Contents

Symbols 9
Preface 10
1. Concrete 10
1.1 Strain Diagrams in The Ultimate Limit State 14
1. 2 Stress - Strain Diagram for Concrete 15
1.2.1 Fracture Behaviour of Concrete under Tension 16
1.2.2 Fracture Behaviour of Concrete under Compression 17
1.3 Stress-strain Diagram for Reinforcing Steel 17
1.4 Properties of Materiale 18
1.4.1 Elasticity and Plasticity 19
1.4.2 Lightweight Concrete 21
1.4.3 Heavyweight Concrete 23
1.4.4 High-Strength Concrete 25
1.4.5 Steel Fibre Reinforced Concrete 26
1.4.5.1 Uniaxial Tension 27
1.4.5.2 CEB/FIB Model Code (1993) 28
1.4.5.3 USA - ACI 318-95 (1995) 29
1.4.5.4 Norwegian Code NS 3473 (1992) 29
1.4.6 Plastics 29
2. Determination of Load 29
2.1 Loading Standards 29
2.1.1 Action Classification 29
2.1.2 Combinations of Actions 30
2.1.2.1 Dead Load 31
2.1.2.2 Variable Load 33
2.1.2.3 Snow Load 34
2.1.2.4 Wind Load 34
2.2 Determination of Load According to Eurocode 2 34
2.2.1 Characteristic Values 34
2.2.1.1 Movable Partitions 34
2.2.1.2 Imposed Load Reduction 34
2.2.2 Definition of The Snow Load 35
2.2.2.1 Pitched Roofs 35
2.2.2.2 Single-Pitched Roof 36
2.2.2.3 Joined Pitched Roofs 37
2.2.3 Determination of The Wind Load 37
2.2.3.1 Determination of The Internal Pressure Factor 40
2.2.3.2 Overall Wind Effect 40
Example 2.1 44
2.2.4 Temperature Effects 48
Example 2.2.4-1 50
Example 2.2.4-2 50
2.2.5 Seismic Loads 51
2.2.5.1 Ground Acceleration 52
2.2.5.2 Simplified Modal Response Spectrum Analysis 54
2.2.5.2.1 Behaviour Factor (horizontal motion) 55
2.2.5.2.2 Behaviour Factor (vertical motion) 55
2.2.5.2.3 Torsional Effects 55
2.2.5.2.4 Combination of Seismic Action with other Design Actions 55
2.2.5.2.5 Calculation of Displacement 55
2.2.5.2.6 Limitation of Inter-Storey Drift 56
2.2.5.3 Response Spectrum 57
2.2.5.4 Calculation of The Seismic Load 57
2.2.5.5 Seismic Design 58
2.2.5.5.1 Ultimate Limit State 58
2.2.5.5.2 Serviceability Limit State 58
2.2.5.5.3 Earthquake Magnitude, M 59
Example 2.2.5-1 59
Example 2.2.5-2 60
Example 2.2.5-3 61
3.0 Reinforced Concrete 62
3.1 Reinforced Concrete Beams 64
3.1.1 Simply Supported Beam 64
3.2 Curved Beams 67
3.3 Analysis of Frames 71
Example 3.3-1 72
Example 3.3-2

3.3.1 Permissible Ratio of Effective Span to Effective Depth (span/depth ratio) for Simplified Analysis of Deflection Limit. 81
3.3.2 Procedure for Calculation of Equivalent Load 82
3.3.3 Analysis of the Distance of the Extreme Fibre from The Neutral Axis and The Ratio of Reinforcement in Flexural Members 82
3.3.3-1 Analysis of The Distance of the Extreme Fibre from The Neutral Axis and The Ratio of Reinforcement in Flexural Rectangular Members
3.3.3-2 Calculation of Reinforcement Ratio μ_{st} for Various Shapes in Flexural Reinforced Concrete Members 83
3.3.4 Minimum Reinforcement of Flexural Members 84
3.3.4.1 CEB/FIB Model Code (1993) 84
3.3.4.2 GERMAN - DAfStb (1994)
3.3.4.3 Canada - CSA A23.3-94 (1994)
3.3.4.4 Design of Reinforced Concrete Members 87
3.3.4.5 Design of Reinforced Concrete Members 87
3.3.4.6 Design of Reinforced Concrete Members 88
3.3.4.7 Design of Reinforced Concrete Members 88
3.3.4.8 Sections without Compression Reinforcement for Pure Bending or Bending Moment with Axial Force, based on The bi-linear Diagram for Steel and bi-linear Diagram for Concrete
3.3.4.9 Sections without compression reinforcement for pure bending or Bending Moment with Axial Force, based on The bi-linear Diagram for Steel and bi-linear Diagram for Concrete
3.3.4.10 Sections without Compression Reinforcement for Pure Bending or Bending Moment with Axial Force, based on The Parabolic-Rectangular Diagram for Steel and a bi-linear Diagram for Concrete
3.3.4.11 Sections without Compression Reinforcement for Pure Bending or Bending Moment with Axial Force, based on The bi-linear Diagram for Steel and Parabolic-Rectangular Diagram for Concrete
3.3.5 Survay and Basis of Design Reinforced Concrete Members 91
3.3.6 Brackets and Corbels 94
3.4 Prestressed Concrete Strength Design 95
3.4.1 Moment-Curvature Relationship 97
3.4.1.1 The Calculation and The Design Procedure 98
Example 3.4.1.1-1 101
Example 3.4.1.1-2 102
3.4.2 Post – Tensioned Concrete Floors in Multi-Storey Buildings 103
3.4.2.1 Range and Selection of Floors 104
3.4.2.2 Solid Flat Slab 104
3.4.2.3 Beam and Slab 105
3.4.2.4 Ribbed Slab 105
3.4.2.5 Typical Properties 105
3.4.2.6 Bonded Post-Tensioning 106
3.4.2.7 Unbonded Post-Tensioning 106
3.4.2.7.1 Geometry of The Cable 106
3.4.2.8 Prestress Forces and Losses 109
3.4.2.8.1 Procedure for Calculation of Equivalent Load due to Tendons Profile
3.4.2.8.2 Analysis of Externally Prestressed Concrete Beams 110
3.4.2.8.3 Advantages and Disadvantages of Internal and External Post-Tensioning 111
3.5 Roofs 112
3.5.1 Pure Bending 114
3.5.1.1 One-way Reinforced Concrete Slabs 114
3.5.1.2 Two-way Reinforced Concrete Slabs 116
Example 3.5.1.2-1 117
3.5.1.3 Flat Plate 119
3.5.1.4 Stairs and Their Types 123
3.5 Columns 125
3.5.1 Interaction Diagram of Reinforced Concrete Column 127
3.5.2 Stages of The Interaction Diagram and Determination of Strains 128
Example 3.5.2-1 130
Example 3.5.2-2 132
Example 3.5.2-3 132
Example 3.5.2-4 133
3.5.2.1 Teco System 134
3.6 Footings 143
3.6.1 Types of Footings 143

3.6.1.1 Circular and Hexagonal Footings 144
3.6.1.2 Raft Foundations 144
3.6.1.3 Strip, Grid, and Mat Foundations 144
3.6.1.4 Footings on Piles 145
Example 3.6.1.4-1 146
3.6.1.5 Soil Pressure under Footing 151
3.6.1.5.1 Strip (or wall) Footings 152
3.6.1.5.2 Strap Footings 152
3.6.1.5.3 Isolated Footings 152
Example 3.6.1.5.3-1 153
3.6.1.5.4 Combined Footings 155
Example 3.6.1.5.4-1 156
3.7 Joints in Structures 163
3.8 Walls 164
3.8.1 Lateral Load 170
3.9 Retaining Walls 173
3.9.1 Type of Structure 174
3.9.1.2 Design of Reinforced Soil Walls 174
3.9.1.3 Design Criteria. 174
3.9.1.4 Structure Dimensions 175
3.9.1.5 External Stability Computations 175
3.9.1.6 Internal Stability 175
Example 3.9-1 175
Example 3.9-2 177
4. Precast Concrete 178
4.1 Structural Systems to Ensure Overall Stability 178
4.2 Columns 179
4.3 Beams 180
4.4 Beam/Column Skeletal System 181
4.5 Diaphragm Action in Floors 182
4.6 Horizontal Stability 182
4.7 Cantilever Action of Columns 183
4.8 Connections 184
4. 8. 1 Lay-out and Modulation 186
4. 8. 2 Precast Floors and Roofs 187
4. 8. 3 Structural Integrity 187
4. 9 Seismic Design Concepts for Precast Concrete in Buildings 188
4. 9. 1 Horizontal Stability 189
4. 10 Survey of Precast Structural Systems 190
4.10.1 U.S. Conventional System 190
4.10.2 Duotek System 190
4.10.3 Dycore System 190
4.10.4 Dyna-Frame System 191
4.10.5 Filigree Wideslab System 191
4.10.6 PG Connection System 191
4.10.7 RC Layered Construction System 192
4.10.8 RPC-K System 192
4.10.9 IMS System 192
4.10.10 Structurapid System 193
4.10.11 Thomas System 193
4.10.12 BSF-System 193
4.11 Minimum Reinforcement for P/C Beam, Plate, and Shell Elements 194
4.12 Details 195
5. Terminology 200