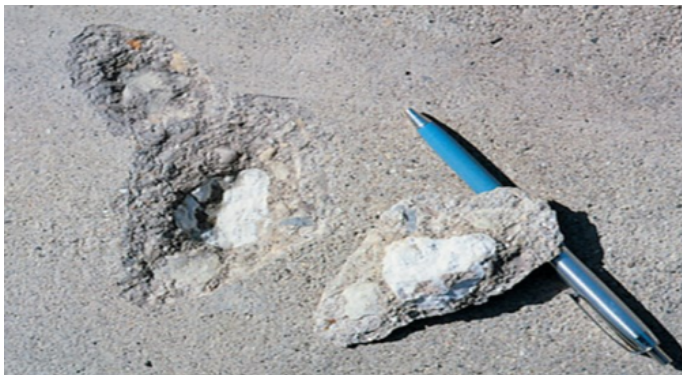


What is a Pop-out?

A pop-out is a small, typically cone shaped cavity that forms on a horizontal concrete surface when a near surface aggregate particle fractures due to localized internal pressure. In many cases, a portion of the fractured aggregate remains bonded to the paste at the base of the cavity. Pop-outs commonly range in size from about 6 mm to 50 mm in diameter or larger.

A related form of surface distress involves the flaking or loss of surface mortar that exposes coarse aggregate without fracturing the aggregate itself. This condition is sometimes referred to as a popoff.



Example of pop-out

Why Do Pop-outs Occur?

Pop-outs occur when a near surface aggregate particle expands and creates enough internal pressure to fracture the particle and the surrounding concrete. This expansion can be caused by either physical or chemical mechanisms.

Physical causes

Physical pop-outs are most commonly associated with aggregate particles near the surface that have high absorption and relatively low density. Under moist conditions, these particles absorb water. When temperatures drop below freezing, the absorbed water expands within the aggregate pores, generating internal pressure that fractures the aggregate and the overlying

concrete surface. The upper portion of the fractured particle is often ejected, along with a small cone of surface mortar.

In some cases, freezing within the aggregate forces moisture into the surrounding mortar rather than fracturing the aggregate itself. This can cause the surface mortar to flake off and expose an intact aggregate particle, a condition often referred to as a popoff.

Physical pop-outs are most commonly observed in exterior flatwork exposed to repeated freezing and thawing in wet conditions and typically appear within the first year after placement. Aggregate types most often associated with pop-outs include low density or highly absorptive materials such as chert, shale, quartzite, and sandstone found in some natural aggregate deposits. These particles are difficult and often impractical to completely remove from aggregate sources. While aggregate standards such as CSA A23.1 place limits on deleterious materials, they do allow small amounts of particles that may be susceptible to pop-outs when exposed to saturated freezing and thawing conditions. Crushed aggregates are generally less prone to this issue because they contain fewer lightweight, porous particles.

Popoffs are also frequently linked to construction practices. Improper finishing, inadequate curing, or poor bond between the mortar and aggregate can trap moisture near the surface. When this moisture freezes, surface mortar may flake off, particularly when de icing salts are present, which can worsen the distress.

Chemical causes

Chemical pop-outs are most often associated with alkali silica reaction. Alkalis from cement or other sources create a highly alkaline environment that reacts with reactive silica in certain aggregates. This reaction produces an ASR gel that absorbs water and expands, dislodging a small portion of surface mortar. These ASR related pop-outs are typically small and are often accompanied by localized discoloration or damp spots on the surface.

Unlike physical pop-outs, the aggregate particle in ASR pop-outs does not usually fracture and split, although microcracking within the aggregate may occur. In some cases, ASR related pop-outs can develop within days of concrete placement.

How to Avoid Pop-outs?

Most pop-outs are primarily aesthetic and do not compromise the structural integrity or long-term durability of concrete slabs. However, a high number of pop-outs can make it easier for water and harmful chemicals to penetrate the concrete, potentially leading to further deterioration. ASR related pop-outs may also signal a potential durability concern at later ages.

Preventing Physical Pop-outs

- Avoid aggregates known to produce pop-outs. In regions like Saskatchewan, many natural aggregates contain particles prone to this issue. If alternative sources are not feasible, some pop-outs in sidewalks or pavements are generally tolerated.
- Where pop-outs are unacceptable, consider using alternate aggregate sources. In some cases, a two-course construction can be used: pop-out-prone aggregate in the lower layer and pop-out-resistant aggregate at the surface. This approach is typically expensive.
- Aggregates can be beneficiated to remove lightweight, porous particles, though this may not be cost-effective for most projects.
- Use concrete with a lower water-to-cementitious materials ratio to reduce saturation and improve surface strength and durability. Avoid adding water during finishing, do not finish while the concrete is still bleeding, and avoid hard steel-troweled surfaces on exterior slabs. Proper curing improves surface strength, reduces permeability, and limits water migration to aggregate. Surface sealing can further reduce pop-out occurrence. These measures reduce the frequency of pop-outs but may not eliminate them entirely.

- Limit maximum aggregate size. Smaller aggregates generate lower internal stresses during freezing, producing fewer and less noticeable pop-outs.

Preventing Chemical Pop-outs (ASR)

- Use non-reactive aggregates when feasible. In many regions, this is not practical.
- Flush concrete surfaces with water after hardening but before final curing to remove alkalis concentrated by evaporating bleed water.
- Incorporate supplementary cementitious materials such as Class F fly ash or slag cement to mitigate potential alkali-silica reaction and reduce ASR related pop-outs.

Three Rules to Consider:

1. Use durable, low absorption aggregates near the surface, and limit maximum aggregate size where appearance matters.
2. Control finishing and curing. Do not finish during bleeding, avoid adding water, and use proper curing, especially for exterior slabs.
3. Reduce chemical reactivity risks by using appropriate mix designs and supplementary cementitious materials, when ASR is a concern.

References

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