

Limits of Deleterious Substances of Aggregate for Concrete

COARSE AGGREGATE			
COARSE PARTICLES	ASTM* C33-03 CLASS 4S	MNDOT #3137 GENERAL USE	MNDOT #3137 BRIDGE SUPER-STRUCTURE
1. Clay lumps & friable particles	Max. 3.0%	Max. 3.5%	Max. 3.0%
2. Chert (less than 2.4 SpGr SSD) Total Spall (MnDOT)	Max. 5.0%	Max. 1%	Max. 0.5%
3. Combined 1 and 2	Max. 5.0%	Max. 3.5%	Max. 3.0%
4. Coal and lignite	Max. 0.5%		
5. Shale •On 1/2" sieve – •Total sample–		Max. 0.4% Max. 0.7%	Max. 0.2% Max. 0.5%
6. Soft iron oxide–		Max. 0.3%	Max. 0.2%
Potential density of popouts per sq. yd. with maximum deleterious limits**	20-30	15-20	5-10

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FINE AGGREGATE		
FINE PARTICLES	ASTM* C33-03 CLASS 4S	MNDOT #3126 GENERAL USE
1. Clay lumps & friable particles	3.0%	
2. Coal and lignite	0.5%	0.3%
3. Other deleterious substances (shale, mica, soft & flaky particles)	–	2.5%

NOTE: The most troublesome deleterious particle in the Midwest, shale, is not identified in the national ASTM specification.

*S Category, severe weathering region: Areas with greater than 500 day-inches weathering index (product of the average annual number of freezing cycle days and the average annual winter rainfall in inches) meets uniform building codes for commercial and residential construction.

**Due to unusual circumstances or weather conditions during placing, finishing, or curing, the number of popouts may vary from those predicted at left.

ARM of Minnesota

Understanding Concrete Popouts

an Explanation of the Concrete Popout Phenomenon

What is a popout?

A **popout** is a hole in a concrete surface left after an aggregate particle has expanded and worked itself loose. This particle, commonly described as “deleterious” by the Minnesota Department of Transportation (MnDOT) and the American Society for Testing and Materials (ASTM), most likely separates from the concrete as a result of (a) a physical reaction, or (b) a chemical reaction.

For more detailed information, call your local concrete contractor, ready-mixed concrete producer or:



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A. The Physical Expansion Popout occurs when a lightweight, porous rock freezes, expands, and consequently fractures. This fractured piece of rock completely separates from the concrete, taking a portion of the surface mortar with it.

B. The Alkali-Aggregate Popout (Chemical Popout) occurs when the alkalies in the portland cement react chemically with the silica in some fine sands, causing an expansion of the silica particle and a resulting small surface popout.

Why do popouts sometimes occur?

When the glaciers of the last Ice Age receded northward through Minnesota 10,000 years ago, they deposited all types of soils, sand and rock. Many of these deposits contain small percentages of deleterious materials, including certain shales, iron oxide particles, unsound cherts, and other soft particles.

A ready-mixed concrete producer utilizes local sand and rock deposits to make concrete as economical as possible for the end user. Often these are the same deposits mentioned in the previous paragraph—deposits which may contain materials that cause popouts.

To help minimize popouts, this sand and rock is typically selected/processed to meet the specifications shown in the enclosed chart.

Local building codes, the American Concrete Institute (ACI), the American Society for Testing and Materials (ASTM), and the Minnesota Department of Transportation (Mn/DOT) highway construction specifications recognize it is impractical to completely eliminate all deleterious material from concrete aggregate. By allowing these small deleterious material percentages, these agencies are accepting the fact that some popouts may occur.

Are popouts in any way harmful to the integrity of a concrete slab?

No. Popouts do not in any way decrease the life of a concrete slab. Popouts will not affect the structural serviceability of the slab now, or in the future. However, some people may find these popouts aesthetically unpleasant.

Can steps other than aggregate substitution be taken to minimize popouts?

Absolutely. The following quality construction procedures will minimize popouts in concrete slabs:

- Use only aggregates that meet standard specifications. Special aggregates containing minimal popout-causing material are available in certain areas upon request
- Use only cements meeting ASTM specifications.
- Use air-entrained concrete.
- Use concrete with the lowest water content and slump possible for the application.
- Do not finish concrete with bleed water on the surface.
- Avoid hard-steel troweling where not needed, such as most exterior slabs.
- Use proper curing methods.
- Use proper sealing methods.

If a popout does occur, can it be patched?

Yes, surfaces with popouts can be repaired. A small patch can be made by cleaning out the spalled particle and filling the void with dry-pack mortar, epoxy mortar, or other appropriate patch material. If the popouts are too impractical to patch individually, a thin-bonded overlay may be used.

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