

TABLE OF CONTENTS

	Introduction	9
CHAPTERS		
1	DATA	23
1.1	Introduction	24
1.2	Data Resources	25
1.3	Metadata	32
1.4	Materials Informatics and Material Ontologies	34
1.5	Sensor-based Data Acquisition	36
1.6	Materials for Smart Buildings and Cities	38
1.7	Materials in Building Information Systems	41
1.8	Materials and the Internet of Things (IoT)	43
1.9	Outlook	47
2	AGENCY	49
2.1	Introduction	50
2.2	Properties	54
2.3	Behavior	60
2.4	Thermodynamics	65
2.5	Performance	72
2.6	Material Systems	77
2.7	Systems Thinking	79
2.8	Outlook	81
3	TIME	83
3.1	Introduction	84
3.2	Spatio-temporality	86
3.3	Multi-scalarity	89
3.4	Data for New Paradigms	93
3.5	Design for Change	96
3.6	Regeneration	99
3.7	Outlook	101

4	FLOWS	105
4.1	Introduction	106
4.2	Geographical Distribution of Resources	107
4.3	Slow Flows and Fast Flows	110
4.4	Materials, Flows, and Data	112
4.5	Urban Metabolism	116
4.6	Material Flows and the Human Scale	119
4.7	Circularity	122
4.8	Circular Flows and Spatial Impact	125
4.9	Material Value and Decision Networks	128
4.10	Material Tracking	130
4.11	Outlook	132
5	UBIQUITY	135
5.1	Introduction	136
5.2	Urban Mining	138
5.3	Critical Zone	141
5.4	Water	143
5.5	Soil	149
5.6	Biomass	160
5.7	Outlook	166
6	INDUSTRY 4.0, 5.0, ...	169
6.1	Introduction	170
6.2	Extended Reality	172
6.3	Haptic Feedback	174
6.4	Gamification	176
6.5	Artificial Intelligence	178
6.6	Advanced Manufacturing	179
6.7	The Internet of Things	181
6.8	Outlook	183
	Conclusion	187
	References	192
	Index	225
	Image Credits	228
	Authors’ Biographies	230
	Acknowledgements	231
	Imprint	232