Testing Canadian Aggregates for Alkali Reactivity

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ABSTRACT

Geographic variation in cement alkalies determines the incidence of alkali aggregate reactivity (AAR) in Canada. The west, with low alkali cements, has few cases compared to the east, where high alkali cements are used. Three different categories of AAR have been recognized. Each category applies to specific rock types with a need for different test methods. Flow charts have been developed to show the testing and decisions necessary to properly evaluate the potential AAR of an aggregate source.

INTRODUCTION

In Canada, as elsewhere, there has been renewed concern and interest in alkali aggregate reactivity (AAR). The Canadian Standards Association published a supplement to the concrete materials and test methods standard (CAN3-A23.1 and .2 -M77) in October 1986. This supplement was devoted to revisions to the appendix and the test methods for AAR. These revisions had originated from the Cement Committee subcommittee on cement-aggregate reactions, and been approved by the main A.23 committee. The purpose of this paper is to describe some of the considerations used in reaching a consensus on ways of controlling AAR in Canada, and briefly describe the testing philosophy.

CEMENT ALKALIES

Cement in western Canada is invariably of lower alkali content (mean 0.6% Na_2O) than that available in the east (mean 1.0% Na_2O). Low alkali cement in eastern Canada is of limited availability and expensive.

These differences in alkali level are reflected in occurrences of AAR. In the west, very few cases have been reported. Damage due to AAR has been associated with exposure to de-icing salt (NaCl) or curing conditions leading to concentration of soluble alkalies at the surface. In the east, from the Manitoba border to Newfoundland, numerous cases of AAR have been reported (130 in Ontario alone). Many different aggregates have been found to be reactive; from Precambrian granites, cherts and argillites of the Shield, to dolomitic limestones, cherty limestones and sandstones of the St. Lawrence lowlands, and Palaeozoic phyllites and greywackes of the Appalachians. For convenience these different reactive aggregates have been grouped into three broad types of reaction, each distinguished by the use of different test methods (Figures 2 and 3).

In the east, because low alkali cement has not been readily available, the general use of reduced levels of cement alkalinity to control AAR has not been practical. Satisfactory pozzolans have also not been widely available until recently. Even today, pozzolans are rarely used to control AAR. Most users have preferred not to use reactive aggregate rather than adopt the more complex testing and inspection procedures often necessary with use of control measures. This position seems to be changing with the recent decision of CN Rail to specify low alkali cement in all their concrete, irrespective of the aggregate being used. The indiscriminate adoption of this kind of corrective measure is viewed with concern by the industry.

TESTING

One of the problems with AAR in Canada has been the general lack of understanding, of the nature and causes of AAR, or even of the consequences of using or selling an alkali reactive aggregate. Until recently, most concrete aggregate producers had never heard of AAR and few had ever tested their aggregate for possible reactivity. The reason for this is due to lack of education and also a lack of insistence by users that the supplier demonstrate the aggregate is not reactive. There are a number of tests for evaluating AAR. These tests are usually complex, expensive and take up to a year to complete, and to add further confusion, different tests have to be used for different possible reactions even with the same rock type (Figure 2). The latest revision of the CSA standard has tried to make AAR testing more understandable to the non-specialist engineer. For too long, the assessment of the reactivity of aggregate has been a blackart. It is hoped that the flow charts (Figures 1-3) will provide a relatively foolproof scheme for assessing aggregate durability. An essential requirement to use this scheme will be a thorough petrographic examination of the aggregate. Failures or errors at that stage will flaw the whole testing procedure.

At present the general philosophy is simple. Evaluate all aggregates for AAR and only take control measures if the aggregate is reactive. The universal use of control measures is too expensive.

Table B1
Suggested Maximum Expansion Values for Various Test Methods for Alkali-Aggregate Reactivity

(See Clause B3.4.4.)

Exposure class (A23.1-M77, Table 7)	**Concrete prism expansion test (A23.2-14A)**	**Mortar bar expansion test (ASTM C227)**	**Accelerated concrete prism expansion test (A23.2-14A, Clause 2.5)**
A, B, C	0.01% at 3 months* 0.025% at 1 year	0.05% at 3 months† 0.10% at 6 months‡	0.04% at 1 year
D	0.04% at any age (1 year)	0.05% at 3 months 0.10% at 6 months	0.075% at 1 year

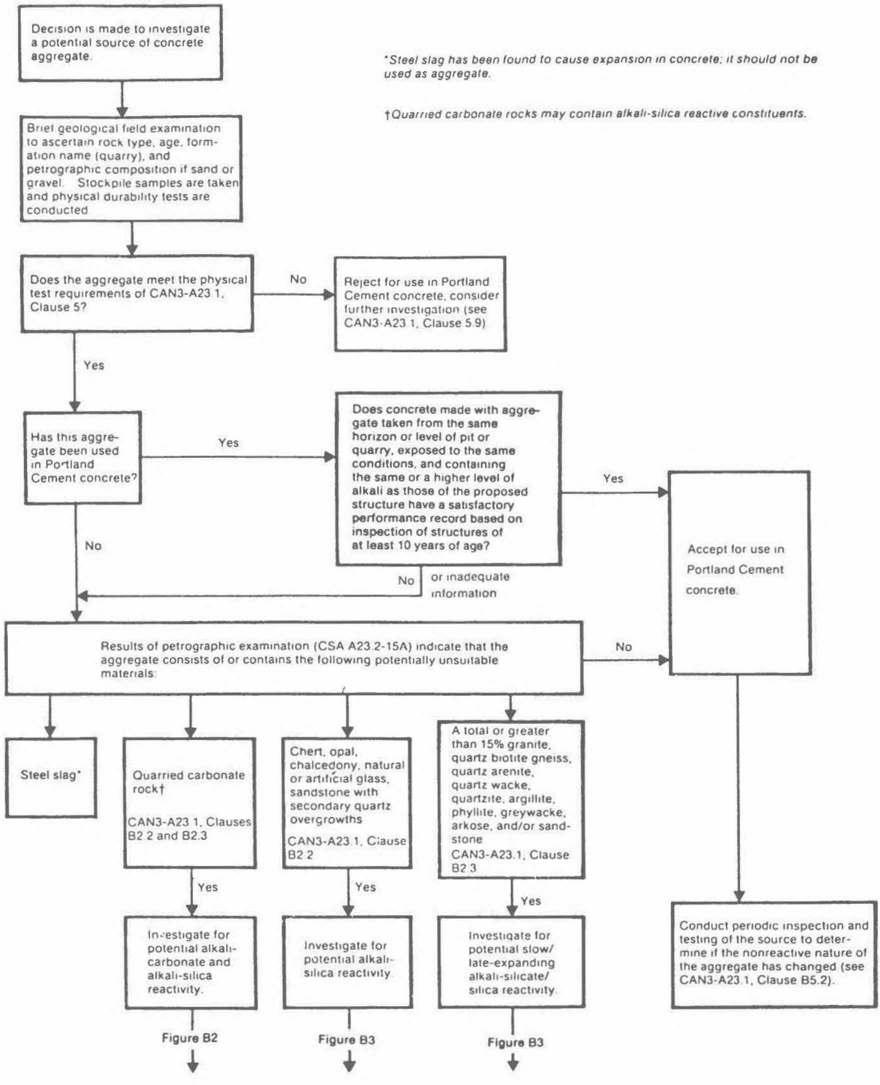

Figure B1
Concrete Aggregate Investigation Flow Chart for Coarse and Fine Aggregates

**A useful guide to textures of alkali-carbonate reactive aggregates is Report EM-31,* "Alkali Aggregate Reactions, Concrete Aggregate Testing and Problem Aggregates in Ontario: A Review", *by C.A. Rogers, 1979. Available from the Ministry of Transportation and Communications, Engineering Materials Office, Soils and Aggregate Section, 1201 Wilson Avenue, Central Building, Room 313, Downsview, Ontario M3M 1J8.*

†A rapid chemical method for preliminary evaluation of potentially alkali-carbonate reactive aggregates is given in Report EM-75, "Evaluation of the Potential for Expansion and Cracking Due to the Alkali-Carbonate Reaction", *by C.A. Rogers, 1986. Published by the Ministry of Transportation and Communications, Engineering Materials Office, Soils and Aggregate Section, 1201 Wilson Avenue, Central Building, Room 313, Downsview, Ontario M3M 1J8.*

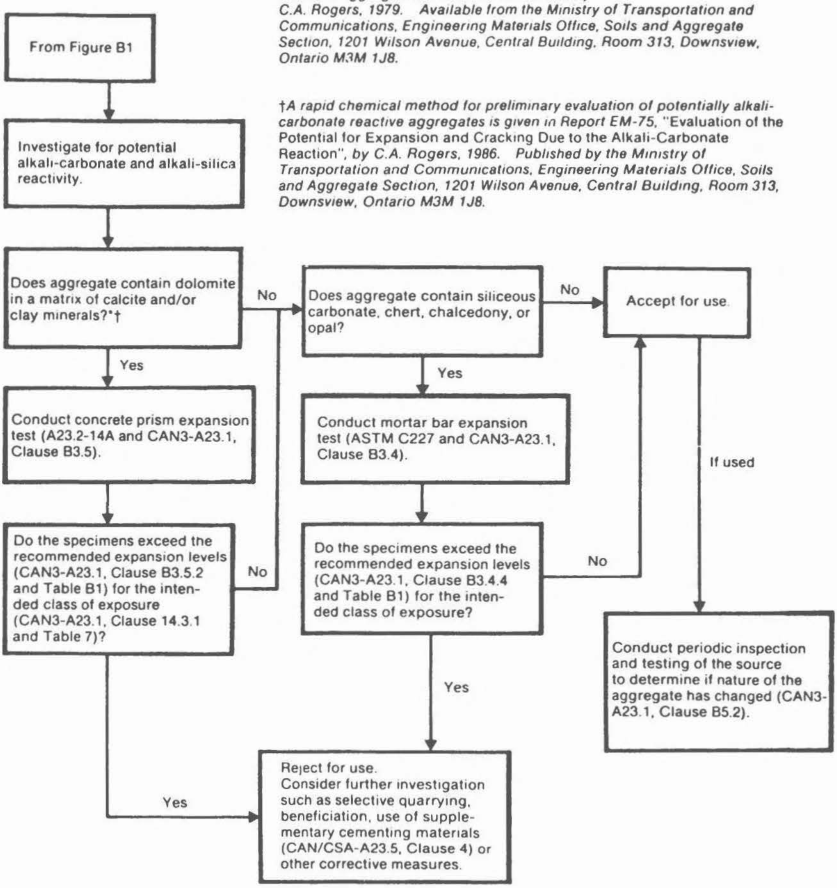

Figure B2
Procedure for Investigation of Suitability of Quarried Carbonate Rocks for Use in Portland Cement Concrete

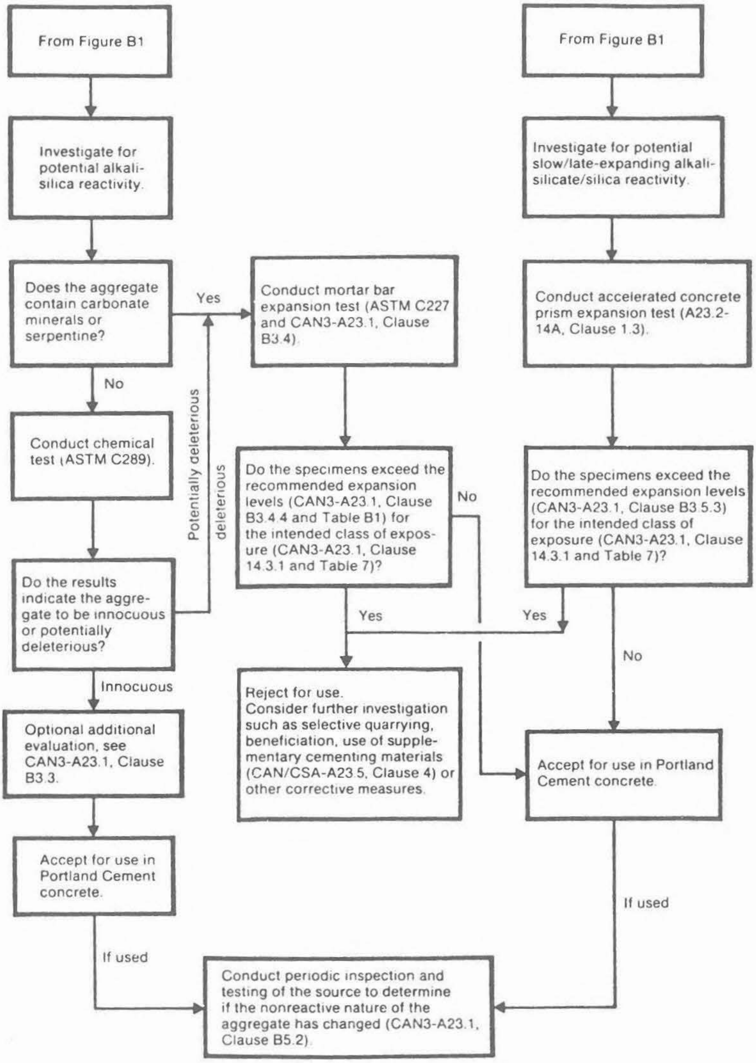

Figure B3
Procedure for Investigation of Suitability of Aggregates That are Potentially Alkali-Silica or Slow/Late-Expanding Alkali-Silicate/Silica Reactive for Use in Portland Cement Concrete