
Contents

Preface.....	xi
Authors.....	xiii
Chapter 1 Nanotechnology and Nanomaterials: An Introduction	1
1.1 Introduction	1
1.2 Definition of Nanoscience and Nanotechnology	2
1.3 Nanoscience and Nanotechnology	2
1.4 Nanoparticles Preparation Methods	4
1.5 Applications of Nanomaterials in Construction	6
References	7
Chapter 2 Applications of Nanomaterials and Nanotechnology in the Construction Industry.....	11
2.1 Introduction	11
2.2 Significance of Nanotechnology in Construction Engineering ...	11
2.3 Nanotechnologies for Concrete	13
2.4 Nanotechnology in the Cement Industry.....	14
2.5 Asphalt.....	15
2.6 Brick	16
2.7 Steel	16
References	17
Chapter 3 Nanomaterial-Based Cement Concrete: Engineering Properties and Durability Performance.....	21
3.1 Introduction	21
3.2 Nanomaterial-Modified Cement Binder	22
3.3 Fresh Properties.....	23
3.4 Strength Performance	24
3.5 Microstructure Properties.....	25
3.6 Durability Properties.....	27
3.7 Summary	29
References	30
Chapter 4 Sustainability of Nanomaterial-Based Self-Healing Concrete.....	35
4.1 Introduction	35
4.2 Sustainability of Smart Concrete	36
4.3 Lifecycle Analysis of Self-Healing Concrete	36
4.4 Production of Nanomaterials.....	37

4.5	Production of Nanoconcrete	38
4.6	Significance of Nanomaterials as Self-Healer	38
4.7	Nano-Silica-Based Self-Healing Concrete	39
4.8	Nanoalumina-Based Self-Healing Concrete	40
4.9	Carbon Nanotube-Based Self-Healing Concrete.....	40
4.10	Titanium Oxide-Based Self-Healing Concrete.....	41
4.11	Nanokaolin and Nanoclay-Based Self-Healing Concrete.....	42
4.12	Nanoiron-Based Self-Healing Concrete	43
4.13	Economy of Nanomaterial-Based Self-Healing Concretes	43
4.14	Safety Features of Nanomaterial-Based Concretes	44
4.15	Summary	44
	References	45

Chapter 5	Engineering Properties of High-Performance Alkali-Activated Mortars	49
5.1	Introduction	49
5.2	Workability Performance	51
5.2.1	Flowability.....	51
5.2.2	Viscosity.....	52
5.2.3	Setting Time	53
5.2.4	Bulk Density.....	53
5.3	Mechanical Properties.....	55
5.3.1	Compressive Strength.....	55
5.3.2	Splitting Tensile Strength	56
5.3.3	Flexural Strength.....	57
5.3.4	Modulus of Elasticity	57
5.3.5	Relationship between CS, STS, and FS.....	58
5.3.6	Statistical Data Analysis	58
5.4	Microstructure Properties.....	60
5.4.1	XRD Patterns of AAMs.....	60
5.4.2	FESEM Analyses	61
5.4.3	EDX Analyses	62
5.4.4	FTIR Spectra.....	65
5.4.5	TGA and DTG Curves	66
5.5	Summary	67
	References	68

Chapter 6	Effect of Nanomaterials on Durability Properties of Free Cement Mortars.....	73
6.1	Introduction	73
6.2	Water Absorption.....	74
6.3	Drying Shrinkage	76
6.4	Carbonation Depth	77
6.5	Abrasion Resistance	79

6.6	Resistance to Freeze-Thawing Cycles	81
6.7	Acid Attack Resistance.....	86
6.8	Resistance to Elevated Temperatures	90
6.9	Summary	96
	References	97

Chapter 7	Nanoparticle-Based Phase Change Materials for Sustained Thermal Energy Storage in Concrete.....	99
7.1	Introduction	99
7.2	Overview of Energy Storage	100
7.2.1	Energy Storage Methods	101
7.2.2	Latent Heat Storage (LHS).....	102
7.2.3	Methods for Latent Heat of Fusion (LHF) and Melting Temperature Measurement	102
7.2.4	TES System	102
7.3	Phase Change Materials	103
7.3.1	Phase Change Materials Classification	103
7.3.2	Organic Materials.....	104
7.3.3	Inorganic Materials	105
7.3.4	Eutectics Materials	106
7.3.5	Hygroscopic Materials	106
7.3.6	Solid to Solid Phase Transforming Materials	107
7.4	Criteria of PCMs to Be Used for TES	107
7.5	Criteria of TES Based on PCMs for Building Applications...	107
7.6	Benefits of TES Based on PCMs for Buildings.....	108
7.7	Technology, Development, and Encapsulation	108
7.8	Nanomaterial-Based PCMs	109
7.8.1	Preparation Methods	109
7.8.2	Interfacial Polymerization	110
7.8.3	Emulsion Polymerization Method (EP)	110
7.8.4	Miniemulsion Polymerization (MEP) Method.....	111
7.8.5	In Situ Polymerization (ISP) Method	113
7.8.6	Sol–Gel Method	113
7.9	PCM Incorporation Procedures in Concrete	116
7.9.1	Immersion Technique.....	116
7.9.2	Impregnation Technique.....	117
7.9.3	Direct Mixing Technique	117
7.10	Effects of CPM on Concrete Properties	118
7.10.1	Fresh Properties.....	118
7.10.2	Mechanical Characteristics	119
7.10.3	Durability Properties.....	120
7.11	Stability of PCM in Concrete	120
7.12	Effects of Nanomaterials on Enhancement TES of PCM	121
7.13	Applications of NE-PCMs in Concrete	123
7.14	Concrete Thermal Energy Storage with NE-PCMs	125

7.15	Environmental Effects.....	125
7.16	Energy and Sustainability	126
7.17	Suggestions for Future Works	127
7.18	Summary	127
	References	128

Chapter 8	Concrete Coatings: Applications of Nanomaterials and Nanotechnology.....	137
8.1	Introduction	137
8.2	Concrete Durability	139
8.3	Coating Technology in Concrete	141
8.4	Nanotechnology and Nanoparticles.....	143
8.5	Nanoparticles and Nanomaterials	144
8.6	Definition of Nanotechnology in Concrete.....	145
8.7	Nanomaterial-Based Concretes	145
8.8	Production of Nanoconcrete	146
8.9	Nanomaterial-Based Concrete Surface Coating.....	147
8.9.1	Polymer Nanocomposite Coatings	147
8.9.2	Silane–Clay Nanocomposite Coatings.....	148
8.9.3	SiO ₂ and/or TiO ₂ Nanoparticle Coating Concrete....	149
8.10	Summary	151
	References	151

Chapter 9	Nanomaterial-Based Concrete Antivirus Surface.....	159
9.1	Introduction	159
9.2	Nanomaterial-Based Antimicrobial Coatings	161
9.3	Types of Nanomaterials for Antimicrobial Coatings	163
9.3.1	Copper (Cu)	163
9.3.2	Silver (Ag)	165
9.3.3	Silica (SiO ₂)	168
9.3.4	Titanium (TiO ₂).....	168
9.3.5	Zinc Oxide (ZnO).....	170
9.4	Summary	172
	References	172

Chapter 10	Nanomaterials: Environmental Health and Safety Considerations ...	181
10.1	Introduction	181
10.2	Safety Considerations	182
10.3	Potential Risks and Concerns.....	184
10.4	Risk of Nanomaterials.....	185
10.5	Toxicity of Nanomaterials	186
10.6	Using Nanomaterials Safely	187
10.7	Mitigation of Public and Environmental Health Impacts	188

10.8	Risk Communication and Technological Impact Assessment	189
10.9	Environmental Implications	190
10.10	Summary	191
	References	192
Chapter 11	Sustainability and Environmental Benefits of Concrete with Nanomaterials	195
11.1	Introduction	195
11.2	Life Cycle Assessment.....	197
11.3	Sustainability of Nanomaterial-Based Concrete	200
11.4	Merits and Demerits of Nanomaterials for Concrete	201
11.5	Economy of Nanomaterial-Based Concretes.....	201
11.6	Environmental Suitability of Nanomaterial-Based Concretes	203
	References	203
	Appendix: Questions and Answers	205
	Index.....	209