Technical Circular T-4/95
March 6, 1995

TO: All Headquarters Directors, Prof. Services, Planning & Major Projects
All Regional Directors
All Regional Managers, Prof. Services, Planning & Operations
All District Highways Managers

SUBJECT:

CONCRETE DAMAGE CAUSED BY ALKALI-AGGREGATE REACTIVITY (AAR)

PURPOSE:

To inform MoTH employees of the current status of the Ministry's AAR investigations, and draw attention to the new (1994) CSA recommendations for minimizing potential AAR damage.

BACKGROUND:

Until recently, there had been little concern over AAR damage in British Columbia. This seems to have been due to the relatively low cement contents in older structural concrete, and the much lower alkali content in B.C. cements compared with cements from elsewhere in Canada and U.S.A.

Recent events, such as the redecking of the Walloper overpass only three years after its construction, the generally higher cement content in modern mixes, and the higher alkali content in cements, caused the Ministry to initiate its own investigation into the potential reactivity of aggregate sources and incidents of structural damage.

An interim report, due for issue in April 1995, will present a detailed review of findings to date, but it seems that a completely reliable set of local guidelines will not be available until at least 1996 or later.

This Technical Circular briefly summarizes the current status, and refers to the CSA 1994 guidelines for minimizing potential AAR damage.

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Attachment

CONCRETE DAMAGE CAUSED BY ALKALI-AGGREGATE REACTIVITY (AAR)

(1) INTRODUCTION

Damage caused by alkali-aggregate reactivity was first identified in California in 1939. The damage was the result of formation of expansive gels when certain aggregates reacted with alkali in the concrete mix. Within one year, reports had been published describing the cause, and suggesting methods for its avoidance. Other research, mainly in the U.S.A., has added some detailed knowledge to the field. Methods of minimizing AAR damage are: avoidance of reactive aggregate sources; use of lower cement content or low-alkali cement; and use of admixtures such as pozzolans to reduce the alkali content.

In the past, cements manufactured in B.C. had roughly half the alkali content as cement from Alberta or U.S.A. Recently, environmental burning regulations have resulted in higher alkali content in B.C. cements. Also, cements imported from Alberta and U.S.A. are now common on Ministry projects. This, combined with the higher cement contents per cubic metre of concrete, compared with, say, 20 years ago, results in a much higher alkali content per cubic metre of concrete.

Recently-observed damage in certain MoTH structures has been identified as being due to alkali-aggregate reactivity. It now seems that some of the damage observed in previous years, and attributed to freezing, salt damage or poor workmanship, may have actually been AAR related.

To date, all AAR damage studied on MoTH projects is alkali-silicate reactivity (ASR) associated with fine-grained silicate rock, mainly of volcanic origin. The other form of AAR, alkali-carbonate reactivity, has not yet been identified.

(2) TEST METHODS

2.1 Aggregate Sources

Petrographic studies carried out by the Ministry since 1991 show that potentially reactive aggregates are more widespread than previously believed. The petrographic analysis, however, identifies as "potentially reactive" many sources which are innocuous.

Mortar bar tests and concrete prism tests more closely model the field performance of concrete made of the same materials, but require as much as three years to yield definitive results. Such tests are clearly not practical within the design and construction time frame of most bridges.

2.2 Existing Concrete

An ultraviolet fluorescent test devised in 19?? by the Strategic Highway R?? P?? (SHRP) shows promise in identifying AAR in existing concrete structures or test cylinders. It main use appears to be in assessing existing structures, and classifying their aggregate sources.

The SHRP test, although apparently more definitive than others, uses uranyl acetate, a chemical which is both highly toxic and radioactive. The Central Materials Laboratory is trying to develop a version of this test which utilizes a harmless fluorescent chemical as a preliminary screening test. It is not expected that such a method, if possible, would be available before 1997.

(3) **ADMIXTURES**

There are two categories of admixtures used to reduce alkali-aggregate reactivity in concrete:

(a) Pozzolans, such as fly ash, have been recognized since ???? as a means of reducing AAR damage. The Ministry's currently recognize use of pozzolans xxx in structural concrete, but not in bridge decks. This policy is under review in light of the recently-developed asphalt/membrane systems now in extensive use. Refer to MoTH Standard Specification 419.

(b) The use of lithium salts has been tested in several States with varying degrees of success. The Ministry installed field test sections at Kamloops in 1993, but monitoring and test cores to date indicate that clear results may require several years.

(4) **CSA STANDARDS**

The most promising development in recent years is the suggested limiting value of alkali per cubic metre of concrete. Research by CSA and others indicates that concrete containing less than this amount of alkali will not suffer significant damage, regardless of the reactivity potential of the aggregate.

After receiving comments on several draft versions, the 1994 CSA standards set 3.0 kilograms of alkali per cubic metre of concrete as a reasonable limiting value. Refer to CSA A23.1-94, Appendix B, page 112. This appendix is not a mandatory part of the standard, but provides a useful guideline.

(5) RECOMMENDATIONS

Pending a detailed study of aggregate sources throughout B.C. and development of definitive laboratory and field test methods, it is recommended that the CSA guidleines be followed by limiting the alkali content to three kilograms per cubic metre of concrete.

This guideline must not, however, be regarded as an alternative to enforcing the requirements of MoTH Standard Specification 211. Rather, by limiting the total alkali content of the concrete, an additional degree of protection against AAR damage is provided.

The Central Materials Laboratory has a large number of published papers on the subject, dating from 1940 to the present. Copies are available to Ministry staff on request.

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