Crossrail Project

Infrastructure design and
construction

Volume 4

Other titles in the Crossrail series:

Crossrail Project: Infrastructure design and construction – Volume 3 (2016)
Crossrail. ISBN 978-0-7277-6129-3

Crossrail Project: Infrastructure design and construction – Volume 2 (2015)
Crossrail. ISBN 978-0-7277-6102-6

Crossrail Project: Infrastructure design and construction – Volume 1 (2014)
Crossrail. ISBN 978-0-7277-6078-4

Crossrail Project

Infrastructure design and
construction

Volume 4

Edited by
Professor Rhys Vaughan Williams
and Mike Black

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:

Crossrail Project: Infrastructure design and construction – Volume 3.
Crossrail. ISBN 978-0-7277-6129-3

Crossrail Project: Infrastructure design and construction – Volume 2.
Crossrail. ISBN 978-0-7277-6102-6

Crossrail Project: Infrastructure design and construction – Volume 1.
Crossrail. ISBN 978-0-7277-6078-4

www.icebookshop.com

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

ISBN 978-0-7277-6359-4

©Thomas Telford Limited and Crossrail 2017

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 author is 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. Whilst 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 author or publishers.

Whilst 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: James Hobbs
Production Editor: Madhubanti Bhattacharyya
Market Development Executive: Elizabeth Hobson
Typeset by Manila Typesetting Company

Printed and bound by TJ International Ltd, Padstow

Contents

Foreword	vii
An introduction to the Crossrail Project	viii
About the editors	ix
Corrosion control in a tunnel environment T. GRADY	1
Fisher Street crossover: construction of the secondary lining C. DIAS, F. MELLO, J. WALLIS, P. CZAJKOWSKI, Y. MAQSUD	19
The thinner pen paradox J. GONZÁLEZ MARTÍ, J. SÁNCHEZ BARRUETABEÑA, D. SYMONIDOU, J. BRZESKI	27
Fire and water – the London Crossrail experience M. KING	43
Effective MEP design techniques and strategy for large subsurface metro projects J. KING	57
The protection of existing DLR viaduct against cross-passage construction impact V. CHANDEGRA, R. BAILEY, F. BERNARDO	71
Amalgamation of tunnel secondary lining and first stage concrete at Whitechapel crossover M. UHRIN, R. BRIERLEY, M. TALLISS, E. MARCHAND	91
SCL primary lining interactions with concrete backfilled temporary tunnels DR C.-K. SHEN	107
Systems architecture models in Crossrail design and delivery – client’s perspective K.-H. LI, G. GEORGIOU	123
Mechanical Design Principles M. DAVID, S. SHERIDAN, S. TURLEY, R. UNDERWOOD, J. KANU, J. MILTON, A. CONMEE	145
The application of stair pressurisation to Crossrail stations, shafts and portals W. FUNG	185
How will rooms operate on loss of mains power? M. DAVID	193
What need for temperature control and ventilation to battery rooms? M. DAVID	207
Protective coverings to services with thermal insulation M. DAVID, N. HOJJATI	219
Duty & stand-by arrangements for VRF and DX cooling systems M. DAVID, B. WILKINSON	225
Control narratives for heating ventilation and air conditioning system for stations shafts and portals W. FUNG	229
Fixed fire-fighting systems G. MULLAN	247

Information management system to handle maintenance alarms from MEP installations at Crossrail stations, shafts and portals	263
W. FUNG	
Towards integration of engineering services at Crossrail stations, shafts and portals	277
W. FUNG, A. WAI LEUNG CHU, S. DAWAR	
Compliance of technical assurance requirements for MEP installations at Crossrail stations, shafts and portals	289
W. FUNG	
Use of non-metallic materials in ventilation airways- a review of aerodynamic performance and material requirements	297
W. FUNG, H. SHONE, A. ASH	
Rooms' mechanical design criteria	313
M. DAVID, J. KANU	
Crossrail's experience of Geotechnical Baseline Reports (GBRs)	323
J. DAVIS	

Foreword

This is the fourth in a series of volumes that will chart the technical progress of the Crossrail project.

Now in its fifth year, I am extremely proud to take responsibility for the Crossrail Technical Papers Competition and publication from my co-editor and colleague, Mike Black.

This competition is still proving to be the primary method of capturing some of the technical and innovative achievements made on the project and the publication contains the best of the papers submitted in 2016. All of which will be made available on Crossrail's Learning Legacy website.

This annual competition has been extremely successful in attracting high quality contributions from authors across the programme who are keen in the truest engineering tradition to share their knowledge and experiences with the wider engineering community.

As we pass through the varying stages of a construction project, these Technical Papers reflect the changing stages from civil and structural engineering, through to tunnel and station fit-out and MEP engineering, with the next edition concentrating on the final stages of fitout and railway systems, all as we move to the railway becoming fully operational in 2019.

Along with our Learning Legacy website, it offers a unique opportunity to pass on invaluable learning to others planning, designing and delivering underground construction and urban metro projects throughout the world.

On behalf of Crossrail Ltd, we take great pride in the publication of this book which records the technical challenges and achievements of the teams delivering the Crossrail project. I hope you enjoy reading about this fascinating project and find its content both an interesting and informative read.

*Professor Rhys Vaughan Williams
Crossrail Head of MEP Engineering
(Mechanical, Electrical & Public Health)*

Crossrail Learning Legacy - <http://learninglegacy.crossrail.co.uk/>

An introduction to the Crossrail Project

The concept of rail tunnels crossing central London to link Paddington and Liverpool Street stations dates back to the 19th century when the Regent's Canal Company were granted permission to build a railway that would link Paddington with London's docks. Although this was aborted, the idea re-appeared in the 1940s and is alluded to in Sir Patrick Abercrombie's County of London Plan and Greater London Plan.

The idea has had many variations since then, but the principles of having twin-bore tunnels large enough to handle main line rolling stock have persisted. This will facilitate an increase in London's rail capacity of 10 per cent and bring an extra 1.5 million people within 45 minutes of central London.

The construction of the Crossrail project began at North Dock in Canary Wharf in May 2009. Eight years on, it is the biggest railway construction project in Europe and is one of the largest single infrastructure investments undertaken in the UK. It consists of 21 kilometres of new twin-bore tunnels under central London and 10 new world-class stations constructed under the largest city in the European Union. The route will link existing Network Rail services from Reading and Heathrow in the west, and Shenfield and Abbey Wood in the east connecting new stations at Paddington, Bond Street, Tottenham Court Road, Farringdon, Liverpool Street, Whitechapel, Canary Wharf, Custom House, Woolwich and Abbey Wood.

The Crossrail tunnels were constructed using eight Tunnel Boring Machines (TBMs) beneath the busy streets of London. These running tunnels, linking the stations, were constructed with precast reinforced concrete segments. The ten new, ticket halls for the eight underground stations, five portals, plus five ventilation and access points along the route, are constructed using secant and diaphragm walls boxes and shafts. The station tunnels and caverns have been constructed using fibre reinforced sprayed concrete lining (SCL). In addition to this, there are multitudes of grouting shafts used to mitigate the effects of ground movement on London's existing infrastructure.

At its peak, the project employed over 10,000 people across more than 40 worksites throughout London and the South East. However, Crossrail is more than a civil engineering project. As the tunnelling and underground construction phase concludes, the project is embarking on the next big challenge involving the mechanical, electrical and architectural disciplines related to rolling stock, rail systems and station fit outs.

Crossrail has relied on tried and tested technology and engineering principles throughout its design and construction programme while recognising its duty to embrace new technologies and innovation wherever practical.

As part of the project's legacy, Crossrail is keen to share its experiences and best practices with the rest of the industry and to showcase the skills of the personnel involved and the successful delivery of each phase of works. This publication presents the culmination of that experience and best practice celebrated by the Crossrail Technical Papers.

About the editors

Professor Rhys Vaughan Williams CEng FIET FIMechE

Rhys is a Chartered MEP Engineer, Fellow of both the IET and the IMechE, and has been appointed Visiting Professor to the School of Applied Science, Computing and Engineering at Wrexham Glyndwr University.

As well as being the subject of major interviews for several Engineering publications, he has conducted many presentations for professional Engineering organisations around the country. With some 30 years professional experience in the Fit-Out of major infrastructure projects across the UK, he specialises in the development, procurement and delivery of the Mechanical, Electrical and Public Health (MEP) works, including Fire Engineering and Lifts & Escalators and as Head of MEP Engineering, is the

Technical Authority for these works on the Crossrail project.

Rhys is also a strong advocate for promoting Engineering to a wider audience providing the Technical Authority to Crossrail's Learning Legacy, co-editor for the Crossrail Technical Papers Competition and Scheme Sponsor for both the IET and IMechE Graduate Recruitment Program.

Mike Black BSc (Hons) MSc CGeol CSci FGS

Mike is the Head of Geotechnics, working within Crossrail's Chief Engineer's Group. He has been with the project for more than 20 years and has been involved in all stages of its development, from early feasibility design, the passage of the Hybrid Bill through Parliament, detailed design and ultimately construction. Mike holds technical authority for all geotechnical matters on Crossrail and his responsibilities have included the design and procurement of Crossrail's ground investigations, defining the geotechnical requirements and standards during design as well as geotechnical oversight and support during construction.

Along with others, Mike has coordinated the Technical Papers Competition on behalf of Crossrail for the past 5 years and has edited or co-edited the previous 3 volumes of the *Crossrail Project: Infrastructure Design and Construction* book.