

Guide to

The interpretation of petrographical examinations for alkali-silica reactivity

ICS 91.100.15

Confirmed
March 2008

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/502, Aggregates, to Subcommittee B/502/2, Aggregates for concrete including those for use in roads and other pavements, upon which the following bodies were represented:

- Association of Consulting Engineers
- British Geological Survey
- British Precast Concrete Federation Ltd.
- County Surveyors' Society
- Department of the Environment, Transport and the Regions
- Department of the Environment, Transport and the Regions (Building Research Establishment)
- Department of the Environment, Transport and the Regions (Highways Agency)
- Quarry Products Association

This British Standard, having been prepared under the direction of the Sector Committee for Building and Civil Engineering, was published under the authority of the Standards Committee and comes into effect on 15 July 1999

© BSI 07-1999

Amendments issued since publication

Amd. No.	Date	Comments

The following BSI references relate to the work on this standard:
Committee reference B/502
Draft for comment 98/101379 DC

ISBN 0 580 28273 2

Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
1 Scope	1
2 Characteristics of UK aggregates	1
3 Classification of aggregates	2
Annex A (informative) Precision of the procedure for qualitative and quantitative petrographic examination of aggregates	7
Annex B (informative) Gel-pat test for the detection of opaline silica	7
Annex C (informative) Example of report form	14
Bibliography	15
Figure B.1 — Typical pat specimen at the end of a test, showing several gel growths — Specimen immersed in the storage solution	11
Figure B.2 — Typical pat specimen at the end of a test, showing several gel growths — Specimen removed from the storage solution but kept wet	12
Figure B.3 — Typical pat specimen at the end of a test, showing several gel growths — An oblique view of the pat after drying in ambient conditions	13
Table 1 — Guidance on rock types	3
Table 2 — Guidance on mineral types	6
Table B.1 — Detection limits for the gel-pat test	10

Foreword

This British Standard has been prepared by Technical Committee B/502/2.

The purpose of this guide is to assist in the selection of aggregate combinations which will minimize the risk of damage to concrete caused by alkali-silica reactivity (ASR).

Current recommendations allow for the risk of damaging ASR to be minimized by limiting the alkali content of the concrete, by using additions (such as pfa or ggbs) or by using an aggregate combination of low reactivity. In many instances either the alkali control or the use of additions may prove to be the most suitable option. However, there may be circumstances when it is considered necessary to specify the use of an aggregate combination of low reactivity.

A method of test using concrete specimens has been developed (BS 812-123) and an accelerated test using mortar-bar specimens is currently being developed. However, a petrographical examination can be completed more quickly and so can be used for a relatively rapid assessment of an aggregate combination. This guide offers advice on the interpretation of the results of the petrographical examination of aggregate samples carried out according to BS 812-104 in terms of the reactivity of a particular aggregate combination.

The principle of the interpretation described in this guide is to ensure that:

- a) the most reactive minerals (opal or opaline silica) are not present in aggregates used; and
- b) aggregates may be classified as being of low, normal or high reactivity on the basis of their petrographic composition.

General precision of the BS 812-104 petrographic examination method has been assessed by trials and the findings apposite to this guidance, in particular the quantification of those constituents considered to be potentially reactive, are summarized in annex A. The detection of those mineral constituents defined in this guide as being the most reactive (i.e. opal or opaline silica) may require use of the gel-pat test in addition to petrographic examination. A suitable method is provided in annex B.

It is essential that the sample examined is adequately representative of the material being assessed. A procedure is given in BS 812-102 for sampling processed aggregates. In interpreting the results of a petrographical examination the method of sampling should be taken into account.

Annexes A, B and C are informative.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligation.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 15 and a back cover.

1 Scope

This British Standard gives guidance on the interpretation of the results of petrographical examination of coarse and fine aggregates, carried out in accordance with BS 812-104, in terms of the susceptibility of the combined aggregate to alkali-silica reactivity (ASR) sufficient to cause damage to concrete in which it is used. The guidance is not applicable to alkali-carbonate reactive materials.

NOTE 1 Guidance on precision expected from the petrographical examination of coarse and fine aggregates, carried out in accordance with BS 812-104, is given in annex A.

NOTE 2 It is recommended that a petrographical examination be carried out by a petrographer who is a member of the Proficiency Scheme for Aggregate Petrographers.

2 Characteristics of UK aggregates

2.1 Rocks are traditionally classified according to their mode of formation, grain size, texture and mineral composition. Crushed rock aggregates, with a few exceptions, retain the geological name of the parent rock. Natural aggregates are sands and gravel formed by geological erosion of rock and are composed of particles of rock and occasionally, particularly in the case of sand, discrete mineral grains. Sometimes, over-sized gravel material is crushed and then blended with the natural aggregate, the resulting aggregate being generally regarded as a natural aggregate.

2.2 Aggregate combinations (i.e. the total coarse and fine aggregate mixture for a given concrete) are mainly classified as being of low, normal or high reactivity on the basis of their petrographic composition (see notes 1 and 2). Aggregates containing detectable amounts of opal or opaline silica are not classified and, in most circumstances, should not be used in concrete (see 2.4).

NOTE 1 A full explanation of this classification system may be found in BRE Digest 330 (1997 edition) [1].

NOTE 2 Experience indicates that most UK aggregate combinations will be classified as being of normal reactivity, with precautions to minimize any risk of ASR damage to concrete being taken in accordance with the appropriate advice provided by BS 5328, BRE Digest 330 [1], Concrete Society Technical Report 1999 [2] and the *Specification for Highway Works* (Highways Agency) [3].

NOTE 3 Minor concentrations of other constituents (e.g. shell) are permitted in aggregates for concrete, within the limits given in BS 882.

2.3 The mineral constituents of concern from the point of view of ASR are the following:

- a) opal or opaline silica;
- b) tridymite;
- c) cristobalite;
- d) quartz with crystal dislocations;
- e) microcrystalline quartz;
- f) highly strained quartz (see Table 1, note 3)
- g) volcanic glass (see Table 1, note 8);

NOTE 1 Tables 1 and 2 give guidance for petrographers on rock types in which potentially alkali-silica reactive constituents occasionally occur. An indication of the reported occurrences in practice in the UK is included

NOTE 2 Definitions of rock and mineral types are included in Tables 1 and 2.

NOTE 3 The reactivity of silica constituents is dependent upon the degree of thermodynamic disorder of the molecular structure, with opal being the most disordered form of silica and unstrained quartz being the least disordered form.

2.4 Opal or opaline silica is the most reactive of the mineral constituents listed in 2.3.

NOTE Opal or opaline silica are very rarely encountered in UK aggregates. However, in situations where they are encountered, they are usually found in low concentrations and often dispersed within aggregate particles. This may lead to difficulties in detecting these particles or constituents using petrography alone. If the presence of these exceptionally reactive constituents is suspected, it will be necessary to undertake a gel-pat test in addition to the petrographical examination (a gel-pat method is given in annex B).

2.5 In the UK most cases of damage from ASR have involved flint and chert (rocks comprising mainly microcrystalline quartz) usually, although not exclusively, found in sand and gravels. However, a few cases of ASR have been identified in which other aggregate types were involved. In these cases crushed greywacke type sandstone (usually referred to simply as greywacke) and greywacke type siltstones (usually referred to in this context as siltstone) have been identified as the reactive aggregate, containing very finely distributed microcrystalline quartz and sometimes also dislocated quartz.

NOTE 1 Investigations (Blackwell and Pettifer [4] and Blackwell et al [5]) into crushed greywackes selected from UK sources have shown, when tested by the method described in BS 812-123 and an accelerated mortar-bar method, that aggregates from about half of the sources would be considered possibly deleterious in use. These tests have shown that expansion increased more or less proportionally with the amount of crushed greywacke present. In some tests concentrations of 10 % greywacke (mixed with ASR-inert aggregates) produced expansion. Concentrations of 30 % greywacke would be considered possibly deleterious in use. As the reactive constituent is concentrated in the fine grained matrix it is not possible to distinguish reactive and non-reactive greywacke type sandstones/siltstones using petrography alone.

NOTE 2 Experience to date indicates that greywacke type sandstone/siltstone particles contained within UK natural sands and gravels exhibit a much lower ASR potential than petrographically similar materials within a crushed rock aggregate.

3 Classification of aggregates

3.1 Although individual aggregates may be classified using the information in this guide, the selection of the appropriate measures for minimizing any risk of ASR will depend upon the classification of the total aggregate combination.

3.2 Any aggregate containing detectable opal or opaline silica should not be classified and, in most circumstances, should not be used in concrete.

3.3 An aggregate or aggregate combination should be classified as being of low reactivity if it wholly (see note) comprises rock and mineral constituents considered to be of low reactivity potential in Tables 1 and 2 and contains no detectable opal or opaline silica (see 3.2).

NOTE In this context, "wholly" is used to define aggregate containing not more than 3 % by mass of rock and any mineral constituents considered to be of normal or high reactivity in Tables 1 and 2.

3.4 An aggregate or aggregate combination should be classified as being of high reactivity if it comprises either more than 10 % crushed greywacke (i.e. greywacke type sandstone or siltstone, see note 1) or recycled demolition waste (see note 2) and contains no detectable opal or opaline silica (see 3.2).

NOTE 1 Natural sand and gravel and gravel aggregates containing uncrushed greywacke material should be classified as being of normal reactivity (see 3.5).

NOTE 2 There is expected to be increased usage of recycled aggregates consisting mainly of crushed concrete and masonry. Pending greater experience of their use, at present it is considered prudent to regard these aggregates as being of high reactivity.

3.5 An aggregate or aggregate combination should be classified as being of normal reactivity if it cannot be classified as being of low (see 3.3) or high (see 3.4) reactivity and contains no detectable opal or opaline silica (see 3.2).

NOTE 1 Aggregate combinations which are classified as being of normal reactivity by petrography may be re-classified as being of low reactivity on the basis of expansion results from the BS 812-123 concrete prism test method. Guidance on the interpretation of these results is given in BS 812-123 and BRE Digest 330 [1]. Preferably such expansion testing should be undertaken as part of an approved quality control procedure.

NOTE 2 Aggregate combinations are sometimes associated with the greatest expansion in concrete when the reacting constituent forms significantly less than 100 %; this is often termed "pessimum behaviour". In many cases, for reasons still being investigated, concrete expansion is decreased or even eliminated as the proportion of reactive constituent increases within the aggregate. In the UK, pessimum behaviour has almost always been associated with reacting flint or chert particles in sand and gravel aggregates. Such flint/chert bearing aggregates will usually be classified by petrography as being of normal reactivity.