



Structure and Performance of Cements

Second Edition

Edited by

J. Bensted and P. Barnes

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London and New York

First published 2002 by Spon Press
11 New Fetter Lane, London EC4P 4EE

Simultaneously published in the USA and Canada
by Spon Press
29 West 35th Street, New York, NY 10001

Spon Press is an imprint of the Taylor & Francis Group

©2002 Spon Press

Typeset in 10/12, Sabon by Newgen Imaging Systems (P) Ltd.

Printed and bound in Great Britain by
St Edmundsbury Press, Bury St Edmunds, Suffolk

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British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data

Structure and performance of cements/J. Bensted and P. Barnes [editors].—2nd ed.
p. cm.

Includes bibliographical references and index.

1. Cement. I. Bensted, J. II. Barnes, P. (John)

TA434. S94 2001
624.1'833—dc21

0-419-23330-X

2001020916

Structure and Performance of Cements

Contributors

Dr L. P. Aldridge
Australian Nuclear Science and Technology
Organisation
Lucas Heights Research Laboratories
PMB7 1, Menai
Bangor
New South Wales 2234
Australia

M. Attfield
Industrial Materials Group
Department of Crystallography
Birkbeck College
University of London
Malet Street
London, WC1E 7HX
UK

Stephen P. Bailey
Industrial Materials Group
Department of Crystallography
Birkbeck College
University of London
Malet Street
London, WC1E 7HX
UK

Prof Paul Barnes
Industrial Materials Group
Department of Crystallography
Birkbeck College
University of London
Malet Street
London, WC1E 7HX
UK

Prof John Bensted
Industrial Materials Group
Department of Crystallography
Birkbeck College
University of London
Malet Street
London, WC1E 7HX
UK

Prof S. Chandra
Division of Applied Concrete Chemistry
Chalmers University of Technology
Sven Hulting Gata 8
S-412 96 Gothenburg
Sweden

Dr A. K. Chatterjee
The Associated Cement Companies Ltd
Research & Consultancy Directorate
CRS Complex
L.B.S. Marg
Thane 400 604
India

Dr T. M. Chrisp
Department of Civil and Offshore Engineering
Heriot-Watt University
Riccarton
Edinburgh, EH14 4AS
UK

Dr Sally L. Colston
Industrial Materials Group
Department of Crystallography
Birkbeck College

University of London
Malet Street
London, WC1E 7HX
UK

Dr D. Damidot
Lafarge Central Laboratory
95 rue du Montmurier
BO 15, 38291
Saint Quentin Fallavier
France

Dr Wolfgang Ehrfeld
IMM Institute of Microtechnology
GmbH
Carl-Zeiss-Strasse 18–20
D-55129 Mainz-Hechsteim
Germany

Dr C. Famy
Lafarge
Laboratoire Central de Recherche
95 Rue du Montmurier – B.P. 15 38291
St Quentin Fallavier Cedex
France

Dr Herbert Freimuth
IMM Institute of Microtechnology
GmbH
Carl-Zeiss-Strasse 18–20
D-55129 Mainz-Hechsteim
Germany

Dr E. M. Gartner
Lafarge
Laboratoire Central de Recherche
95 Rue du Montmurier – B.P. 15 38291
St Quentin Fallavier Cedex
France

Prof Christopher Hall
Division of Engineering and Centre for
Materials Science & Engineering
The University of Edinburgh
King's Buildings
Edinburgh EH9 3JL
UK

Dr I. Hinczak
Cementech Pty. Ltd.
PO Box 362
Liverpool
New South Wales 2170
Australia

Dr D. Hobbs
British Cement Association
Century House
Telford Avenue
Crowthorne
Berkshire, RG11 6YS
UK

Dr S. D. M. Jacques
Industrial Materials Group
Department of Crystallography
Birkbeck College
University of London
Malet Street
London, WC1E 7HX
UK

Dr Hans J. Jakobsen
Instrument Centre for Solid-State
NMR Spectroscopy
Department of Chemistry
University of Aarhus
DK-8000 Aarhus C
Denmark

Dr I. Jawed
Transportation Research Board
National Research Council
Washington D.C. 20418
USA

Dr Tom R. Jones
New Materials Group
Imerys Minerals Ltd
John Keay House
St Austell
Cornwall, PL25 4DJ
UK

Contributors

Dr A. C. Jupe
Industrial Materials Group
Department of Crystallography
Birkbeck College
University of London
Malet Street
London, WC1E 7HX
UK

Prof H. Justnes
SINTEF
Civil & Environmental Engineering Group
Cement & Concrete Group
N-7034 Trondheim
Norway

Prof Wiesław Kurdowski
Institute of Building Materials
Academy of Mining and Metallurgy
Al. Mickiewicza
Pawilion A3
Krakow
Poland

Dr E. Lang
Abteilungsleiter
Forschungsgemeinschaft
Eisenhuettenschlacken EV
Forschungsinstitut
Bliersheimer Str 62
D-47229 Duisberg
Germany

P. Livesey
Castle Cement Ribblesdale Ltd
Clitheroe
Lancashire BB7 4QF
UK

Dr Karen Luke
Now at:
Halliburton Energy Services
Duncan Technology Center
2600 South 2nd Street
Duncan, Oklahoma 73536
USA

Dr S. Lunt
Thermo VG Scientific
Imberhorne Lane
West Sussex, RH19 1UB
UK

Prof F. Massazza
Laboratorio Centrale
Italcementi-SCF S.p.A.
Via Gabriele Camozzi 124
I-24100 Bergamo
Italy

Dr C. E. Matulis
CSIRO Coal and Energy Technology Division
Lucas Heights Research Laboratories
PMB7
Bangor
New South Wales 2234
Australia

Prof W. J. McCarter
Department of Civil and Offshore Engineering
Heriot-Watt University
Riccarton
Edinburgh, EH14 4AS
UK

S. Morgan
Industrial Materials Group
Department of Crystallography
Birkbeck College
University of London
Malet Street
London, WC1E 7HX
UK

R. Pisula
Industrial Materials Group
Department of Crystallography
Birkbeck College
University of London
Malet Street
London, WC1E 7HX
UK

Dr David O'Connor
Industrial Materials Group
Department of Crystallography
Birkbeck College
University of London
Malet Street
London, WC1E 7HX
UK

Prof Herbert Pöllman
Institut für Geologische Wissenschaften und
Geiseltalmuseum
Martin Luther Universität
D-06099 Halle (Saale)
Germany

Dr I. Richardson
Civil Engineering Materials Unit
School of Civil Engineering
University of Leeds
Leeds, LS2 9JT
UK

Prof K. L. Scrivener
Lafarge
Laboratoire Central de Recherche
95 Rue du Montmurier – B.P. 15 38291
St Quentin Fallavier Cedex
France

Dr Jørgen Skibsted
Instrument Centre for Solid-State
NMR Spectroscopy
Department of Chemistry
University of Aarhus

DK-8000 Aarhus C
Denmark

Dr G. Starrs
Department of Civil and Offshore Engineering
Heriot-Watt University
Riccarton
Edinburgh, EH14 4AS
UK

Prof H. F. W. Taylor
Maundry Bank
Lake Road
Coniston, Cumbria LA21 8EW
UK

Dr J. C. Taylor
CSIRO Coal and Energy Technology Division
Lucas Heights Research Laboratories
PMB7
Bangor
New South Wales 2234
Australia

Prof J. F. Young
Center for Cement Composite Materials
205 Ceramics Building
105 S. Goodwin Avenue
University of Illinois at Champaign-Urbana
Urbana, Illinois 61801
USA
Now at:
R.D.2 Katikati
New Zealand

Preface

Structure and Performance of Cements was first published in 1983. Much has changed over the last 18 years, but still, a surprisingly large number of the reasons given then for the need for such a book are equally valid today; these include:

- Cements constitute the second largest manufactured commodity (by weight) in the world
- Most peoples' lives are continually dependent upon the properties of cements
- Only a small fraction of income derived from the manufacture and marketing of cements is spent on research into the properties and applications of cements, including new developments

However, although the basic starting materials for the manufacture of most cements have not changed very much, the subject has in fact moved on appreciably. Cements today have a greater number and range of applications than ever before. The various types of cements now available (with and without inclusions of additives/admixtures) have increased significantly in numbers. New techniques of examination have arrived and our understanding of the performance requirements and utilization of many different types of cements has improved.

In particular, wet process manufacture for Portland cements is declining rapidly because of the high energy costs involved in driving off the water from the raw material slurries. Modern developments now permit more environmentally friendly dry process manufacture from soft raw materials like chalk and clay with their significant moisture contents using flash calciners. Also important environmentally friendly uses for materials, previously regarded as industrial wastes in

the manufacture of cements, save substantial amounts of traditional fuels like coal, gas and oil. Such pyrotechnic processes now allow wastes that used to be dumped, to be disposed off safely by burning in cement kilns on a routine basis.

This is complemented by cement extension, which means that industrial by-products such as pulverized fuel ash (pfa), ground granulated blast-furnace slag (ggbfs) and condensed silica fume (csf or 'microsilica') can partially replace Portland cement clinker in cements. Such replacement permits substantial benefits in the range of applications of the finished cements in grouts, mortars and concretes.

The second edition of the book has been produced, like the first edition, for those scientists and engineers working in both the cement and general construction industry and for research and development specialists in universities and colleges, who need an up-to-date knowledge in key areas of cement technology that have moved on since 1983. It is not intended to be a standard textbook dealing with the whole range of cement types and their applications. Instead, a focused tome has been produced with contributions by a multinational consortium of authors to indicate the global developments that have arisen over the last seventeen years. Modern cement manufacturing methods, key types of cement extenders and important examining techniques, both new, and developments in existing important methods, have been highlighted for addressing a global audience. This updated book is intended to reflect both current production and research in the cement arena, but, as indicated above, is not intended to be an exhaustive treatise, which would have been unmanageably large.

The order of presentation reflects the evolutionary developments that have arisen, and is divided roughly into three broad categories:

- Basic materials and methods – cement manufacture, cement phase composition, Portland cement hydration, calcium aluminate cements, properties of concrete with admixtures, special cements, various reaction/corrosion mechanisms.
- Cement extenders – ggbs, natural pozzolans, pfa, metakaolin and csf – where there have been considerable developments in terms of quality and application; many other extenders have not been included where there is still much basic work needed.
- Techniques of examination highlighted include the well established X-ray diffraction and electron microscopy, where there have been numerous developments in the last seventeen years, together with more recently introduced

methods (electrical impedance, NMR, synchrotron radiation-based techniques) which, with cement-based composite microstructures, need to be drawn to the attention of a wider audience. Some of the more traditional techniques have been excluded since relatively few novel applications have appeared in recent years.

As the editors, we have endeavoured to obtain a widespread balance of authors from a number of different countries around the world. Many of these authors are well known internationally. They are joined by others who are newer to the field and who help to establish a broader viewpoint, both technically and through wide international coverage. We feel privileged to have succeeded in bringing such a distinguished worldwide group of authors together in one book under the umbrella title of *Structure and Performance of Cements*.

Notation

Standard cement chemistry notation is assumed throughout this book:

$A = \text{Al}_2\text{O}_3$	$C = \text{CaO}$	$\overline{C} = \text{CO}_2$	$F = \text{Fe}_2\text{O}_3$	$f = \text{FeO}$
$H = \text{H}_2\text{O}$	$K = \text{K}_2\text{O}$	$M = \text{MgO}$	$N = \text{Na}_2\text{O}$	$S = \text{SiO}_2$
$\overline{S} = \text{SO}_3$	$T = \text{TiO}_2$	C-S-H denotes a variable composition		

AFm denotes a solid solution range within the monosulphate-type structure (i.e. calcium monosulpho-aluminate hydrate to calcium monosulpho-ferrite hydrate).

AFt denotes a solid solution range within the ettringite-type structure (i.e. calcium trisulpho-aluminate hydrate to calcium trisulpho-ferrite hydrate).

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