CAN YOU AFFORD TO RISK AN ALKALI AGGREGATE REACTION?

ASH DEVELOPMENT ASSOCIATION

FLY ASH TECHNICAL NOTES

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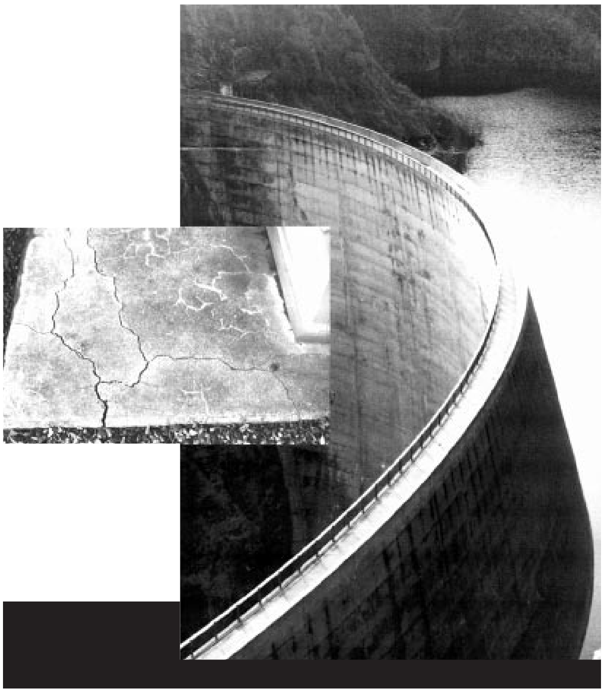


Gordon River Dam

At the Gordon River Dam, commercial fly ash was used to give lower heat of hydration. The aggegates have since proven to be alkali reactive. Associated structures, where fly ash was not used, are showing distress (see inset). The dam is unaffected.

INTRODUCTION

Alkali Aggregate Reaction (AAR) can seriously damage concrete and has caused severe problems in some Australian structures. Concrete specifiers should consider this risk in their designs. The addition of fly ash to the concrete provides economical insurance.

WHAT IS AAR?

Alkali aggregate reaction is a generic term for three different types of destructive expansive reactions that can occur in concrete. It can occur when concrete containing a potentially reactive aggregate responds to a relatively high level of alkalis from the cement or the environment. In Australia, alkali-silica reaction, ASR, is the prevalent form.

Susceptible aggregates which contain silica in a glassy form can be attacked by alkalis present in the cement. Alternatively the alkalis may be present in the environment as sea spray or in groundwater. The result is an alkali-silicate gel which occupies a larger volume than the original soluble ions from which it was formed.

The gel expands into any internal spaces where moisture may have been present. This may cause cracking and eventual failure of the structure. The expansion may occur at times up to 20 years after construction, depending upon circumstances.

WHAT CONDITIONS PROMOTE AAR?

Three factors must be present:

- reactive silica in the aggregate
- significant alkalinity
- moisture

Heat and humidity promote the most rapid reactions. With highly reactive materials however, even dew can provide enough moisture to sustain the process.

As an interesting aside, it is actually the higher strength grades of concrete that are most likely to show distress from AAR. Because of lower permeability, moisture is more likely to be retained in the concrete. In addition, because there is less void space available, a smaller quantity of reaction products is required to cause expansion at a destructive level.

Fly ash reduces the permeability of the concrete, but because the fly ash reacts with available alkalis, it removes that essential component of the reaction. As such, it is an effective means of reducing the risk of AAR occurring.

THE PESSIMUM* EFFECT

For a given reactive aggregate, there is a critical or "pessimum" mixture that will cause the maximum disruption in concrete. Once started, AAR is virtually impossible to stop whilst moisture is still available.

* Pessimum - opposite of optimum - proportion which maximises the negative effects.

WHERE DOES AAR OCCUR?

AAR has been reported in many parts of Australia, from Perth to North Queensland and Southern Tasmania in wharves, bridges swimming pools, reservoirs, pavement and other structures.

Within Australia, as well as overseas, the occurrence of AAR in bridges has been particularly reported. Bridge construction often uses high strength concrete. The exposure to weather and sometimes salt spray provide some of the conditions necessary for AAR to proceed.

MINIMISING THE CHANCES OF AAR

There are several preventative actions which will reduce the risk of occurrence of all three varieties of AAR. Most of the actions require detailed knowledge of the performance of either the cements or aggregates proposed to be used.

The most recommended action is the inclusion of fly ash, so that if a potential for reaction does exist, the fly ash will mitigate its effects.

SELECTION OF AGGREGATE

Wherever possible, both fine and coarse aggregates should be selected on the basis of proven satisfactory performance. This performance must however be measured over an extended period of time, because of the length of time taken for the reactions to become apparent.

If potentially reactive aggregate must be used, the following precautions are recommended:

1. Cement
A low alkali portland cement or alternatively a blended cement should be used. The alkali content should not exceed 0.6% and the portland cement content of the concrete should not exceed 380kg/m^3.

2. Fly Ash
At least 30% of the total cementitious material in the concrete should be fine grade fly ash complying with AS3582.1.

3. Structural design
The structure should be designed to shed water.

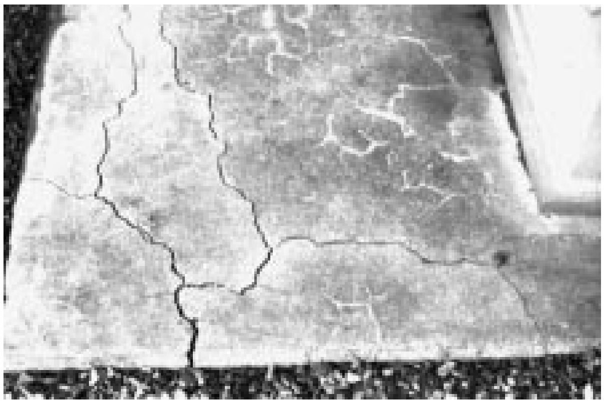
WHY TAKE THE RISK?

The specification of fly ash as an essential component of concrete will provide significant durability advantages compared to normal concrete. In addition the fly ash provides insurance against all forms of AAR.

Will this increase the cost of the concrete? In areas where fly ash is regularly available, there will be no cost penalty. The fly ash provides free insurance. In areas remote from a fly ash source, freight costs may be incurred. A small price to pay for peace of mind.

Further Reading
ADAA Case Studies Nos. 1 and 2 describe the performance of fly ash concrete at Tallowa Dam, where a potentially reactive aggregate was used.

"Alkali Aggregate Reaction - Guidelines on Minimising Damage to Concrete Stuctures in Australia" (CDCAA-T47), was produced by the Cement and Concrete Association of Australia and is now marketed by Standards Australia as HB79-1996.



AAR expansion is an associated structure at Gordon River Dam

Technical assistance on AAR or on other benefits of the use of fly ash in concrete may be obtained from Barry Butler, Development Coordinator, Ash Development Association of Australia,

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