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EVALUATION OF AAR POTENTIAL OF LIMESTONE AGGREGATES IN INDIA

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ABSTRACT

Investigations on the alkali aggregate reactivity of three Indian limestone aggregate samples do not reveal the indications of any deleterious reactions. The development of white rims in laboratory and field specimens for the dolomitic limestone necessitated the understanding of the mechanism involved.

1. INTRODUCTION

This paper presents the results of systematic evaluation of three limestone aggregate samples occurring in different parts of India for potential alkali carbonate reactivity, when used in concrete for construction of hydraulic structures. In India, instances of distress to concrete constructions due to alkali-aggregate reactivity are rather recent and no record of evaluation of limestone aggregates were available. As such, these limestone samples were subjected to petrography, concrete prism test - both at normal and elevated temperature regimes, rim development test, rock cylinder test and characterisation in XRD and SEM systems, in addition to mortar bar tests; the results of which are presented in the paper.

2. DESCRIPTION OF LIMESTONE SAMPLES

Three limestone samples (one dolomitic) proposed for three different constructions were evaluated. In addition, core samples from a six years old concrete in a dam nearing completion containing the same dolomitic limestone aggregates were also evaluated. The constituents of the limestone samples determined by optical microscopy and the clay content for the dolomitic limestone sample determined chemically in terms of total insoluble residue, which includes silt size and larger particles also, are given in Table 1 and described below;

2.1 Limestone 1

These are fine grained rocks with abundant calcite. Little amount of quartz occur among the calcite. Nearly 10 percent secondary calcite occur as small bands within the fine grained primary calcite. The average grain size of primary calcite is around 5 microns and upto 150 microns in secondary calcite. Apart from quartz, some amount of iron oxide is also present as an accessory mineral.

TABLE 1

CONSTITUENTS OF LIMESTONE SAMPLES, %

Sl No	Constituent	Limestone 1	Limestone 2	Dolomite
1	Primary calcite	74	40	25
2	Secondary Calcite	12	-	-
3	Calcium silicates	-	25	-
4	Dolomite	4	-	70
5	Quartz	6	25	-
6	Biotite	-	4	-
7	Iron oxide	-	6	-
8	Accessories	4	-	5
9	Clay	-	-	6.3

2.2 Limestone 2

The rock exhibits medium to coarse grained inequigranular texture. Calcite grains show variation in grain size from 100 to 300 microns and that of quartz grains varies from 100 to 600 microns. The calcium-silicate minerals are mostly diopside. At some of the places biotite shows leaching effect liberating iron oxide.

2.3 Dolomite

Megascopically it is black in colour, exhibits conchoidal fracture and is highly jointed and cleavable. Under microscope, it shows alternation of calcite and dolomite laminae. The calcite grains are very fine and range in size from 20 to 25 microns. The dolomite grains range in size from 40 to 45 microns. Minute specs of quartz are also found present in the matrix.

3. EXPERIMENTAL RESULTS AND DISCUSSION

Evaluation of the aggregate samples were carried out with ordinary portland cements containing different levels of total alkalies (Na_2O equivalent) varying from 0.5 to 1.13 percent. For the concrete core samples, the alkali content in the cements used for the construction were not known and the records reveal that cements from a number of sources with total alkali contents varying widely were used.

3.1 Expansion Tests

Expansions on concrete prisms as per CSA-A 23.2-14A, mortar-bar tests as per ASTM-C227 and rock cylinder tests as per ASTM-C586 were carried out. The alkali content in the cement and the temperature regime are indicated in Table 2 which also lists the expansion obtained up to 180 days. Additionally, mortar-bar tests were carried out at an elevated temperature regime of 60°C. The net expansion in all the tests were within the permissible limits and the aggregates could therefore be held to be non-expansive. These trends were expected in view of the fact that the limestone samples were not of argillaceous nature and the clay content in the dolomitic limestone sample was rather limited i.e., for a dolomite content of 70% the clay content was only 6.3%. However, the composition of dolomitic limestone is such that it falls in the rim developing category (1). The expansion trends of rock cylinder test show expansion steadily without initial contraction, as noticed in some limestone samples from the Middle East (2).

TABLE 2

RESULTS OF EXPANSION TESTS (UPTO 180 DAYS)

Sample	Concrete Prism CSA 23.2-14A			Rock Cylinder (ASTM-C227)	Mortar Bar (ASTM-C586)		
	Alkali in cement (Na_2O eq)	Temp °C	Expansion %	Expansion %	Alkali in cement (Na_2O eq)	Temp °C	Expansion %
LS 1	1.00	38	0.035	0.040	--	--	--
LS 2	1.13	27	0.0145	--	0.50	38	0.0146
		38	0.0337			60	0.0264
					1.13	38	0.0308
						60	0.0392
Dolomite	0.89	27	0.0200	0.035	0.57	38	0.0172
		38	0.0456		1.00	38	0.0248

3.2 Rim-Formation

In addition to being of expansive category, limestone aggregates, depending upon their composition and formation could also develop rims, the effect of which on the durability of concrete is not yet well understood. For this purpose the dolomitic limestone sample was also subjected to rim-development tests as per Bisque and Lemish (3). Prominent rims were observed on the longitudinally cut mortar bars after an exposure period of two months with the exception that these rims were white instead of the commonly reported dark rims. However, these rims were found to be acid insoluble (Fig 1). Similar white rims were also noticed on the concrete core samples obtained from the dam under construction visible to the naked eye (Fig 2) as also observed around calcareous aggregates by Regourd (4). On the other hand, the commonly reported dark reaction rims were not observed.

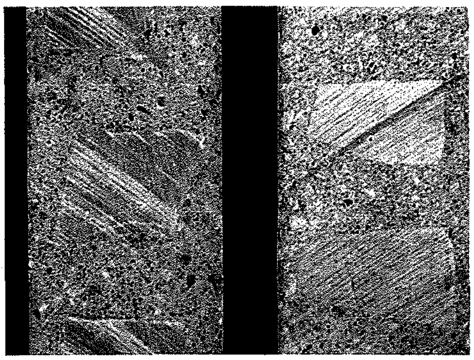

Fig 1. White rims formed on mortar bars under rim development test.

Fig 2. White rims observed on concrete core samples.

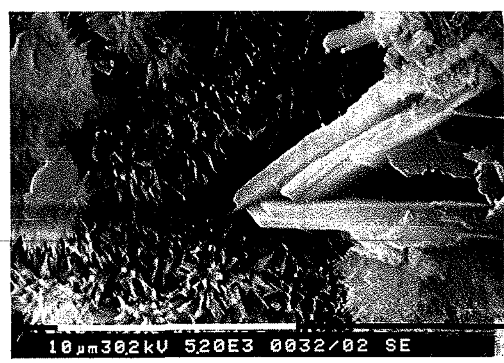

Fig 3. Crystalline reaction products under SEM.

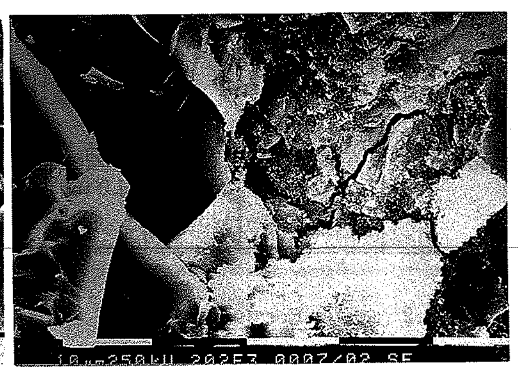

Fig 4. Amorphous reaction products under SEM.

On examination through scanning electron microscope, the reaction rims bordering the aggregates were found to be mostly crystalline with needle like crystals, although somtimes amorphous nature was also detected (Figs 3 and 4). The EDAX spectra of the reaction rim (Fig 5) shows predominant presence of potassium which was larger than the silica phase present. XRD of the reaction products, shown in Fig 6 showed prominant presence of dolomite and α-quartz

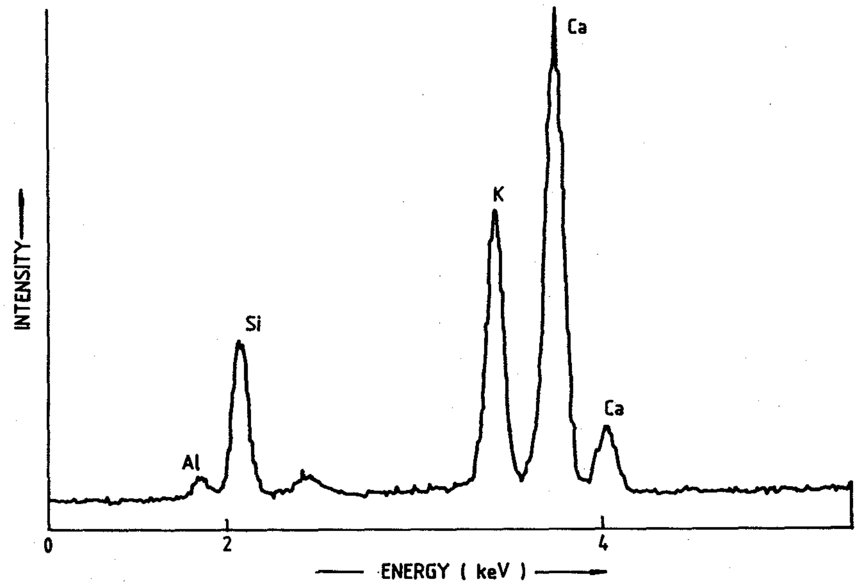

Fig 5. EDAX of Reaction Rim.

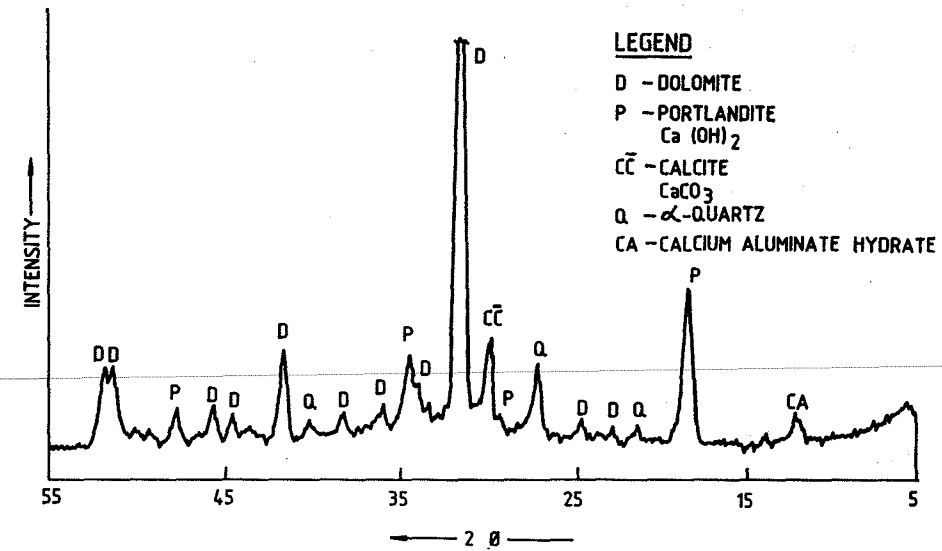

Fig 6. X-Ray Diffractogram of Reaction Products.

along with presence of calcium carbonate and calcium hydroxide. No Mg bearing reaction phase could be detected either in XRD or EDAX. From the various studies discussed above, it appears that no dedolomitization reactions, involving alkali carbonate reactivity which can result in either excessive expansions or in the development of dark reaction rims have taken place.

4. CONCLUSIONS

The common methods for evaluation of alkali carbonate reaction-potential of aggregates gave consistent results with three Indian limestone aggregates. The aggregates are found to be of non-expansive type. White rims on the dolomitic limestone samples in both the laboratory and field conditions revealed crystalline reaction products under SEM and no dedolomitization reaction could be noticed.

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