Polymer Support Fluids in Civil Engineering

Polymer Support Fluids in Civil Engineering

Carlos Lam

DPhil CEng MICE MHKIE

Stephan A. Jefferis

PhD CEng CEnv FICE CGeol FGS FRSA

Published by ICE Publishing, One Great George Street,
Westminster, London SW1P 3AA

Full details of ICE Publishing representatives and distributors can be found at: www.icebookshop.com/bookshop_contact.asp

Other titles by ICE Publishing:

Civil Excavations and Tunnelling – A Practical Guide, Second edition
R. Tatiya. ISBN 978-0-7277-6153-8

ICE Specification for Piling and Embedded Retaining Walls,
Third edition

Institution of Civil Engineers. ISBN 978-0-7277-6157-6

Earthworks: A Guide, Second edition

P. Nowak and P. Gilbert. ISBN 978-0-7277-4116-5

www.icebookshop.com

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

ISBN 978-0-7277-5786-9

© Thomas Telford Limited 2018

ICE Publishing is a division of Thomas Telford Ltd, a wholly-owned subsidiary of the Institution of Civil Engineers (ICE).

All rights, including translation, reserved. Except as permitted by the Copyright, Designs and Patents Act 1988, no part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying or otherwise, without the prior written permission of the Publisher, ICE Publishing, One Great George Street, Westminster, London SW1P 3AA.

This book is published on the understanding that the authors are solely responsible for the statements made and opinions expressed in it and that its publication does not necessarily imply that such statements and/or opinions are or reflect the views or opinions of the publishers. The right of Carlos Lam and Stephan Jefferis to be identified as authors of this work has been asserted by them in accordance with sections 77 and 78 of the Copyright, Design and Patents Act 1988. While every effort has been made to ensure that the statements made and the opinions expressed in this publication provide a safe and accurate guide, no liability or responsibility can be accepted in this respect by the authors or publisher.

While every reasonable effort has been undertaken by the author and the publisher to acknowledge copyright on material reproduced, if there has been an oversight please contact the publisher and we will endeavour to correct this upon a reprint.

Commissioning Editor: Michael Fenton
Development Editor: Maria Inês Pinheiro
Production Editor: Madhubanti Bhattacharyya
Market Development Executive: Elizabeth Hobson

Typeset by Academic + Technical, Bristol

Index created by Laurence Errington

Printed and bound in Great Britain by TJ International, Padstow

This book is dedicated to the contractors, consultants, academics and material suppliers who have done so much over many years to advance the understanding of excavation support fluids in civil engineering. Without their unstinting help this book would not have been possible. We also recognise the special contributions of our families, teachers and students.

Contents

About the authors

ix

01	Introduction to fluid-supported excavation	1
	1.1. What is a support fluid?	1
	1.2. Terminology	1
	1.3. A brief history of drilling and support fluids	2
	1.4. How support fluids work	5
	1.5. Critical functions of support fluids	7
	References	13
02	Constraints on the use of bentonite support fluids	17
	2.1. Introduction	17
	2.2. The steady decline in the reserves and the perceived reduction in performance of some bentonites	17
	2.3. Mixing and hydration requirements of bentonite fluids	18
	2.4. Requirement of surface treatment plant	21
	2.5. Disposal of used fluids: environmental regulations and on-site treatment	22
	2.6. Environmental impact	25
	2.7. Soil dispersion	26
	References	27
03	Introduction to polymers and polymer fluids	29
	3.1. Introduction	29
	3.2. What is a polymer?	29
	3.3. Basic polymer science	30
	3.4. Basic classification of polymers of interest for use as support fluids	34
	3.5. Dissociation of polymers in solution	41
	3.6. Key properties of polyacrylamides	45
	References	53
04	Commercial polymer systems	57
	4.1. Introduction	57
	4.2. Natural biodegradable polymers	59
	4.3. Polyacrylamide-based systems	64
	4.4. Blended polymer systems	83
	References	86
05	Site equipment and procedures	89
	5.1. Introduction	89
	5.2. Polymer fluid mixing	89

	5.3. Pumping	92
	5.4. Storage and self-cleaning	96
	5.5. Managing excavations in soils with high groundwater pressures	100
	5.6. Excavation tools	102
	5.7. Cleaning in excavations	105
	5.8. Recycling and rejuvenation for reuse	107
	5.9. Disposal	109
	References	110
06	Fluid properties and field testing	113
	6.1. Introduction	113
	6.2. Dissolved solids and electrical conductivity	113
	6.3. pH	114
	6.4. Water hardness	118
	6.5. Viscosity	120
	6.6. Density	131
	6.7. Sand content	137
	6.8. Residual polymer concentration	138
	References	142
07	Applications of polymer fluids to the construction of deep foundations around the world	145
	7.1. Introduction	145
	7.2. Europe	145
	7.3. Africa	157
	7.4. Asia	159
	7.5. The Americas	170
	References	182
08	Detailed analysis of case studies	187
	8.1. Introduction	187
	8.2. Glasgow	187
	8.3. Stratford, London	201
	References	226
09	Rheological properties of polymer support fluids	229
	9.1. Introduction	229
	9.2. Fundamentals of non-Newtonian fluid flow	229
	9.3. Laboratory techniques	232
	9.4. Flow behaviour	235
	9.5. Transient viscoelastic properties	252
	References	261

10	Specifications and associated controls	265
	10.1. Introduction	265
	10.2. Polymer types	265
	10.3. Sampling locations	266
	10.4. Test procedures commonly employed	267
	10.5. Excavation practice	271
	10.6. Review of existing polymer fluid specifications	271
	10.7. Concluding remarks	283
	References	283
	Index	285

About the authors

Carlos Lam DPhil CEng MICE MHKIE

Carlos Lam holds degrees from The Hong Kong Polytechnic University, Imperial College London and the University of Oxford, all in civil engineering. He was formerly a lecturer in geotechnical engineering at The University of Manchester and served on the editorial advisory panel of the *Proceedings of the Institution of Civil Engineers – Geotechnical Engineering*. He currently works for the Geotechnical Engineering Office in Hong Kong. He has received several awards, including the Fugro Prize from the Geotechnical Division of the Hong Kong Institution of Engineers. He has published extensively on the use of polymer fluids for geotechnical construction in international journals and conferences. He gratefully acknowledges the support of the ICE Research and Development Enabling Fund in the preparation of this book.

Stephan Jefferis PhD CEng CEnv FICE CGeol FGS FRSA

Stephan Jefferis is a director of Environmental Geotechnics Ltd, a visiting professor at the University of Oxford and an emeritus professor of the University of Surrey, and was the chairman of the British Geotechnical Association from 2015 to 2017. He has over 40 years of experience in research and consultancy on geotechnical processes. He has worked extensively and internationally on the application of bentonite, bentonite–cement and polymer slurries in piling, diaphragm walling, tunnelling and cut-off walls. He is the author of over 100 papers, and is regularly invited as a keynote speaker in international conferences.