Findings from Alkali Silica Reaction Research and Implications for Aggregate Suppliers

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Introduction

Alkalis from Portland cement react with reactive silica found in some aggregates causing expansion and cracking that can lead to deformation in concrete structures. This process is termed alkali silica reaction (ASR) and while once a significant problem for infrastructure has now largely been controlled. Three conditions are necessary for the reaction to significantly affect the serviceability of concrete:

- Reactive aggregates that typically contain glassy phases or strained quartz that are present in some volcanic and metamorphic rocks in New Zealand
- Sufficient alkalis such as sodium and potassium found in Portland cement, some salts and in chemical admixtures used in concrete
- High moisture levels to allow expansion of the silica gel that imbibes water molecules causing swelling and internal expansion that can result in cracking of concrete

Control of ASR in New Zealand is done using guidelines given CCANZ TR3 that use a risk assessment approach when designing concrete structures with potentially reactive aggregates. This approach was a significant improvement on other more prescriptive overseas guidelines but unfortunately was rather simplistically applied by most specifiers (e.g. application of the general concrete alkali limit of 2.5 kg/m^3 rather than assessing the real risk in terms of environment and service conditions). Recently the concrete alkali limit for reactive aggregates has been questioned by some concrete suppliers given that the same concrete alkali limit is set at 2.8 kg/m^3 in Australia and 3.2 kg/m^3 in the United Kingdom.

A research programme was therefore initiated to reassess the current concrete alkali limit used in New Zealand using more modern ASR testing methodology. This change in testing methodology was required as the quick chemical method used in the 1980's and 1990's was no longer supported by ASTM and because these techniques have been shown to be less reliable than modern concrete prism testing (i.e. some aggregates such as greywacke show false positive results). Currently the reactivity of concrete aggregates used in New Zealand are based on the following hierarchy of information:

- Track record of service in the field without any notable issues related the ASR-induced expansion
- Petrographic analysis of aggregate confirming that geology of rock does not contain potentially reactive phases such as glassy silica or strained quartz minerals that cause ASR
- Confirmation from chemical testing in accordance with ASTM C289 that material is non-reactive, which measures the chemical response of a ground rock powder to a hydroxide solution

Concrete aggregates assessed in this manner and having a history of being non-reactive should not require a full reassessment even if TR3 is revised in 2020 (e.g. greywacke and most basalt deposits). Periodic assessment using petrographic analysis will continue as before and should be done to confirm new areas of quarries are non-reactive and consistent with previous material.

Affordable Concrete (ASR) Research

The purpose of this research was to assess whether the general concrete alkali limit could be increased from the existing level of 2.5 kg/m^3 for concrete aggregates supplied to the Auckland and Waikato construction markets. The main reactive aggregate studied was Waikato River sand that is known to be

highly reactive and has been responsible for expansion and cracking damage of numerous structures in the region. Once the new ASR testing methodology had been shown to be sound, further testing was also initiated on Bay of Plenty andesite used in Tauranga.

Findings from this research were consistent and appeared to be reliable in the sense that clear trends and patterns were found that followed theoretical predictions. These findings from the research are as follows:

- The current concrete alkali limit could possible be lifted, which would produce economic benefits for quarries and concrete suppliers (i.e. less need to import non-reactive aggregates)
- New testing methodology using concrete prism testing is more reliable than quicker methods, which are no longer suitable except for petrographic analysis, which is still extremely useful
- Once the remainder of the laboratory findings are complete in late 2019 there will be sufficient data to revise CCANZ TR3 and have this published in 2020

Revision of CCANZ TR3

The full extent of this revision is not certain and will depend on the final findings from the ASR research and the consensus of the review committee. In general terms the following is likely to appear in the document that might be relevant to suppliers of concrete aggregates:

- Increase in the general concrete alkali limit reducing importation of concrete aggregates when supplying concrete for high strength applications (prestressed, marine or infrastructure concrete)
- Reactivity of New Zealand aggregates used in concrete will be listed as before and these are unlikely to change (i.e. previously non-reactive aggregate will remain classified as being non-reactive)
- The recommended ASR testing methodology will change in that the quick chemical testing method will be replaced by concrete prism testing that typically takes either 4 months (CPT-60 done at 60 ^{0}C) or 12 months (CPT-38 done at 38 ^{0}C)
- Notes will be added about some previously non-reactive aggregates that have been shown to be mildly reactive but the exact classification is uncertain on these (e.g. Rangitikei River sand containing traces of reactive volcanics and certain Southland and Nelson greywackes containing reactive volcanics)

Future Research and Protocols

CCANZ TR11 – Properties of New Zealand Aggregates (2003) will be revised in 2020 with the intention of surveying the reactivity of concrete aggregates used nationally. This research will however only be started once the proposed testing protocol for TR3 has been confirmed and equipment commissioned at the University of Canterbury. Should quarry operators want to undertake ASR assessment in 2019 they should contact Australian laboratories such as Boral, AARB or UTS and get pricing and logistics for running concrete prism testing (RILEM AAR-3). Quarries should consider undertaking this type of ASR testing in the following circumstances:

- When dealing with previously untested aggregates from new quarries and deposits
- When aggregates have been classified as non-reactive but petrographic analysis show potentially reactive phases and minerals (some greywacke sands containing glassy volcanic traces)
- When quarry is supplying to large infrastructure projects where structural specifications require recent confirmation of reactivity status (usually petrographic analysis is sufficient but occasionally performance testing is states as being mandatory)