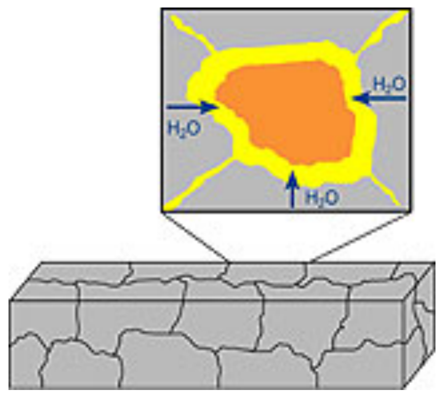
# ASR in Concrete Slabs

## What the Experts Say;

**I.** **PCA;** (the Portland Cement Association): *Alkali-silica reaction (ASR)* "…In ASR, aggregates containing certain forms of silica will react with alkali hydroxide in concrete to form a gel that swells as it adsorbs water from the surrounding cement paste or the environment. These gels can swell and induce enough expansive pressure to damage concrete."

Typical indicators of ASR are random map cracking and, in advanced cases, closed joints and attendant spalled concrete. Cracking due to ASR usually appears in areas with a frequent supply of moisture, such as close to the waterline in piers, near the ground behind retaining walls, near joints and free edges in pavements, or in piers or columns subject to wicking action. Petrographic examination can conclusively identify ASR.




**II.** **ASTM; ASTM C1293 - 08b Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction:**

Alkali-silica reaction (ASR) is a chemical interaction between some siliceous constituents of concrete aggregates and hydroxyl ions. The concentration of hydroxyl ion within the concrete is predominantly controlled by the concentration of sodium and potassium.
This test method is intended to evaluate the potential of an aggregate or combination of an aggregate with pozzolan or slag to expand deleteriously due to any form of alkali-silica reactivity.
When testing an aggregate with pozzolan or slag, the results are used to establish minimum amounts of the specific pozzolan or slag needed to prevent deleterious expansion. Pozzolan or slag from a specific source can be tested individually or in combination with pozzolan or slag from other sources.

**ASTM C33:** This specification defines the requirements for grading and quality of fine and coarse aggregate for use in concrete. Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof. Fine aggregate shall be free of injurious amounts of organic impurities (ASR[1]). Fine aggregate for use in concrete that will be subject to wetting, extended exposure to humid atmosphere, or contact with moist ground shall not contain any materials *that are deleteriously reactive with the alkalis in the cement in amount sufficient to cause excessive expansion of mortar or concrete*[2]. Fine aggregate subjected to five cycles of the soundness test shall have a required weighted average loss. Coarse aggregate shall consist of gravel, crushed gravel and crushed stone, air-cooled blast furnace slag, or crushed hydraulic-cement concrete, or a combination thereof. The sampling and test methods shall be done with grading and fineness modulus test, organic impurities test, effect of organic impurities on strength test, soundness test, clay lumps and friable particles test, coal and lignite test, bulk density of slag test, abrasion of coarse aggregate test, reactive aggregate test, freezing and thawing test, and chert test method.

III. **American Concrete of Iowa**: Alkali-Silica reaction is the reaction between the alkalis (sodium and potassium) in Portland Cement and certain siliceous rocks or minerals, such as opaline chert, strained quartz, and acidic volcanic glass, present in some aggregates; the products of the reaction may cause abnormal expansion and cracking in concrete in service.

In Iowa (in our area), alkali aggregate reactions occur in two distinct forms;

1. Alkali silica reactivity, which occurs in concrete with reactive coarse aggregate
2. Popouts, which is a surface blemish, resulting from an expansive reaction in the fine aggregate near the concrete surface.

IV. **Peter Craig; Concrete Constructives**: There is growing evidence that suggests an alkali-related reaction called ASR can occur in the near-surface region of a concrete slab. When it occurs, the reaction can contribute to the blistering and disbondment of low-permeance coating systems. To differentiate this near-surface reaction from conventional ASR, we have named this condition near-surface alkali reaction (NSAR). Many consultants are currently studying this failure condition. It appears that the alkali-related reaction associated with coating failures is occurring with fine aggregate particles in the top 1/16 to 3/16 inches of the near-surface region of the concrete. In fact, near surface alkali reactions may be a greater problem than first supposed. Such reactions occur in the contact area of the cement paste to the aggregate's surface. Since there's a larger total surface area of fine aggregate particles in this near-surface region of a concrete slab, there's a greater potential of alkali-related chemical reactions[3].

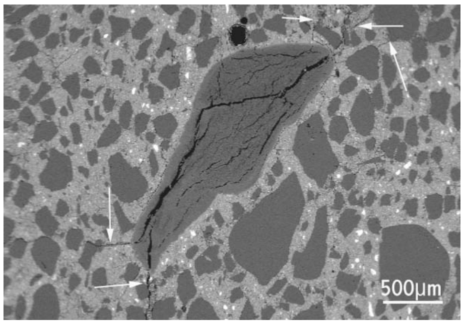
V. **Nicholas B. Winter**; WHD Microanalysis Consultants, 2009: "Understanding Cement": ASR is the most common form of alkali-aggregate reaction (AAR) in concrete; the other, much less common, form is alkali-carbonate reaction (ACR). ASR and ACR are therefore both subsets of AAR.

ASR is caused by a reaction between the hydroxyl ions in the alkaline cement pore solution in the concrete and reactive forms of silica in the aggregate (e.g. chert,

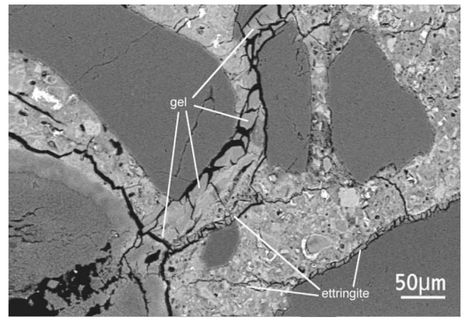
[1] ACT language addition
[2] Underlining and Italics; ACT
[3] NSAR in Concrete Slabs; Problem Clinic; Peter Craig; http://www.floorworks3.com/uploads/2/7/4/8/2748193/nsar-in-concrete-slabs.pdf

quartzite, opal, strained quartz crystals). A gel is produced, which increases in volume by taking up water and so exerts an expansive pressure, resulting in failure of the concrete. In unrestrained concrete (that is, without any reinforcement), ASR causes characteristic 'map cracking'.

Gel may be present in cracks and within aggregate particles. The best technique for the identification of ASR is the examination of concrete in thin section, using a petrographic microscope.




Viewed under a scanning electron microscope, this slide photo shows a chert aggregate particle with extensive internal cracking due to ASR.

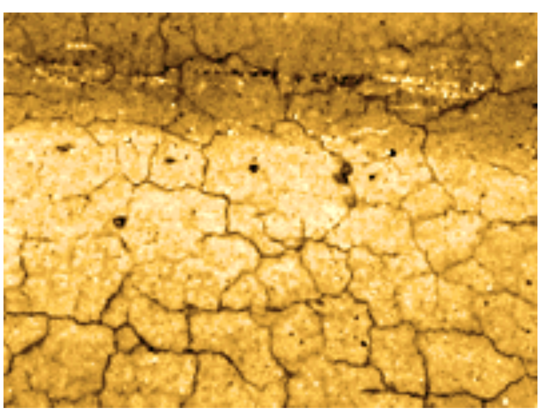



This photo shows a detail of the chert particle in the previous image (white arrows; top right) and the adjacent cement paste showing the ASR gel being pushed into the cracks made by the swelling of the paste around the aggregate.

## VI. What does ASR look like?

ASR itself is a reaction within the concrete matrix/paste and aggregate and cannot be "seen" by the naked eye. The only outward evidence of ASR in any given slab is the manifestation in flooring systems caused by the by-product of the reaction or the expansive gel (meta-silicate): blisters, failed adhesives, spalls or "popouts" and in un covered concrete; cracking in a "map pattern" or irregular semi-rectangular or polygon-like shapes such as in the photos below.

In many cases, in early ASR there is no evidence at all of any reaction going on, but when a non-permeable flooring system such as vinyl, rubber or epoxy or a water vapor reduction system such as the AC•Tech 2170™ System, is installed and "caps" the slab, then the process/reaction may speed up considerably. The older and longer this reaction takes place, the more obvious the manifestations become and whether the concrete is covered or not covered will not matter.



These two photos show classic cracking or "map-pattern" cracks manifested in ASR contaminated concrete. This pattern is usually associated with ASR, but only Petrographic Thin Slice core analysis can ascertain whether it is or isn't ASR activity.

## VII. What to do if ASR is suspected:

- Take Cores: Perform Thin Slice Petrography, (TSP) - but TSP may not reveal full blown ASR, it is not always readily apparent especially in newer concrete, but there may be other "telltales" that are indicators of the presence of ASR aggregate;
- ASR is not caused by or prevented by any flooring install or preparation process, you cannot "put ASR" in the hardened concrete, the concrete aggregate either has it or it doesn't
- ASR develops over time in uncovered and covered concrete slabs– impermeable systems applied to the concrete surface tend to speed the reaction up.
- There is no known "cure" for ASR- only the jackhammer and a remedial process/recommendation that we have found to buy more time for the slab.
- In many cases, a floor hardener may have been applied in large amounts to try to 'harden' up what was thought of as soft concrete, (in reality ASR). This may be a sodium or potassium silicate, which may tend to initially mask the ASR problem.

**A NOTE OF CAUTION:**

Any core sample taken prior to a coating system application on newer ASR infected concrete may not reveal active ASR; but when a non-permeable membrane or flooring system is applied, the reaction speeds up and may become very destructive very fast and then show up on Thin Section Petrography. The covering/coating system does not cause ASR, merely speeds it up.

## VIII. What is it?

- ASR= Alkali Silica Reaction; <u>expansive</u> reaction of aggregate to high alkaline and moist environment, both moisture & Alkalinity must be present
- The reaction with the moisture and alkalinity produces an expanding "gel".
- ASR is in the aggregate; ASTM C33 is the governing standard for aggregate in readymix concrete.
- ASR is recognized as a construction defect, it is not an installation error by the flooring installer.
- ASR is a permanent condition; it will not go away but continue to degrade the concrete matrix and destroy any surface applied flooring systems at an unpredictable rate. If the concrete has ASR aggregate, it has it, there is no such thing as a just a "little ASR".


ASR "Triangle"
Must have all three "ingredients"
for ASR to occur

**IX. What is the solution then?** There is nothing specifically written as to how to handle ASR 100% other than complete removal and replacement of the concrete with no ASR causing components. AC•Tech does, however, have a basic procedure, which we have used for a number of years with some success. This is not a cure, as there is no "cure" for ASR, but rather a method of restoring a bad floor and utilizing 4 – 5 or more years of usage before a more comprehensive solution can be made; a new floor.

When dealing with coatings and/or flooring systems, topical or near surface ASR is very problematical in the presence of moisture. As this type of ASR is found in rock fragments, meaning sand size, these small rock grains react very readily to elevated levels of moisture and alkalinity in the concrete matrix. Keep in mind that if the concrete contains little moisture and/or were allowed to breath (no coating system or flooring system), ASR may not be activated as the moisture is one of the necessary ingredients of ASR and the vapor will escape through the open cap of the concrete.

The procedure which we use when aggregate or surface fragments prone to ASR are identified is to shot blast the concrete to a CSP-5[4] profile to destroy as much as the ASR prone aggregate as possible. Next to treat the deck with lithium nitrate to inhibit future ASR if possible. Then install a moisture insensitive screed cap with a highway grade polymer in the mixing water to inhibit salt migration to the top of the grout cap. Then shot blast the grout cap to a CSP-2 profile. Install the moisture mitigation coat, then the finish flooring system.

**The "ACT Solution" procedure is as follows**:

1. Remove existing floor coverings, mastics, underlayments and all coatings;
2. Shot blast the cap to an ICRI CSP-5 profile using #460/550 shot;
3. Clean/vacuum deck to a dust free condition, apply (Euclid/ FMC) lithium nitrate to concrete ~ 250-300 sf/gal. Allow to dry thoroughly;
4. Install an isolation screed of Combimix 760 ~ 3/8". Mixing water AC•Tech SB Bonding Agent to potable water in a 1:3 ratio;
5. Upon cure, brush/shot blast the isolation screed to a CSP-2 profile.
6. Install AC Tech 2170™ @ 100 sf/gal for moisture mitigation;
7. AC•Tech may provide a limited warranty on this procedure on a case-by-case basis, but due to the uncertainty and unpredictability of the concrete degradation no long-term warranty is available. Consult the AC•Tech Technical staff on this matter.

**ASR Checklist:**

A. Look for compromised flooring systems, blisters, etc., especially when a moisture reduction system has been installed;
B. On uncovered floors & after shotblasting, check for "map-crack" pattern;
C. Call for core testing to be performed; IR, IC, EDXA/XRD & Thin Slice
D. Identify ASR through the Petrographic Thin Slice core testing analysis;
E. When ASR findings are confirmed present the "ACT solution" to the owner;
F. If the owner selects to proceed, make sure they understand-NO WARRANTY;
G. Use the "ACT solution" procedure;
H. Monitor floor through the coming years for performance;
I. If owner does not want to use the "ACT solution", then please dismiss the project.

[4] Guideline No. 03732: Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays. www.icri.org