Materials Bulletin: Alkali-Silica Reaction (ASR) Brief

Why is ASR Bad?
ASR can cause serious expansion and cracking in concrete. This can result in major structural problems, which can lead to costly removal and replacement. The reaction can occur years after the concrete was placed. Structures most at risk are bridges, hydraulic structures, exposed frames, pavements, and foundations.

What is ASR?
ASR is a reaction between the alkali hydroxides in concrete and reactive forms of silica in the aggregate. The reaction forms a gel that swells when moisture is present. The two step process can be visualized as:

1. Alkali + Silica → Gel reaction Product
2. Gel reaction Product + Moisture → Expansion

Factors Affecting ASR
For the reaction to occur the following three conditions must be present:

1. Sufficiently high alkali content of the cement
2. Reactive forms of silica in aggregate
3. Sufficient Moisture

If one of these three conditions is missing the reaction cannot occur.

How does NC DOT Mitigate the Problem?
The best way to avoid ASR is to take appropriate precautions before the concrete is placed. Section 1024-1 of the NC DOT Standard Specifications for Roads and Structures addresses these precautions.

1. The alkalinity of any cement, expressed as sodium-oxide equivalent, shall not exceed 1.0%.

2. For mix designs that contain non-reactive aggregates and cement with an alkali content less than 0.6%, straight cement or a combination of cement and fly ash, cement and ground granulated blast furnace slag or cement and microsilica may be used. The pozzolan quantity shall not exceed the amount shown below.

3. For mixes that contain cement with an alkali content between 0.6% and 1.0%, use a pozzolan in the amount shown below.

4. For mixes that contain a reactive aggregate documented by the Department, use a pozzolan in the amount shown below.

Class F Fly Ash	20% by weight of required cement content, with 1.2 lbs. Class F fly ash per lb. of cement replaced.
GGBF Slag	35% - 50% by weight of required cement content, with 1 lb. slag per lb. of cement replaced.
Microsilica	4-8% by weight of required cement content, with 1 lb. microsilica per lb. of cement replaced.

Owner	Location	Quarry Number
Quarries that have shown ASR in the field and Laboratory		
Hanson	Princeton	CA 64
Martin Marietta	Pomona	CA 51
	Thomasville	CA 102
Vulcan	Gold Hill	CA 85
Quarries that have shown ASR in the Laboratory		
Martin Marietta	Asheboro	CA 30
	Bakers	CA 32
Vulcan	Havre de Grave (Maryland)	CA 345

Table 1: Aggregate Sources That Have Exhibited ASR as Documented by the Department

Producer	Facility	Sodium Oxide Equiv.
Cementos, Argos	Atlanta, GA	0.42
	Harleyville, SC	0.48
	Roberta Plant	0.40
	Knoxville, TN	0.49
Cemex	Knoxville, TN	0.49
Essroc	Speed, IN	0.60
	Martinsburg (LA)	0.57
	Martinsburg (HA)	0.67
Giant	Harleyville, SC	0.46
Holcim	Holly Hill, SC	0.49
	Holly Hill, SC (Slag Modified)	0.46
Lafarge	Ravena, NY	0.69
Lehigh	Union Bridge	0.52
	Leeds	0.49
Roanoke	Cloverdale, VA	0.63

Table 2: Average Sodium Oxide Equivalent values of common cement sources used in North Carolina

Note: **Red designates pozzolan required**
Yellow designates pozzolan required when used with potentially reactive aggregate (see Table 1)
Green designates no pozzolan required