

CONTENTS

CHAPTER 1. ASSESSMENT OF THE ORIGINAL BUILDING

1.1.	INTRODUCTION.....	1
1.2.	DOCUMENTATION.....	2
1.2.1.	General.....	2
1.2.2.	Building classification.....	2
1.2.2.1.	<i>Classification based on historical significance</i>	2
1.2.2.2.	<i>Classification based on use</i>	2
1.2.3.	Structural Assessment Data.....	2
1.2.3.1.	<i>Reinforced Concrete</i>	3
1.2.3.2.	<i>Masonry</i>	4
1.2.3.3.	<i>Steel - Iron</i>	7
1.2.3.4.	<i>Timber</i>	9
1.2.4.	Level of Knowledge (Eurocode 8.3 – Sections 3.3 – 3.5).....	10
1.2.4.1.	<i>Definition</i>	10
1.2.4.2.	<i>Identification</i>	12
1.2.5.	Reinforced Concrete.....	14
1.2.6.	Masonry & Stone Structures.....	15
1.2.7.	Steel/Iron Structures.....	16
1.2.8.	Timber Structures.....	17
1.2.9.	Discrete Block Structures.....	17
1.3.	PERFORMANCE REQUIREMENTS AND DESIGN CRITERIA.....	18
1.3.1.	General Structural Performance Levels.....	18
1.3.2.	Performance level Due to Load Carrying Systems.....	18
1.4.	STRUCTURAL MODELLING AND ANALYSIS.....	22
1.4.1.	General.....	22
1.4.2.	Structural Modelling.....	22
1.4.3.	Analysis Types.....	23
1.4.3.1.	<i>Linear Static Procedure (Equivalent Seismic Load Method)</i>	23
1.4.3.2.	<i>Linear Dynamic Procedures</i>	23
1.4.3.3.	<i>Nonlinear Static Procedure (Pushover Method)</i>	24
1.5.	SAFETY EVALUATION.....	25
	REFERENCES.....	26

CHAPTER 2. REHABILITATION STRATEGIES

2.1.	PRINCIPLES FOR RESTORATION INTERVENTIONS ON MONUMENTAL AND HISTORICAL BUILDINGS	27
2.1.1.	Introduction	27
2.1.2.	Venice Charter	29
2.1.2.1.	<i>Definitions</i>	29
2.1.2.2.	<i>Conservation</i>	30
2.1.2.3.	<i>Restoration</i>	30
2.1.2.4.	<i>Historic sites</i>	31
2.1.2.5.	<i>Excavations</i>	31
2.1.2.6.	<i>Publications</i>	31
2.1.2.7.	<i>Observations</i>	31
2.1.3.	Historical Gardens (Florence Charter 1981)	32
2.1.4.	Charter for the Conservation of Historic Towns and Urban Areas (Washington Charter 1987)	32
2.1.5.	Charter for the Protection and Management of the Archaeological Heritage (1990)	32
2.1.6.	Charter on the Protection and Management of Underwater Cultural Heritage (1996)	32
2.1.7.	International Cultural Tourism Charter (1999)	32
2.1.8.	Charter on the Built Vernacular Heritage (1999)	32
2.1.9.	Principles for the Preservation of Historic Timber Structures (1999)	32
2.1.10.	Principles for the analysis, conservation and structural restoration of architectural heritage (2003)	33
2.1.10.1.	<i>General criteria</i>	33
2.1.10.2.	<i>Researches and diagnosis</i>	34
2.1.10.3.	<i>Remedial measures and controls</i>	34
2.2.	PERFORMANCE VS. REHABILITATION LEVELS	36
2.2.1.	Classification for historical buildings	36
2.2.2.	Design seismic action	36
2.2.3.	Performance criteria for structural and non-structural elements and various building types (temple, masonry buildings, timber, steel, concrete). Accepted – non accepted failures	37
2.3.	REHABILITATION STRATEGIES: DESIGN CRITERIA FOR STRUCTURAL INTERVENTIONS	37
2.3.1.	Analysis criteria	38
2.3.1.1.	<i>Building representation</i>	38
2.3.1.2.	<i>Design parameters</i>	38
2.3.1.3.	<i>Types of analysis</i>	39
2.3.2.	Safety verification	41

2.3.2.1. <i>Safety elements</i>	41
2.3.2.2. <i>Verifications</i>	41
2.4. VALIDATION CRITERIA	43
2.4.1. Introduction	43
2.4.2. Values assessment	44
2.4.2.1. <i>Examples</i>	44
2.4.3. Technical aspects	45
2.4.3.1. <i>Reversibility</i>	45
2.4.3.2. <i>Compatibility</i>	45
2.4.3.3. <i>Local conditions</i>	47
2.4.3.4. <i>Quality control</i>	47
2.4.4. Structural aspects	47
2.4.4.1. <i>Accompanying measures</i>	47
2.4.4.2. <i>Technical support</i>	48
2.4.4.3. <i>Installation/Erection</i>	48
2.4.5. Economic aspects	48
REFERENCES	48

CHAPTER 3. VALIDATION CASE STUDIES

3.0. VALIDATION OF EXISTING REHABILITATION INTERVENTIONS	49
3.1. THE BALANOS INTERVENTION ON THE ACROPOLIS MONUMENTS (1902-1930), ATHENS – GREECE	50
3.1.1. Introduction	50
3.1.2. Eretheion Restoration (1902 – 1907)	50
3.1.3. Propylaia Restoration (1909 – 1917)	52
3.1.4. Parthenon Restoration (1923 – 1930)	56
3.1.5. Evaluation of the intervention	57
3.1.6. Responsible of the intervention	60
3.2. CHURCH ST. SOPHIA, OHRID - MACEDONIA	60
3.2.1. Introduction	60
3.2.2. Historical background	61
3.2.3. Damage assessment	63
3.2.4. Description of past interventions	65
3.2.5. Design requirements	70
3.2.6. Rehabilitation options	72
3.2.7. Evaluation of the intervention	72
3.3. THE BASTION 23, ALGIERS - ALGERIA	74
3.3.1. Introduction	74
3.3.2. Typology of the Bastion 23 Houses	76

3.3.3.	Historical background	77
3.3.4.	Damage assessment	77
3.3.5.	Description of past interventions	78
3.3.5.1.	<i>The consolidation</i>	78
3.3.6.	Rehabilitation design	80
3.3.6.1.	<i>Conventional Repair and Strengthening Methods that could be used</i> ..	80
3.3.7.	Critical evaluation of proposed interventions	82
3.3.7.1.	<i>Incompatibilities of concrete and cement mortar with old masonry and clay mortar</i>	83
3.3.8.	Evaluation of the intervention	83
3.3.9.	Conclusions	84
3.4.	DIPLOMATIC HALL OF THE ROYAL PALACE OF NAPLES - ITALY	85
3.4.1.	Introduction	85
3.4.2.	Structural scheme	85
3.4.3.	Structural degradation	87
3.4.4.	The retrofitting intervention	88
3.4.4.1.	<i>The beam floor</i>	88
3.4.4.2.	<i>The vault</i>	89
3.4.4.3.	<i>The truss</i>	89
3.4.5.	Evaluation of the intervention	89
3.4.6.	Responsible of the intervention	91
3.5.	CHURCH OF S.GIOVANNI BATTISTA, CARIFE (AV) - ITALY	91
3.5.1.	Introduction	91
3.5.2.	Structural scheme	91
3.5.3.	Structural degradation	92
3.5.4.	The retrofitting intervention	92
3.5.5.	Interventions	94
3.5.6.	Evaluation of the intervention	95
3.5.7.	Responsible of the intervention	96
3.6.	“BAROC” PALACE, TIMIȘOARA - ROMANIA	97
3.6.1.	Introduction	97
3.6.1.1.	<i>Description of the functional features</i>	97
3.6.1.2.	<i>Description of the structural features</i>	98
3.6.2.	Historical background	99
3.6.3.	Damage assessment	99
3.6.4.	Description of past interventions	100
3.6.5.	Design requirements	100
3.6.6.	Rehabilitation design	101
3.6.7.	Interventions	101
3.6.8.	Evaluation of the intervention	104
3.6.9.	Conclusions	105

3.6.10.	Responsible of the intervention	105
3.7.	“BANLOC” MANOR HOUSE - ROMANIA	105
3.7.1.	Introduction	105
3.7.1.1.	<i>Description of the structural features</i>	105
3.7.2.	Historical background	106
3.7.3.	Damage assessment	106
3.7.4.	Description of past interventions	107
3.7.5.	Design requirements	107
3.7.6.	Rehabilitation design	108
3.7.6.1.	<i>Interventions</i>	109
3.7.7.	Evaluation of the intervention	110
3.7.8.	Conclusions	111
3.7.9.	Responsible of the intervention	111
3.8.	RESTORATION OF THE PALACE OF JUSTICE, BUCHAREST - ROMANIA	111
3.8.1.	Introduction	111
3.8.2.	Pathology of the building	114
3.8.3.	Restoration principles and application	115
3.8.4.	Evaluation of the intervention	118
3.8.5.	Conclusions	119
3.8.6.	Responsible of the intervention	119
3.9.	RESTORATION OF THE TRAJAN MARKET HALL, BUCHAREST - ROMANIA	120
3.9.1.	Introduction	120
3.9.2.	Pathology of the building	122
3.9.3.	Restoration principles and application	123
3.9.4.	Evaluation of the intervention	124
3.9.5.	Conclusions	124
3.9.6.	Responsible of the intervention	124
3.10.	MUNICIPAL MARKET IN KARDITSA - GREECE	125
3.10.1.	Introduction	125
3.10.2.	Pathology of the building	126
3.10.3.	Restoration principles and application	128
3.10.4.	Conclusions	130
3.10.5.	Evaluation of the intervention	130
3.10.6.	Responsible of the intervention	131
3.11.	THE BEDOUINS’ CHILDREN SCHOOL IN BE’ER SHEVA - ISRAEL	131
3.11.1.	Introduction	131
3.11.2.	Description of building	132
3.11.2.1.	<i>Foundations</i>	132
3.11.2.2.	<i>Ground floor</i>	133
3.11.2.3.	<i>Walls</i>	133

3.11.2.4.	<i>Columns</i>	135
3.11.2.5.	<i>First storey floor</i>	136
3.11.2.6.	<i>Roof</i>	137
3.11.2.7.	<i>Seismic hazard in the Be'er-Sheva region</i>	139
3.11.3.	<i>Remedial actions</i>	139
3.11.4.	<i>Conclusions</i>	140
3.11.5.	<i>Post Restoration report – May 2007</i>	140
3.11.6.	<i>Evaluation of the intervention</i>	142
3.11.7.	<i>Responsible of the intervention</i>	143
3.12.	POST – EARTHQUAKE RESTORATION OF THE MEMORIAL CHURCH OF THE HOLY SPIRIT JAVORCA, TOLMIN - SLOVENIA	143
3.12.1.	<i>Introduction</i>	143
3.12.2.	<i>Pathology of the building</i>	144
3.12.3.	<i>Restoration principles and application</i>	145
3.12.4.	<i>Evaluation of the intervention</i>	147
3.12.5.	<i>Responsible of the intervention</i>	148
3.13.	DEUTSCHE BANK BUILDING IN NAPLES - ITALY	149
3.13.1.	<i>Introduction</i>	149
3.13.2.	<i>Structural scheme</i>	149
3.13.2.1.	<i>Structural scheme a</i>	150
3.13.2.2.	<i>Structural scheme b</i>	151
3.13.2.3.	<i>Structural scheme c</i>	151
3.13.2.4.	<i>Structural scheme d (frames 6 and 7 of FIGURE 3.13.2)</i>	151
3.13.2.5.	<i>Structural degradation</i>	151
3.13.3.	<i>Retrofitting intervention</i>	152
3.13.3.1.	<i>Columns and tie beam elements</i>	152
3.13.3.2.	<i>Floor structures</i>	153
3.13.3.3.	<i>Protection of steel surfaces</i>	154
3.13.4.	<i>Evaluation of the intervention</i>	154
3.13.5.	<i>Responsible of the intervention</i>	156
3.14.	THE JOLLY HOTEL IN CASERTA - ITALY	156
3.14.1.	<i>Introduction</i>	156
3.14.2.	<i>The retrofitting intervention</i>	157
3.14.3.	<i>Evaluation of the intervention</i>	158
3.14.4.	<i>Responsible of the intervention</i>	159
3.15.	WEST UNIVERSITY, TIMOȘOARA - ROMANIA	159
3.15.1.	<i>Introduction</i>	159
3.15.2.	<i>Description of the structural features</i>	160
3.15.3.	<i>Description of the loading / Romania</i>	161
3.15.4.	<i>Historical background</i>	161
3.15.5.	<i>Damage assessment</i>	162

3.15.6.	Description of past interventions.....	162
3.15.7.	Design requirements.....	163
3.15.7.1.	<i>Rehabilitation design</i>	163
3.15.7.2.	<i>Conclusions</i>	164
3.15.8.	Interventions.....	164
3.15.9.	Critical evaluation.....	164
3.15.10.	Evaluation of the intervention.....	165
3.15.11.	Responsible of the intervention.....	166
REFERENCES	166

CHAPTER 4. SELECTED CASE STUDIES

4.1.	MUSTAFA' PASHA MOSQUE IN SKOPJE.....	169
4.1.1.	Introduction.....	169
4.1.2.	Historical Background.....	169
4.1.3.	Building features.....	170
4.1.3.1.	<i>Geometrical features</i>	170
4.1.3.2.	<i>Mechanical Features of the main constructional materials</i>	171
4.1.4.	Damage Assessment and Past retrofitting intervention.....	172
4.1.5.	Seismic analysis.....	173
4.1.5.1.	<i>Structural Modelling methods and member properties</i>	173
4.1.5.2.	<i>Numerical Analysis</i>	175
4.1.6.	The Large scale model.....	180
4.1.7.	Rehabilitation Strategies.....	181
4.1.8.	Critical Evaluation of Proposed interventions and Conclusion.....	185
4.2.	GOTHIC ABBEY CHURCH IN FOSSANOVA.....	187
4.2.1.	Introduction.....	187
4.2.2.	Historical Background.....	187
4.2.3.	Geometrical features.....	188
4.2.4.	Mechanical features of the main constructional materials.....	190
4.2.5.	Past retrofitting interventions.....	190
4.2.6.	Seismic analysis.....	191
4.2.6.1.	<i>Structural Modelling methods</i>	191
4.2.7.	Pre – experimental analysis for shaking table test.....	192
4.2.7.1.	<i>FEM elastic analysis</i>	192
4.2.7.2.	<i>Collapse mechanism analysis</i>	195
4.2.8.	Rehabilitation Strategies.....	200
4.2.8.1.	<i>Evaluation of seismic capacity</i>	200
4.2.8.2.	<i>Experimental investigation after shaking table tests</i>	203
4.2.8.3.	<i>New tightening device adopted and tested</i>	206

4.2.9.	Critical evaluation of proposed interventions and conclusions	207
4.3.	SAINT NIKOLA CHURCH IN PSACHA	210
4.3.1.	Introduction	210
4.3.2.	Historical Background.....	210
4.3.3.	Building features	212
4.3.3.1.	<i>Geometrical features</i>	212
4.3.4.	Damage Assessment and Past retrofitting interventions	213
4.3.4.1.	<i>Conservation works</i>	213
4.3.5.	Seismic analysis.....	214
4.3.5.1.	<i>Structural modelling methods and member properties</i>	214
4.3.5.2.	<i>Mathematical models</i>	214
4.3.5.3.	<i>Material Characteristics</i>	214
4.3.6.	Evaluation of the seismic response.....	216
4.3.6.1.	<i>Spectral analysis</i>	216
4.3.7.	Seismic analysis results of the existing structure	216
4.3.8.	Rehabilitation Strategies.....	217
4.3.8.1.	<i>Masonry elements in elevation: Steel Reinforcement “tiers and injection”</i>	218
4.3.8.2.	<i>Masonry elements in Foundation: Base isolations</i>	219
4.3.8.3.	<i>Analysis results of the seismically- upgraded structure</i>	224
4.3.8.4.	<i>Verification of upgraded structure</i>	226
4.3.9.	Critical Evaluation of Proposed interventions and Conclusions	227
4.4.	ACROPOLIS OF ATHENS	229
4.4.1.	Introduction	229
4.4.2.	Historical Background.....	229
4.4.3.	Building features	230
4.4.4.	Damage assessment.....	232
4.4.5.	Past retrofitting intervention.....	233
4.4.6.	Seismic analysis: Parthenon Pronaos	234
4.4.6.1.	<i>Structural modelling methods and member properties</i>	234
4.4.7.	Rehabilitation strategies: New architrave connections – stainless steel or titanium	237
4.4.8.	Critical Evaluation of Proposed intervention	239
4.4.9.	Conclusions	240
4.5.	BEYLERBEYI PALACE IN ISTANBUL	240
4.5.1.	Introduction	240
4.5.2.	Historical Background.....	241
4.5.3.	Building features	241
4.5.3.1.	<i>Mechanical features of the main constructional materials</i>	243
4.5.4.	Damage Assessment.....	244
4.5.5.	Past retrofitting intervention.....	245

4.5.6.	Seismic analysis.....	246
4.5.6.1.	<i>Evaluation of the seismic response</i>	247
4.5.7.	Rehabilitation strategies	252
4.5.7.1.	<i>Foundation: Base Isolation</i>	252
4.5.7.2.	<i>Masonry structures: Fibre Reinforced Polymer Overlays (FRP)</i>	259
4.5.7.3.	<i>Floor structures: Consolidation of the Slabs to Have Rigid Diaphragm Behaviour</i>	261
4.5.8.	Conclusions	263
4.6.	GALLERY "UMBERTO I" IN NAPLES	264
4.6.1.	Introduction	264
4.6.2.	Historical Background.....	265
4.6.3.	Building features	265
4.6.3.1.	<i>Geometrical features</i>	265
4.6.3.2.	<i>Mechanical Features of the main constructional material: experimental activity</i>	267
4.6.4.	Damage assessment.....	270
4.6.5.	Past retrofitting intervention.....	271
4.6.6.	Seismic analysis.....	272
4.6.7.	Structural modelling methods and members properties	272
4.6.7.1.	<i>Geometrical model</i>	272
4.6.7.2.	<i>Material characteristics</i>	272
4.6.7.3.	<i>The load modelling</i>	272
4.6.7.4.	<i>The load combinations</i>	275
4.6.8.	Results of numerical analysis	275
4.6.9.	Durability analysis against atmospheric corrosion.....	279
4.6.10.	Rehabilitation strategies	280
4.6.10.1.	<i>FRP strengthen: pultruded plate</i>	280
4.6.11.	Critical evaluation of proposed interventions.....	280
4.6.12.	Conclusions	280
4.7.	ROYAL PALACE IN NAPLES	281
4.7.1.	Introduction	281
4.7.2.	Historical Background and typological evolution.....	282
4.7.3.	Building features	283
4.7.3.1.	<i>Geometrical features</i>	283
4.7.3.2.	<i>Mechanical features of the main constitutional materials</i>	285
4.7.4.	Damage assessment.....	286
4.7.5.	Past retrofitting intervention: wooden structures	286
4.7.6.	Analysis: The historical apartment.....	287
4.7.6.1.	<i>The survey</i>	287
4.7.7.	Damage Assessment of the historical apartment.....	294
4.7.8.	Seismic Analysis	296

4.7.9.	Structural modelling methods and member properties	297
4.7.9.1.	<i>Geometrical model and material characteristics</i>	297
4.7.9.2.	<i>Loading model</i>	299
4.7.10.	Results of numerical analysis	299
4.7.10.1.	<i>Design requirements</i>	300
4.7.11.	Rehabilitation strategies	300
4.7.11.1.	<i>Rehabilitation strategies: the methodologies applied</i>	303
4.7.12.	Critical evaluation of the result and Conclusions	303
4.8.	MEDINA IN SALE'	304
4.8.1.	Introduction	304
4.8.2.	Historical Background	305
4.8.3.	Building features	306
4.8.4.	The building site characterization	307
4.8.5.	Geological classification of the Site	308
4.8.5.1.	<i>Seismic refraction tomography acquisition</i>	309
4.8.5.2.	<i>Penetrometry Test</i>	312
4.8.5.3.	<i>Seismic Hazard Parameters</i>	313
4.8.5.4.	<i>Ambient Noise Recording</i>	313
4.8.6.	Mechanical features of the main constructional materials: experimental activities	314
4.8.6.1.	<i>Experimental Results on the Salé-Stone elements</i>	316
4.8.6.2.	<i>Experimental Results on a Sample of Lime-Mortar</i>	318
4.8.6.3.	<i>Experimental results on wood</i>	318
4.8.7.	Damage Assessment	319
4.8.7.1.	<i>Foundations</i>	319
4.8.7.2.	<i>Ground floor</i>	319
4.8.7.3.	<i>Stairs</i>	322
4.8.7.4.	<i>First Floor</i>	322
4.8.7.5.	<i>Roof</i>	326
4.8.8.	Description of past interventions	326
4.8.9.	Seismic analysis	327
4.8.10.	Structural modelling method and member properties	327
4.8.10.1.	<i>Material Characteristics: Masonry</i>	327
4.8.10.2.	<i>The Load modelling</i>	329
4.8.11.	Seismic load and vulnerability analysis	335
4.8.11.1.	<i>General</i>	335
4.8.11.2.	<i>Response Spectrum in Algerian building code</i>	336
4.8.11.3.	<i>Seismic analysis for a 12 %g acceleration</i>	339
4.8.11.4.	<i>Considerations and Design requirements</i>	342
4.8.12.	Rehabilitation strategies	343
4.8.12.1.	<i>General</i>	343

4.8.12.2.	<i>Foundation</i>	343
4.8.12.3.	<i>Vertical elements: Wall and Columns</i>	345
4.8.12.4.	<i>Floor Structures</i>	346
4.8.12.5.	<i>Economical issues</i>	357
4.8.13.	<i>Conclusions</i>	358
4.9.	KOLETTI BUILDING IN ATHENS	358
4.9.1.	<i>Introduction</i>	358
4.9.2.	<i>Building Features</i>	359
4.9.2.1.	<i>Geometrical features</i>	359
4.9.2.2.	<i>Mechanical features of the main constructional materials</i>	361
4.9.2.3.	<i>Loading Conditions</i>	361
4.9.3.	<i>Basis for evaluation of seismic behaviour</i>	362
4.9.3.1.	<i>Structural modelling</i>	362
4.9.3.2.	<i>Plastic hinge model</i>	364
4.9.3.3.	<i>Methods of analysis</i>	364
4.9.3.4.	<i>Current trend in nonlinear static procedures</i>	366
4.9.4.	<i>Seismic analysis</i>	368
4.9.4.1.	<i>Lateral loading</i>	368
4.9.4.2.	<i>Pushover analysis</i>	370
4.9.4.3.	<i>Torsional Effects</i>	373
4.9.4.4.	<i>Modal analysis</i>	375
4.9.4.5.	<i>Dynamic elastic analysis</i>	376
4.9.5.	<i>Rehabilitation strategies</i>	378
4.9.6.	<i>Retrofitting with bracing</i>	380
4.9.6.1.	<i>Retrofit using steel concentric bracing with and without INERD connections</i>	380
4.9.6.2.	<i>Retrofit using steel concentric bracing and eccentric bracing with active links</i>	381
4.9.6.3.	<i>Behaviour of the retrofitted structure</i>	385
4.9.7.	<i>Retrofitting with shear panels</i>	387
4.9.7.1.	<i>General methodology</i>	387
4.9.7.2.	<i>The retrofitted structure design curves</i>	391
4.9.7.3.	<i>Sizing of steel shear panels</i>	393
4.9.7.4.	<i>Strength based design</i>	395
4.9.7.5.	<i>Stiffness based design</i>	396
4.9.7.6.	<i>Selection of shear panel devices</i>	398
4.9.7.7.	<i>Design of the steel frame</i>	400
4.9.7.8.	<i>Behaviour of the retrofitted structure</i>	401
4.9.7.9.	<i>Concluding remarks</i>	403
4.9.8.	<i>Retrofitting with BRBs</i>	403
4.9.8.1.	<i>Seismic hazard assessment</i>	403

4.9.8.2. <i>Generality about BRB Retrofitting System</i>	404
4.9.8.3. <i>Design Criteria of the BRB Retrofitting System</i>	405
4.9.8.4. <i>Basic modelling assumptions</i>	407
4.9.8.5. <i>Analysis results of the structure equipped with BRBs</i>	408
4.9.8.6. <i>Performance comparison</i>	409
4.9.8.7. <i>Concluding remarks</i>	412
4.9.9. <i>Retrofitting with viscous dampers</i>	412
4.9.9.1. <i>Fully stressed design method</i>	412
4.9.9.2. <i>Design algorithm</i>	412
4.9.9.3. <i>Analysis results of the seismically-upgraded structure</i>	414
4.9.9.4. <i>Concluding remarks</i>	421
4.9.10. <i>Retrofitting with tuned mass dampers</i>	423
4.9.10.1. <i>Vulnerability assessment</i>	423
4.9.10.2. <i>Analysis results of the existing structure</i>	423
4.9.10.3. <i>Seismic upgrading measures</i>	425
4.9.10.4. <i>Analysis results of the seismically-upgraded structure</i>	429
4.9.10.5. <i>Concluding remarks</i>	431
4.9.11. <i>Retrofitting by using concrete shear wall panels</i>	433
4.9.11.1. <i>General</i>	433
4.9.11.2. <i>Addition of RC Structural Wall Panels</i>	433
4.9.11.3. <i>Seismic analysis results</i>	434
4.9.11.4. <i>Concluding remarks</i>	438
REFERENCES	439

CHAPTER 5. OVERVIEW OF RELEVANT CODES AND GUIDELINES

5.1. INTRODUCTION	449
5.2. TRADITIONAL TECHNIQUES	457
5.2.1. Introduction	457
5.2.2. STANDARD and Codes	457
5.2.2.1. <i>Europe - CEN 2005d. EN 1998-3. Design of structures for earthquake resistance. Part 3: Assessment and retrofitting of buildings</i>	457
5.2.2.2. <i>Australia – AS 3826-1998 strengthening existing buildings for earthquakes</i>	458
5.2.2.3. <i>USA</i>	458
5.2.3. GUIDELINES & MANUALS	462
5.2.3.1. <i>Italy</i>	462
5.2.3.2. <i>Japan</i>	464
5.2.3.3. <i>New Zealand</i>	465
5.2.3.4. <i>USA</i>	466
5.3. FIBRE REINFORCED POLYMERS (FRPS)	471

5.3.1.	Introduction	471
5.3.2.	Standards and Codes	472
5.3.2.1.	<i>Europe - CEN 2005d. EN 1998-3. Design of structures for earthquake resistance. Part 3: Assessment and retrofitting of buildings</i>	472
5.3.3.	Guidelines and Manuals: FRP	472
5.3.3.1.	<i>Europe</i>	472
5.3.3.2.	<i>Greece - Greek recommendations for pre- and post-seismic interventions in buildings. 2001</i>	474
5.3.3.3.	<i>Italy</i>	474
5.3.3.4.	<i>United Kingdom</i>	476
5.3.3.5.	<i>Japan - JBDPA 2001. Guidelines for seismic retrofit of existing reinforced concrete buildings</i>	478
5.3.3.6.	<i>USA</i>	478
5.4.	SEISMIC ISOLATION	479
5.4.1.	Introduction	479
5.4.2.	Design Codes	479
5.4.2.1.	<i>Europe</i>	479
5.4.2.2.	<i>Italy - Technical regulations for the design, assessment and seismic retrofit of buildings: Chapter 10 (Ordinanza 3274, 2003, English translation)</i>	482
5.4.2.3.	<i>USA</i>	482
5.4.3.	Guidelines and manuals	485
5.4.3.1.	<i>Europe</i>	485
5.4.3.2.	<i>Japan - Notification 2009. 2000, 2007</i>	487
5.4.3.3.	<i>New Zealand - T. E. Kelly. 2001. Base isolation of structures – Design guidelines</i>	487
5.4.3.4.	<i>USA</i>	491
5.4.4.	Devices and Materials Testing Codes and Guidelines for Base Isolation	500
5.4.4.1.	<i>Europe</i>	500
5.4.4.2.	<i>Italy: CNR-10018. 1999. Bearing devices for structures. (in Italian)</i>	506
5.4.4.3.	<i>USA</i>	508
5.5.	ENERGY DISSIPATION	513
5.5.1.	Introduction	513
5.5.2.	Design Codes	513
5.5.3.	Guidelines and Manuals	515
5.5.4.	Devices and Materials Testing Guidelines and Handbooks for Energy Dissipation	521
5.5.4.1.	<i>Europe - CEN 2005e. prEN 15129. Anti-seismic devices</i>	521
5.5.4.2.	<i>USA</i>	522
5.6.	PROHITECH COUNTRIES NATIONAL PRACTICE	524
5.6.1.	<i>Algeria</i>	526

5.6.2. Belgium 527

5.6.3. Egypt 527

5.6.4. Greece 527

5.6.5. Israel 530

5.6.6. Italy 530

5.6.7. Macedonia 531

5.6.8. Morocco 532

5.6.9. Portugal 533

5.6.10. Romania 535

5.6.11. Slovenia 536

5.6.12. Turkey 537

5.7. ADVANCED ISSUES 538

5.7.1. Introduction 538

5.7.2. Design of seismic isolated structures according to USA Code 539

5.7.3. Development of regulations for seismic isolation and passive Energy
dissipation of buildings and bridges in Italy and Europe
(Dolce and Santarsiero 2004) 540

5.7.4. Suggestions for improvement 544

5.7.4.1. *Base Isolation* 544

5.7.4.2. *Energy Dissipating Devices* 546

REFERENCES 546