THE HIGHWAYS AGENCY

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THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT FOR
NORTHERN IRELAND

The Assessment of Concrete Structures affected by Alkali Silica Reaction

Summary: This document provides guidance on the strength assessment of concrete structures affected by Alkali Silica Reaction.

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REGISTRATION OF AMENDMENTS

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VOLUME 3 HIGHWAY STRUCTURES: INSPECTION AND MAINTENANCE

SECTION 4 ASSESSMENT

PART 10

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THE ASSESSMENT OF CONCRETE STRUCTURES AFFECTED BY ALKALI SILICA REACTION

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1. INTRODUCTION

General

1.1 In recent years a considerable number of bridges in the UK have been diagnosed as suffering from ASR (Alkali Silica Reaction). In severe cases, this reaction leads to extensive cracking and has therefore caused considerable concern. Initially it was assumed that the presence of ASR would lead to substantial reductions in strength. More recently, however, extensive research has shown that ASR has much less effect on strength than would be imagined from the appearance of affected members. Indeed a number of tests have identified some increase in strength due to ASR.

1.2 Various methods have been investigated for assessing ASR affected structures [1]. However, recent research suggests that the use of BD 44 (DMRB 3.4) formulae in conjunction with the in- situ concrete compressive strength is as reliable as any approach. It is generally conservative as the strength of many structures with ASR is less affected by ASR than is concrete compressive strength. There are, however, a few situations where greater strength reductions than implied by concrete compressive strength could occur. These are considered in Chapter 2 of this Advice Note.

Scope

1.3 This document gives guidance on the assessment of structures affected by ASR. It is to be read in conjunction with BD 44 (DMRB 3.4) and BA 44 (DMRB 3.4), and should be used in the assessment of structures where the presence of ASR is confirmed.

Implementation

1.4 This Advice Note should be used in all future assessments of structures or structural elements. It should also be taken into account in assessments currently at hand unless, in the opinion of the Overseeing Organisation, this would result in an unacceptable additional expense or delay.

2. STRENGTH ASSESSMENT

Inspection

2.1 Structures suspected of suffering from ASR should have a "Special Inspection" in accordance with BA 35 (DMRB 3.3) before they are assessed. The information required from this is essentially as for unaffected structures. However, special attention should be given to the possibility of delamination and any evidence of this should be reported. Delamination and excessive cracking particularly in areas of high bond or shear stress should also be noted. In such areas attempts should be made to see if there are cracks in line with the reinforcement.

2.2 If cracking, even of the characteristic map form, is observed it does not necessarily indicate that ASR is the primary cause. Even in concretes which are known to be susceptible to ASR, such cracking may be due to other causes. It should not be assumed that ASR is the cause until other explanations have been eliminated. Guidance on the correct diagnosis of ASR is given in reference 2.

2.3 The strength reductions due to mild amounts of ASR are not great and expansions of less than 0.7mm/m, based on core expansion tests at 20°C and 100% relative humidity, do not normally cause any significant loss of strength. Structures with these mild amounts of ASR, i.e with an estimated 0.7mm/m or less of free expansion, do not therefore require special investigation.

Concrete Properties

2.4 It is normally necessary to rely on a combination of cores and judgement to obtain estimates of concrete strength. Reference 3 gives advice on cores in ASR affected structures. Due to the cracks induced by the ASR, cores taken from ASR affected structures are liable to give rather variable results. However, the strength of the structure appears to be better indicated by strengths obtained from relatively intact cores. Chana and Korobokis (Ref. 4), found that cores under-estimated strength even when excessively cracked cores were rejected. Where it is not possible to take sufficient cores to give reliable strength estimates, reliance will have to be placed on judgement. If the degree of ASR can be quantified into an estimated free expansion (see Reference 2), the strength loss from this can be conservatively estimated from Reference 3.

2.5 Some aspects of structural behaviour, such as bond and shear, are more closely related to tensile than compressive strength. However, tensile tests on cores taken from ASR affected concrete give results which are too variable to be of much practical use.

Delamination

2.6 In structures which are severely affected by ASR, delamination of cover concrete can occur. This is extremely rare and such delamination is much more frequently caused by corrosion of reinforcement. Even if the delamination is caused by ASR, it is liable to lead to reinforcement corrosion and to require remedial action. Strength assessment is therefore only required to ensure the immediate safety of the structure.

2.7 If the cover concrete is delaminating over significant areas the structure should be assessed ignoring the cover concrete in those regions. The bond with bars which are in the plane of delamination should also be ignored. The bars should also be ignored for the purposes of calculating the ultimate concrete shear stress, v_c.

Bond Strength

2.8 The presence of ASR is one of many factors which affect bond strength. Detailed recommendations on the prediction of bond strength are given by Chana and Korobokis[5,6]. In general the recommendations of BD 44 (DMRB 3.4) are safe in all sections with links. Where sections have no links and have low cover the BD 44 values may be unsafe and special investigation is required.

Future Deterioration

2.9 With the possible exception of delamination, any reduction of strength due to ASR is as a result of the deterioration of concrete properties and not the expansion itself. The strength reduction is not progressive and, for structures which are regularly inspected in accordance with the Overseeing Organisations' procedures, it will normally be sufficient to assess them on the basis of present condition with no allowance for future deterioration.

3. REFERENCES

1. Clark L A Critical Review of the Structural Implications of ASR in Concrete. TRL Contractor Report 169,1989.

2. British Cement Association. The Diagnosis of Alkali Silica Reaction. Wexham Springs. Second edition. (1992.)

3. The Institution of Structural Engineers. Structural Effects of Alkali Silica Reaction; Technical Guidance on the Appraisal of Existing Structures. July 1992.

4. Chana P S and Korobokis G A. Structural Performance of Reinforced Concrete Affected by Alkali Silica Reaction: Contractor Report 267, Crowthorne, Transport and Road Research Laboratory.

5. Chana P S. Bond strength of reinforcement in concrete affected by Alkali Silica Reaction. Crowthorne. Transport and Road Research Laboratory, Contractor Report 141, 1989.

6. Chana P S and Korobokis G A. Bond Strength of Reinforcement in Concrete Affected by Alkali Silica Reaction: Phase ii. Crowthorne. Transport and Road Research Laboratory, Contractor Report 233, 1991.

7. **Design Manual for Roads and Bridges (DMRB)**
Volume 3 Section 4.

BD 44. The Assessment of Concrete Highway Bridges and Structures (DMRB 3.4).

BA 44. The Assessment of Concrete Highway Bridges and Structures (DMRB 3.4).

BA 35. Inspection and Repair of Concrete Highway Structures (DMRB 3.3).

4. ENQUIRIES

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