TABLE OF CONTENTS

		Page
ABBREVIATIONS		9
INTRODUCTION		10
1	**THE INDUSTRIAL REVOLUTION AND ITS CONSEQUENCES**	15
2	**DEVELOPMENT MOTIVES OF THE THEORY OF ENVIRONMENTALLY COMPATIBLE STRUCTURES (ECS)**	19
2.1	Environmental Impact of the Industrial Growth in the 20th and 21st Centuries	19
2.2	Environmental Impacts of Buildings and Civil Engineering Structures	20
2.3	Focus of the Textbook	21
2.4	(E-C) Factor Reflecting the Extra Cost of EC Buildings	23
3	**THEORY OF ECS**	26
3.1	Concept of the Theory of ECS	26
3.2	Three Principles of the Theory of ECS - General Comments	28
3.3	Comments to the Three Principles of the Theory of ECS	33
3.4	Design Characteristics (DCH) as Practical Design Tools of the Theory of ECS	35
3.4.1	Concept of the DCH	35
3.4.2	Design Characteristics of Common and Special Buildings - DCH of Indoor Facilities and Reconstructions	39
3.4.3	Comments to the DCH's	44
3.4.4	Research, Experimental Studies and Development in the Field of ECS	44
3.5	Analytical and Non-analytical Optimization of the DCH's	45
3.5.1	Commentary on Engineering and Environmental Optimization	46
3.5.2	Comments on the Environmental Effect of Greenhouse Gas Emissions	47
3.6	Environmental Impact of Structural Forms and Systems	49
3.6.1	Introduction	49
3.6.2	Definitions	51
3.6.3	Impact of the Structural Form on the Environmental Compatibility of Structures	53
3.6.4	Physical Geometry (PhG) - a New Concept of Form-finding Process	57
3.6.5	Examples of Physically Defined Forms (PhDF) in Structural Engineering, Architecture and in Nature	61
3.6.6	Examples of Physically Defined Structural Forms (PhDF) Generated by Nature or Applied in Structural Design	76
3.6.7	Physically Defined Forms in Hydrotechnics and Futurology of Structural Forms	84

3.7 Energy Production and CO_2 Emission Interrelationship 86
3.7.1 Carbon Containing Fuels 85
3.7.2 Production of Carbon Dioxide 85
3.7.3 Production of Energy 86
3.7.4 Energetic Efficiency 86
3.7.5 Relation between Carbon Dioxide Emission and Energy Production 87
3.8 Sustainable Electricity Generation with Solar Updraft Towers 88
3.8.1 Introduction 88
3.8.2 The Solar updraft Tower – a Solution for Sunny Countries 89
3.8.3 Investment Cost and Levelised Electricity Cost 96
3.8.4 Ecological Analysis 96
3.8.5 Conclusion 98
3.9 Principles and Strategies for Achieving Environmental Compatibility in Rehabilitation of Structures 98
3.9.1 Principles and Strategies for Environmentally Compatible Renovations 99
3.9.2 Ratio of Primary to Secondary Structure 100
3.9.3 Comments 102
3.10 Primary and Secondary Structural Parts – Comments on Quantifying the Evironmental Impact Assessment (EIA) 102
3.10.1 Introduction 102
3.10.2 Methods Using LCA 103
3.10.3 Credit Based Methods 103
3.10.4 Some Comments on the Environmental Assessment Methods for Buildings 108
3.10.5 Incorporating the LCA Methods into the Credit Based Methods 108
3.11 Environmentally Compatible Structural Materials (ESCM) - European Experience 112
3.11.1 Environmental Aspects of Materials 112
3.11.2 Wood - Timber 114
3.11.3 Natural Stones 116
3.11.4 Clay Products - Ceramics 117
3.11.5 Binders 118
3.11.6 Concrete 119
3.11.7 Mortar and Plaster 119
3.11.8 Autoclaved Masonry Elements 120
3.11.9 Metals 120
3.11.10 Glass 122

3.11.11 Insulation Materials 122
3.11.12 Covering and Cladding Materials 124
3.11.13 Plastic 125
3.11.14 Bitumen 126
3.11.15 Natural Materials 126
3.11.16 Indicators of Material Production 127
3.12 Environmentally Compatible Structural Materials (ESCM) - Canadian experience 129
3.12.1 Introduction 129
3.12.2 Embedded Energy of Common Structural Materials 130
3.12.3 Embodied Energy and Effectiveness of Materials 133
3.12.4 Greenhouse Gas and Structural Materials 134
3.12.5 Greenhouse Gas and Effectiveness of Materials 135
3.12.6 Embedded Energy and Thermal Efficiency 135
3.12.7 Greenhouse Gas and Thermal Efficiency 136
3.12.8 Multi Functional Materials and Assemblies 136
3.12.9 Whole Life Environmental Impact 136
3.12.10 Materials Selection and the Quality of Life 137
3.12.11 Conclusion 138
3.13 Design of environmentally compatible structures with regard to accidental fires 138
3.13.1 Introduction 138
3.13.2 Analysis of Fires and Fire Scenarios in Relation to ECS 138
3.13.3 Toxic Products and Environmental Pollution Released during a Fire 141
3.13.4 Principles for the Application of Building Materials in Load-bearing Environmentally Compatible Structures 143
3.13.5 Fire Protection of Building Structures and its Environmental Effects 146
3.13.6 Fire-Suppressing Board Lining 149
3.13.7 Glued Linings of Mineral Fibers 152
3.14 References 152
4 ENVIRONMENTALLY COMPATIBLE BRIDGE AND HYDRAULIC STRUCTURES 157
4.1 Environmentally Compatible Bridge Structures 157
4.1.1 Traditional Design of Bridges and the Way to ECS 157
4.1.2 Selecting of Bridge Structures Considering Environmental Compatibility 158
4.1.3 Some Important Aspects of Environmentally Compatible Bridges 169
4.1.4 Conclusion to EC Bridges 182

4.2 EC Hydraulic Structures 183
4.2.1 Introduction 183
4.2.2 Fundamental Differences between the Classic Design Procedure of River Hydraulic Structures and the Design Procedure of ECS 185
4.2.3 EC Design Procedures 187
4.2.4 Global Lasting Dynamic Equilibrium 187
4.2.5 Dam Service Life 189
4.2.6 Exploitation of Natural Resources in Dam Construction 190
4.2.7 Embankment Dams 190
4.2.8 Concrete Dams 192
4.2.9 Demands for Concrete in Massive Dams with Gravity Effect 192
4.2.10 Overflow, Outlet and Intake Dam Structures 196
4.2.11 Physically Defined Surfaces in Hydraulic Engineering 196
4.2.12 Examples 198
4.2.13 Summary and recommendations 204
4.3 References 206
5 CASE STUDIES OF ECS 208
5.1 Environmentally Compatible Structures in Canada 208
5.1.1 Buildings in Canada 208
5.1.2 Characteristics of Three Structural Systems Commonly Used in Canada 209
5.1.3 Comments on the Environmental Compatibility of Systems A, B and C 213
5.2 Environmentally Compatible Structures in Japan 216
5.2.1 The Characteristics of Environmentally Compatible Structures in Japan 216
5.2.2 The Current Techniques for ECS Construction in Japan 216
5.2.3 The assessment methods of ECS techniques in Japan: CASBEE 217
5.2.4 Examples of environmentally compatible structures in Japan [11] 218
5.2.5 Concluding remarks 224
5.3 References 224
6 BIBLIOGRAPHY 225
AUTHOR LIST 234