
Table of Contents

1	Thermoanalytical Techniques.....	1
1.0	INTRODUCTION	1
2.0	CLASSICAL TECHNIQUES	2
2.1	Differential Thermal Analysis and Differential Scanning Calorimetry	2
2.2	DSC	5
2.3	Calibration of DTA and DSC	7
2.4	Thermogravimetry	12
2.5	High Resolution TG	14
3.0	MODERN TECHNIQUES	20
3.1	Thermomechanical Analysis (TMA)	20
3.2	Dynamic Mechanical Analysis (DMA)	22
3.3	Dielectric Analysis (DEA)	23
3.4	Conduction Calorimetry	26
	REFERENCES	30
2	Introduction to Portland Cement Concrete	35
1.0	PRODUCTION OF PORTLAND CEMENT	36
2.0	COMPOSITION	37
3.0	INDIVIDUAL CEMENT COMPOUNDS	38
3.1	Tricalcium Silicate	38
3.2	Dicalcium Silicate	43
3.3	Tricalcium Aluminate	44
3.4	The Ferrite Phase	45
4.0	RELATIVE BEHAVIORS OF INDIVIDUAL CEMENT MINERALS	46
5.0	HYDRATION OF PORTLAND CEMENT	48

6.0	PROPERTIES OF CEMENT PASTE	51
6.1	Setting	51
6.2	Microstructure	52
6.3	Bond Formation	53
6.4	Density	54
6.5	Pore Structure	54
6.6	Surface Area and Hydraulic Radius	54
6.7	Mechanical Properties	55
7.0	PERMEABILITY OF CEMENT PASTE	56
8.0	DIMENSIONAL CHANGES	57
9.0	MODELS OF HYDRATED CEMENT	57
10.0	MATHEMATICAL MODELS	58
11.0	CONCRETE PROPERTIES	60
11.1	Workability	60
11.2	Setting	61
11.3	Bleeding and Segregation	61
11.4	Mechanical Properties	61
12.0	DURABILITY OF CONCRETE	62
13.0	ALKALI-AGGREGATE EXPANSION	63
14.0	FROST ACTION	63
15.0	SEA WATER ATTACK	64
16.0	CORROSION OF REINFORCEMENT	65
17.0	CARBONATION OF CONCRETE	65
18.0	DELAYED/SECONDARY ETTRINGITE FORMATION	66
	REFERENCES	67

3	Formation and Hydration of Cement and Cement Compounds	71
1.0	INTRODUCTION	71
2.0	RAW MATERIALS	73
3.0	CLINKERIZATION	77
4.0	SYNTHESIS OF CEMENT PHASES	82
5.0	POLYMORPHISM IN SILICATES	87
6.0	HYDRATION	89
6.1	Calcium Silicates	89
6.2	Calcium Aluminates	99
6.3	Calcium Aluminates Plus Gypsum	104
7.0	PORTLAND CEMENT	111
8.0	CaO-SiO ₂ -Al ₂ O ₃ -H ₂ O AND RELATED SYSTEMS	118
9.0	DURABILITY ASPECTS	122
9.1	Aggregates	122
9.2	Magnesium Oxide	124
9.3	High Temperature Effects	126
9.4	Freezing-Thawing Processes	127
9.5	Carbonation	131
9.6	Chemical Attack	134
9.7	Aged Concrete	135
	REFERENCES	136

4	Introduction to Concrete Admixtures	143
1.0	INTRODUCTION	143
2.0	ACCELERATORS	145
2.1	Effect of Calcium Chloride on Calcium Silicates	146
2.2	Effect of Calcium Chloride on Calcium Aluminate	149
2.3	Effect of Calcium Chloride on Cement	150
2.4	Effect of Calcium Chloride on Concrete	151
2.5	Triethanolamine (TEA)	153
2.6	Formates	156
2.7	Other Non-Chloride Accelerators	159
3.0	WATER REDUCERS AND RETARDERS	162
3.1	Introduction	162
3.2	Retarders	164
3.3	Water Reducers	167
4.0	SUPERPLASTICIZERS	169
5.0	AIR-ENTRAINING AGENTS	173
6.0	MINERAL ADMIXTURES	174
6.1	Fly Ash	175
6.2	Slag	176
6.3	Silica Fume	176
7.0	MISCELLANEOUS ADMIXTURES	177
7.1	Expansion Producers	178
7.2	Pigments	178
7.3	Dampproofing and Waterproofing Admixtures	178
7.4	Pumping Aids	178
7.5	Flocculating Admixtures	178
7.6	Bacterial, Fungicidal, and Insecticidal Admixtures	179
7.7	Shotcreting Admixtures	179
7.8	Antiwashout Admixtures	179
7.9	Corrosion Inhibiting Admixtures	179
7.10	Alkali-Aggregate Expansion Reducing Admixtures	180
7.11	Polymer-Modified Mortars/Concrete	180
7.12	Admixtures for Oil Well Cements	180
7.13	Antifreezing Admixtures	181
	REFERENCES	182
5	Accelerating Admixtures	189
1.0	INTRODUCTION	189
2.0	CALCIUM CHLORIDE	190
3.0	NON-CHLORIDE ACCELERATORS	202
	REFERENCES	218
6	Retarding and Water Reducing Admixtures	221
1.0	INTRODUCTION	221

2.0	LIGNOSULFONATES	222
2.1	Tricalcium Aluminate	222
2.2	Tricalcium Aluminate-Gypsum-Calcium Lignosulfonate-Water	224
2.3	Tetracalcium Aluminoferrite-Calcium Lignosulfonate-Water	225
2.4	Tricalcium Silicate-Lignosulfonate-Water	226
2.5	Dicalcium Silicate-Lignosulfonate-Water System	229
2.6	Tricalcium Silicate-Tricalcium Aluminate- Lignosulfonate-Water System	230
2.7	Cement-Lignosulfonate-Water System	232
3.0	SUGAR-FREE LIGNOSULFONATE	235
4.0	HYDROXYCARBOXYLIC ACIDS	238
5.0	SUGARS	239
6.0	PHOSPHONATES	240
7.0	CONDUCTION CALORIMETRIC ASSESSMENT OF RETARDERS	245
8.0	SLUMP LOSS	248
9.0	ABNORMAL SETTING	251
10.0	READY-MIX CONCRETE	252
11.0	OTHER ADMIXTURES	254
12.0	IDENTIFICATION OF WATER REDUCERS/RETARDERS	254
	REFERENCES	257
7	Superplasticizing Admixtures	261
1.0	INTRODUCTION	261
2.0	TRICALCIUM ALUMINATE	262
3.0	TRICALCIUM ALUMINATE-GYPSUM SYSTEM	265
4.0	TRICALCIUM SILICATE	269
5.0	CEMENT	273
6.0	THERMAL ANALYSIS OF SUPERPLASTICIZERS	287
	REFERENCES	289
8	Supplementary Cementing Materials and Other Additions	293
1.0	INTRODUCTION	293
2.0	FLY ASH	294
3.0	SILICA FUME	300
4.0	SLAGS	308
5.0	RICE HUSK ASH	319
6.0	METAKAOLINITE	323
7.0	NATURAL POZZOLANS	328
8.0	RELATIVE EFFECTS OF POZZOLANS AND THEIR MIXTURES	332
9.0	MISCELLANEOUS ADDITIVES	338
	REFERENCES	345

9 Introduction to Non-Portland Cement Binders and Concrete 355

1.0 INTRODUCTION 355

2.0 MAGNESIUM OXYCHLORIDE CEMENT 356

 2.1 Description 356

 2.2 Hydration Reactions 356

 2.3 Microstructure Development 357

 2.4 Strength Development 357

 2.5 Resistance To Water 360

3.0 MAGNESIUM OXYSULFATE CEMENT 360

 3.1 Hydration 360

 3.2 Strength Development 361

4.0 CALCIUM ALUMINATE CEMENTS 362

 4.1 Description 362

 4.2 Hydration 363

 4.3 Strength Development 365

 4.4 Strength and the Conversion Reaction 365

 4.5 Inhibition of C3AH6 Formation 366

 4.6 Durability 367

 4.7 Chemical Admixtures 367

 4.8 Refractory Applications 369

5.0 PORTLAND CEMENT–CALCIUM ALUMINATE CEMENT BLENDS 370

 5.1 Introduction 370

 5.2 Hydration 370

 5.3 Setting Behavior and Ettringite Nucleation 372

 5.4 Early Strength Development 373

 5.5 CAC-Based Expansive Cement Reactions 375

 5.6 Chemical Admixtures 378

6.0 PHOSPHATE CEMENT SYSTEMS 379

 6.1 Description 379

7.0 MAGNESIA PHOSPHATE CEMENT BINDERS 381

 7.1 Mechanical Properties 381

 7.2 Additives 385

 7.3 Calcium Phosphate-Based Materials 386

 7.4 Lime Silico-Phosphate Cement 387

8.0 REGULATED-SET CEMENT 388

 8.1 Description 388

 8.2 Paste and Mortar Hydration 388

9.0 MECHANICAL PROPERTIES AND DURABILITY OF JET SET-BASED CEMENT SYSTEMS 392

 9.1 Strength, Microhardness, and Modulus of Elasticity 392

 9.2 Durability 395

 9.3 Gypsum 395

REFERENCES 397

10 Non-Portland Rapid Setting Cements	403
1.0 INTRODUCTION	403
2.0 CALCIUM ALUMINATE CEMENTS	404
2.1 Basic Reactions	404
2.2 Thermal Analysis of Hydrated Calcium Aluminate Cements	405
3.0 JET SET (REGULATED-SET) CEMENT	422
3.1 Hydration of $11\text{CaO}\cdot 7\text{Al}_2\text{O}_3\cdot \text{CaF}_2$	422
4.0 MAGNESIUM OXYCHLORIDE AND MAGNESIUM OXYSULFATE CEMENT SYSTEMS	430
5.0 ZINC OXYCHLORIDE CEMENT	437
6.0 MAGNESIA-PHOSPHATE CEMENTS	438
7.0 HYDROXYAPATITE	444
REFERENCES	446
11 Gypsum and Gypsum Products	449
1.0 INTRODUCTION	449
2.0 DIFFERENTIAL THERMAL ANALYSIS (DTA) AND DIFFERENTIAL SCANNING CALORIMETRY (DSC)	450
3.0 THERMOGRAVIMETRIC ANALYSIS (TG)	454
4.0 DEHYDRATION OF GYPSUM	455
5.0 SIMULTANEOUS TG-DTG-DTA	459
6.0 CONVERSION REACTIONS	462
6.1 Dihydrate to β -Anhydrite	462
6.2 Conversion of Soluble to Insoluble Anhydrite	467
7.0 CONTROLLED TRANSFORMATION RATE THERMAL ANALYSIS (CRTA)	467
7.1 CRTA and Kinetic Modeling	473
8.0 A THREE STEP GYPSUM DEHYDRATION PROCESS	477
9.0 INDUSTRIAL APPLICATIONS	480
9.1 Portland Cement and Stucco	480
9.2 Gypsum-Based Cements	482
9.3 Sedimentary Rocks Containing Gypsum	484
9.4 Quality Control of Commercial Plasters	484
9.5 White Coat Plaster	487
9.6 Expanding Cement	488
REFERENCES	488
12 Clay-Based Construction Products	491
1.0 INTRODUCTION	491
2.0 THERMAL BEHAVIOR AND IDENTIFICATION OF CLAYS AND ACCESSORY MINERALS	492
2.1 DTA of Clay Minerals	492
2.2 Other Thermal Methods	500
2.3 Accessory Minerals	505

- 3.0 APPLICATIONS 508
 - 3.1 Analysis of Brick Clays 508
 - 3.2 Thermal Efficiency of Kilns 508
 - 3.3 Dark Color of Soils 508
 - 3.4 Bloatability of Clays 510
 - 3.5 Weathering of Roofing Slates 513
 - 3.6 Soil Stabilization 514
 - 3.7 Structural Ceramics 514
 - 3.8 Solid Waste in Clay Bricks 517
 - 3.9 Archaeological Investigations 518
- 4.0 DURABILITY OF CLAY BRICKS 519
 - 4.1 Dimensional Changes 519
 - 4.2 Saturation Coefficient 521
 - 4.3 Firing Temperature of Clay Brick 521
 - 4.4 Brick Particulate Additives for Concrete 526
- REFERENCES 529

13 Introduction to Organic Construction Materials 531

- 1.0 INTRODUCTION 531
- 2.0 ADHESIVES AND SEALANTS 538
 - 2.1 Adhesives 538
 - 2.2 Sealants 547
- 3.0 PAINTS AND COATINGS 553
- 4.0 ASPHALT - BITUMINOUS MATERIALS 560
- 5.0 ROOF COVERING MATERIALS 563
 - 5.1 Polymers 565
 - 5.2 Membrane Characteristics 568
- REFERENCES 573

14 Sealants and Adhesives 579

- 1.0 INTRODUCTION 579
- 2.0 TEST METHODS 580
- 3.0 APPLICATIONS 584
 - 3.1 Sealants 584
 - 3.2 Adhesives 599
- REFERENCES 606

15 Roofing Materials 611

- 1.0 INTRODUCTION 611
- 2.0 BITUMINOUS ROOFING MATERIAL 612
- 3.0 SYNTHETIC ROOFING MEMBRANES 613
- 4.0 APPLICATIONS 615
- REFERENCES 627

16	Paints and Coatings	633
1.0	INTRODUCTION	633
2.0	PAINTS	634
3.0	COATINGS	640
3.1	Intumescent Coatings	640
3.2	Silicone Coatings	645
3.3	Organic Coatings Degradation (Service-Life)	647
3.4	Inorganic Coatings	649
3.5	Miscellaneous Coatings	650
	REFERENCES	652
Index	655	