EVALUATION OF AGGREGATES FOR AAR USING ACCELERATED TEST METHODS

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ABSTRACT

There are many accelerated test methods adopted for determination of the potential reactivity of concrete aggregates . They have given satisfactory results with a few aggregates , but many of them were not reliable with aggregates from different countries . As many aggregates must be evaluated in a few days before construction , these testing methods need to be reliable, rapid and reproducible .

In the present investigation aggregates from various sources are evaluated for alkali aggregate reactivity . They will be used in the concrete of a number of dams which are under construction in Iran . Chemical methods and accelerated mortar bar tests were used for determining the alkali - reactivity of the aggregates . The concrete prism methods will be carried out for the confirmation of the accelerated test results .

Test results show that some of the accelerated test methods can be reliable for the types of concrete aggregates used in this investigation .

Keywords : Alakli - aggregate reactivity, Accelerated tests, Mortar bar .

INTRODUCTION

Alkali - aggregates reactivity (AAR) in concrete is an undesirable chemical reaction that may occur between soluble alkalies in the pore fluid and certain types of aggregates . AAR often develops as a slow progressively deteriorating process , with the first visible signs taking anywhere from a few months to many years to develop.

Except for a few "text book" cases , notable signs , such as map - cracking , oozing gel , and popouts , aren't evident. The apparent symptoms , most often excessive or abnormal structural distortions and cracking, are not unique to AAR . Taken individually , these symptoms may be mistakenly attributed to other causes of structural problems , such as foundation deficiencies, inadequate reinforcement , temperature , or other effects .

AAR produces concrete expansion and can generally lead to a loss of strength , stiffness (cracking) , and generates undesirable deformations and disturbances in the equilibrium of internal forces .

A few concrete dams and other structures in Iran are suffering from deteriorations induced by alkali - aggregates reaction (AAR) that impair the durability , serviceability , and might also affect , in long term , the safety of the installation .

In this study the results of two rapid chemical screening test(CSA A 23.2-26A and ASTM C 289) and one rapid Mortar Bar Method (CSA A 23.2-25A) with petrographic examination on a number of aggregates is presented (1,2). The CSA A23.2-26A test is used for the evaluation of carbonate aggregates

The aim of this investigation is to study the behavior of some aggregates that will be used or have been used in the concrete in a number of dams built or under construction in Iran .

TEST PROGRAM

Materials

1- Aggregates

In this study 14 types of aggregates obtained from 4 dams have been tested. The dams which have been selected for this investigation are:

1. Shahid Rajai (with 5 aggregate types)
2. Maroon (with 2 aggregate types)
3. Karkheh (with 3 aggregate types)
4. Ahar (with 4 aggregate types)

The petrography and the physical properties of the aggregates used in this investigation are given in Table 1.

TABLE 1 :Petrography and physical properties of the coarse and fine aggregates .

Aggregates	Rajai	Maroon	Karkheh	Ahar
Type	Quarried carbonate Rock	Gravel glacial deposit	Carbonate Rock	Carbonate Rock
Rock Type	limestone (more calcite and less Dolomite)	limestone (Calcite Dolomite Quartz)	Siliceous limestone (quartz and feldspar calcite)	Siliceous limestone (calcite, quartz, feldspar)

2- Portland Cement

The physical properties and the chemical composition of the cement used is given in Table 2 .

TABLE 2 : Chemical Analysis of the Cement

cement	Insoluble residue	SiO_2%	CaO%	Al_2O_3%	Fe_2O_3%	MgO%	So_3%	free calcium oxide	loss of ignition	Na_2O%	K_2O %
Tehran	0.5%	21.2%	62.5%	5%	3.1	3.15	2.85	0.6	1.4	0.7	0.88

TEST PROCEDURES

Petrography

Lists of potentially reactive minerals and corresponding host rock types are available from a number of publications (3,4). The pertrographic examination of aggregates in thin sections under the optical microscope usually allows recognition of potentially reactive mineral phases of rocks .

Further microscopic examination of thin section of concrete samples will be carried out at a later stage for the confirmation of alkali carbonate or alkali silica reactions.

ASTM C 289 Chemical Test

The ASTM C 289 chemical method is one of the most widely used test for evaluating the potential reactivity of silica-bearing aggregates. Its use is mainly because it requires only small quantities of material and results can be obtained within a few days (1) .

CSA A 23.2-26A Chemical Test

This is a modified chemical test which is in the process of being adopted in the Canadian Standards for AAR, covers the evaluation of potential alkali-carbonate reactivity of quarried carbonate rocks. In this test method, a representative sample of the aggregates to be tested is reduced in particle size, small jaw crusher and a disk pulverizer, to pass a 160 μ m sieve. The material is then carefully homogenized and sent for chemical analysis for CaO , MgO and AL_2O_3 (2).

CSA A 23.2-25A Mortar Bar Test

Mortar bar for this test are made in accordance with CSA A23.2-25 A and immersed after demoulding in water at 23 C with the containers immediately placed in an oven and stored at 80 C. The next day, the zero reading is taken, then the bars immersed in a 1N NaOH solution and reading are taken each working day (2).

TEST RESULTS

Alkali - Aggregate Reactivity Testing

The results of ASTM C 289 chemical test for Rajai dam are given in Fig 1. This figure gives the plots of Sc (Dissolved silica mM/l) versus Rc (Reduction in alkalinity mM/l) for series of aggregates . The results of chemical analysis of aggregates are shown in Tables 3 to 6 . related plots are given in Figs 2 and 3 . In each cases the amount of Al_2O_3 versus the CaO: In each case the amount of AL_2O_3 versus the CaO : MgO ratio are ploted in Figs 2 and 3 . The results of accelerated mortar bar test method are given in Figs 4 to 5.

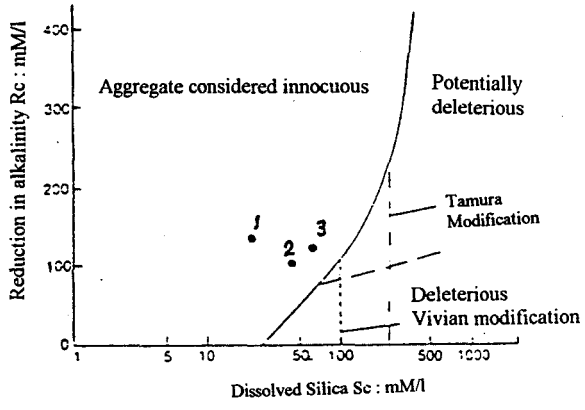

Fig1 : Results of ASTM C 289 chemical test for the Rajai dam aggregates.

* P.E = Potentially Expansive N.E = None Expansive

TABLE 3 : Chemical analysis of the Shahid Rajai aggregates

S.NO	L.I	SiO_2%	Fe_2O_3%	Al_2O_3%	MgO%	CaO%	So_3%	$C\bar{L}$%	$\frac{CaO}{MgO}$	Result
1	30.2	25.7	2.75	3.75	1.98	35.75	0.1	0.05	18.66	P.E
2	29	29.6	2.75	3.5	2.2	33	0.12	0.03	15	P.E
3	32.5	24.5	1.9	4.6	1.2	34.75	0.1	0.04	28.96	P.E
4	30.8	23.1	1.75	2.75	1.8	40.3	0.1	0.01	22.39	P.E
5	31.9	23.5	3	4.5	2.98	34	0.14	0.03	11.4	P.E

TABLE 4 : Chemical analysis of the Maroon aggregates

S.NO	L.I	SiO_2%	Fe_2O_3%	Al_2O_3%	MgO%	CaO%	So_3%	$C\bar{L}$%	$\frac{CaO}{MgO}$	Result
1	39.1	6.8	0.5	3	1.7	49	0.075	0.03	28.8	P.E
2	40.8	8.5	1.25	1.5	1.8	45.25	0.11	0.02	25.14	NON.E

TABLE 5 : Chemical analysis of the Karkheh aggregates

S.NO	L.I	SiO_2%	Fe_2O_3%	Al_2O_3%	MgO%	CaO%	So_3%	$C\bar{L}$%	$\frac{CaO}{MgO}$	Result
1	14	57	0.75	2.75	1.9	23	0.085	0.02	12.10	P.E
2	29.7	32	1.5	1.25	1.2	34.5	0.11	0.04	28.75	NON.E
3	28.1	31.3	0.9	2.35	1.9	35.75	0.09	0.03	18.5	P.E

TABLE 6 : Chemical analysis of the Ahar aggregates

S.NO	L.I	SiO_2%	Fe_2O_3%	Al_2O_3%	MgO%	CaO%	So_3%	$C\bar{L}$%	$\frac{CaO}{MgO}$	Result
1	8.7	56.4	5	13.25	3.17	12	0.08	0.02	3.8	P.E
2	17.7	39.8	5	13	3.08	21.75	0.09	0.016	7	P.E
1	6.2	54.1	8.5	19.5	2.89	8.85	0.075	0.018	2.96	P.E
2	9.7	49.1	6.75	19.25	3	11.75	0.074	0.018	3.92	P.E

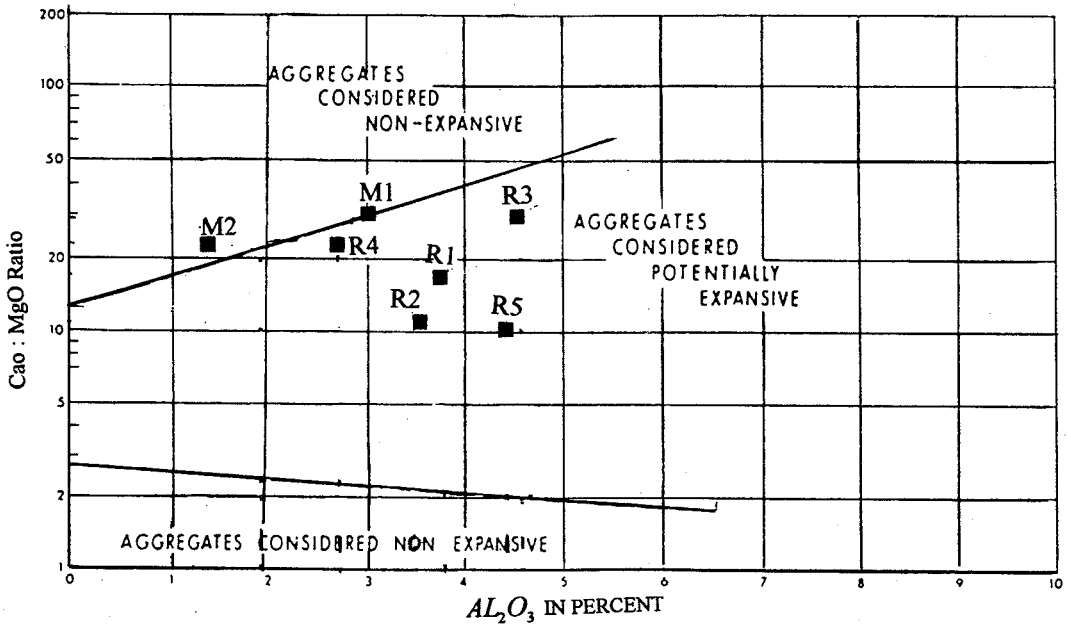

Fig2 : Results of the CSA A 23.2-26A chemical test

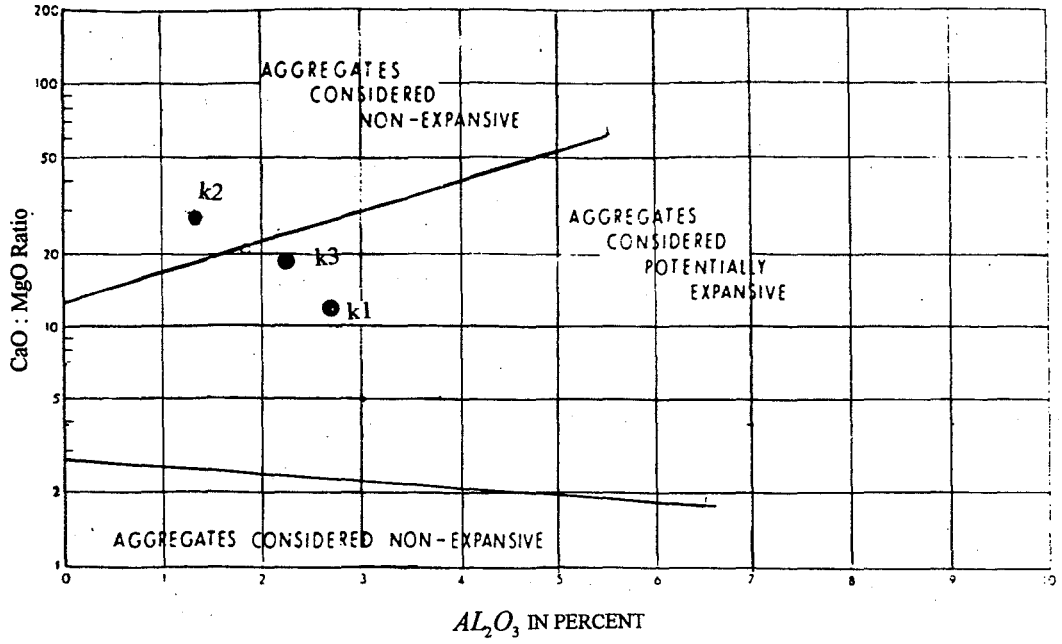

Fig3 : Results of the CSA A 23.2-26A chemical test

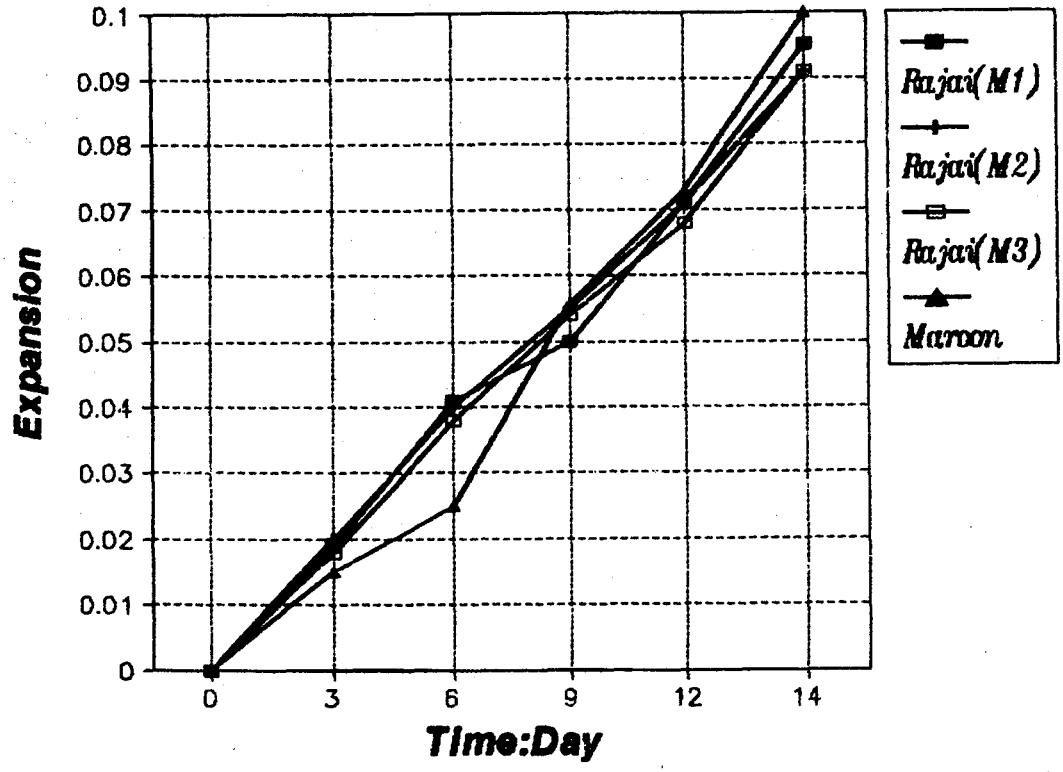

Fig4 : Results of the CSA accelerated Mortar bar testing of 1) shaid rajaii ; 2) Maroon aggregates According to CSA A23.2-25A.

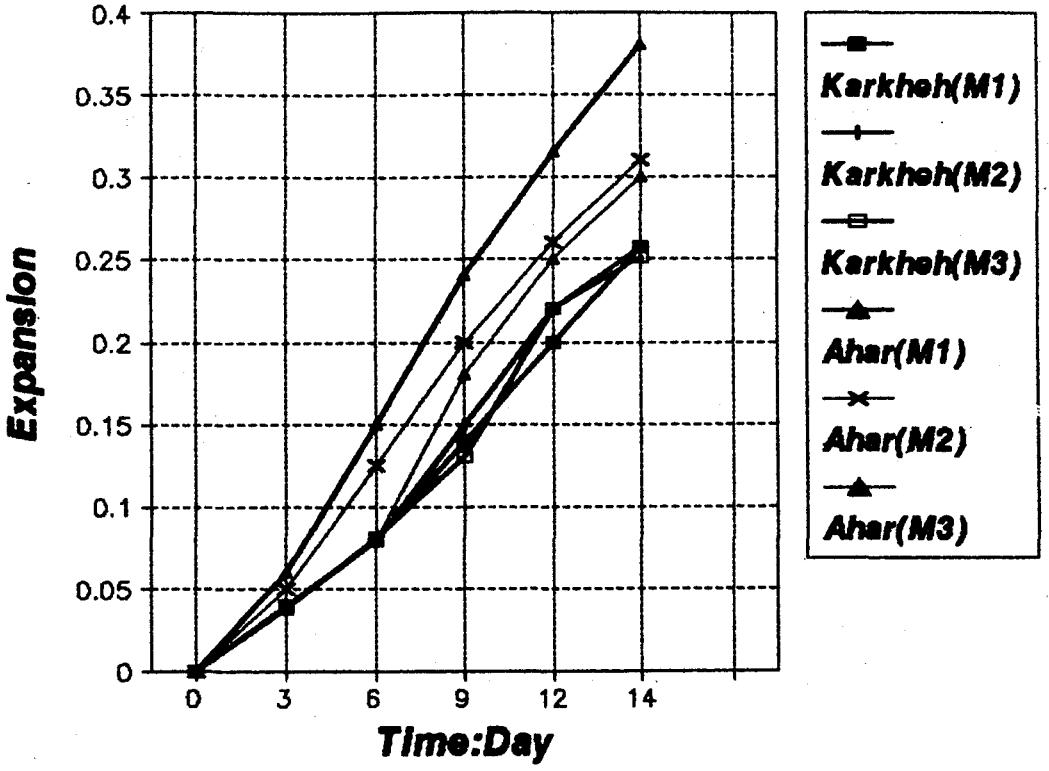

Fig5 :Results of the CSA accelerated Mortar bar testing of 3. Karkheh ; 4. Ahar aggregates According to CSA A23.2-25A.

DISCUSSION

Petrographic examination :

Shahid Rajai dam : According to the test , the aggregate originate from a grey limestone deposit . The material is made up of fine particles which differs from massed to crystalline formations . They are composed of mostly calcite and lesser dolomite .

Maroon dam : The same properties as above have been obtained for Maroon aggregates and the existance of dolomite and calcite minerals in the rocks indicate the potential alkali-aggregate reactivity in the dam(ACR).

Karkheh dam : According to x-ray diffraction analysis the aggregates used in construction were made up of some quartz and lesser feldspar.

Ahar dam:The aggregate is composed of siliceous limestones, with mineral references components of (60% $CaCO_3$, 30-35% quartz and 10-12% feldspar and calcite) .

ASTM C 289 Chemical Test

From the results obtained for different aggregates it can be seen that this test is not applicable for the carbonate rocks and therefore this test was carried out for comparison purposes. The results of the tests show that the Rajai aggregates can be considered innocuous (see Fig 1) .

CSA A 23.2-26A Chemical Method

In this study each series of aggregates was tested and the results show that most of aggregates can be considered " potentially expansive " . These results shoud be confirmed either by satisfactory service record or concrete prism test.

CSA A 23.2-25A Mortar Bar Method

Results of the CSA accelerated mortar bar test showed that the aggregates from Rajai and Maroon expanded less than 0.1% at 14 days , which was the proposed expansion limit .
The results of other aggregtes such as Karkheh and Ahar showed that expansion of mortar bars were greater than 0.1% at 14 days . Comparison of the results of mortar bar tests with the results of chemical tests and petrographic examination reveals that these aggregates contain reactive silica and reactive carbonate phases . The concrete prism test should be carried out to confirm these results .

CONCLUSION

1- Most of the aggregates used for dams in Iran are carbonate aggregates. Therefore the chemical tests for alkali silica reactivity are not suitable tests for these aggregates.
2- The results of a modified chemical test show that most of the aggregates investigated were reactive aggregates , Long term concrete prism tests are needed to confirm the results of the chemical test .
3- The aggregates with high reactive silica contents showed higher expansion in both CSA A23.2-25A and CSA A23.2-26A tests revealing the fact that the ASR and ACR tests are necessary tests for the aggregate investigated in this study .
4- The results of the accelerated mortar bar test show that some aggregates were very reactive . The expansion of the bars was about three times the permissible value .

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