Field Experience with Alkali-Aggregate Reaction in Concrete: Western United States

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●IN THE absence of more specific delineation of the area to be covered by this discussion the author interpreted his assignment to include the area west of the Mississippi River. Accordingly, the information obtained pertains to the 20 states comprising this region. Later it was learned that a similar report covering the Central United States had been assigned to another author. Therefore, some overlap exists in the areas covered in the two reports.

To obtain the information needed a circular letter was sent to the Materials Engineers of the highway departments of the 20 Western States. The response was gratifying, in that replies were received from all but two states. The first question asked was:

> Do you know of any construction within your state, consisting of highway pavements or structures or airport runways, in which the aggregates used have a proven record of unsatisfactory service with respect to the alkali-aggregate reaction when used with high-alkali cement and which have been used in concrete of other make-up which has given improved results in service?

No state in its reply volunteered information regarding runway construction. Therefore, the information obtained pertains only to highway structures and pavements.

Eleven states replied that no distress assignable to alkali aggregate had been observed in their states to their knowledge. However, three midwestern states referred to trouble with the cement-aggregate reaction, which they did not consider to be the same as the alkali-aggregate reaction.

The remaining seven states all reported distress from alkali-aggregate reaction. Highway pavements or structures were cited as evidence. An eighth state, Washington, that did not reply to the inquiry, is known from published reports to have experienced trouble. With the exception of Nebraska and part of Wyoming, all of the eight states lie west of the Continental Divide.

Additional information was requested from those states that answered the first question in the affirmative. These replies are summarized briefly in alphabetical order in the following:

Wayne O'Harra, reporting for Arizona, cited distress attributed to alkali-aggregate reaction in two pavements and numerous structures either known or believed to have been constructed with cements high in alkalies. For the past ten years all cement has been specified to contain less than 0.60 percent alkalies. Air entrainment was also started at the same time. During this period observations have shown that the methods of correction have been effective. He does not feel that field evidence alone proves conclusively that low-alkali cement, of itself, has been responsible for the observed improvement. However, mortar bar expansion tests in the laboratory show that low-alkali cement is effective in reducing expansion.

Alkali-aggregate reaction in California highway work has been extensive. Much of it has been reported in the literature and need not be repeated here. For the past 15 years the sole corrective measure has been the use of low-alkali cement. Many highly reactive aggregates containing either opal or intermediate igneous glass have been used. The results have been fully satisfactory, judging from fairly comprehensive field surveys.

L. F. Erickson referred to numerous bridges and pavements in southeastern Idaho that have been adversely affected by alkali-aggregate reaction. He mentioned specifically two structures near Pocatello built with cement that presumably contained about 0.74 percent alkalies (Na_2O equiv.). In 1944 a new structure using essentially the same aggregates was constructed with low-alkali cement (Na_2O equivalent, 0.53 percent).

A recent inspection at the age of 12 years shows no evidence of distress.

W. M. Carver, reporting for Nebraska, referred to the well-known experience in Kimball in which serious expansion developed in pavements within a year after construction. The aggregates were from local sources and the cement contained over 1.30 percent alkalies. There has been no construction with low-alkali cements and Kimball aggregates. Distress elsewhere in Nebraska is attributed to cement-aggregate reaction.

G.W. Harra of Oregon reported serious distress in a number of bridges in Malheur County that were constructed during 1927-28, during which time the available cement contained in excess of 1 percent of alkalies. The high alkali content during this period was due to a change in the shale being used. Previously the cement was believed to have been low in alkalies. Since 1930 the average alkali content has been about 0.4 percent. Virtually the same aggregates have been used in all construction. Except for construction during the 1927-28 period, the results have been satisfactory.

D.F. Larsen, reporting for Utah, stated that some distress had been observed in concrete in which gel relics have been found. However, unsound aggregate, and freezing and thawing have been factors. He is unable to differentiate clearly between the three possible causes of distress. No mention was made of corrective measures.

I.E. Russell stated that alkali-aggregate reaction has caused adverse results in structures in Laramie, Wyoming. The cement used contained between 1.3 and 1.4 percent alkalies and the aggregates were from the Laramie River. In 1945, curbs and gutters were constructed with Laramie River aggregates and a cement containing 0.66 percent alkalies. This work, now 11 years old, shows no evidence of adverse alkali-aggregate reaction.

TABLE 1

SUMMARY OF REPLIES FROM 20 WESTERN STATES

State	No Reply	No Alkali-Aggregate Reaction	Cement-Aggregate Reaction	Alkali-Aggregate Reaction
Arizona				x
Arkansas		x		
California				x
Colorado		x		
Idaho				x
Iowa		x	x	
Kansas		x	x	
Louisiana		x		
Minnesota		x		
Nebraska			x	x
Nevada	x			
New Mexico		x		
North Dakota		x		
Oklahoma		x		
Oregon				x
South Dakota		x		
Texas		x		
Utah				x
Washington	x			x
Wyoming				x
Total	2	11	3	8

No reply has been received from Washington, but the author can state from personal experience that six bridges built with Cowlitz River or White River aggregates, both containing Mt. Rainier andesite, and cements from two mills believed to have contained from 0.8 to over 1.0 percent alkalies, showed serious distress from alkali-aggregate reaction at an early date. Six other bridges, similarly situated, built with Cowlitz River aggregates and cements from two mills that were believed to have contained less than 0.6 percent of alkalies, showed no evidence of adverse alkali-aggregate reaction up to ages of at least 20 years. As far as known, no type of corrective measure other than low-alkali cement has been attempted in Washington. The results of this survey show the following:

Of the twenty states lying west of the Mississippi River, alkali-aggregate reaction has been observed in highway work in eight of them. In one of these, Utah, evidence of distress from this cause is inconclusive, and results of corrective measures, if attempted, were not reported. Another state, Nebraska, has observed distress from alkali-aggregate reaction but has no knowledge of possible corrective measures in the field.

Six states reported that excellent performance of from 10 to 20 years has been obtained when low-alkali cement has been used with aggregates that have been clearly established by field experience to be reactive.

Idaho reported that distress occurred with a cement containing 0.74 percent Na_2O equivalent (assumed). Wyoming reported satisfactory results at the age of 11 years with reactive aggregates and a cement containing 0.66 percent alkalies (basis of computation not stated). In the remaining six states there appears to have been no experience with cements having alkali contents in the range of 0.6 to 0.8 percent.

None of the states reporting has had experience with corrective measures other than low-alkali cement. No information was developed concerning experience in airport runways.