

Concrete in Practice

What, why & how?



CIP 40 - Aggregate Popouts

WHAT is a Popout

A *popout* is a small, generally cone-shaped, cavity in a horizontal concrete surface left after a near-surface aggregate particle has fractured due to localized internal pressure. Frequently, part of the fractured aggregate particle will be found at the bottom of the cavity adhered to the paste below the popout cone. The popout cavity can range from ¼ in. (6 mm) to few inches in diameter.

Another type of surface distress observed is mortar flaking to expose coarse aggregate particles without fracturing the aggregate. This distress is sometimes referred to as a *popoff*.

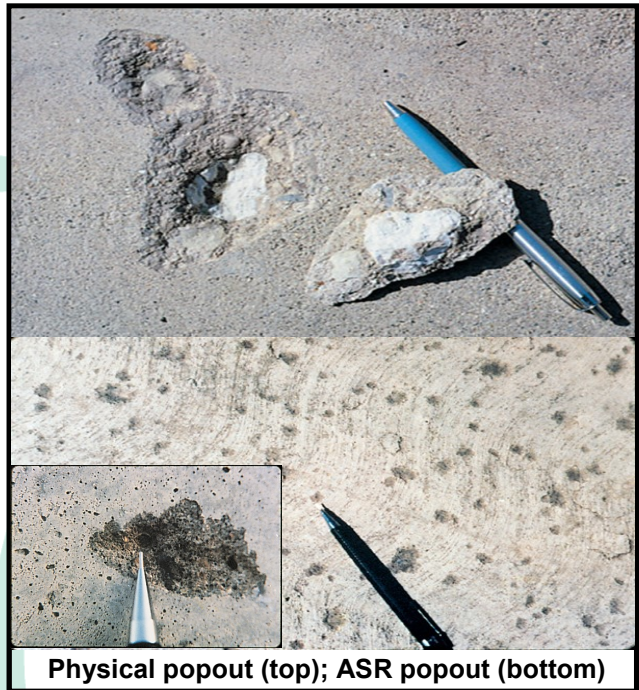
WHY do Popouts Occur

The aggregate particle expands and fractures as a result of a physical action or a chemical reaction:

Physical

The origin of a physical popout usually is a near-surface aggregate particle having a high absorption (porosity) and lower relative density (specific gravity). In moist conditions, the aggregate particle absorbs moisture. In winter, as this absorbed moisture freezes, it expands within the aggregate pores to create internal pressure that fractures the particle and the overlying concrete surface. The top portion of the fractured aggregate particle separates from the concrete surface taking a portion of the surface mortar with it. In some cases, the aggregate forces water into the surrounding mortar as it freezes and may cause the surface mortar to pop off, exposing an intact aggregate particle. Clay balls, coal, wood or other contaminants can absorb water and swell even without freezing, but the resulting pressure rarely is great enough to cause popouts. There are reported cases of grain (soybeans, corn) contamination of aggregate shipments that have resulted in surface popouts. Such occurrences are not within the scope of this document.

Popouts as a result of physical action are typically observed on exterior flatwork in climates subject to freezing and thawing under moist conditions. These typically occur during the first year after placement. The most common type of particles resulting in popouts are low density chert in some natural aggregate deposits. It is generally not easy or cost effective to remove these particles from aggregate



Physical popout (top); ASR popout (bottom)

sources. Crushed aggregates are less likely to contain lightweight, absorptive particles that are susceptible to popouts. Specifications for concrete aggregates, such as ASTM C33, have maximum limits, but permit some quantity of types of particles that may cause popouts when exposed to freezing and thawing in the saturated condition.

Popoffs are often the result of poorly installed concrete due to improper finishing, or lack of curing. Moisture trapped above aggregate particles or poor bond between the mortar and aggregate particles will result in mortar flaking, generally associated with freezing of moisture. Use of deicing salts can exacerbate mortar flaking or popoffs.

Chemical

The cause of a popout due to a chemical reaction is often related to alkali-silica reaction (ASR). Alkalis from cement or other source cause an environment of high pH (high concentrations of hydroxyl ions) causing the breakdown of silica and formation of an ASR gel. The gel absorbs water and expands, removing a small portion of the surface mortar with it. These are referred to as ASR popouts. They are typically small and are often accompanied by a small spot that is discolored and/or appears to be damp. The aggregate particle does not often

fracture and split as is the case of popouts from physical action. However, ASR can result in micro-fractures within the aggregate particles. Some alkali-silica reaction popouts can occur within a few days after the concrete is placed.

HOW to Avoid Popouts

Most popouts are aesthetic defects that do not impact the structural performance or long-term service life of the concrete slabs. A large number of popouts however make it easier for water and other harmful chemicals to enter the concrete, which can ultimately lead to other forms of deterioration. ASR popouts may indicate a potential later age durability problem.

The following steps can be taken to avoid concrete popouts.

Physical Popouts

1. Avoid using aggregates that contain particles which have a history of causing popouts. In some parts of the United States, the available natural aggregates contain particles that are likely to result in surface popouts. If alternate aggregates are not economically available, some level of popouts on sidewalks and pavements is generally accepted in these locations.
2. If popouts are unacceptable, an alternate source of aggregates must be used. If appropriate, two-course construction can be used, whereby the popout susceptible aggregate is used for the lower course and the pop-out free aggregate that is used for the surface course. This is typically an expensive option for most applications.
3. Aggregates can be beneficiated to remove lightweight materials, but the added cost of beneficiation can be prohibitive for most uses.
4. Use a concrete mixture with a lower water to cementitious materials ratio, as this will reduce the likelihood of saturation and will have a higher strength and durability. Do not add water to the surface during finishing or conduct final finishing while the concrete is still bleeding. Do not use hard steel-troweled surfaces for exterior slabs. Provide proper curing, as this results in improved strength of the concrete, especially on the surface. This will also reduce permeability thereby lowering the amount of water migrating to coarse aggregate particles. Consider sealing the concrete surface. All of these steps can reduce the frequency, but will not necessarily, eliminate popouts.
5. Reduce the maximum aggregate size, as smaller aggregates will develop lower stresses due to freezing, and fewer popouts will occur. Those

that do will be smaller and less objectionable.

Chemical Popouts

1. Use a non-reactive aggregate. This is often not a practical option in many regions
2. Flush the surfaces with water after the concrete has hardened and before applying the final curing. This will remove the alkalis that may have accumulated at the surface as bleed water evaporates.
3. Use concrete mixtures with supplementary cementitious materials that will mitigate the potential for ASR, such as Class F fly ash or slag cement.

HOW to Repair Popouts

Before planning repair program, it is advisable to assess the cause of the popouts and the potential for future deterioration. This can be done by obtaining core samples and having them evaluated by a qualified petrographer.

Popouts can be repaired by chipping out the remaining portion of the aggregate particle in the surface cavity, cleaning the resulting void, and by filling the void with a proprietary repair material such as a dry pack mortar, epoxy mortar, or other appropriate material following procedures recommended by the manufacturer. It will be difficult to match the color of the existing concrete. If the popouts in a surface are too numerous to patch individually, a thin bonded concrete overlay may be used to restore a uniform surface appearance. Recommendations for installing such overlays is beyond the scope of this publication.

References

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