

Index

Chapter I - Introduction to terminology

1.1	SCOPE	Pg.	1
1.2	THE INGREDIENTS OF CONCRETE.....	Pg.	1
1.3	THE MANUFACTURE OF CONCRETE.....	Pg.	4
1.4	THE MECHANICAL PRPERTIES OF CONCRETE.....	Pg.	5
1.5	DURABILITY OF STRUCTURES.....	Pg.	9
1.6	MIX-DESIGN.....	Pg.	9
1.7	FROM MIXING TO CURING.....	Pg.	11

Chapter II - Cement

2.1	CEMENT: THE HEART OF THE CONCRETE.....	Pg.	13
2.2	CEMENTS ARE NOT ALL THE SAME.....	Pg.	13
2.3	THE NEED FOR NORMS ON CEMENTS.....	Pg.	13
2.4	THE PROLIFERATION OF CEMENTS IN EUROPE.....	Pg.	14
2.5	SETTING TIME OF CEMENTS.....	Pg.	15
2.6	STRENGTH CLASS OF CEMENTS.....	Pg.	16
2.7	PORTLAND CEMENT.....	Pg.	17
2.8	POZZOLAN.....	Pg.	18
2.9	SLAG.....	Pg.	21
2.10	FLY ASH AND SILICA FUME	Pg.	22
2.11	TYPES OF CEMENT.....	Pg.	26

Chapter III - Hydration, setting and hardening

3.1	HYDRATION, SETTING AND HARDENING.....	Pg.	29
3.2	THE HYDRATION OF PORTLAND CEMENT.....	Pg.	29
3.3	THE HYDRATION OF ALUMINATES.....	Pg.	30
3.4	THE ROLE OF GYPSUM IN THE SETTING OF CEMENT.....	Pg.	31
3.5	THE HYDRATION OF SILICATES.....	Pg.	32
3.6	THE ROLE OF LIME.....	Pg.	36

Chapter IV - Aggregates

4.1	THE ROLE OF AGGREGATES.....	Pg.	39
4.2	THE ACCEPTANCE CRITERIA OF AGGREGATES.....	Pg.	40
4.2.1	CHLORIDE.....	Pg.	40
4.2.2	SULPHATE.....	Pg.	40
4.2.3	ALKALI-REACTIVE SILICA.....	Pg.	41
4.2.4	ALKALI-CARBONATE REACTION.....	Pg.	43
4.2.5	CLAY AND OTHER FINE MATERIALS.....	Pg.	43
4.2.6	ORGANIC SUBSTANCES.....	Pg.	44
4.2.7	FROST ATTACK.....	Pg.	44

4.2.8	MECHANICAL PROPERTIES.....	Pg.	44
4.3	GRADING OF AGGREGATES.....	Pg.	45
4.3.1	GRADING.....	Pg.	45
4.3.1.1	Sieve analysis.....	Pg.	46
4.3.1.2	Ideal grading distribution.....	Pg.	48
4.3.1.3	Optimal combination of aggregates.....	Pg.	51
4.4	AGGREGATE MOISTURE.....	Pg.	54
4.5	INFLUENCE OF THE AGGREGATE MOISTURE ON CONCRETE PERFORMANCE	Pg.	56
4.6	AGGREGATE MOISTURE.....	Pg.	57
4.7	EFFECT OF MAXIMUM SIZE AND PARTICLE SIZE DISTRIBUTION ON THE WATER REQUIREMENT.....	Pg.	60
4.8	AGGREGATES FOR HIGH-PERFORMANCE CONCRETES.....	Pg.	61
Chapter V - Water			
5.1	THE ROLE OF WATER.....	Pg.	63
5.2	THE MAGIC OF MIX-DESIGN.....	Pg.	63
5.2.1	LYSE'S RULE.....	Pg.	63
5.2.2	ABRAMS'S LAW.....	Pg.	65
5.2.3	WATER REQUIREMENT.....	Pg.	66
5.3	THE WATER ADDITION ON THE JOB-SITE.....	Pg.	67
5.4	RESPONSIBILITY FOR THE WATER ADDITION ON THE JOB-SITE.....	Pg.	67
Chapter VI - Workability of fresh concrete			
6.1	THE IMPORTANCE OF WORKABILITY.....	Pg.	71
6.2	THE CHOICE OF WORKABILITY.....	Pg.	73
6.3	ADVANTAGES OF A WORKABLE CONCRETE FOR THE CONTRACTORS.....	Pg.	74
6.4	WORKABILITY AND RELIABILITY OF THE STRUCTURES.....	Pg.	75
6.5	DEGREE OF CONSOLIDATION.....	Pg.	77
6.6	STRENGTH OF SPECIMENS AND CORES.....	Pg.	79
6.7	COMPLEMENTARITY OF WORKABILITY AND CONSOLIDATION.....	Pg.	80
Chapter VII - Bleeding and segregation			
7.1	BLEEDING.....	Pg.	83
7.2	BLEEDING IN CEMENT PASTE.....	Pg.	83
7.2.1	BLEEDING AND CEMENT FINENESS.....	Pg.	84
7.2.2	BLEEDING AND MINERAL ADDITIONS.....	Pg.	86
7.2.3	BLEEDING AND CHEMICAL ADMIXTURES.....	Pg.	86
7.2.4	MIXING PROCEDURES.....	Pg.	87
7.3	BLEEDING IN MORTAR.....	Pg.	88
7.3.1	GROUTING MORTARS.....	Pg.	88
7.3.2	EXCAVATION FILLING MORTAR.....	Pg.	88
7.4	BLEEDING IN CONCRETE.....	Pg.	88
7.4.1	BLEEDING IN CONCRETE INDUSTRIAL FLOORS.....	Pg.	88
7.4.2	BLEEDING AND STEEL-CONCRETE BOND.....	Pg.	90

7.4.3	BLEEDING AND NEW PLACEMENT.....	Pg.	91
7.4.4	BLEEDING AND TRANSITION ZONE.....	Pg.	91
7.5	HOW TO REDUCE BLEEDING AND SEGREGATION IN CONCRETE.....	Pg.	93
Chapter VIII - Concrete porosity			
8.1	KINDS OF PORES IN CONCRETE.....	Pg.	95
8.2	CAPILLARY POROSITY AND STRENGTH.....	Pg.	97
8.3	CAPILLARY POROSITY AND ELASTIC MODULUS.....	Pg.	99
8.4	CAPILLARY POROSITY AND PERMEABILITY.....	Pg.	99
8.5	CAPILLARY POROSITY AND DURABILITY.....	Pg.	99
Chapter IX - Mechanical properties			
9.1	STRENGTH.....	Pg.	103
9.2	STRENGTH OF THE CEMENT PASTE.....	Pg.	104
9.3	COMPRESSIVE STRENGTH OF CONCRETE.....	Pg.	104
9.3.1	INFLUENCE OF COMPACTION OF FRESH CONCRETE ON COMPRESSIVE STRENGTH.....	Pg.	106
9.3.2	INFLUENCE OF CURING TEMPERATURE ON COMPRESSIVE STRENGTH.....	Pg.	108
9.4	CHARACTERISTIC STRENGTH.....	Pg.	108
9.5	STRENGTH CLASS ACCORDING TO THE EUROPEAN NORM.....	Pg.	113
9.6	FLEXURAL AND TENSILE STRENGTHS.....	Pg.	115
9.7	CORRELATION OF FLEXURAL OR TENSILE STRENGTHS WITH COMPRESSIVE STRENGTH.....	Pg.	116
9.8	CORRELATION BETWEEN COMPRESSIVE STRENGTH AND MODULUS OF ELASTICITY.....	Pg.	117
Chapter X - Deterioration of reinforced concrete			
10.1	CAUSES OF DETERIORATION.....	Pg.	121
10.2	CORROSION OF METALLIC REINFORCEMENTS.....	Pg.	124
10.2.1	CORROSION PROMOTED BY CARBONATION.....	Pg.	126
10.2.2	CORROSION PROMOTED BY CHLORIDE.....	Pg.	131
10.3	CONCRETE DETERIORATION IN THE CEMENT PASTE.....	Pg.	139
10.3.1	CONCRETE DAMAGE BY SULPHATE ATTACK OF CEMENT PASTE... 10.3.1.1 External sulphate attack.....	Pg.	142
10.3.1.2	Internal sulphate attack.....	Pg.	144
10.3.2	CONCRETE DAMAGE BY LEACHING OUT OF CEMENT PASTE.....	Pg.	145
10.3.3	CONCRETE DAMAGE BY FREEZING AND THAWING CYCLES..... 10.3.3.1 Durability factor to assess frost-resistance.....	Pg.	151
10.3.4	SURFACE CRACKING DUE TO PHYSICAL EFFECTS.....	Pg.	152
10.3.5	SURFACE CONCRETE DAMAGES DUE TO MECHANICAL STRESSES..	Pg.	153
10.4	DAMAGE BY ALKALI-AGGREGATE REACTION.....	Pg.	154
10.4.1	DAMAGE BY ALKALI-SILICA REACTION.....	Pg.	154
10.4.2	DAMAGE BY ALKALI-CARBONATE REACTION.....	Pg.	157

Chapter XI - Durability of concrete

11.1	CLASSES OF EXPOSURE.....	Pg.	159
11.2	EXPOSURE CLASS XC: CARBONATION.....	Pg.	161
11.3	EXPOSURE CLASS XD: CHLORIDES OTHER THAN FROM SEA WATER.....	Pg.	163
11.4	EXPOSURE CLASS XS: CORROSION BY CHLORIDES FROM SEA WATER.....	Pg.	164
11.5	EXPOSURE CLASS XF: FREEZING-THAWING.....	Pg.	165
11.6	EXPOSURE CLASS XA: CHEMICAL AGGRESSION.....	Pg.	167
11.7	PRESCRIPTIONS FOR LONG TERM DURABILITY.....	Pg.	169
11.7.1	LONG TERM DURABILITY OF REINFORCING BARS.....	Pg.	170
11.7.2	LONG TERM DURABILITY IN XA3 EXPOSURE CLASS.....	Pg.	170

Chapter XII - Mix-design

12.1	DEFINITION OF MIX DESIGN.....	Pg.	159
12.2	MIXING WATER AS A FUNCTION OF WORKABILITY, AGGREGATE TYPE AND ADMIXTURE.....	Pg.	177
12.3	WATER/CEMENT RATIO AS A FUNCTION OF STRENGTH AND CEMENT TYPE.....	Pg.	178
12.4	WATER-CEMENT RATIO AND AIR AS A FUNCTION OF DURABILITY.....	Pg.	179
12.5	COMBINATION OF THE AVAILABLE AGGREGATES.....	Pg.	182

Chapter XIII - Chemical admixtures

13.1	CLASSIFICATION OF CHEMICAL ADMIXTURES.....	Pg.	185
13.2	ACCELERATORS.....	Pg.	185
13.2.1	SETTING ACCELERATORS.....	Pg.	186
13.2.2	HARDENING ACCELERATORS.....	Pg.	188
13.3	RETARDERS.....	Pg.	189
13.4	AIR-ENTRAINING AGENTS.....	Pg.	189
13.5	CORROSION INHIBITORS.....	Pg.	190
13.6	ASR-INHIBITORS.....	Pg.	191
13.7	HYDROPHOBIC ADMIXTURES.....	Pg.	191
13.8	VISCOSITY MODIFYING AGENTS.....	Pg.	194
13.9	SHRINKAGE-REDUCING ADMIXTURES.....	Pg.	195
13.10	WATER-REDUCERS.....	Pg.	197
13.11	SUPERPLASTICIZERS OR HIGH-RANGE WATER REDUCERS.....	Pg.	199
13.11.1	WHY SUPERPLASTICIZERS ARE IMPORTANT.....	Pg.	200
13.11.2	THE PROGRESS IN SUPERPLASTICIZERS.....	Pg.	202
13.11.3	MECHANISMS OF ACTION OF SUPERPLASTICIZERS.....	Pg.	203
13.11.4	PROGRESS IN SLUMP RETENTION.....	Pg.	207
13.11.5	SPECIAL MULTI-FUNCTIONAL SUPERPLASTICIZERS.....	Pg.	210
13.11.6	HOW TO USE IN PRACTICE SUPERPLASTICIZERS.....	Pg.	216
13.11.6.1	Strength increase by using superplasticizer.....	Pg.	217
13.11.6.2	Cement-reduction by using superplasticizer.....	Pg.	217
13.11.6.3	Workability-increase by using superplasticizer.....	Pg.	218

Chapter XIV - Temperature and concrete

14.1	IMPORTANCE OF TEMPERATURE.....	Pg.	221
14.2	INFLUENCE OF TEMPERATURE ON STRENGTH DEVELOPMENT.....	Pg.	221
14.3	INFLUENCE OF TEMPERATURE ON SITE ORGANIZATION.....	Pg.	224
14.4	THERMAL TREATMENT IN PRECAST CONCRETE.....	Pg.	225
14.5	HEAT OF HYDRATION AND THERMAL GRADIENTS.....	Pg.	228

Chapter XV - Curing, Drying-shrinkage, and cracking

15.1	WHY CURING OF CONCRETE IS IMPORTANT.....	Pg.	235
15.1.1	PROPER CURING.....	Pg.	235
15.2	INFLUENCE OF CURING ON CONCRETE STRENGTH.....	Pg.	237
15.3	INFLUENCE OF CURING ON DURABILITY.....	Pg.	239
15.4	SHRINKAGE OF CONCRETE.....	Pg.	240
15.5	PLASTIC SHRINKAGE.....	Pg.	240
15.6	DRYING SHRINKAGE.....	Pg.	243
15.6.1	STANDARD DRYING SHRINKAGE OF CONCRETE.....	Pg.	246
15.6.2	PREDICTION OF DRYING SHRINKAGE IN CONCRETE STRUCTURES...	Pg.	249
15.6.3	EXAMPLE OF PREDICTION OF DRYING SHRINKAGE IN A CONCRETE STRUCTURE.....	Pg.	252
15.7	AUTOGENOUS SHRINKAGE.....	Pg.	254

Chapter XVI - Creep in concrete

16.1	ELASTIC STRAIN, CREEP AND RELAXATING.....	Pg.	257
16.2	BASIC AND DRYING COMPRESSIVE CREEP.....	Pg.	259
16.3	PREDICTION OF COMPRESSIVE CREEP IN CONCRETE STRUCTURES.....	Pg.	262
16.4	NUMERICAL APPLICATION OF THE CREEP IN CONCRETE STRUCTURES....	Pg.	266

Chapter XVII - High-strength concrete

17.1	HIGH-STRENGTH VS. HIGH-PERFORMANCE CONCRETE.....	Pg.	269
17.2	THE ROLE PLAYED BY SILICA FUME IN HSC.....	Pg.	273
17.3	INFLUENCE OF TRANSITION ZONE ON CONCRETE STRENGTH.....	Pg.	275
17.4	DENSIFIED SMALL PARTICLE (DSP) CONCRETES.....	Pg.	278
17.4.1	PERFORMANCE LIMITS OF DSP CONCRETES.....	Pg.	280
17.5	REACTIVE POWDER CONCRETE.....	Pg.	281

Chapter XVIII - Self-Compacting Concrete (SCC)

18.1	INTRODUCTION: PRECURSORS OF SCC.....	Pg.	285
18.2	COMPOSITION OF SELF-COMPACTING CONCRETE.....	Pg.	287
18.3	THEOLOGICAL MEASUREMENTS OF SCC.....	Pg.	288
18.4	COMPOSITION OF SCC AND ORDINARY FLOWING CONCRETE.....	Pg.	291
18.5	PROPERTIES OF SCC IN THE HARDENED STATE.....	Pg.	292
18.5.1	COMPRESSIVE STRENGTH.....	Pg.	294
18.5.2	STEEL-CONCRETE BOND OF SCC.....	Pg.	295
18.5.3	DRYING SHRINKAGE AND CREEP OF SCC.....	Pg.	296

18.6	THE ROLE OF NEW RAW MATERIALS FOR SCC.....	Pg.	300
18.7	PRATICAL APPLICATIONS OF SCC.....	Pg.	304
18.7.1	ARCHITECTURAL SCC.....	Pg.	304
18.7.2	HIGH-STRENGTH SCC.....	Pg.	307
18.7.3	MASS CONCRETE SCC.....	Pg.	309
18.7.4	PRECAST LIGHTWEIGHT SCC.....	Pg.	312
18.7.5	SHRINKAGE-COMPENSATING SCC IN THE ABSENCE OF WET CURING..	Pg.	315

Chapter XIX - Structural lightweight concrete

19.1	LIGHTEWIGHT CONCRETE.....	Pg.	319
19.2	LIGHTEWIGHT CONCRETE IN THE PANTHEON, ROME.....	Pg.	319
19.3	CLASSIFICATION OF LIGHTWEIGHT CONCRETES.....	Pg.	321
19.4	STRUCTURAL LIGHTWEIGHT CONCRETES.....	Pg.	322
19.5	STRUCTURAL READY-MIXED LIGHTWEIGHT CONCRETES.....	Pg.	323

Chapter XX - Fibre-reinforced concrete

20.1	BEHAVIOUR OF FIBRE-REINFORCED CONCRETE.....	Pg.	327
20.2	TYPER OF FIBRES.....	Pg.	327
20.3	APPLICATIONS OF FIBRE-REINFORCED CONCRETES.....	Pg.	327
20.3.1	USE OF POLYMER MICRO-FIBRES.....	Pg.	329
20.3.2	IMPROVED USE OF POLYMER MACRO-FIBRES.....	Pg.	330
20.3.3	CRACK-FREE CONCRETE FLOORS WITHOUT METALLIC WIRE-MESH AND WET-CURING.....	Pg.	331
20.4	LABORATORY TESTS ON REDUCED DRYING SHRINKAGE.....	Pg.	331
20.5	FIELD TESTS ON CRACK-FREE CONCRETE WITHOUT WIRE-MESH AND WET-CURING.....	Pg.	335
20.6	BEHAVIOUR OF FIBRE-REINFORCED CONCRETE IN TENSION.....	Pg.	339
20.7	IMPACT-STRENGTH OF STEEL FIBRE-REINFORCED CONCRETE.....	Pg.	341
20.8	USE OF PVA FIBRES.....	Pg.	343

Chapter XXI - Shrinkage-compensating concrete

21.1	EXPANSIVE AGENTS.....	Pg.	347
21.2	HOW TO MEASURE THE RESTRAINED EXPANSION.....	Pg.	348
21.3	SPECIMEN EXPANSION VS. REAL STRUCTURE EXPANSION.....	Pg.	351
21.4	THE PAST TIME OF EXPANSIVE AGENTS.....	Pg.	352
21.5	LIME VERSUS SULPHO-ALUNIMATE AS EXPANSIVE AGENTS.....	Pg.	353
21.6	LIME-BASED EXPANSIVE AGENT.....	Pg.	354
21.7	PRACTICAL APPLICATIONS ON SRA-CAO COMBINATION IN THE ABSENCE OF WET CURING.....	Pg.	357

Chapter XXII - Shotcrete

22.1	DEFINITIONS.....	Pg.	363
22.2	ACI RECOMMENDATIONS FOR RIGHT SHOTCRETING.....	Pg.	363
22.2.1	ON SITE COMPOSITION.....	Pg.	364

22.2.2	SUBSTRATE-SHOCRETE BOND.....	Pg.	365
22.2.3	ADHESION AMONG DIFFERENT LAYERS OF SHOCRETE.....	Pg.	366
22.2.4	FILLING BEHIND THE STEEL REINFORCEMENTS.....	Pg.	367
22.2.5	LOSS OF SHOTCRETE.....	Pg.	367
22.3	SHOTCRETE COMPOSITION.....	Pg.	369
22.4	AUXILIARY MATERIALS FOR SHOTCRETE.....	Pg.	369
22.4.1	MINERAL ADDITIONS FOR SHOTCRETE.....	Pg.	369
22.4.2	FIBRES FOR SHOTCRETE.....	Pg.	370
22.4.3	CHEMICAL ADMIXTURES FOR SHOTCRETE.....	Pg.	371
22.5	HIGH PERFORMANCE SHOTCRETE (HPS).....	Pg.	373
Chapter XXIII - Recycled concrete			
23.1	INTRODUCCION.....	Pg.	375
23.2	PROCESS OF RECYCLING DEMOLISHED CONCRETE.....	Pg.	377
23.3	PROPERTIES OF RECYCLED AGGREGATES.....	Pg.	379
23.3.1	DENSITY OF RECYCLED AGGREGATES.....	Pg.	379
23.3.2	WATER ABSORPTION.....	Pg.	379
23.3.3	CONTAMINANT PRODUCTS.....	Pg.	381
23.4	FRESH CONCRETES WITH RECYCLED AGGREGATES.....	Pg.	382
23.5	HARDENED CONCRETES WITH RECYCLED AGGREGATES.....	Pg.	382
Chapter XXIV - Concrete exposed to fire			
24.1	FIRE ENDURANCE.....	Pg.	385
24.2	CONCRETE BEHAVIOUR DURING IN THE FIRE.....	Pg.	385
24.3	INFLUENCE OF THE COVER ON THE FIRE ENDURANCE.....	Pg.	388
24.4	INFLUENCE OF LOADING IN SERVICE ON THE FIRE EFFECTS.....	Pg.	382
24.5	BEHAVIOUR OF HIGH-STRENGTH CONCRETE DURING THE FIRE.....	Pg.	391
24.6	THE INFLUENCE OF METALLIC FIBRES ON THE FIRE.....	Pg.	392
24.7	INFLUENCE OF POLYMERIC FIBRES ON THE FIRE BEHAVIOUR.....	Pg.	394
Chapter XXV - Concrete prescriptions			
25.1	INTRODUCTION.....	Pg.	395
25.2	COMPOSITION SPECIFICATIONS.....	Pg.	395
25.3	PERFORMANCE SPECIFICATIONS.....	Pg.	396
25.3.1	CONCRETE PERFORMANCE SPECIFICATION.....	Pg.	396
25.3.1.1	Performance specifications of hardened concrete....	Pg.	396
25.3.1.2	Performance specifications of fresh concrete.....	Pg.	397
25.3.2	SPECIFICATIONS FOR THE CONTRACTOR.....	Pg.	397
25.3.2.1	Correct positioning of spacers.....	Pg.	398
25.3.2.2	Specification on compaction of fresh concrete.....	Pg.	398
25.3.2.3	Proper curing of the concrete surface.....	Pg.	399