Gernot Minke

Building with Earth

Design and Technology of a Sustainable Architecture

Second and revised edition

Birkhauser - Publishers for Architecture Basel • Boston • Berlin

", ", ", " HOCHSTH! M E t i ^ LIECHTENSTEIN -• Bibliothek

Preface 7

I The technology of earth building

1 Introduction 11

History 11 Earth as a building material: the essentials 13 Improving indoor climate 15 Prejudices against earth as a building material 18

2 The properties of earth as a building material 19

Composition 19 Tests used to analyse the composition of loam 21 Effects of water 24 Effects of vapour 29 Influence of heat 31 Strength 32 pH-value 35 Radioactivity 35 Shelter against high-frequency electromagnetic radiation 35

3 Preparing of loam 36

Soaking, crushing and mixing 36 Sieving 38 Mechanical slurrying 38 Water curing 38 Thinning 38

4 Improving the earth's characteristics

by special treatment or additives 39 Reduction of shrinkage cracks 39 Stabilisation against water erosion 40 Enhancement of binding force 42 Increasing compressive strength 43 Strength against abrasion 47 Increasing thermal insulation 47

5 Ramnied earthworks 52

Formwork 53 Tools 54 Method of construction 55 Shaping of openings 55 New wall construction techniques 56 Rammed earth domes 59 Drying 59 Labour input 60 Thermal insulation 60 Surface treatment 60

6 Working with earth blocks 61 History 61 Production of earth blocks 62 Material composition 65 Laying earth blocks 65 Surface treatment 66 Fixing fasteners to walls 67 Lightweight loam blocks 67 Special acoustic green bricks 68

7 Large blocks and prefabricated panels 69
Large blocks 69
Prefabricated wall panels 70
Floor slabs 70
Floor tiles 71
Extruded loam slabs 71

8 Direct forming with wet loam 72

Traditional wet loam techniques 72 The "Dunne loam loaf" technique 74 The *stranglehm* technique 75

9 Wet loam infill in skeleton structures 80

Thrown loam 80 Sprayed loam 80 Rolls and bottles of straw loam 81 Lightweight loam infill 82 Infill with *stranglehm* and earth-filled hoses 82

10 Tamped, poured or pumped lightweight loam 83

Formwork 83 Tamped lightweight straw loam walls 83 Tamped lightweight wood loam walls 84 Tamped, poured or pumped lightweight mineral loam walls 85 Pumped lightweight mineral loam floors 88 Loam-filled hollow blocks 89 Loam-filled hoses 90

11 Loam plasters 92

Preparation of ground 92 Composition of loam plaster 92 Guidelines for plastering earth walls 94 Sprayed plaster 95 Lightweight mineral loam plaster 95 Thrown plaster 95 Plastered straw bale houses 95 Wet formed plaster 96 Protection of corners 96

12 Weather protection of loam surfaces 98

Consolidating the surface 98

Paints 98 Making surfaces water-repellent 101 Lime plasters 101 Shingles, planks and other covers 103 Structural methods 103

13 Repair of loam components 104

The occurrence of damage in loam components 104 Repair of cracks and joints with loam fillers 104 Repair of cracks and joints with other fillers 105 Repairing larger areas of damage 105 Retrofitting thermal insulation with lightweight loam 106

14 Designs of particular building elements 107

Joints 107 Particular wall designs 108 Intermediate floors 110 Rammed earth floorings 112 Inclined roofs filled with lightweight loam 115 Earth-covered roofs 115 Earth block vaults and domes 117 Earthen storage wall in winter gardens 131 Loam in bathrooms 132 Built-in furniture and sanitary objects from loam 133 Wall heating systems 134 Passive solar wall heating system 134

15 Earthquake-resistant building 135

Structural measures 136 Openings for doors and windows 140 Bamboo-reinforced rammed earth walls 141 Domes 144 Vaults 145 Textile walls with loam infill 147

Built examples

Residences

Two semi-deatched houses, Kassel, Germany 150 Residence cum office, Kassel, Germany 152 Residence at Phoenix, Arizona, USA 154 Farmhouse, Wazirpur, India 156 Honey house at Moab, Utah, USA 157 Residence, La Paz, Bolivia 158 Residence, Turku, Finland 159 Residence and studio at Gallina Canyon, New Mexico, USA 160 Residence at Villa de Leyva, Colombia 162 Low Compound at Scottsdale, Arizona, USA 164 Residence at Des Montes, near Taos, New Mexico, USA 166 Casita Nuaanarpoq at Taos, New Mexico, USA 168 Residence and office at Bowen Mountain, New South Wales, Australia 169 Vineyard residence at Mornington Peninsula, Victoria, Australia 170 Residence, Helensville, New Zealand 172 Residence, Sao Francisco Xavier, Brazil 174 Three-family house, Stein on the Rhine, Switzerland 176

Cultural, Educational and Sacral Buildings

School at Solvig, Jama, Sweden 177 Kindergarten, Sorsum, Germany 178 School in Rudrapur, Bangladesh 180 Kindergarten and nursery of Druk White Lotus School, Ladakh, India 182 Panafrican Institute for Development, Ouagadougou, Burkina Faso 184 Youth centre at Spandau, Berlin, Germany 186 Printing plant in Pielach, Austria 188 Office building, New Delhi, India 190 Mii amo spa at Sedona, Arizona, USA 192 Tourist resort at Baird Bay, Eyre Peninsula, South Australia 194 Charles Sturt University at Thurgoona, New South Wales, Australia 195 Chapel of the central clinic in Suhl, Germany 196 Cultural centre, La Paz, Bolivia 198 Mosque, Wabern, Germany 199 Chapel of Reconciliation, Berlin, Germany 200 Center of Gravity Foundation Hall at Jemez Springs, New Mexico, USA 202

Future prospects 204 Measures 205 Bibliographical references 206 Acknowledgements 207 Illustration credits 207