

EARTH MASONRY

Design and construction guidelines

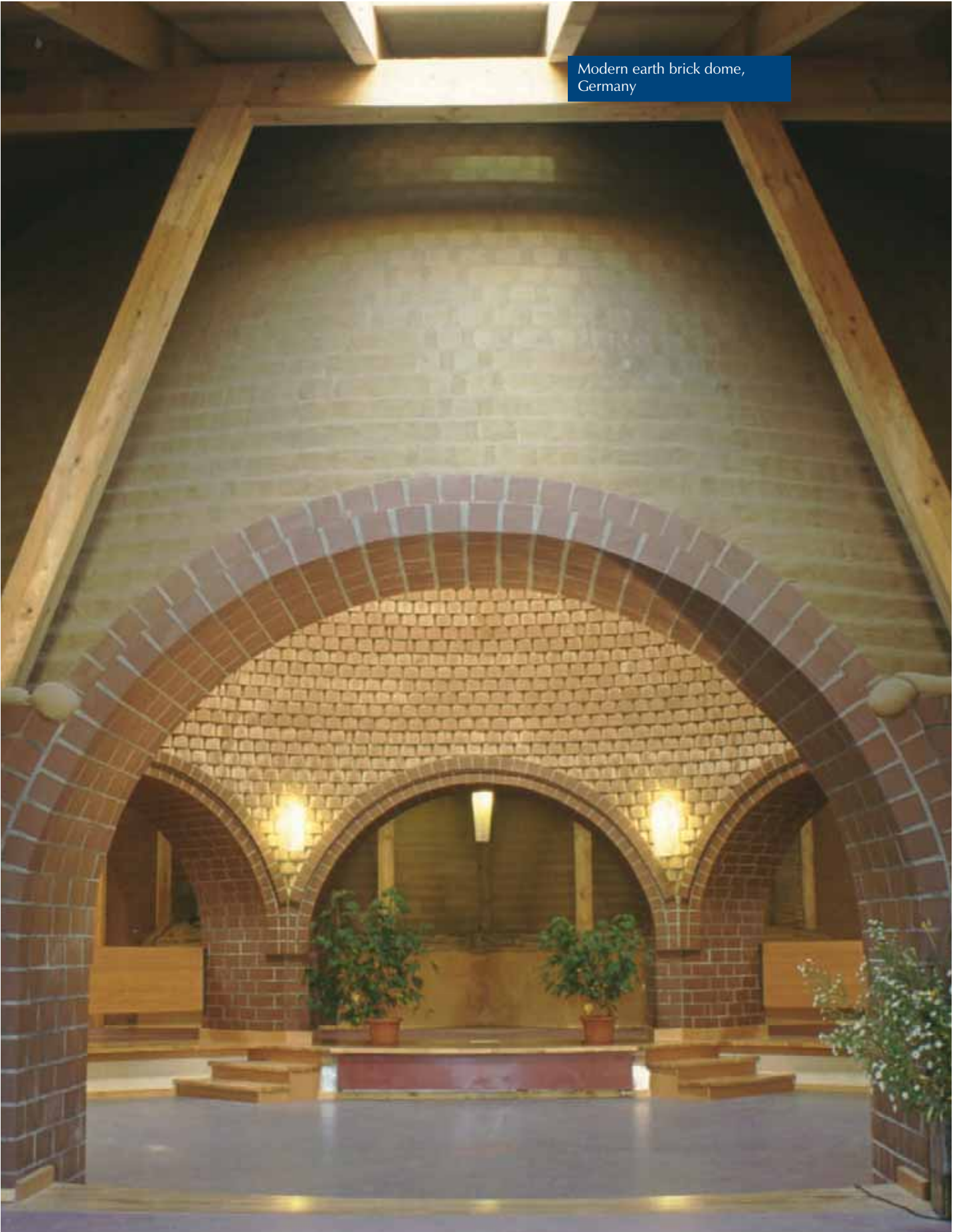
Tom Morton

Foreword by Rab Bennetts



bre press

Modern earth brick dome,
Germany



Published by IHS BRE Press

Details of all publications from IHS BRE Press are available from:

www.ihsbrepres.com

or

IHS BRE Press, Willoughby Road, Bracknell,

Berkshire RG12 8FB

Tel: 01344 328038

Fax: 01344 714440

Email: brepres@ihs.com

Printed on paper sourced from responsibly managed forests

Cover images:

Main and lower right image: Tom Morton

Upper right image: Schauer and Volhard Dipl.-Ing. Architekten

Middle right image: Dr Gernot Minke

Back cover image: Claytec

Prelim images:

Page ii: Dr Gernot Minke

Page x, xii, xix and xx: Tom Morton

Page xviii: Claytec

Index compiled by Margaret Binns

Request to copy any part of this publication should be made to:

IHS BRE Press, Garston, Watford WD25 9XX

Tel: 01923 664761

Email: brepres@ihs.com

IHS BRE Press makes every effort to ensure the accuracy and quality of information and guidance when it is published. However, we can take no responsibility for the subsequent use of this information, nor for any errors or omissions that it may contain

EP 80

© Tom Morton 2008

First published 2008

ISBN 978-1-86081-978-0

CONTENTS

List of illustrations	vii
Foreword	xi
Preface	xiii
Acknowledgements	xiv
Scope and structure	xv
Glossary	xvi
1 INTRODUCTION	
1.1 What is earth masonry?	1
1.2 Why use earth masonry?	1
1.3 A brief history of earth masonry	15
1.4 Practical advantages and disadvantages	22
2 PRELIMINARY DESIGN CONSIDERATIONS	
2.1 Appropriate applications	25
2.2 Earth masonry in the construction process	31
2.3 Codes, testing and building standards	34
2.4 Compliance with UK building standards	38
3 MATERIALS FOR EARTH MASONRY	
3.1 Raw materials	43
3.2 Bricks and blocks	46
3.3 Mortars	53
3.4 Plasters	55
3.5 Paints and other coatings	
4 DETAILED DESIGN CONSIDERATIONS	
4.1 Appearance	61
4.2 Structural design	66
4.3 Shrinkage and thermal movement	70
4.4 Moisture	72
4.5 Thermal characteristics	80
4.6 Acoustic characteristics	84

4.7 Performance in fire	85
4.8 Design for durability	88
4.9 Typical design details	89
5 BUILDING EARTH MASONRY	
5.1 Keeping people informed	95
5.2 Transportation, delivery and storage	95
5.3 Building walls	97
5.4 Plastering	101
5.5 Services	103
5.6 Fixings	104
5.7 Aftercare	106
5.8 Health and safety	107
6 LIVING WITH EARTH MASONRY	
6.1 Common defects in new construction	111
6.2 Unusual causes of damage	113
6.3 Repairs and maintenance	114
6.4 Alterations	116
7 THE FUTURE OF EARTH MASONRY?	
7.1 Earth in a sustainable construction industry	117
7.2 Developing manufacturing capability	122
Appendix A: Standards	127
Appendix B: Testing procedures	129
References	131
Further reading	133
Useful contacts	135
Index	138

LIST OF ILLUSTRATIONS

Figure no. and description	Page no.			
CHAPTER 1				
1-1 to 1-4: Atelier Darmstadt, Berlin. © Schauer U Volhard Dipl.-Ing. Architekten.	2	1-19: Quechua Family Compound, Peru. © Yoshio Komatsu.	12	1-39: East Harling, Norfolk. © John McCann.
1-5: Neal's Yard HQ, Dorset. © Feilden Clegg Bradley Architects.	3	1-20 to 1-25: Fachwerksanierung Morfelden, Germany. © Schauer U Volhard Dipl.-Ing. Architekten.	14	1-40: Rowardenan Visitor Facility, Loch Lomond.
1-6: Erdhugelhaus SolArc, Germany. © Archy Nova	4	1-26: The Great Wall of China. © John Warren.	15	1-41: Exhibition Centre, The Netherlands. © Rebecca Little.
1-7: Values of 'factory gate' embodied carbon for masonry materials. Morton et al (2005). Other data: Hammond and Jones (2006).	4	1-27: Friday Mosque, Djenne, Mali. © Yoshio Komatsu.	15	1-42: Atelier Darmstadt, Berlin. © Schauer U Volhard Dipl.-Ing. Architekten.
1-8: Site waste, Kirk Park, Dalguise.	5	1-28: Taos Pueblo, New Mexico.	16	1-43: The Schoolhouse, Cottown, Perthshire.
1-9: Ridge Winery, California.	5	1-29: Haumont House, Nebraska. © Nebraska State Historical Society Photograph Collections.	16	CHAPTER 2
1-10: Former claypit, Errol Brickworks, Perthshire.	6	1-30: Corse Croft, Huntly, Scotland.	17	2-1: Rowardenan Visitor Facility, Loch Lomond.
1-11: Rates of moisture absorbancy, after Dr Gernot Minke (2006).	7	1-31: Quechua domed houses, Peru. © Yoshio Komatsu.	17	2-2: Kirk Park, Dalguise, Perthshire.
1-12: Disease and relative humidity, after Arundel et al, (1986).	8	1-32: Conical turf masonry domes, Chipaya, Bolivia. © Yoshio Komatsu.	17	2-3: New housing, France. © Chris Morgan.
1-13: Relative humidity graph.	8	1-33: Black Carr, Norfolk. © John McCann.	19	2-4: Mains of Branshogle, Stirlingshire.
1-14: Trinitatis Nursery, Germany. © Rentzch & Reiter Architekten.	9	1-34: Clay bat walls, Fen Lane, East Harling. © Dirk Bouwens.	19	2-5: Earth brick infill to modern timber post-and-beam. © Joern Wingender.
1-15: Kirk Park, Dalguise, Perthshire.	9	1-35: Internal clay bat partition. High Bridgeham, Norfolk. © John McCann.	20	2-6: Earth brick infill in the Balkans. © John Warren.
1-16: Ridge Winery, California.	10	1-36: Purton Green, England. © John Warren.	20	2-7: Earth masonry infill to concrete frame, Ecuador. © Elizabeth Parker.
1-17: Yazd, Iran.	12	1-37: Point House, Attleborough. © John McCann.	21	2-8: Earth masonry infill to timber frame.
1-18: Arizona, USA.	12	1-38: Watton Terraces, Wymondham. © Dirk Bouwens.	21	2-9: Traditional earth brick vaults and domes, Iran. © Yoshio Komatsu.
				2-10: Earth masonry vault, Erdhugelhaus SolArc. © Archy Nova.

4-21: RH fluctuations graph.	74	5-4: Forklift.	96	CHAPTER 6	6-1: Lintel cracking.	111
4-22: MC fluctuations graph.	75	5-5: Mudmasons, Yemen. © <i>Yoshio Komatsu</i> .	98		6-2: Plaster crack.	112
4-23 to 4-26: ESRP test wall, (Morton and Little, awaiting publication).	76	5-6: Bricklayer, UK.	98		6-3: Surface dusting.	112
4-27: Kirk Park, Dalguise, Perthshire.	77	5-7: Block system. © <i>Akristos Ltd.</i>	98		6-4: Water erosion, Iran.	114
4-28: BRE spray tests. © <i>Rebecca Little</i> .	78	5-8: Clay mortar mixing.	98		6-5: Ice house, Kashan, Iran.	115
4-29: Devon cob blocks.	78	5-9: Mortar batch samples.	99		6-6: Ridge Winery, California.	116
4-30: Thermal insulation improved by perforations and fibre.	81	5-10: Framing around door.	99		6-7: Local impact damage.	116
4-31: Thermal conductivity graph, after <i>Minke, 2006</i> .	81	5-11: Timber lintel.	100	CHAPTER 7	7-1: Sprayed plaster. © <i>Jenny Andersson</i> .	118
4-32: Light earth blocks. © <i>Rebecca Little</i> .	82	5-12: Curved corners, Kirk Park, Dalguise, Perthshire.	100		7-2: Naterra blocks. © <i>Akristos Ltd.</i>	119
4-33: U-value graph.	82	5-13: Finishing coat.	101		7-3: Domestic dome, Rostorf, Germany. © <i>Dr Gernot Minke</i> .	119
4-34: Public Hi-Fi Recording Facility, Austin, Texas. © <i>Frank Meyer</i> .	84	5-14: First coat of plaster, Kirk Park, Dalguise, Perthshire.	101		7-4: Nursery, Oranienburg- Eden, Germany. © <i>Dr Gernot Minke</i> .	120
4-35: Fire test. © <i>Errol Brick Company Ltd.</i>	86	5-15: Sprayed plaster. © <i>Jenny Andersson</i> .	102		7-5: Dry stacking © <i>Jenny Andersson</i> .	120
4-36: North Residence, New Zealand. © <i>Graeme North</i> .	86	5-16: Metal corner bead.	102		7-6: Erdhugelhaus SolArc. © <i>Archy Nova</i> .	120
4-37: Wall base detail.	89	5-17: Timber corner beads.	102		7-7: Old Schoolhouse, Cottown, Perthshire © <i>Rebecca Little</i> .	121
4-38: Window head detail.	90	5-18: Electrical box.	103	7-8: Mii Amo Spa, Arizona. © <i>Harry Zernike</i> .	122	
4-39: Window head detail.	90	5-19: Leckerston farmhouse, Fife.	103	7-9: UK brick and block deliveries, 1979-2000. (DTi, 2006).	122	
4-40: Window head elevation.	90	5-20: Wall heating pipes. © <i>Joern Wingender</i> .	104	7-10: UK clay extraction, 1970-2000 (Sheerin, 2002).	123	
4-41: Window jamb.	90	5-21: Mains of Branshogle, Stirlingshire. © <i>Simpson & Brown Architects</i> .	104	7-11: Brick and block imports and exports, 1996-2005. (DTi, 2006).	123	
4-42: Dry stacked lining.	91	5-22: Metal fixings. © <i>Neil May</i> .	105	7-12: Contemporary earth house, Germany. © <i>Claytec</i> .	124	
4-43: Internal partition head.	91	5-23: Mains of Branshogle, Stirlingshire.	105	Public Hi-Fi Recording Facility, Austin, Texas. © <i>Frank Meyer</i> .	126	
4-44: Timber framed partition.	91	5-24: Atelier Darmstadt, Berlin. © <i>Schauer U Volhard Dipl.-Ing. Architekten</i> .	105			
4-45: Door jamb 1.	92	5-25: Mains of Branshogle. Stirlingshire.	106			
4-46: Door jamb 2.	92	5-26: Sanford Winery, California. © <i>Fred Webster</i> .	106			
4-47: Door jamb 3.	92	5-27: Haddenham Methodist Church. © <i>Neil May</i> .	107			
4-48: Door jamb 4.	93	5-28: Earth masonry dust.	108			
4-49: Door jamb 5.	93					
4-50: Door jamb 5: elevation.	94					
4-51: Door jamb 6.	94					
4-52: Door jamb 6: elevation.	94					
CHAPTER 5						
5-1: Naterra blocks. © <i>Akristos Ltd.</i>	95					
5-2: Water damage on site.	96					
5-3: Dry blay mortar.	96					

Mains of Branshogle,
Stirlingshire



FOREWORD

Rab Bennetts
Bennetts Associates

With public opinion finally endorsing the need for higher levels of sustainability, this book is a timely reminder that some all-but-forgotten forms of construction offer a signpost to the way ahead.

Earth masonry – unfired bricks, adobes and cob blocks that are free from cement additives – is one of those ancient technologies that all but died out in western society, but has remained alive and well in parts of the world untouched by industrialisation and conventional measures of prosperity. Now that the search is on for building techniques and materials that have far less impact on the environment than the bricks and blocks of modern construction, earth masonry has once again emerged as a sound and practical alternative.

Like rammed earth, recycled materials or planted roofs, earth masonry is not alone in being ‘rediscovered’ but the post-war dominance of products that rely on energy-intensive, relatively cheap manufacture means that our ability to use these low impact methods is hampered by a simple loss of traditional knowledge or the instinct required to avoid routine failures of performance. Even natural ventilation and passive solar control

for larger buildings now have to be proven by computer analysis to gain acceptance in our risk-averse markets, because centuries of intuitive understanding has virtually disappeared.

The primary purpose of this book, then, is to fill in the considerable gaps in our understanding of earth masonry, with a factual account of issues such as density, moisture control, strength and construction details. But there is a secondary role for this book, which is to explore the cultural background to earth masonry, with a refreshing enthusiasm for the subject born of conviction for its potential, even for sizeable projects. The key to unlocking this potential is to think in local terms – the available raw materials, the labour force, the means of manufacture, distribution and of course the climate. As with much else in the search for sustainability, globalisation of the construction industry is being questioned as never before, not simply for its harmful environmental effects but also for its tendency to steamroller construction cultures across the world into uniformity. Earth masonry represents part of the fightback towards a more responsive, environmentally benign approach.

The Earth Store, The Genesis Project, Somerset College of Arts and Technology

the earth store



2 PRELIMINARY DESIGN CONSIDERATIONS

This chapter describes the main factors influencing a decision on whether and how earth masonry is appropriate for a particular project. It outlines suitable applications of earth masonry, including monolithic walls, infill to timber frame walls, vaults and floors. Design codes, testing and compliance with UK building standards are discussed. Key factors in using earth masonry in a construction and procurement process are also highlighted.

2.1 APPROPRIATE APPLICATIONS

Earth masonry can be used in a variety of ways in buildings. The limits of what is appropriate vary with climate and culture, as do the potential benefits thereby gained. For example, hot dry locations can exploit thermal mass in monolithic walls and vaulted roofs, while cool wet situations will benefit from the regulation of internal humidity in layered constructions.

Modern architectural and engineering design has considerable potential to transcend the constraints of vernacular use. However, such work is in its infancy, as is the availability of progressive high-performance unfired clay products.

This section therefore describes the situation as it exists today, which remains essentially based on traditional models of masonry design. The potential of market applications to develop in the future is described in section 7.1.3.

2.1.1 External walls

Earth masonry can be used for external walls, with two key points governing its use.

Thermal conditions

Earth masonry gives good thermal mass, but not good thermal insulation. In UK conditions, solid earth masonry walls are usually appropriate only for unheated buildings that have a diurnal, rather than a seasonal, heating need. That is, the mass of earth masonry can balance a hot day against a cold night, but it cannot stretch this effect to balance a hot summer against a cold winter. In heated buildings, earth masonry should be used in an insulated, layered construction. Here, the earth masonry

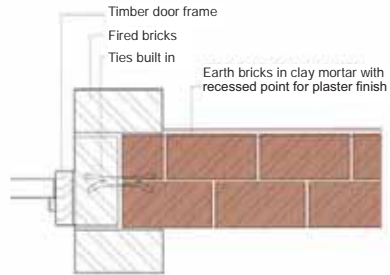


Fig. 4-51: Door jamb 6.
(See Fig. 7-3.)

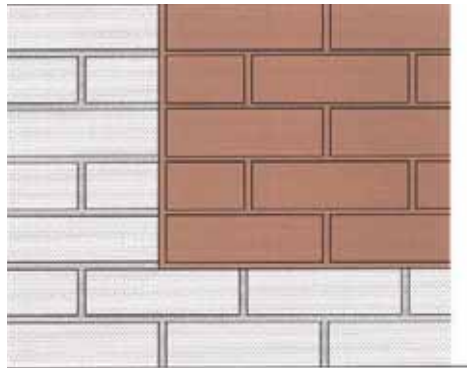


Fig. 4-52: Door jamb 6: elevation.