairs should always be carried out by skilled and experienced crews;
- Repair techniques should be established early in the construction program, preferably using the pre-construction test panels, and a repair standard acceptable to all parties established;
- Repairs should then be undertaken at the earliest possible opportunity (preferably as soon as the form has been stripped) in order to ensure that the repair and the concrete are given the same curing and/or other treatments;
- Surfaces which are to be tooled and which exhibit significant defects such as blowholes or honeycombing must be patched prior to tooling. Reliance should not be placed on tooling to mask such defects. Appropriate time should be allowed for the patches to gain strength before tooling is commenced;
- Extreme care should be taken to establish a colour match between the

concrete surface and the patch. To achieve this, it will generally be necessary to substitute part of the original cement (perhaps as much as 40%) with Off-White cement. Patching with the original mix will almost inevitably result in a darker colour.

The choice of materials to be used and the repair technique will depend on the size and configuration of the defect. Blowholes may be filled with a colour-controlled patching mortar using a spatula. The surface should be lightly moistened prior to patching and an earth-damp mixture forced into the hole. Care should be taken not to smear the surface of the surrounding concrete with the patching mortar.

Repair techniques for honeycombing vary with the depth and the area involved. In shallow areas, all loose or partly adhering material should be removed, and the periphery of the area trimmed to a depth of 4-6 mm. The existing concrete should then be primed with a bonding agent and a suitable mortar packed into the hole and consolidated. The surface should then be finished to match the surrounding concrete, being careful not to overwork it.

Acrylic modified-Portland cement materials are available for patching work and, in general, appear to provide better performance than unmodified materials.

Where more extensive repairs and patching are required it may be possible to form up the area and to place concrete behind the forms. Forms used in this situation should have patterns and absorbency characteristics similar to the original formwork.

Bonding agents may be employed in such situations, but care should be taken that they are suitable for the application. (e.g. PVA-based bonding agents should not be used in locations where the concrete may become wet as they tend to re-emulsify in such conditions.)

Defects such as minor grout runs, form scabbing and some hydration staining can be remedied by rubbing the surface with a carborundum stone. Such treatments should be limited to small areas.

Acid etching, bleaching or similar treatments should be considered only as a last resort as the results may well exacerbate problems instead of curing them. Very careful consideration should always be given to whether repairs and remedial work will improve or worsen the appearance of the concrete. In certain cases the application of a photocatalytic coating may be required to achieve the desired finish.

Table 16.1 – Applicability of Surface Classes (from Table 3.2.1 in AS 3610.1)

	Class 1	Class 2	Class 3	Class 4	Class 5
Visual characteristics	Visual quality important. Highest quality attainable. Subject to close scrutiny. Best possible uniformity of appearance. Excellent quality of edge and joint details.	Visual quality important. Uniform quality and texture over large areas. Built to close tolerances. Consistently good quality of edge and joint details.	Visual quality important. Good visual quality when viewed as a whole.	Visual quality not significant. Appearance not important. Good general alignment.	Visual quality not significant. Alignment and appearance not important.
Suitable uses	Selected small elements contained in a single pour. Areas of special importance in limited quantities.	General external and internal facades intended to be viewed in detail and as a whole.	General external and internal facades intended to be viewed as a whole.	Surfaces concealed from general view. Surfaces to have thick applied finishes after preparation.	Totally concealed areas.
Surface treatment	Not applicable	Reference should be made to permitted tolerances prior to selection of applied material.	Reference should be made to permitted tolerances prior to selection of applied material.	Reference should be made to permitted tolerances prior to selection of applied material.	Not suitable
Situations where not to be used	For whole elevations or extended surface areas, trafficable slopes, soffits, formed tops of slopes except where means to dissipate air are employed, form liners. Is not applicable where treatment is to 100% of surface.	Formed tops of slopes except where means to dissipate air are employed.	No restriction	No restriction	No restriction

	Class 1	Class 2	Class 3	Class 4	Class 5
Colour control	May be specified. Refer to Clause 3.4.4 in AS 3610.1 for the limits of the best colour consistency that can be expected.	May be specified. Refer to Clause 3.4.4 in AS 3610.1 for the limits of the best colour consistency that can be expected.	May be specified. Refer to Clause 3.4.4 in AS 3610.1 for the limits of the best colour consistency that can be expected.	Excluded	Excluded
General	If these classes are required, they must be specified in the project documents.	If these classes are required, they must be specified in the project documents.	If these classes are not specified in the project documents, selection of appropriate class is by the visual characteristics and suitable uses set out above.	If these classes are not specified in the project documents, selection of appropriate class is by the visual characteristics and suitable uses set out above.	If these classes are not specified in the project documents, selection of appropriate class is by the visual characteristics and suitable uses set out above.

Table 16.2 – Physical Defects and their Causes

Defect	Description	Most probable causes
Honeycombing	Coarse stony surface with air voids, lacking in fines.	• Formwork: – Leaking joints. • Concrete mix: – Insufficient fines; – Workability too low. • Placing methods: – Segregation; – Inadequate compaction. • Design: – Highly congested reinforcement; – Section too narrow.
Blowholes	Individual cavities usually less than 12 mm diameter. Smaller cavities approximately hemispherical; larger cavities often expose coarse aggregate.	• Formwork: – Form face impermeable, with poor wetting characteristics; – Face inclined, face too flexible. • Release agent: – Neat oil without surfactant. • Concrete mix: – Too lean; – Sand too coarse; – Workability too low. • Placing methods: – Inadequate compaction; – Rate of placing too slow.
Mortar loss or grout loss or scouring	Sand textured areas devoid of cement. Usually associated with dark colour on adjoining surface. Irregular eroded areas and channels having exposed stone particles.	• Formwork: – Leaking at joints, tie holes, and the like. • Concrete mix: – Excessively wet; – Insufficient fines; – Too lean. • Placing methods: – Water in forms, excessive vibration of wet mix; – Low temperature.
Misalignment	Step, wave, bulge or other deviation from intended shape.	• Formwork: – Damaged, deformed under load; – Joints not securely butted. • Placing methods: – Too rapid or careless.

Defect	Description	Most probable causes
Plastic cracking	Short cracks, often varying in width across their length. On vertical faces, cracks are more often horizontal than vertical.	• Formwork: – Poor thermal insulation; – Form profiles or reinforcement which restrain settlement of the concrete. • Concrete mix: – High water/cement ratio; – Low sand content; – Excessive or insufficient bleeding of mix. • Ambient conditions: – Conditions leading to high evaporation of moisture from concrete.
Scaling, spalling or chipping, and form scabbing	Scaling is the local flaking or peeling away of a thin layer of mortar from the concrete. Spalling or chipping is the local removal of a thicker layer or edge of mortar. Form scabbing is the adhesion of portions of form surface, including sealant or barrier paint, to the concrete.	• Formwork: – Inadequate stripping taper; – Inadequate stiffness; – Movement of form lining due to change of concrete hydrostatic pressure with depth; – Keying of concrete into wood grain, saw kerfing / interstices in form surfaces; – Local weakness of form face. • Ambient conditions: – Frost action may cause spalling. • Stripping: – Too early stripping may cause scaling; – Too late stripping may cause scabbing.
Crazing	A random pattern of fine shallow cracks dividing the surface into a network of areas from about 5 mm to 75 mm across.	• Formwork: – Form face of low absorbency, smooth or polished. • Concrete mix: – A high water/cement ratio combined with cement-rich mix can be a cause. • Curing: – Inadequate.

Table 16.3 – Colour Variations and their Causes
***NOTE**: Some of the defects noted below may lessen or disappear with time, especially on surfaces exposed to weathering. It is not possible to state exactly what can be expected to happen on any particular surface. Some defects may appear sooner than others after stripping the forms.*

Defect	Description	Most probable causes
Inherent colour variation	Variation in colour of the surface.	• Materials: – Change of cement brand; – Change of source of fine and coarse aggregate; – Variation in admixtures. • Concrete mix: – Variations in mixing procedure.
Aggregate transparency	Dark areas of size and shape similar to the coarse aggregate. Mottled appearance.	• Formwork: – Too flexible, causing a 'pumping' action during compaction. • Concrete mix: – Low sand content; – Gap grading of sand. • Placing methods: – Excessive vibration.
Negative aggregate transparency	Light areas of size and shape similar to the coarse aggregate. Mottled appearance.	• Materials: – Aggregate dry or highly porous. • Curing: – Too rapid drying.
Hydration staining or discolouration (due to moisture movement within or from plastic concrete)	Variation in shape of the surface. Hydration staining and discolouration have a tendency to be severe at the top of a lift and at construction joints due to localised variations in water/cement ratio, incomplete compaction, and differential loss of moisture. Indentation of construction joints tends to disguise this discolouration by throwing the affected areas into shadow.	• Formwork: – Variable absorbency; – Leaking through joints. • Release agent: – Uneven or inadequate application. • Curing: – Uneven.
Segregation discolouration, or sand runs (separation of fine particles due to bleeding at the surface of the form)	Variation in colour or shade, giving a flecked appearance.	• Formwork: – Low absorption; – Water in bottom of forms. • Concrete mix: – Lean, high water/cement ratio; – Unsuitably graded aggregate. • Placing methods: – Excessive vibration; – Low temperature.

Defect	Description	Most probable causes
Dye discolouration or contamination	Discolouration foreign to the constituents of the mix.	• Formwork: – Stains, dyes, dirt on form face, timber stains, rust from reinforcement or metal form components. • Release agent: – Impure or improperly applied. • Mix materials: – Dirty; – Contaminated by pyrites, sulfates, clay, organic matter or other impurities. • Curing: – Contaminated curing compounds; – Contaminated curing water; – Dirty covers.
Oil discolouration	Cream or brown discolouration. Sometimes showing sand or coarse aggregate.	• Release agent: – Excessive amount; – Low viscosity; – Impure; – Applied too late or unevenly.
Lime bloom or efflorescence	White powder or bloom on surface.	• Design: – Permitting uneven washing by rain. • Release agent: – Type. • Curing: – Uneven conditions.
Retardation dusting	Matrix lacking in durability. Dusty surface which may weather to expose aggregate and which will erode freely under light abrasion at early ages – particularly in the period immediately following stripping of formwork.	• Formwork: – Retarder in or on form faces; – Loss of contact between form face and hardening concrete (rapid drying). • Release agent: – Unsuitable; – Excessive use of chemical release agent; – Water soluble emulsion cream*; – Unstable cream; – Oil with excessive surfactant. • Curing: – Inadequate (very rapid drying).
Banding	Coarse texture corresponding to the width of the slipform, the bands often being of different colour.	• Slipforming: – Stop-start method of slipforming; – Hardened concrete behind slipform cannot be finished off at the same age as the rest and has different hydration conditions; – A more nearly continuous slipform motion causes less prominent banding.

***NOTE**: * 'Cream' refers to an emulsion of an oily material in water.*

6 REFERENCES

1) CCAA, '*Guide to Off-Form Concrete Finishes'*, CCAA T57 (2006)

7 RELEVANT AUSTRALIAN STANDARDS

1) AS 1012 – *Methods of testing concrete*
2) AS 1379 – *The specification and supply of concrete*
3) AS 3600 – *Concrete structures*
4) AS 3610.1 – *Formwork for concrete, Part 1: Specifications*

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