Contents

		The state of the s	
	Contributor contact deta	ails particles among achoose A.	xv
	Woodhead Publishing S	eries in Energy	xxi
	Preface		xxvii
Part I	Introduction to mode		1
1	Overview of modern	earth building	3
3.2		Nottingham, UK, R. LINDSAY, Earth	
		and M. KRAYENHOFF, SIREWALL Inc,	
1.1			3
1.2		rth building	5
1.3		lern earth building in the current	
1.6	and future construction		- 6
1.4	Changes in the modern		7
1.5		of the modern construction	
			10
1.6	References		16
2	Hygrothermal behavio	ur and occupant comfort in	
		Functional principles of Passive 8	17
	M. R. HALL and S. CASEY, U	Iniversity of Nottingham, UK	
2.1	Introduction		17
2.2	Hygrothermal loads and	modelling shows summer	19
2.3		perties of earth materials	25
2.4		and passive air conditioning	29
2.5	Indoor health and air qu		33
2.6	Sources of further information		36
2.7	References		37
2.8	Appendix: nomenclature	for sorts	40

L. S. Recon, Plants, International September of a Relationary

vi	Contents	
3	Fabric insulation, thermal bridging and acoustics in modern earth buildings C. J. Hopfe, Cardiff University, UK and M. R. Hall, University of Nottingham, UK	41
3.1	Introduction	41
3.2	Approaches to fabric insulation	42
3.3	Thermal bridging theory	56
3.4	Thermal bridging simulation tools	60
3.5	Acoustic reverberation	62
3.6	Sources of further information	67
3.7	References	69
3.8	Appendix: nomenclature	71
	Woodness Publishing Series in Energy	
4	Modern earth building codes, standards and	
	normative development	72
	H. Schroeder, Bauhaus University Weimar, Germany	
4.1	Introduction: a short history of building codes for using	
	earth as a building material	72
4.2	Types of 'standards' for earth buildings	75
4.3	Normative documents for earth building	77
4.4	Selecting the parameters for earth building standards	87
4.5	New developments in earth building standards	98
4.6	Conclusions	103
4.7	References	105
5	Passive house design: a benchmark for thermal mass fabric integration L. Rongen, University of Applied Sciences, Erfurt and Rongen Architects, Germany	110
5.1	Introduction	110
5.2	Description of Passive House	112
5.3	Functional principles of Passive House	117
5.4	Case studies of Passive Houses in different climates	128
5.5	Examples of Passive House architecture in Germany	134
5.6	Estada tranda	148
5.7	Sources of further information	151
5.8	References	151

	Contents	vii
Part II	Earth materials engineering and earth down and	
	construction and a second second second to second s	153
	References	
6	Soil materials for earth construction: properties,	155
	classification and suitability testing L. N. Repdi, Florida International University, USA, A. K. Jain	155
	and H-B. Yun, University of Central Florida, USA	
6.1	Introduction	155
6.2	Soil formation	155
6.3	Soil types and rectiniques in beath American dute and I	157
6.4	Soil consistency	163
6.5	Compaction of soil and transformer should enominated	167
6.6	Conclusion severally has enemaling angleted attachange	170
6.7	References and the second seco	170
6.8	Appendix	171
7	Alternative and recycled materials for earth	
	construction	172
	A. Dawson, University of Nottingham, UK	
7.1	Introduction	172
7.2	Classification	176
7.3	Types of alternative material	179
7.4	Characteristics of alternative and recycled materials	190
7.5	Form of recycled and alternative materials: bulk or binder	193
7.6	Leaching	195
7.7	Physical and mechanical properties of alternative and	107
7.0	recycled materials	197 198
7.8	The use and reuse life cycle Future trends and conclusions	200
7.9 7.10	Sources of further information	201
7.10	References	201
7.11	Appendix	203
7.12	House remail early construction (untilized)	
8	Soil mechanics and earthen construction: strength	
	and mechanical behaviour	204
	C. E. Augarde, Durham University, UK	
8.1	Introduction	204
8.2	Basic mechanics	205
8.3	Fundamental soil behaviour	209
8.4	Effective stress	211
8.5	Models of shear strength for soils	212
8.6	Unsaturated son behaviour	217
8.7	The use of soil mechanics in earthen construction	220

viii	Contents	
8.8	Future trends	220
8.9	Sources of further information	221
8.10	References	221
9	Soil stabilisation and earth construction: materials,	
	properties and techniques	222
	M. R. Hall, K. B. Najim and P. Keikhaei Dehdezi, University of Nottingham, UK	
7.61	THE REST OF THE PROPERTY OF THE PARTY OF THE PROPERTY OF THE PROPERTY OF THE PARTY	
9.1	Introduction Basiland In 2	222
9.2	Lime stabilisation	
9.3	Cement and pozzolans	229
9.4	Bituminous binders and emulsions	
9.5	Synthetic binders, polymers and adhesives	246
9.6	Fibre reinforcement	247
9.7	Selection tool for modern stabilised earth construction	249
9.8	References	253
10	Integral admixtures and surface treatments for	
	modern earth buildings	256
	R. Kebao and D. Kagi, Tech-Dry Building Protection Systems Pty Ltd, Australia	
10.1	Introduction	256
10.2	Integral admixtures for modern earth construction	258
10.3	Surface treatment for modern earth buildings	270
10.4	Future trends	279
10.5	Sources of information	281
10.6	References	281
11	Weathering and durability of earthen materials and	10
	structures and the second to be second	282
	J-C. Morel, University of Lyon, France, Q-B. Bul, University of Savoie, France and E. Hamard, IFSTTAR, France	
11.1	Introduction	282
11.2	Water content increase in earthen walls	283
11.3	Strategies to increase the durability of earth walls	
11.4	Current tests for assessing the durability of earthen	
	materials	288
11.5	Confirm and finishes of conth structures	203
11.6	I to to to-ting of couth walls	207
11.7	Estate total and applications	200
11.8	A 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	300
11.9		301
11.10	References	302

	Contents	ix
Part III	Earth building technologies and earth	
	construction techniques	305
12	History of earth building techniques P. Jaquin, Integral Engineering, UK	307
12.1	Introduction (1279)	307
12.2	Earth building techniques in Asia	309
12.3	Earth building techniques in Africa	313
12.4	Earth building techniques in Europe	315
12.5	Earth building techniques in North America	316
	Earth building techniques in South America	318
12.7	Earth building techniques in Australasia	319
12.8	Conclusions	320
12.9	Bibliography	321
134	Conservation of historic earth publishess, management	
13	Stabilised soil blocks for structural masonry in earth	
	construction	324
	B. V. VENKATARAMA REDDY, Indian Institute of Science Bangalore,	
	India	
13.1	Introduction and the speciment (TOZIVI) and he shall seed	324
13.2	Soil stabilisation techniques	327
13.3	Production of stabilised soil blocks (SSBs)	330
13.4	Characteristics of stabilised soil blocks (SSB)	336
13.5	Cement-soil mortars for stabilised soil block (SSB)	
	masonry	349
13.6	Stabilised soil block masonry	351
13.7	Long-term performance, repair and retrofitting of stabilised soil block (SSB) buildings	353
13.8	Case studies of cement stabilised soil block (CSSB) buildings	356
13.9	References	361
14	Modern rammed earth construction techniques D. Easton and T. Easton, Rammed Earth Works, USA	364
14.1	Introduction	364
14.2	Material sourcing	366
14.3		368
14.4	Formwork	371
14.5	Installation	377
14.6	Future trends and conclusions	383
14.7	Sources of further information	384

X	Contents	
15	Pneumatically impacted stabilized earth (PISE) construction techniques	385
	D. Easton, Rammed Earth Works, USA	
15.1	Introduction	385
15.2	Materials used for pneumatically impacted stabilized earth	200
	(PISE) construction The forming system	388
15.3	The forming system	389
15.4	Reinforcement of pneumatically impacted stabilized earth	391
15 5	(PISE) walls Equipment for proportioning, mixing and placement	392
15.5 15.6	The pneumatically impacted stabilized earth (PISE) method	395
15.7	Conclusion	399
15.8	Appendix	399
13.6	Plote remitterement - griquegolistill	
16	Conservation of historic earth buildings G. CALABRESE, Architect, Australia	401
		401
16.1	Introduction	401 402
16.2	Common causes of deterioration on historic earth buildings	404
16.3	Conservation of earth architecture Case study of the UNESCO heritage site of Diriyah in the	404
16.4	Atturaif region of Saudi Arabia	405
16.5	Case study of earth buildings in Italy: Loreto Aprutino in the	
10.5	Abruzzo region	415
16.6	Conclusions	423
16.7	Sources of further information	424
16.8	References	424
Part I	V Modern earth structural engineering	425
17	Earth masonry structures: arches, vaults and domes J. F. D. Dahmen, University of British Columbia, Canada and J. A. Ochsendorf, MIT, USA	427
17.1	Introduction	427
17.2	Structural theory for arches, vaults and domes	429
17.3	Earth masonry arches	436
17.4	Earth masonry vaults	437
17.5	Earth masonry domes	448
17.6	Material properties of earth masonry structure	453
17.7	Design and construction criteria for earth masonry structures	456
17.8	Future trends	457
17.9	Acknowledgments	458
17.10	Sources of further information	458

	Contents	A1
17.11	References	459
18	Structural steel elements within stabilised rammed	
	earth walling	461
	R. Lindsay, Earth Structures Group, Australia	
18.1	Introduction	461
18.2 18.3	Structural steel for stabilised rammed earth (SRE) walling Design parameters for using structural steel within stabilised	461
18.4	rammed earth (SRE) walling The use of steel lintels for stabilised rammed earth (SRE)	465
18.5	applications Steel columns embedded within stabilised rammed earth	468
	(SRE) walls	470
18.6	Structural systems for elevated or 'precast' stabilised	
107	rammed earth (SRE) panels	474
18.7 18.8	North American structural steel Conclusion	478
18.9	A CONTRACT OF THE PROPERTY OF	479
18.10	Acknowledgements Sources of further information	479 479
19	Natural disasters and earth buildings: resistant design	
	and construction H. W. Morris, University of Auckland, New Zealand	481
19.1	Introduction	481
19.2	Earthquakes and earth buildings	485
19.3	Earthquake engineering	498
19.4	Wind and storms storms are all a supported that the second of	522
19.5	Earth building design for wind resistance	525
19.6	Flood hazards and earth buildings	529
19.7	Volcanoes and landslides	531
19.8	Future trends	533
19.9	Sources of further information	533
19.10	References	534
20	Embankments and dams W. Wu, T. G. Berhe and T. Ashour, University of Natural Resources and Applied Life Sciences, Austria	538
20.1	indicardas significa a regional significa e significa	520
20.1	Introduction Types and selection of embankment dams	538
20.2 20.3	Types and selection of embankment dams	539
20.3	Zoning of embankment dams and construction materials	541 543
20.4	Embankment dam construction specifications	
20.5	Stability analysis of embankment dams Dam freeboard equipment	548 549

×ii	Contents	
20.7	Failure mechanisms	549
20.8	Maintenance of embankment dams	554
20.9	Future trends	555
20.10	Norms and standards	556
20.11	References All Management and Al	557
Part V	Application of modern earth construction:	
200	international case studies	559
21	North American modern earth construction M. Krayenhoff, SIREWALL Inc., Canada	561
21.1	Introduction	561
21.2	Seventh generation thinking and earth construction	563
21.3	The interplay of indoor and outdoor weather	564
21.4	Applications of earth construction in hot climates	583
21.5	Applications of earth construction in wet and cold	
DET	climates	585
21.6	Optimizing rammed earth compressive strength	587
21.7	North American-style rammed earth	594
21.8	Case studies of North American earth construction	600
21.9	Design elegance of modern earth buildings	604
21.10	Future trends	606
21.11	Sources of further information	608
21.12	Acknowledgements	608
22	Australian modern earth construction R. Lindsay, Earth Structures Group, Australia	609
22.1	Introduction	609
22.2	Uses of stabilised rammed earth in different regions of Australia	610
22.3	Approaches to material type and selection	612
22.4	Formwork and construction techniques: the 'Stabilform system'	616
22.5	Stabilised rammed earth (SRE) walls	632
22.6	Diring Court among company	635
22.7	Standards and specifications for modern earth construction in Australia	639
22.8	The cost of stabilised rammed earth (SRE) construction in Australia	640
22.9	Case studies of modern earth buildings in Victoria,	641
22.10	Future trends	646

	Contents	XIII
2.11	Sources of further information	647
2.12	Acknowledgements	648
2.13	References	648
23	European modern earth construction M. R. Hall, University of Nottingham, UK and W. Swaney, Earth Structures (Europe) Ltd, UK	650
23.1	Introduction	650
23.2	Conservation and revival of traditional techniques	651
23.3	Modern earth construction techniques	654
23.4	Case studies of modern earth buildings throughout Europe	663
23.5	Future trends	682
23.6	Acknowledgements and the Deliver the Acknowledgements	685
23.7	Sources of further information	685
23.8	References	687
24	Modern rammed earth construction in China R. K. Wallis, SIREWALL China, GIGA and A00 Architecture, China	688
24.1	Introduction	688
24.2	Challenges for modern rammed earth construction in	689
24.3	Opportunities for modern rammed earth construction in China	691
24.4	Approaches to material type and selection	692
24.5	Construction techniques and formwork	697
24.6	Case studies	699
24.7	Future trends	710
24.8	References	711
Anna	ndices	713
Appe	Hulces	
A1	Techno-economic analysis and environmental assessment of stabilised rammed earth (SRE)	715
	building construction R. Lindsay, Earth Structures Group, Australia	715
A 1 1	Introduction	715
A1.1 A1.2	The technical parameters of modern earth wall	
A1.2	construction	716
A1.3	An economic analysis of modern earth wall construction	722
A1.4	An environmental analysis of modern earth wall	728

xiv	Contents		
A1.5	Conclusions		733
A1.6	References		734
	Fundamental Company		
A2	Techno-economic analysis and environme	ental	
9231	assessment of stabilized insulated ramm	ed earth	
	(SIREWALL) building		735
	M. Krayenhoff, SIREWALL Inc., Canada		
A2.1	Introduction		735
A2.1	The environmental impact of stabilized insul	ated rammed	
A2.2	earth building	Modern carri	736
A2.3	The economic impact of stabilized insulated	rammed earth	
A2.5	building	Public medici	742
A2.4	Stabilized insulated rammed earth building to	echnologies	744
A2.5	Acknowledgements	Scotter of m	748
A2.6	References		748
12.0			
	Index		749