

Multicolour Illustrative Edition

CONCRETE TECHNOLOGY

THEORY AND PRACTICE

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**Dedicated
To
My Beloved Father
V. VENKAPPA SHETTY**

FOREWORD

As one who has closely watched the author's interest and involvement in concrete technology for the past several years, I have great pleasure in writing this foreword.

Concrete is by far the most widely used construction material today. The versatility and mouldability of this material, its high compressive strength, and the discovery of the reinforcing and prestressing techniques which helped to make up for its low tensile strength have contributed largely to its widespread use. We can rightly say that we are in the age of concrete.

It is easy to make concrete. There is an old saying that broken stone, sand, and cement make good concrete. But the same proportion of broken stone, sand and cement also make bad concrete. This is mainly because the quality of the end product depends as much, and perhaps more, on the man on the job as on the constituent materials. The difference between good concrete and bad concrete lies in quality control. Extensive research work was, therefore, carried out almost from the beginning of this century not only on the materials but also on the methods used for concrete making. Still, not many men on the job seem to make use of the known techniques for making good concrete which is necessary for achieving strong, durable, and economical construction. This textbook by Prof. M.S. Shetty will, therefore, help to generate a better awareness of the potential of concrete.

The book deals with several aspects of concrete technology and also covers the latest developments that have taken place in India and abroad. The coverage is comprehensive and complete. The properties of the constituent materials of concrete have been explained very lucidly in the text. The information on admixtures and on special concretes, such as air-entrained concrete, vacuum concrete, light-weight concrete, and gap-graded concrete, will be very useful to concrete engineers and those engaged in precast concrete construction. At many places in the text, the author touches upon some important, down-to-earth problems and gives specific recommendations based on his own knowledge and vast experience. The chapter on mix design gives simple and scientific procedures for the benefit of practising engineers and concrete technologists.

One of the welcome features of this book is the inclusion of detailed information on recent developments relating to fibre-reinforced concrete, sulphur-impregnated concrete, and different types of polymer concrete. The author has highlighted the potential of these new materials and has laid emphasis on the need for further research.

The text has been written in simple language and is supplemented by numerous illustrative examples, charts, and tables. The author has succeeded in presenting all the relevant information on concrete technology in a very effective manner. I am sure the book will be well received by students of concrete technology as well as practising engineers and research workers.

M. RAMAIAH
Director
Structural Engineering
Research Centre
Madras

ACKNOWLEDGMENTS

What made me interested in concrete technology was my association with Shri M.R. Vinayaka of Associated Cement Company, when he was working at Koyna Dam Concrete Research Laboratory. My interest was further enhanced while teaching this fascinating subject to the graduate and postgraduate students at the College of Military Engineering. I am grateful to them.

I gratefully acknowledge the following institutions and societies in the reproduction of certain tables, charts and information in my book:

The American Concrete Institute, the American Society for Testing and Materials, the Cement and Concrete Association, the Portland Cement Association, the Institute of Civil Engineers, London, Department of Mines, Ottawa, Canada, the Concrete Association of India, the Cement Research Institute of India, the Central Building Research Institute, Roorkee, the Structural Engineering Research Centre, Madras, the Central Road Research Institute, Delhi, and the Bureau of Indian Standards.

A book of this nature cannot be written without the tremendous background information made available by various research workers, authors of excellent books and articles which have been referred to and listed at the end of the chapters and at the end of this book. I am thankful to them.

I also wish to express my sincere thanks to the Commandant, College of Military Engineering for extending all facilities and words of encouragement while working on this book.

My special gratefulness is due to Smt. Brinda Balu and Dr. Balasubramanian for going through the manuscript with such diligence as to bring it into the present state.

My special thanks are due to Dr. M. Ramaiah, Director, Structural Engineering Research Centre, Madras, who obliged with a foreword to this book.

Lastly I am grateful to M/s S. Chand and Co., Ltd., for taking the responsibility of publishing this book.

Place: Pune, 1982

M.S. SHETTY

PREFACE TO THE SIXTH EDITION

It gives me immense pleasure that the book first published in 1982, has seen more than 25 reprints. The popularity of this book amongst students and practicing engineers has given me the encouragement to revise this book to make it more useful to them. The proposal and encouragement given by officers of S. Chand & Company to bring this **Sixth Edition in multicolour** should make the book more useful and attractive

Concrete technology is becoming a major branch of civil engineering. It is becoming the backbone of infrastructural developments of every country. It has made tremendous advancement in the western and the eastern world. Though India is lagging behind, we are catching up fast with the rest of the world.

It can be recalled that in the preface to the first edition (1982) I had mentioned that the cement production in India was 22 million tons. This was about eight decades after we first started manufacturing Portland Cement (1904). It is heart warming to note that in the subsequent two decades after 1982 i.e. in 2004, the production of cement has crossed 120 million tons. Today we are the second largest producer of cement in the world, only behind China.

The quantity of concrete and other cement products made, utilising over 120 million tons of cement to cater for the tremendous infrastructural development that is taking place in the country, is making the concrete industry one of the biggest in monetary terms. Western and Eastern countries have been making concrete of strength M40, M80, M100 and over. In the recent past, we in India have started using concrete of strength M30, M50 and even M75. We have a long way to go to learn and practice the art and science of making High Performance Concrete (HPC) yet. The recent revision of IS 456, code of practice for plain and reinforced concrete is guiding concrete technologists to make strong and durable concrete.

I have grown older by twenty three years since I wrote the first edition. During these 23 years and especially in the last 15 years, I have had opportunities to deliver numerous lectures, training site engineers, conducting trials at large project sites, throughout the country which has made me once again a student of concrete technology and motivated me to revise this book.

Major revision has been carried out in Fifth and Sixth Edition. Topics, such as blended cements, use of admixtures and their use, field trials to find out their suitability, compatibility and dosage, RMe, pumping of concrete, latest methods mix design step by step, and extensive unconventional deliberation on durability, have been included.

Another special feature of this Sixth Edition is the inclusion of SELF COMPACTING CONCRETE, a revolutionary method of concrete construction. This innovative method which is found only in journals and seminar proceedings is rarely incorporated in text books. Similarly, other latest research information on Bacteria Concrete Geopolymer Concrete and Basalt fibre concrete are also included.

The book incorporates relevant information on numerous Indian standard specifications and code of practices relating to cement and concrete, including the latest revision of IS 456 of 2000 in respect of section 2 on materials, workmanship, inspection, testing and acceptance criteria. The book should serve as a vehicle to disseminate the information to all those who are interested in concrete construction.

I am sure that this **multicolour revised edition** will prove to be very useful to students of engineering, architects, practicing engineers and teachers in all engineering colleges. If this book helps to enthuse the readers and enable them to make better concrete at our construction sites, I would feel that my efforts are well rewarded.

I would like to express my sincere thanks to Shri Samir Surlaker, an authority on admixtures and construction chemicals in India, for helping me to enhance the technical content of this book. I am also thankful to the officers and staff of M/s S. Chand & Company Ltd. who were extremely amicable and helpful to bringing out this sixth edition in **Multicolour**.

Place: Pune

May 2005

M.S. SHETTY

PREFACE TO THE FIRST EDITION

Cement mortar and concrete are the most widely used construction materials. It is difficult to point out another material of construction which is as versatile as concrete. It is the material of choice where strength, permanence, durability, impermeability, fire resistance and abrasion resistance are required. It is so closely associated now with every human activity that it touches every human being in his day to day living.

Cement concrete is one of the seemingly simple but actually complex materials. Many of its complex behaviours are yet to be identified to employ this material advantageously and economically. The behaviour of concrete with respect to long-term drying shrinkage, creep, fatigue, morphology of gel structure, bond, fracture mechanism and polymer modified concrete, fibrous concrete are some of the areas of active research in order to have a deeper understanding of the complex behaviour of these materials.

In any country, construction accounts for about 60 per cent of the plan outlay. Out of this, cement and cement product would account for more than 50 per cent. Today in India the annual consumption of cement is in the order of 22 million tonnes. It is estimated that the cost of mortar and concrete made from 22 million tons of cement would work out to about Rs. 4,000 crores which is about 1/5 of the plan outlay for the year 1982–83. It is in this context that the knowledge of concrete technology assumes importance.

Concrete is a site-made material unlike other materials of construction and as such can vary to a very great extent in its quality, properties and performance owing to the use of natural materials except cement. From materials of varying properties, to make concrete of stipulated qualities, an intimate knowledge of the interaction of various ingredients that go into the making of concrete is required to be known, both in the plastic condition and in the hardened condition. This knowledge is necessary for concrete technologists as well as for site engineers.

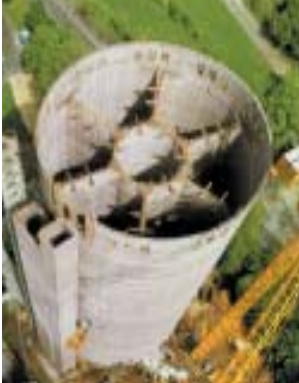
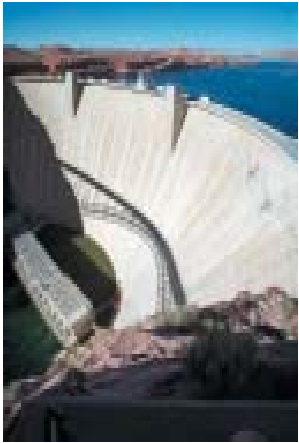
This book is written mainly to give practical bias into concrete-making practices to students of engineering and site engineers. Practical bias needs good theoretical base. Approach to practical solution should be made on the basis of sound theoretical concept. Sometimes, theory, however good, may not be applicable on many practical situations. This is to say, that particularly in concrete-making practices both theory and practice go hand in hand more closely than in many other branches of Engineering mainly because it is a site made material.

There are many good books written on this subject. But there are only a few books dealing with conditions, practice and equipment available in this country. Moreover, most of the books refer to only British and American standards. It has been the endeavour of the author to give as much information as possible about the Indian practice, Indian standard specifications and code of practices for concrete making. If this book helps the reader to make better concrete in the field, my efforts, I feel, are rewarded.

Place: **Pune**

M.S. SHETTY

CONTENTS

<i>Chapter No.</i>		<i>Page No.</i>
1.	CEMENT	1-26
	General	1
	Early History of Modern Cement	2
	Manufacture of Portland Cement	5
	Wet Process	6
	Dry Process	9
	Chemical Composition	14
	Hydration of Cement	17
	Heat of Hydration	18
	Calcium Silicate Hydrates	19
	Calcium Hydroxide	20
	Calcium Aluminate Hydrates	21
	Structure of Hydrated Cement	22
	Transition Zone	22
	Water Requirements for Hydration	25
		
2.	TYPES OF CEMENT AND TESTING OF CEMENT	27-65
	Types of Cement	28
	ASTM Classification	28
	Ordinary Portland Cement	29
	Rapid Hardening Cement	30
	Extra Rapid Hardening Cement	30
	Sulphate Resisting Cement	31
	Portland Slag Cement	31
	Application of GGBS Concrete	33
	Quick Setting Cement	33
	Super Sulphated Cement	34
	Low Heat Cement	34
	Portland Pozzolana Cement	35
	Advantages of PPC	36
	Grading of PPC	37
	Application	37
	Air-Entraining Cement	37
	Coloured Cement	38
	Hydrophobic Cement	39
	Masonry Cement	39
	Expansive Cement	40
	IRS-T40 Special Grade Cement	40
	Oil-Well Cement	41
	Rediset Cement	41
		

Properties of Rediset	41
Applications	42
High Alumina Cement	42
Hydration of High Alumina Cement	42
High Alumina Cement Concrete	43
Refractory Concrete	44
Very High Strength Cement	45
Macro-defect free Cement	45
Densely Packed System	45
Pressure Densification and Warm Pressing	45
High Early Strength Cement	46
Pyramment Cement	46
Magnesium Phosphate Cement	46
Testing of Cement	47
Field Testing	47
Fineness Test	48
Sieve Test	49
Air Permeability Method	49
Standard Consistency Test	50
Setting Time Test	50
Initial Setting Time	52
Final Setting Time	53
Strength Test	53
Soundness Test	54
Heat of Hydration	55
Chemical Composition Test	56
Test Certificate	56
3. AGGREGATES AND TESTING OF AGGREGATES	66-118
General	66
Classification	67
Source	67
Aggregates from Igneous Rocks	68
Aggregates from Sedimentary Rocks	68
Aggregates from Metamorphic Rocks	68
Size	69
Shape	70
Texture	73
Measurement of Surface Texture	74
Strength	74
Aggregate Crushing Value	75
Aggregate Impact Value	76
Aggregate Abrasion Value	76
Deval Attrition Test	76
Dorry Abrasion Test	76
Los Angeles Test	77
Modulus of Elasticity	77
Bulk Density	78



Specific Gravity	78
Absorption and Moisture Content	78
Bulking of Aggregate	80
Measurement of Moisture Content of Aggregates	81
Drying Method	82
Displacement Method	82
Calcium Carbide Method	82
Electrical Meter Method	82
Automatic Measurement	82
Cleanliness	83
Soundness of Aggregate	85
Alkali-Aggregate Reaction	85
Factors Promoting Alkali-Aggregate Reaction	86
High Alkali Content in Cement	88
Availability of Moisture	89
Temperature Condition	89
Mechanism of Deterioration of Concrete	89
Control of Alkali Aggregate Reaction	89
Thermal Properties	90
Grading of Aggregates	91
Sieve Analysis	93
Combining Aggregates to obtain Specified Gradings	94
Specific Surface and Surface Index	96
Standard Grading Curve	100
Crushed Sand	105
Gap Grading	107
Testing of Aggregates	107
Test for Determination of Flakiness Index	107
Test for Determination of Elongation Index	109
Test for Determination of Clay and Fine Silt	110
Test for Determination of Organic Impurities	111
Test for Determination of Specific Gravity	112
Test for Bulk Density and Voids	112
Mechanical Properties of Aggregates	113
Test for Aggregate Crushing Value	113
Test for "Ten per cent Fines" Value	114
Test for Aggregate Impact Value	114
Test for Aggregate Abrasion Value	115
4. WATER	119-123
Qualities of Water	119
Use of Sea Water for Mixing Concrete	122
5. ADMIXTURES AND CONSTRUCTION CHEMICALS	124-217
General	124
Admimxtures	125
Construction Chemicals	126
Plasticizers (Water Reducers)	126



Action of Plasticizers		128
Dispersion		128
Retarding Effect		128
Superplasticizers (High Range Water Reducers)		129
Classification of Superplasticizer		130
Effect of Superplasticizers on Fresh Concrete		131
Compatibility of Superplasticizers and Cement		131
Factors Effecting Workability		136
Type of Superplasticizers		136
Dosage		136
Mix Composition		137
Variability in Cement Composition		137
Mixing Procedure		137
Equipment		138
Site Problems in the use of Superplasticizers		138
Slump Loss	140	
Steps for Reducing Slump Loss		140
Other Potential Problems		142
Effect of Superplasticizers on the Properties of Hardened Concrete		143
New Generation Superplasticizers		144
Carboxylated Acrylic Ester (CAE)		144
Multicarboxylatether (MCE)		147
Retarders		148
Retarding Plasticizers		149
Accelerators		149
Accelerating Plasticizers		158
Air-entraining Admixtures		158
Air-entraining Agents		159
Factors Affecting Amount of Air-entrainment		159
The Effect of Air-entrainment on the Properties of Concrete		160
Resistance to Freezing and Thawing		161
Effect on Workability		162
Effect on Strength		163
Effect on Segregation and Bleeding		166
Effect on Permeability		169
Effect on Chemical Resistance		169
Effect on Sand, Water and Cement Content		169
Unit Weight		170
Alkali Aggregate Reaction		170
Modulus of Elasticity		170
Abrasion Resistance		170
Optimum Air Content in Concrete		171
Measurement of Air Content		171
Gravimetric Method		171
Volumetric Method		173
Pressure Method		173
The Water Type Meter		173
Pozzolanic or Mineral Admixtures		174

Pozzolanic Materials	175
Natural Pozzolans	175
Artificial Pozzolans	175
Fly Ash	176
Effect of Fly Ash on Fresh Concrete	179
Effect of Fly Ash on Hardened Concrete	180
Durability of Concrete	180
High Volume Fly Ash Concrete (HVFA)	180
Properties of (HVFA) Fresh Concrete	181
Bleeding and Setting Time	181
Heat of Hydration	182
Curing of (HVFA) Concrete	182
Mechanical Properties of (HVFA) Concrete	182
Durability of (HVFA) Concrete	182
Use of High Volume Fly Ash	183
Silica Fume	183
Indian Scenario	184
Available Forms	184
Pozzolanic Action	185
Influence on Fresh Concrete	185
Influence on Hardened Concrete	186
Mixing	186
Curing	186
Rice Husk Ash	186
Surkhi	187
Metakaolin	188
Ground Granulated Blast Furnace Slag (GGBS)	189
Performance of GGBS in Concrete	191
Fresh Concrete	191
Hardened Concrete	191
Damp-Proofing and Water-Proofing Admixtures	192
Gas Forming Agents	193
Air-Detraining Agents	194
Alkali Aggregate Expansion Inhibitors	194
Workability Agents	195
Grouting Agents	195
Corrosion Inhibiting Agents	196
Bonding Admixtures	196
Fungicidal, Germicidal and Insecticidal Admixtures	196
Colouring Agents	197
Miscellaneous Admixtures	197
Damp-proofers	197
Construction Chemicals	198
Membrane Forming Curing Compounds	200
Drying Behaviour	201
Types of Curing Compounds	201
Application Procedure	201
General Characteristics	202



Water Retention Test	203
Polymer Bonding Agents	204
Polymer Modified Mortar for Repair and Maintenance	204
Mould Releasing Agents	205
Installation Aids	205
Floor Hardners and Dust Proofers	206
Non-Shrink High Strength Grout	207
Surface Retarders	207
Bond Aid for Plastering	208
Ready to use Plaster	208
Guniting Aid	208
Construction Chemicals for Waterproofing	209
Integral Waterproofing Compound	210
Acrylic Based Polymer Coatings	210
Mineral Based Polymer Modified Coatings	211
Protective and Decorative Coatings	212
Chemical DPC	212
Waterproofing Adhesives for Tile, Marble and Granite	213
Silicone based Water Repellant Materials	214
Injection Grout for Cracks	214
Joint Sealants	215
Concrete Repair Systems	215
Stages for Repair Works	215
6. FRESH CONCRETE	218-297
Workability	219
Factors Affecting Workability	220
Water Content	220
Mix Proportions	220
Size of Aggregate	221
Shape of Aggregate	221
Surface Texture	221
Grading of Aggregate	221
Use of Admixture	221
Measurement of Workability	222
Slump Test	222
K-Slump Tester	224
Remarks	227
Compacting Factor Test	227
Flow Test	228
Flow Table Apparatus	229
Accessory Procedure	230
Kelly Ball Test	231
Vee Bee Consistometer Test	232
Segregation	233
Bleeding	234
Method of Test for Bleeding	236



Setting Time of Concrete	236
Process of Manufacture of Concrete	238
Batching	238
Volume Batching	238
Weigh Batching	240
Measurement of Water	241
Mixing	241
Hand Mixing	242
Machine Mixing	242
Mixing Time	245
Retempering	246
Maintenance of Mixer	247
Transporting	247
Mortar Pan	247
Wheel Barrow	248
Crane Bucket and Ropeway	249
Truck Mixer and Dumper	249
Belt Conveyors	249
Chute	249
Skip and Hoist	249
Transit Mixer	250
Pumps and Pipeline	251
Development of Concrete Pump	251
Concrete Pumps	251
Types of valve	252
Pipeline and Couplings	252
Laying the Pipeline	253
Capabilities of Concrete Pump	253
Pumpable Concrete	254
Design Consideration	255
Choosing Correct Pump	256
Common Problems	258
Clearing Blockages	259
Placing Concrete	259
Form Work	261
Stripping Time	261
Under Water Concreting	262
Compaction of Concrete	265
Hand Compaction	266
Compaction by Vibration	267
Internal Vibrator	268
Formwork Vibrator	268
Table Vibrator	269
Platform Vibrator	269
Surface Vibrator	269
Compaction by Pressure and Jolting	269
Compaction by Spinning	269
Vibratory Roller	269



General Points on Using Vibrators	270
Further Instructions on use of Vibrators	270
Height of Concrete Layer	271
Depth of Immersion of Vibrator	271
Spacing and Number of Insertion Positions	272
Speed of Insertion	272
Duration of Vibration	273
Vibrating Concrete at Junctions	273
Vibrating Reinforced Concrete	273
Vibrating Near the Form Work	273
Vibrating High Walls and Columns	276
Over Vibration	276
Output of Immersion Vibrations	276
Revibration	276
Vibration of Light-weight Concrete	277
Curing of Concrete	277
Curing methods	279
Water curing	279
Membrane curing	280
Application of Heat	281
Steam curing	282
High Pressure Steam curing	287
Curing by Infra-red Radiation	288
Electrical curing	289
Miscellaneous Methods of Curing	289
When to Start Curing	289
Finishing	291
Formwork Finishes	291
Surface Treatment	292
Exposed Aggregate Finish	293
Bush Hammering	293
Applied Finish	293
Miscellaneous Finish	294
Wear Resistant Floor Finish	294
Requirement of a Good Finish	295
Grinding and Polishing	295
Craziness	295
Whisper Concrete Finish	296



7. STRENGTH OF CONCRETE	298-324
General	298
Water / Cement Ratio	299
Gel / Space Ratio	301
Gain of Strength with Age	303
Accelerated Curing Test	306
Maturity Concept of Concrete	306
Effect of Maximum Size of Aggregate	311



Relation between Compressive and Tensile Strength	311
Centre Point and Third Point Loading	314
Bond Strength	315
Aggregate Cement Bond Strength	316
High Strength Concrete	318
Seeding	319
Revibration	319
High Speed Slurry Mixing	319
Use of Admixture	319
Inhibition of Cracks	319
Sulphur Impregnation	319
Use of Cementitious Aggregate	319
Ultra High Strength Concrete	319
Compaction by Pressure	319
Helical Binding	320
Polymer Concrete	320
Reactive Powder Concrete	320
High-Performance Concrete (HPC)	321
Aggregates for HPC	322



8. ELASTICITY, CREEP AND SHRINKAGE 325-348

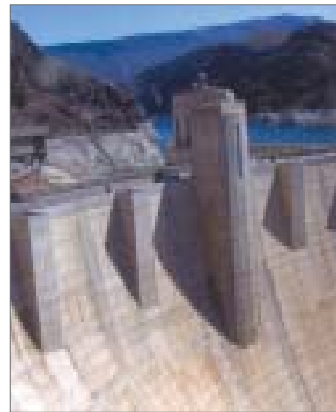
Elastic Properties of Aggregate	325
Relation between Modulus of Elasticity and Strength	328
Factors Affecting Modulus of Elasticity	329
Dynamic Modulus of Elasticity	331
Poisson's Ratio	332
Creep	332
Rheological Representation of Creep	333
Macroscopic Rheological Approach	333
Microscopic Rheological Approach	334
Hydration under Sustained Load	335
Measurement of Creep	336
Factors Affecting Creep	339
Influence of Aggregate	339
Influence of Mix Proportions	339
Influence of Age	339
Effect of Creep	339
Shrinkage	340
Plastic Shrinkage	341
Drying Shrinkage	343
Factors Affecting Shrinkage	344
Moisture Movement	347
Autogeneous Shrinkage	347
Carbonation Shrinkage	347



9. DURABILITY OF CONCRETE 349-419

General	349
Strength and Durability Relationship	350

Volume Change in Concrete	352
Definition of Durability	352
Significance of Durability	352
Impact of W/C Ratio on Durability	353
Permeability	354
Permeability of Cement Paste	354
Permeability of Concrete	356
Interaction between Permeability, Volume Change and Cracking	357
Factors Contributing to Cracks in Concrete	361
Plastic Shrinkage Cracks	361
Settlement Cracks	362
Bleeding	362
Delayed Curing	362
Constructional Effects	363
Early Frost Damage	363
Unsound Materials	364
Shrinkage	364
Drying Shrinkage	365
Thermal Shrinkage	365
Thermal Conductivity	367
Thermal Diffusivity	368
Specific Heat	370
Coefficient of Thermal Expansion	370
Mass Concrete	372
Thermal Expansion and Shrinkage	373
Extensibility	375
Joints in Concrete	376
Construction Joints	376
Expansion Joints	376
Contraction Joints	379
Isolation Joints	381
Concrete Subjected to High Temperature	382
Fire Resistance	382
Freezing and Thawing	383
Deicing Effects of Salts	387
Moisture Movements	387
Transition Zone	387
Biological Process	388
Structural Design Defficiencies	388
Chemical Action	389
Sulphate Attack	389
Methods of Controlling Sulphate Attack	390
Use of Sulphate Resisting Cement	390
Quality of Concrete	390
Use of Air-entrainment	390
Use of Pozzolana	390
High Pressure Steam Curing	390
Use of High Alumina Cement	390



Alkali-Aggregate Reaction	394
Acid Attack	395
Concrete in Sea Water	396
Carbonation	398
Rate of Carbonation	398
Measurement of Depth of Carbonation	400
Chloride Attack	400
Corrosion of Steel (Chloride Induced)	402
Corrosion Control	404
Metallurgical Methods	405
Corrosion Inhibitors	405
Coatings to Reinforcement	406
Fusion Bonded Epoxy Coating	407
Galvanised Reinforcement	408
Cathodic Protection	408
Coatings to Concrete	408
Design and Detailing	409
Nominal Cover to Reinforcement	409
Crack Width	411
Deterioration of Concrete by Abrasion, Erosion and Cavitation	411
Effects of Some Materials on Durability	412
Action of Mineral Oils	412
Action of Organic Acids	412
Vegetables and Animal Oils and Fats	412
Action of Sugar on Concrete	413
Action of Sewage	413
Surface Treatments of Concrete	413
Maximum Cement Content	415
Concluding Remarks on Durability	418
10. TESTING OF HARDENED CONCRETE	420-457
Compression Test	421
Moulds	422
Compacting	422
Compaction by Hand	423
Compaction by Vibration	423
Capping Specimens	424
Neat cement	424
Cement mortar	424
Sulphur	424
Hard plaster	425
Curing	425
Making and Curing Compression Test Specimen in the Field	425
Failure of Compression Specimen	425
Effect of Height / Diameter Ratio on Strength	427
Comparison between Cube and Cylinder Strength	428
Flexural Strength of Concrete	428
Determination of Tensile Strength	429



Procedure	431
Placing of Specimen in the Testing Machine	431
Indirect Tension Test Methods	433
Ring Tension Test	434
Advantage of ring tension test	434
Limitations of ring tension test	434
Double Punch Test	434
Factors Influencing the Strength Results	435
Test Cores	436
Strength of cores	437
Non-Destructive Testing Methods	437
Schmidt's Rebound Hammer	439
Limitation	439
Rebound number and strength of concrete	440
Penetration Techniques	441
Pullout test	444
Dynamic or Vibration Method	444
Resonant Frequency Method	445
Usefulness of resonant frequency method	445
Pulse Velocity Method	446
Techniques of measuring pulse velocity through concrete	447
Factors affecting the measurement of pulse velocity	447
Smoothness of contact surface under test	447
Influence of path length on pulse velocity	448
Temperature of concrete	448
Moisture condition of concrete	448
Presence of reinforcement	448
Accuracy of measurement	449
Applications	449
Establishing uniformity of Concrete	449
Establishing acceptance criteria	449
Determination of pulse modulus of elasticity	450
Estimation of strength of concrete	450
Determination of setting characteristics of concrete	450
Studies on durability of concrete	450
Measurement of deterioration of concrete due to fire exposure	451
Relationship between Pulse Velocity and Static Young's Modulus of Elasticity	452
Combined Methods	452
Radioactivity Methods	452
Nuclear Methods	453
Magnetic Methods	454
Electrical Methods	454
Tests on Composition of Hardened Concrete	454
Determination of Cement Content	454
Determination of Original w/c Ratio	455
Physical Method	455
Accelerated Curing Test	456



11. CONCRETE MIX DESIGN	458-503
General	458
Concept of Mix Design	459
Variables in Proportioning	459
Various Methods of Proportioning	460
Statistical Quality Control of Concrete	460
Common Terminologies	461
Calculation of Standard Deviation and Coefficient of Variation	463
Relation between Average Design Strength and Specified Minimum Strength	463
American Concrete Institute Method of Mix Design	466
Data to be Collected	466
Example: ACI Committee 211.1-91 Method	471
Road Note Number 4 Method	473
DOE Method of Concrete Mix Design	474
Example — DOE Method	477
Concrete Mix Design Procedure for Concrete with Fly-Ash	482
Example of Mix Design with Fly-Ash with DOE Method	482
Mix Design for Pumpable Concrete	484
Example: Basic Design Calculations for a Pumpable Concrete Mix	488
Indian Standard Recommended Method of Concrete Mix Design	489
Illustrative Example of Concrete Mix Design	495
Rapid Method	498
Steps of Mix Design based on rapid method	499
Sampling and Acceptance Criteria	500
Frequency of Sampling	500
Test Specimen	501
Test Results	501
Acceptance Criteria	502
Compressive Strength	502
Flexural Strength	502
Inspection and Testing of Structures	502
Core Test	502
Load Test for Flexural Member	502
Non-destructive Test	503
12. SPECIAL CONCRETE AND CONCRETING METHODS	504-607
Special concrete	504
Light-weight concrete	506
Pumice	506
Diatomite	507
Scoria	507
Volcanic Cinders	507
Saw Dust	507
Rice Husk	507
Brick Bats	508
Cinder, Clinker and Breeze	508
Foamed Slag	508
Bloated Clay	509
Sintered Fly Ash	509



Exfoliated Vermiculite	509
Expanded Perlite	509
Light-weight Aggregate Concrete	510
Structural Light-weight Concrete	513
Workability	513
Design of Light-weight Aggregate Concrete Mix	514
Mixing Procedure	514
Aerated Concrete	514
Properties	516
No-fines Concrete	517
Mix Proportion	517
Drying Shrinkage	518
Thermal Conductivity	519
Application	519
High Density Concrete	520
Types of Radiation Hazards	521
Shielding Ability of Concrete	521
Concrete for Radiation Shielding	522
Sulphur-Infiltrated Concrete	525
Application	526
Fibre Reinforced Concrete	526
Fibres used	527
Factors Effecting Properties	528
Relative Fibre Matrix Stiffness	528
Volume of Fibres	528
Aspect Ratio of Fibres	529
Orientation of Fibres	529
Workability	530
Size of coarse Aggregate	530
Mixing	530
Application	531
Glass Fibre Reinforced Cement	531
Current Development in (FRC)	532
High Fibre Volume Micro-Fibre System	532
Slurry Infiltrated Fibre Concrete	532
Compact Reinforced Composites	532
Polymer Concrete	532
Type of Polymer Concrete	533
Polymer Impregnated Concrete	533
Polymer Cement Concrete	534
Polymer concrete	534
Partially Impregnated Concrete	535
Properties of Polymer Impregnated Concrete	536
Stress-Strain Relationship	536
Compressive Strength	536
Tensile Strength	537
Creep	539
Shrinkage due to Polymerisation	539
Durability	539
Water Absorption	540
Coefficient of Thermal Expansion	540



Resistance to Abrasion	540
Wear and Skid Resistance	540
Fracture of Polymer Impregnated Concrete	540
Application of Polymer Impregnated Concrete	541
Cold Weather Concreting	542
Effects of Cold Weather on Concrete	542
Low Temperature but above 0°C	453
Low Temperature but below 0°C after Concreting	543
Temperature Below 0°C at the Time of Concreting	544
Hardened Concrete Subjected to Freezing and Thawing	544
Concreting Methods at Sub-zero Temperature	544
Hot Weather Concreting	552
Precautions Taken	554
Aggregates	554
Water	555
Production and Delivery	556
Prepacked Concrete	556
Vacuum Concrete	558
Rate of Extraction of Water	558
Vacuum Dewatered Concrete	560
Gunite or Shotcrete	562
Dry-Mix Process	562
Wet-Mix Process	563
Advantages of Wet and Dry Process	563
General Use of Shotcrete	563
Concluding Remarks on Shotcrete	565
Recent Studies	566
Ferrocement	566
Casting Techniques	568
Hand Plastering	568
Semi-Mechanised Process	568
Centrifuging	569
Guniting	570
Application	570
Roller Compacted Concrete	570
Self compacting Concrete (SCC)	572
Material for SCC	573
Example of SCC Mixes	574
Requirements for self-compacting concrete	575
Workability Requirement for the fresh SCC	576
Production and Placing	577
Mix Design	577
Test Methods	578
Slump flow Test	579
J-ring test	580
V-Funnel Test	581
L-Box test method	582
U-Box Test	583
Full Box Test	584
Orimet test	587
Complexities involved in making SCC	588
New Generation Plasticizers	589
Indian Scenario of SCC	590



Experience of Delhi Metro Project	590
Experience of Mock-up Trials at Tarapur Atomic Power Project	591
Use of SCC Kaiga	592
Trials at SERC Chennai	594
Study at Hong Kong	595
How economical is Self Compacting Concrete	597
Bacterial Concrete	598
Experimental Investigations	598
Zeopolymer Concrete	599
Basalt fibre concrete and concrete reinforced with basalt fibre reinforcements	602
General Reference Books	608-611
List of Indian Standard Specifications and Code of Practices, Related to Cement and Concrete	612-616
Subject Index	617-624



CONCRETE

IN THE UNENDING SERVICE OF NATION BUILDING

LET US LEARN THIS SUBJECT TO BE A
PART OF THE NATION BUILDING TEAM



SARDAR SAROVAR DAM : Sardar Sarovar Project is an Inter-State Multi-Purpose project of National importance. It is one of the largest projects under implementation anywhere in the world.



◀ **THE IDUKKI HYDROELECTRIC PROJECT, KERALA :** The reservoir covers nearly 60 square kilometres and has a catchment of 649 square km. Water from the reservoir is taken down to the underground power house at Moolamattom through an underground tunnel, yielding an average gross head of 2182 feet (665 metres). The project has an installed capacity of 780 MW with firm power potential of 230 MW at 100 per cent load factor.

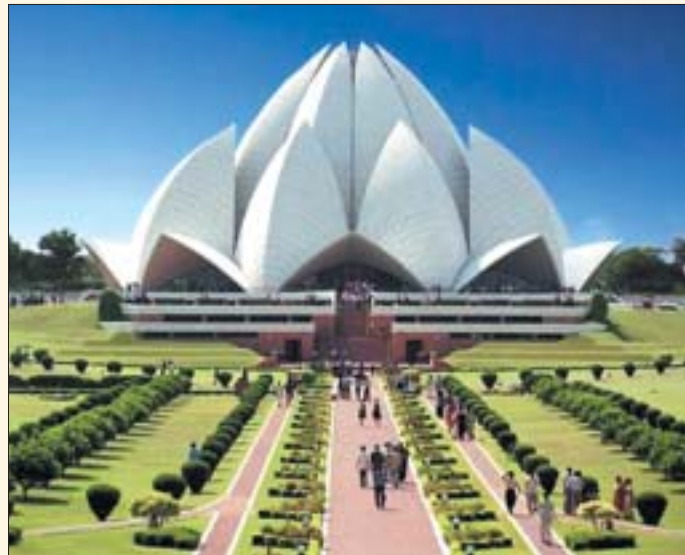
▶ **THE BHAKRA DAM** is a majestic monument across river Sutlej. The construction of this project was started in the year 1948 and was completed in 1963 . It is 740 ft. high above the deepest foundation as straight concrete dam being more than three times the height of Qutab Minar. Bhakra Dam is the highest Concrete Gravity dam in Asia and Second Highest in the world.



▶ **SAI GANGA approach canal** for water supply to Chennai Metro.



◀ DELHI METRO Railway Station under construction.



▶ THE BAHÁ'Í HOUSE OF WORSHIP known as the Lotus Temple, built near New Delhi.



Diamond shaped 'MANI KANCHAN' - Gem & Jewellery Park at Kolkata.



Unconventional building with pleasing architecture.



TARAPUR ATOMIC POWER PROJECT : Reactor Building no. 3 & 4.



Fully automatic construction of concrete pavement.

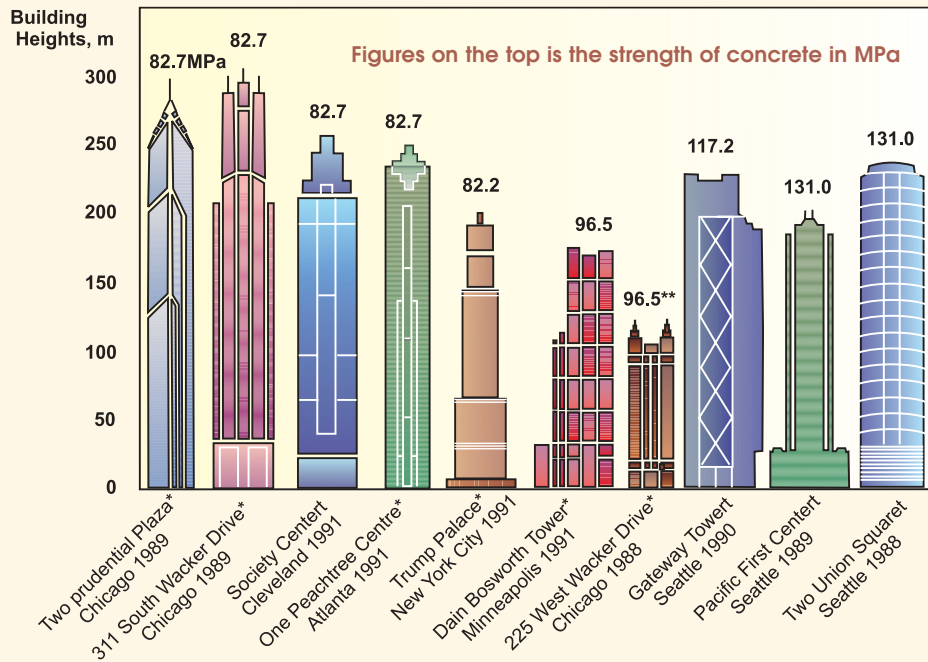


▲
A view of large oval shaped dome under construction over Connaught Place Metro Railway Station. It is going to be a new landmark over Delhi Metro. It will be a modern version of Palika garden – A pride feature of Delhi Metro Project.

▶
Sky Bus Metro, Goa

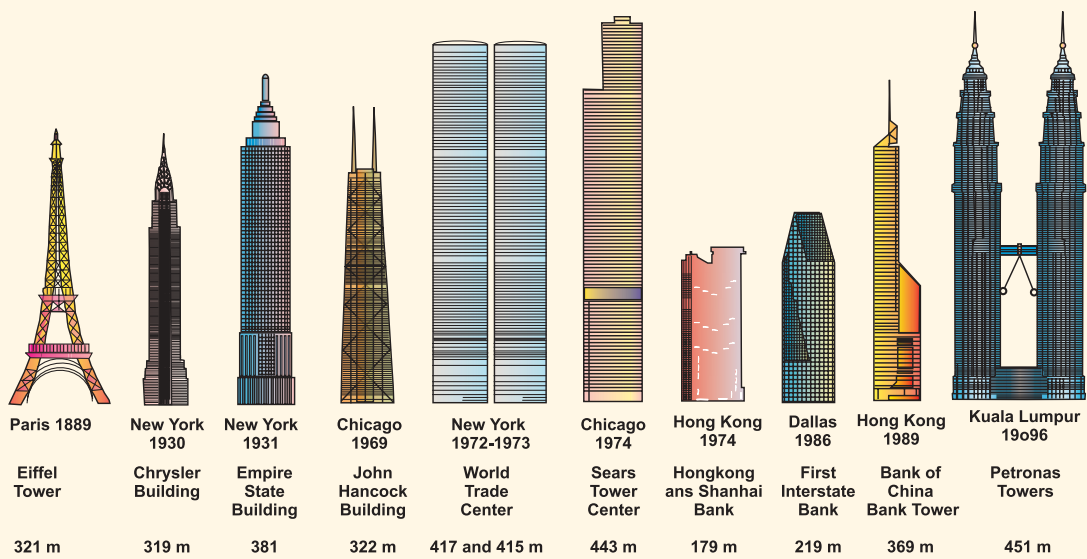


SOME LANDMARK HIGHRISE BUILDINGS IN THE WORLD



* Reinforced concrete frame
 † Composite concrete/steel frame
 ** Also includes one experimental column of 117 MPa

SOME HIGHRISE BUILDINGS AROUND THE WORLD





▲ CHANNEL TUNNEL RAIL LINK (UK).
Tunnel diameter : 6.84 m and 8.15 m. Number of segments 9+key. Segment thickness : 350 mm. Concrete grade : 60 MPa. Dramix steel fibre reinforcement is used for casting segments without conventional steel.



▲ PETRONAS TWIN TOWERS in Kuala Lumpur Malaysia : One of the tallest (451m.) buildings in the world.

. . . . and many many more to expand and reshape the world we live in, — all in concrete.