



Contents

	Preface	XIII
0	Introduction	1
0.1	Subject of the book	1
0.2	Units and symbols	1
0.3	References and literature	5
1	Performances	7
1.1	In general	7
1.2	Definitions and basic characteristics	7
1.3	Advantages	7
1.4	Performance arrays	7
1.5	Design based on performance metrics	10
1.5.1	The design process	10
1.5.2	Integrating a performance analysis	10
1.6	Impact on the building process	11
1.7	References and literature	11
2	Materials	13
2.1	In general	13
2.2	Array of material properties	13
2.3	Thermal insulation materials	14
2.3.1	Introduction	14
2.3.2	Apparent thermal conductivity	14
2.3.2.1	In general	14
2.3.2.2	Impact of the transport modes	14
2.3.3	Other properties	19
2.3.3.1	Mechanical	19
2.3.3.2	Physical	19
2.3.3.3	Fire	20
2.3.3.4	Sensitivity to temperature, IR and UV	20
2.3.4	Materials	20
2.3.4.1	Insulating building materials	20
2.3.4.2	Insulation materials	23
2.3.4.3	Insulating systems	34
2.3.4.4	Recent developments	35
2.4	Water, vapour and air flow control layers	37
2.4.1	In general	37

Performance Based Building Design 1. From Below Grade Construction to Cavity Walls.

First edition. Hugo Hens.

© 2012 Ernst & Sohn GmbH & Co. KG. Published 2012 by Ernst & Sohn GmbH & Co. KG

2.4.2	Water barriers	38
2.4.2.1	A short history	38
2.4.2.2	Bituminous membranes	39
2.4.2.3	Polymer-bituminous membranes	39
2.4.2.4	High-polymer membranes	41
2.4.3	Vapour retarders and vapour barriers	42
2.4.4	Air barriers	44
2.5	Joints	44
2.5.1	In general	44
2.5.2	Joint solutions and joint finishing options	45
2.5.3	Performance requirements	46
2.5.3.1	Mechanical	46
2.5.3.2	Building physics related	46
2.5.4	Sealant classification	46
2.5.5	Load and sealant choice	48
2.5.6	Structural design of sealed joints	49
2.5.7	Points of attention	50
2.6	References and literature	51
3	Excavations and building pit	55
3.1	In general	55
3.2	Realisation	55
4	Foundations	57
4.1	In general	57
4.2	Performance evaluation	57
4.2.1	Structural integrity	57
4.2.1.1	Equilibrium load bearing capacity	57
4.2.1.2	Settling load bearing capacity	58
4.2.2	Building physics	60
4.2.3	Durability	60
4.3	Foundation systems	61
4.3.1	In general	61
4.3.2	Spread foundations	61
4.3.2.1	Footings	61
4.3.2.2	Foundation slabs	63
4.3.2.3	Soil consolidation	63
4.3.3	Deep foundations	63
4.3.3.1	Wells	63
4.3.3.2	Piles	64
4.4	Specific problems	65
4.4.1	Eccentrically loaded footings	65
4.4.2	Footings under large openings	66
4.4.3	Reinforcing and/or deepening existing foundations	66
4.4.3.1	Footings	66

Contents	IX
4.4.3.2 Wells	67
4.4.3.3 Pressed piles	67
4.5 References and literature	68
5 Building parts on and below grade	69
5.1 In general	69
5.2 Performance evaluation	69
5.2.1 Structural integrity	69
5.2.1.1 Static stability	69
5.2.1.2 Strength and stiffness	70
5.2.2 Building physics, heat, air, moisture	71
5.2.2.1 Air tightness	71
5.2.2.2 Thermal transmittance	73
5.2.2.3 Transient response	88
5.2.2.4 Moisture tolerance	91
5.2.2.5 Thermal bridging	98
5.2.3 Building physics: acoustics	100
5.2.4 Durability	101
5.2.5 Fire safety	101
5.2.6 Soil gases	101
5.3 Design and execution	101
5.3.1 Basements	101
5.3.2 Drainages	102
5.3.2.1 In general	102
5.3.2.2 Properties	103
5.3.2.3 Design	103
5.3.3 Waterproof encasement	105
5.3.3.1 Inside	105
5.3.3.2 Outside	107
5.3.4 Waterproof concrete	108
5.4 References and literature	109
6 Structural options	111
6.1 In general	111
6.2 Performance evaluation	112
6.2.1 Structural integrity	112
6.2.2 Fire safety	113
6.3 Structural system design	115
6.3.1 Vertical loads	115
6.3.2 Horizontal load	116
6.3.2.1 Massive structures	116
6.3.2.2 Skeleton structures	119
6.3.3 Dynamic horizontal loads	121
6.4 References and literature	121

7	Floors	123
7.1	In general	123
7.2	Performance evaluation	124
7.2.1	Structural integrity	124
7.2.2	Building physics: heat-air-moisture	125
7.2.2.1	Air tightness	125
7.2.2.2	Thermal transmittance	126
7.2.2.3	Transient response	128
7.2.2.4	Moisture tolerance	129
7.2.2.5	Thermal bridging	135
7.2.3	Building physics: acoustics	136
7.2.3.1	Airborne noise	136
7.2.3.2	Impact noise	136
7.2.4	Durability	137
7.2.5	Fire safety	138
7.3	Design and execution	139
7.3.1	In general	139
7.3.2	Timber floors	140
7.3.2.1	Span below 6 m	140
7.3.2.2	Spans above 6 m	142
7.3.3	Concrete slabs and prefabricated structural floor units	142
7.3.3.1	Span below 6 m	142
7.3.3.2	Span above 6 m	145
7.3.4	Steel floors	146
7.3.4.1	Span below 6 m	146
7.3.4.2	Span above 6 m	146
7.4	References and literature	147
8	Outer wall requirements	149
8.1	In general	149
8.2	Performance evaluation	149
8.2.1	Structural integrity	149
8.2.2	Building physics: heat, air, moisture	150
8.2.2.1	Air tightness	150
8.2.2.2	Thermal transmittance	151
8.2.2.3	Transient response	152
8.2.2.4	Moisture tolerance	153
8.2.2.5	Thermal bridging	153
8.2.3	Building physics: acoustics	153
8.2.4	Durability	154
8.2.5	Fire safety	155
8.2.6	Maintenance and economy	155
8.3	References and literature	155

9	Massive outer walls	157
9.1	Traditional masonry walls	157
9.1.1	In general	157
9.1.2	Performance evaluation	157
9.1.2.1	Building physics: heat, air, moisture	157
9.1.2.2	Building physics: acoustics	160
9.1.2.3	Durability	160
9.1.2.4	Fire safety	160
9.1.3	Conclusion	160
9.2	Massive light-weight walls	160
9.2.1	In general	160
9.2.2	Performance evaluation	161
9.2.2.1	Structural integrity	161
9.2.2.2	Building physics: heat, air, moisture	162
9.2.2.3	Building physics: acoustics	170
9.2.2.4	Durability	171
9.2.2.5	Fire safety	172
9.2.2.6	Maintenance	172
9.2.3	Design and execution	172
9.2.3.1	In general	172
9.2.3.2	Specific	173
9.3	Massive walls with inside insulation	174
9.3.1	In general	174
9.3.2	Performance evaluation	174
9.3.2.1	Structural integrity	174
9.3.2.2	Building physics: heat, air, moisture	174
9.3.2.3	Building physics: acoustics	190
9.3.2.4	Durability	190
9.3.2.5	Fire safety	191
9.3.2.6	Global conclusion	192
9.3.3	Design and execution	192
9.4	Massive walls with outside insulation	194
9.4.1	In general	194
9.4.2	Performance evaluation	195
9.4.2.1	Structural integrity	195
9.4.2.2	Building physics: heat, air, moisture	195
9.4.2.3	Building physics: acoustics	206
9.4.2.4	Durability	207
9.4.2.5	Fire safety	209
9.4.2.6	Maintenance	209
9.4.2.7	Global conclusion	209
9.4.3	Design and execution	209
9.4.3.1	Clad stud systems	209
9.4.3.2	EIFS-systems	210
9.5	References and literature	212

10	Cavity walls	215
10.1	In general	215
10.2	Performance evaluation	217
10.2.1	Structural integrity	217
10.2.2	Building physics: heat, air, moisture	218
10.2.2.1	Air tightness	218
10.2.2.2	Thermal transmittance	221
10.2.2.3	Transient response	234
10.2.2.4	Moisture tolerance	235
10.2.2.5	Thermal bridges	244
10.2.3	Building physics: acoustics	244
10.2.4	Durability	245
10.2.1	Fire safety	246
10.2.1	Maintenance	246
10.3	Design and execution	247
10.3.1	New construction	247
10.3.1.1	Airtight, as few thermal bridges as possible	247
10.3.1.2	Correct cavity trays where needed	248
10.3.1.3	Excluding air looping and wind washing	249
10.3.2	Post-filling existing cavity walls	250
10.4	References and literature	251
11	Panelized massive outer walls	255
11.1	In general	255
11.2	Performance evaluation	256
11.2.1	Structural integrity	256
11.2.2	Building physics: heat, air, moisture	257
11.2.2.1	Air tightness	257
11.2.2.2	Thermal transmittance	257
11.2.2.3	Transient response	259
11.2.2.4	Moisture tolerance	259
11.2.2.5	Thermal bridging	260
11.2.3	Building physics: acoustics	260
11.2.4	Durability	260
11.2.5	Fire safety	261
11.2.6	Maintenance	261
11.3	Design and execution	261
11.4	References and literature	262