Results of 1953 Questionnaire on Cement-Aggregate or Alkali-Aggregate Reaction in Concrete

● THE FOLLOWING questionnaire was circulated to all the state highway organizations, the various Corps of Engineers Divisions, and other interested organizations in 1953. The replies to this questionnaire are given in Table 1.

QUESTIONNAIRE

1. Have you observed any concrete in your State or Division that is developing:
   a. Alkali-aggregate reaction Yes ( ) No ( )
   b. Cement-aggregate reaction Yes ( ) No ( )
   (If the answer to question one part a. or part b. is yes, please answer as many of the following as you can; but if the answer is no, proceed to question 11.)

2. Which of the following characteristics develops in the concrete?

Loss of strength	( )	Scaling	( )
Expansion	( )	Blow-ups	( )
Contraction	( )	Exudations	( )
Cracking	( )	Other	( )

   Remarks:

3. What types of structures were affected?

Pavements	( )	Structures	( )
Bridges	( )	Dams	( )
Handrails	( )	Others	( )

   Remarks:

4. At what age is the reaction discernible? ( ) Years

5. At what ages does the reaction seem to stop? ( ) Years

6. What portions of the affected structures show the most reaction?
   a. Where the concrete is damp and in the shade.
   b. Where the concrete is dry and in the sun.
   c. Where the concrete is damp with one or more surfaces dry and exposed to the sun.

7. Has the reaction been correlated with any characteristic of cement composition, and if so, to what characteristic of the cement?

8. Has the reaction been correlated with any characteristic of the aggregate?
   Yes ( ) No ( )
   a. Name the rock types with which the reaction is associated.
   b. Name any minerals occurring in the rocks, or separately, that are suspected of contributing to the reaction.

9. What corrective measures have been tried to retard or prevent the reaction?

10. Have any of the corrective measures been successful?
    Yes ( ) No ( )
    a. If your answer to question 10 is yes, is your decision as to success based on laboratory or field experience? (_____)

b. If based on field experience, how many years experience? (_____)

11. What laboratory tests do you employ in aggregates or cements that are designed to avoid reaction?
    a.
    b.
    c.

12. What requirements are included in specifications for cement, aggregate, or construction to avoid reaction?

TABLE

RESULTS OF 1953 QUESTIONNAIRE ON CEMENT-AGGREGA
COMMITTEE ON DURABILITY O

Reporting Agency	1a. Alkali-Aggregate Reaction	1b. Cement-Aggregate Reaction	2 Resulting Characteristics Developed	3 Structure Types Affected	4 Age Reaction Discernible, yr	5 Age Reaction Ceases, yr	6 Portion of Structure Showing Most Reaction	7 Reaction Correlated with Cement Characteristic
Alabama	Yes	Yes	Expansion, cracking, exudations, others	Pavements Bridges Handrails	4-8	7	Lighter parts of structure	No
Arizona	Yes	-	Expansion, cracking, loss of strength blow-ups, exudations	Pavements Bridges Handrails Structures Dams Others	2	Unknown	Where subject to wide temp & moisture content changes	Alkali Content
Arkansas	No	No	-	-	-	-	-	-
California	Yes	No	Expansion, cracking, exudations	Pavements Bridges Handrails Structures	1-5	?	Where damp with one or more dry surfaces exposed to sun	Alkali Content
Delaware	No	No	-	-	-	-	-	-
Florida	Yes	-	Cracking, expansion, blow-ups, exudations	Pavements Bridges	Unknown	Unknown	Concrete dry and in sun	Alkali Content
Georgia	Yes	-	Cracking, loss of strength expansion, exudations	Pavements Bridges Handrails	6	15+	Alternate wet and dry	-
Idaho	Yes	Yes	Loss of strength expansion, cracking, scaling, blow-ups	Pavements Bridges Handrails	2	Unknown	Handrails Curbs Pier caps	Alkali Content
Illinois	No	No	-	-	-	-	-	-
Indiana (Purdue U.)	-	Yes	Expansion, cracking, blow-ups	Pavements Bridges Handrails	12-20	?	-	No
Kansas	-	Yes	Loss of strength, expansion, cracking	Pavements Bridges Handrails Structures	7	20 or more	Where damp with one or more dry surfaces exposed to sun	-
Kentucky	-	Yes	Cracking, scaling, blow-ups	Pavements Bridges Handrails Structures	-	-	-	No
Louisiana	No	No	-	-	-	-	-	-
Maryland	No	No	-	-	-	-	-	-
Massachusetts	No	No	-	-	-	-	-	-
Michigan	No	No	-	-	-	-	-	-
Minnesota	No	No	-	-	-	-	-	-
Missouri	Possibly	Don't know	Map cracking	Pavements Abutments Handrails	3-10	Unknown	Where damp on one side, no observation of effect of sun or shade	No
Nebraska	Yes	Yes	Loss of strength, expansion, cracking, blow-ups, exudations	Pavements Bridges Handrails Structures	5	10	Where damp with one or more dry surfaces exposed to sun	High alkali content
New Hampshire	No	No	-	-	-	-	-	-
New Jersey	-	Yes	Expansion, cracking, blow-ups, exudations	Pavements Bridges Handrails Structures	4	Unknown	Where damp and in shade, where damp with one or more dry surfaces exposed to sun.	No. Possible relation of high C_3A (22%)
North Carolina	No	No	-	-	-	-	-	-
North Dakota	No	No	-	-	-	-	-	-
Ohio	No	No	-	-	-	-	-	-
Oklahoma	No	No	-	-	-	-	-	-

OR ALKALI-AGGREGATE REACTIONS IN CONCRETE BY HRB
CONCRETE—CHEMICAL ASPECTS

8	8a.	8b.	9	10	10a.	10b.	11	12
Reaction Correlated with Aggregate Characteristic	Rock Types Associated with Reaction	Mineral Types Associated with Reaction	Corrective Measures Employed	Corrective Measures Successful?	Success Based on Lab. or Field Experience	Years of Field Experience	Lab. Tests Designed to Avoid Reaction	Specification Requirements to Avoid Reaction
No	-	-	Low alkali cement, entrained air, pozzolans	?	-	-	Alkali content	0.6% max. alkali
Yes	Andesites	-	Low alkali cement, entrained air	Yes	Field	7	Alkali content	0.6% max. alkali
-	-	-	-	-	-	-	None	None
Yes	Opaline shales, intermediate volcanics	Opal, tridymite, volcanic glass	Low alkali content	Yes	Both	10	Chemical analysis, mortar bars, petrographical & lithographical examination	Low alkali cement with reactive aggregates
-	-	-	-	-	-	-	AASHO, T-21-42 - organic impurities in sands for concrete	-
Only with high alkali cement	Montgomery, Ala., or Tuscaloosa, Ala. aggregates (with high alkali cement)	-	Low alkali cement with these aggregates	Unknown	-	-	Alkali content	Less than 0.6% alkali with reactive aggregate
-	Chert gravel granite, gneiss	Chalcedony, opal	Water proof painting	Reasonably	Field	6	Alkali content	0.6% max. alkali as Na_2O
No	-	Cherts, obsidian, rhyolite	Low alkali cement	Yes	Both	10	Alkali content, expansion bars	Less than 0.6% alkali
-	-	-	-	-	-	-	None	None
No	Limestone	-	None	-	-	-	None	None
Yes	Granite, quartzite, calcite, basalt	Feldspar, quartz, mica, chalcedony, chert, silicates	Additions of crushed limestone	Yes	Both	15	Wetting and drying tests on concrete made with cement and aggregate for 12 months	3"x4"x16" beams in wetting & drying test shall not expand in excess of 0.05% at 160 days nor more than 0.07% at 365 days
No	-	-	None	-	-	-	-	-
-	-	-	-	-	-	-	None	None
-	-	-	-	-	-	-	None	None
-	-	-	-	-	-	-	None	ASTM Standard Specifications
-	-	-	-	-	-	-	Mortar Bars chemical analysis, ASTM potential reactivity of aggregates	None
-	-	-	-	-	-	-	None	None
Yes	Chert gravel, limestone	-	No chert gravel except in mass concrete	Don't know	-	-	Stanton's Mortar Bar Test	No chert gravel except in mass concrete
Yes	-	Opal	20-30% fly ash, 30% crushed limestone in aggregate	Yes	Both	7 (Limestone)	Mortar bar test, wetting and drying test of concrete beams, Bureau Recl. test for pot. reactivity of aggregates	No aggregate shall be used that will cause excessive expansion. Use of 30% limestone in concrete.
-	-	-	-	-	-	-	None	None
No	Dolomite	-	None	-	-	-	None	Dolomite not permitted
-	-	-	-	-	-	-	None	None
-	-	-	-	-	-	-	None	None
-	-	-	-	-	-	-	None	None
-	-	-	-	-	-	-	None	None

TABLE

Reporting Agency	1a. Alkali-Aggregate Reaction	1b. Cement-Aggregate Reaction	2 Resulting Characteristics Developed	3 Structure Types Affected	4 Age Reaction Discernible, yr	5 Age Reaction Ceases, yr	6 Portion of Structure Showing Most Reaction	7 Reaction Correlated with Ceme Characteri
Oregon	Yes	Yes	Loss of strength, scaling, blow-ups, exudations	Bridges Handrails	5(10	?	Where damp and in the shade	No
Pennsylvania	No	No	-	-	-	-	-	-
Rhode Island	No	?	Other (Complete disintegration of face and top of concrete curbing)	Poured-in-place and some pre-cast curbing	1	?	Where damp with one or more dry surfaces exposed to sun	No
South Dakota	No	No	-	-	-	-	-	-
Tennessee	No	No	-	-	-	-	-	-
Texas	-	Probably	Loss of strength, expansion, cracking, scaling, blow-ups	Pavements	5	Unknown	-	No
Utah	Yes	Yes	Expansion, cracking	Bridges Structures	2	?	Where damp with one or more dry surfaces exposed to sun	-
Virginia	Yes	-	Cracking, exudations	Pavements Handrails	Unknown	Unknown	Where damp and in shade	No
West Virginia	No	No	-	-	-	-	-	-
Wisconsin	No	No	-	-	-	-	-	-
District of Columbia	No	No	-	-	-	-	-	-
Missouri River Division Lab. Corps of Eng.	No	No	-	-	-	-	-	-
North Pacific Division Lab. Corps of Eng.	Yes	Yes	Expansion, cracking, scaling	Bridges Handrails Dams	Variable	Unknown	Where damp with one or more dry surfaces exposed to sun	No
South Atlantic Division Lab. Corps of Eng.	Yes	-	Expansion, cracking, exudations	Dams Lock Walls	8	Continuing	Where damp with one or more dry surfaces exposed to sun	Alkali content
South Pacific Division Lab. Corps of Eng.	Yes	-	Loss of strength, expansion, cracking, scaling, blow-ups, exudations, others	Pavements Bridges Handrails Structures Dams	1/2-10	?	-	Alkali
Southwestern Division Lab. Corps of Eng.	No	No	-	-	-	-	-	-
Waterways Experiment Station Corps of Eng.	Yes	Yes	Presence of reaction products as seen by microscope	Pavements Structures	Unknown	Unknown	Where damp with one or more dry surfaces exposed to sun	No data
Bureau of Reclamation, Department of Interior	Yes	Yes	Loss of strength, expansion, cracking, exudations	Pavements Bridges Handrails Structures Dams	2	Continuing	Where damp and in shade, where damp with one or more dry surfaces exposed to sun	Alkali content
National Sand and Gravel Association	Yes	Yes	Expansion, cracking, exudations	Pavements Bridges	4	Unknown	Where moisture is present	No data

No answers received from:

Colorado	New Mexico
Connecticut	New York
Iowa	South Carolina
Maine	Vermont
Mississippi	Washington
Montana	Wyoming
Nevada	

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8a.	8b.	9	10	10a.	10b.	11	12
Rock Types Associated with Reaction	Mineral Types Associated with Reaction	Corrective Measures Employed	Corrective Measures Successful?	Success Based on Lab. or Field Experience	Years of Field Experience	Lab. Tests Designed to Avoid Reaction	Specification Requirements to Avoid Reaction
-	-	Silicone treatment, air-entraining agent, type II cement	Yes. (Silicone appears to deter hand-rail scaling)	Field	2	None	Air entraining agent added at batch plant, type II cement
-	-	-	-	-	-	Sodium sulphate 5 cycles for aggregate, autoclave test for cement	Pass above tests
-	-	All pre-cast curb is bush-hammered on exposed face and top	Yes	Field	15	None	None
-	-	-	-	-	-	None	None
-	-	-	-	-	-	Alkali content	0.6% Max. alkali when engineer specified low alkali cement
-	-	None	-	-	-	None	None
-	Basalt, cherts	Type II low alkali cement	Yes	Both	10	Jar Test outlined by D.O. Woolf P.R.A.	Air entrained type II low alkali (0.6% max.)
Phyllite, some cherts and sandstones	-	None	-	-	-	Current research program	None
-	-	-	-	-	-	None	None
-	-	-	-	-	-	None	None
-	-	-	-	-	-	None	None
-	-	-	-	-	-	Potential alkali reactivity of cement-aggregate combinations, Pot. Reac. of Aggregates, alkali content	None
Quartzite & glassy volcanics in river gravels	Opal, chalcedony, volcanic glass	Low alkali cement	Yes	Lab.	-	Petrographic analysis of aggregates, mortar bar test, quick chemical	Low alkali cement
Chert	Chalcedony (Opal)	Under observation	-	-	-	Alkali content, mortar bar, alkali-reactivity chemical alkali-reactivity	0.6% max. alkali (Na Equivalent)
Opaline cherts, chalcedonic cherts, rhyolites, andesites	Opal, chalcedony	Low alkali cement	Yes	Both	13	Petrography, quick chemical, mortar bars	Low alkali cement
-	-	-	-	-	-	Quick chemical tests, mortar bar tests	Low alkali cement, non-reactive aggregates approved
Chert	Chalcedony	Low alkali cement	Not known	-	-	Petrography, mortar bar tests quick chemical, examination	Aggregates shall be obtained from approved sources. Low alkali cement specified with potentially reactive aggregates
Opal, cherts, siliceous limestone, chalcedony, acid to intermediate volcanic rocks such as andesites, rhyolites, tuffs	Opal, tridymite, cristobalite, silica rich volcanic glass, zeolites	Waterproof affected concrete, low alkali cement, use pozzolanic addition or avoid reactive aggregate	Yes	Both	-	Petrography, mortar bars, quick chemical	0.6% max. alkali (as Na equivalent) or use of pozzolan with reactive aggregates. Reactive aggregates avoided when possible.
-	-	-	-	-	-	-	-