DATAsheet

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AVOIDING Surface Imperfections in Concrete: blowholes, crazing, dusting, flaking, honeycombing and popouts

Blowholes

WHAT ARE BLOWHOLES?

Blowholes (sometimes called bug holes) are individual rounded or irregular cavities that are formed against the formwork and become visible when it is stripped. Small blowholes (less than, say, 10 mm) tend to be approximately hemispherical while larger ones are irregular and often expose coarse aggregate particles.

They tend to be more prevalent towards the top of a concrete placement than at the bottom, due to the increased compaction and static head at the bottom layer of the pour.

Generally, they are regarded as an appearance problem though a concentration of large blowholes may lead to loss of durability. Under AS 3610 *Formwork for Concrete*, the size/extent of blowholes is therefore one of the criteria by which an off-form surface finish can be evaluated. This Standard incorporates full-size photographs, which enable a particular surface to be assessed for compliance with the specified class of finish.

When using normal, ie impermeable, forms it is impossible to achieve a blowhole-free surface. However, the use of permeable forms may significantly reduce, if not eliminate, the incidence of blowholes.

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WHAT CAUSES BLOWHOLES?

Blowholes are caused by the entrapment of air against the inside face of the formwork. The extent to which they occur is dependent on:

- the texture and stickiness of the formwork surface,
- the inclination of the surface (the incidence of blowholes is increased where the formwork surface slopes inwards),
- the use of a poorly proportioned or sticky concrete mix, and
- the amount of vibration.

PRACTICES TO MINIMISE THE OCCURRENCE OF BLOWHOLES

To minimise the incidence of blowholes:

- Use rigid well-braced formwork.
- Avoid the use of inwardly-sloping forms where possible.
- Apply a thin coat of a form-release agent that spreads evenly and is not sticky.
- Where appropriate use permeable formwork.
- Avoid 'sticky' concrete mixes, eg ones that may be over-sanded or have a high percentage of air-entrainment, and mixes that are too lean.
- Place concrete at a rate such that its rise up the form is not less than 2 m/h vertically.
- Ensure that the member is adequately compacted (see ***Compaction of Concrete*** data sheet for guidance on size of vibrator, spacing of insertion points and technique).
- Pull vibrator up slowly through the concrete layer allowing time for the entrapped air to rise to the surface.
- Ensure the concrete against the surface is properly compacted.
- Revibrate the top placement layer at about the same time as if a further layer was being placed on top.

REPAIR OF BLOWHOLES

It is better to minimise the occurrence of blowholes than to try and repair the surface. Generally, unless the surface is going to be viewed from close range, the frequency and distribution of blowholes for a Class 3 surface finish as specified in AS 3610 will be acceptable from an appearance point of view.

If repairs are contemplated, consideration should be given to the appearance of the repaired surface relative to adjacent untreated surfaces. Filling the holes with a slightly different coloured concrete may make the blowholes more obvious. Also, repairs should be carried out at a stage that will allow the final architectural treatment to be completed.

As a general rule, mortar used for patching should be made from the same materials as the original concrete except that a proportion of off-white cement should be mixed with the original cement to lighten the colour and thus better match the existing surface. Alternatively, thick applied coatings such as high-build or thick epoxy coatings may be used to fill and/or mask blowholes. ■

Crazing

WHAT IS CRAZING?

Crazing or craze cracking (sometimes referred to as map cracking) is a network of fine random surface cracks spaced from 10 to 70 mm apart, dividing the surface up into irregular hexagonal areas. They are always most prominent when the surface has been wet and then dries off, leaving the damp cracks outlined against the dry surface.

They are a surface feature and though unsightly are unlikely to lead to structural or serviceability problems. There is no repair method, thus it is best to take precautions, as outlined below, to avoid them.

WHAT CAUSES CRAZING?

Crazing is caused by the shrinkage of the surface layer relative to the base concrete. Usually it occurs because one or more poor concrete practices are adopted, eg:

- Using too wet a mix
- Finishing of the surface too early, ie while bleed water is present
- Overworking the surface, thus bringing too many fines to the surface
- Adding driers to the surface to try and remove bleed water
- Not commencing curing early enough (three hours after completion of finishing is too late) or using inadequate curing procedures (such as intermittent wetting and drying).

On formed surfaces, it usually occurs where shiny, impermeable formwork is used and this is coupled with inadequate curing.

PRACTICES TO MINIMISE THE OCCURRENCE OF CRAZING

To minimise the risk of crazing:

- Use lower slump concretes and do not add water to the mix.
- Use concrete mixes with low bleed characteristics.
- Do not commence finishing until bleed water has disappeared from the surface. (Bleed water can be removed from the surface by drawing/rolling a loosely-held hose across the surface.)
- Do not use driers such as neat cement to soak up the bleed water.
- Do not overwork the concrete as this brings an excess of fines to the surface.
- Commence curing promptly after finishing is complete and ensure the surface is subject to continuous curing for, say, three to seven days. (Intermittent wetting and drying increases the risk of crazing.)
- On flat surfaces, use a broom finish where appropriate. (This ensures the surface is not overworked and masks any crazing.)

Particular care is necessary where dry-shake colour finishes are being used. The overworking of the dry-shake material by steel trowel will often result in crazing. The dry-shake material should be worked into the surface with a composite or magnesium float and this should be followed by a maximum of two steel trowel passes. ■

Dusting

WHAT ARE DUSTING FLOORS?

A dusting floor surface is marked by an accumulation of fine material requiring to be swept up after the floor has been used. Also, a hand rubbed over the surface of a dusting floor will be coated with a fine powder.

WHAT CAUSES DUSTING FLOORS?

Dusting of the surface is caused by the surface layer being weak and the matrix not properly bonding the fine aggregate particles. This can be caused by:

- Inappropriate concrete specification for the required abrasion resistance.
- The concrete having been finished too early (while bleed water is still rising to the surface) thus leading to the surface having a high water-cement ratio and hence lower strength.
- The surface having been inadequately compacted or not properly finished resulting in inadequate abrasion resistance.
- The surface having been improperly or inadequately cured.

PRACTICES TO MINIMISE THE OCCURRENCE OF DUSTING FLOORS

To minimise the incidence of dusting:

- Specify an appropriate concrete strength for abrasion resistance, ie not less than that given in Clause 4.7 AS 3600[1].
- Don't commence finishing the surface too early. Wait until bleed water has stopped rising to the surface, ie when the sheen disappears. (For a discussion on site factors that influence bleeding see Suprenant and Malisch[2].)
- Compact the surface of the floor with a surface vibrator and/or use one of the finishing techniques giving improved abrasion resistance, eg several passes with a helicopter float[3].
- Ensure the surface is properly cured either by keeping it continuously damp for three to seven days, coating it with an appropriate membrane curing compound, or covering it with a polythene sheet[4].

REPAIR OF DUSTING FLOORS

Repair of dusting floors is difficult and it is best to avoid or minimise the incidence of the problem by using the techniques outlined above. Recommended repair methods are:

- Apply a chemical surface hardener or dust inhibitor.
- Grind the floor and apply a proprietary sealing compound.
- Grind the floor to remove the weak surface layer and apply a bonded topping.
- Apply an unbonded topping (overlay) on the existing floor. ■

Flaking

WHAT IS FLAKING?

Flaking is where discrete pieces of the surface become detached leaving a rough indentation behind. The pieces are usually flat, hence the name 'flakes'. Scaling should not be confused with flaking. Scaling is delamination of the concrete surface when exposed to freeze-thaw cycles and although the appearance is similar the mechanism is different.

WHAT CAUSES FLAKING FLOORS?

Flaking is caused by inappropriate finishing techniques that seal the surface and trap the water which would otherwise have risen to the surface as bleed water. This water accumulates below the surface forming a plane of weakness and resulting in delamination of the surface layer.

Premature sealing of the surface can be caused by:

- Commencing finishing too early because the ambient conditions dry the bleed water from the surface and the lack of sheen suggests that bleeding has finished. Note that some finishing tools more than others tend to seal the surface, eg a hand strike-off with a magnesium straightedge tends to seal the surface while a strike-off with a wood or magnesium bull-float pass leaves the surface open[5].
- The use of driers on the surface to absorb bleed water.

PRACTICES TO MINIMISE THE OCCURRENCE OF FLAKING FLOORS

To minimise the incidence of flaking:

- Specify air-entrained concrete as these concrete have slower bleed rates and have been shown to be less sensitive to the use of particular finishing techniques than non-air-entrained concretes[5].
- Avoid the use of finishing techniques that tend to seal the surface, eg a hand strike-off with a magnesium straightedge[5].
- In summer, use an evaporative retarder to prevent rapid surface drying and give time for the bleed water to rise to the surface.
- Use wind breaks and, where practical, shade the surface to minimise the incidence of rapid drying of the surface.
- Don't commence finishing the surface too early. Wait until bleed water has stopped rising to the surface, ie when the sheen disappears.
- Avoid the use of driers, especially neat cement, to mop up the bleed water.
- When using dry shakes to provide a coloured surface, exercise caution in their application to avoid them behaving as driers.

REPAIR OF FLAKING FLOORS

Repair of flaking floors is difficult and it is best to avoid or minimise the incidence of the problem by using the techniques outlined above.

Recommended repair techniques are:

- Grind the delaminated areas back to sound concrete and apply a proprietary sealing compound.
- Remove the delaminated concrete and apply a bonded topping or epoxy coating to the floor. ■

Honeycombing

WHAT IS HONEYCOMBING?

Honeycombing refers to voids in concrete caused by the mortar not filling the spaces between the coarse aggregate particles. It usually becomes apparent when the formwork is stripped, revealing a rough and 'stony' concrete surface with air voids between the coarse aggregate. Sometimes,

however, a surface skin of mortar masks the extent of the defect. Honeycombing may extend some depth into the member.

Honeycombing is always an aesthetic problem, and depending on the depth and extent may reduce both the durability performance and the structural strength of the member.

WHAT CAUSES HONEYCOMBING?

Honeycombing is caused either by the compaction not having been adequate to cause the mortar to fill the voids between the coarse aggregate, or by holes and gaps in the formwork allowing some of the mortar to drain out of the concrete. In some cases, the member shape and detailing/placement of the reinforcement compounds the effect of inadequate compaction.

PRACTICES TO MINIMISE THE OCCURRENCE OF HONEYCOMBED CONCRETE

To minimise the incidence of honeycombed concrete:

- Ensure the mix has sufficient fines to fill the voids between the coarse aggregate.
- Use a mix with appropriate workability for the situation in which it is to be placed.
- Ensure the concrete is fully compacted and the placing methods minimise the risk of segregation.
- Ensure the reinforcement layout and the section shape will permit the concrete to flow around the reinforcement and completely fill the forms.
- Check that the formwork is rigid and well braced, the joints are watertight and any penetrations through the formwork, eg form ties, are properly sealed.

REPAIR OF HONEYCOMBING

It is always better to avoid imperfections such as honeycombing in concrete rather than have to repair them. However, if honeycombing does occur then it can be repaired using the following techniques.

The extent and depth of the honeycombed area first needs to be defined. This can be done by chiselling out the affected area to expose sound concrete or by using non-destructive testing techniques such as impact-echo.

If the honeycombed area is small in extent and depth does not significantly jeopardise the quality of the cover concrete protecting the reinforcement then, it can be repaired by patching with mortar of a similar colour to the base concrete.

Any lightly attached stones should be removed before the mortar is worked into the spaces between the aggregate ensuring that it completely fills the honeycombed area. The area should be slightly over filled and screeded off to give a similar texture to the surrounding surface. The patch should then be cured.

Consideration needs to be given to the appearance of the repaired surface relative to adjacent untreated surfaces. As a general rule, mortar used for patching should be made from the same materials as the original concrete except that a proportion of off-white cement should be mixed with the original cement to lighten the colour and thus better match the existing surface.

If the honeycombing is extensive and penetrates down to the reinforcement or even deeper then it is necessary to cut out the defective concrete and replace it with sound concrete. It is essential that the reinforcement be surrounded by sound concrete. The advice of a suitably qualified engineer should be obtained to check that the load-carrying capacity of the member, as repaired, will be satisfactory. ■

Popouts

WHAT ARE POPOUTS?

Popouts are roughly conical depressions in the concrete surface created by localised pressure within the concrete, usually occurring after the concrete has been in place for some time. They can be categorised as small, medium or large depending on whether the diameter of the cavity is 10 mm or less, 10 to 50 mm, or greater than 50 mm respectively.

WHAT CAUSES POPOUTS?

They are usually caused by the expansion of a deleterious aggregate particle located near the surface or the expansion (due to freezing) of water absorbed by an aggregate particle. In either case, the particle breaks away from the mass of the concrete carrying with it the surface layer of mortar.

Experience has shown that generally it is coarser sizes of deleterious aggregate, eg 9.5 to 19 mm, that give rise to the problem. Deleterious aggregates include chert, weathered dolomite, and shale but contaminants such as pieces of wood, clay and coal can also cause popouts.

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PRACTICES TO MINIMISE THE OCCURRENCE OF POPOUTS

To minimise the incidence of popouts:

- Use aggregates free from deleterious particles that are known to cause popouts.
- Use higher strength concrete that will better resist the tensile stresses leading to popouts.
- Ensure that good concrete practices are employed on the project as poor compaction and inadequate curing will increase the likelihood of popouts.
- If alkali reactive aggregates are identified then the use of measures as outlined in *Alkali Aggregate Reaction – Guidelines on Minimising the Risk of Damage to Concrete Structures in Australia*[6] should be followed.

REPAIR OF POPOUTS

In general, repair is very labour-intensive and thus the damage is frequently tolerated. In Canada, where the problem is frequently encountered (due to the higher exposure to freeze-thaw conditions), it has been suggested that an incidence of up to 10 pockmarks per square metre is acceptable.

Repairs can be made by filling the popout crater with a mortar of similar colour to the base concrete. As a general rule, mortar used for patching should be made from the same materials as the original concrete except that a proportion of off-white cement should be mixed with the original cement to lighten the colour and thus better match the existing surface. ■

REFERENCES

1 *AS 3600 Concrete structures* Standards Australia, 2001.

2 Suprenant, B A and Malisch, W R 'Diagnosing slab delamination' Concrete Construction January, February and March 1998.

3 *Industrial floors and pavements: Guidelines for design construction and specification* Cement and Concrete Association of Australia, 1999.

4 *Guide to concrete construction* Cement and Concrete Association of Australia and Standards Australia, 1994.

5 Suprenant, B A and Malisch, W R 'Sealing effects of finishing tools' *Concrete Construction* September 1999, pp 39–43.

6 *Alkali Aggregate Reaction – Guidelines on Minimising the Risk of Damage to Concrete Structures in Australia.* T47 Cement and Concrete Association of Australia and Standards Australia 1996.

FURTHER INFORMATION

Further information on good concreting practices can be downloaded from the Cement Concrete and Aggregates Australia website at **www.concrete.net.au**.

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