

ATC-3-06 Amended

Tentative Provisions for the Development of Seismic Regulations for Buildings

Includes 1982 “Amendments to ATC-3-06 Tentative Provisions for the Development of Seismic Regulations for Buildings for Use in Trial Designs” (Appendix B)

by

APPLIED TECHNOLOGY COUNCIL
555 Twin Dolphin Drive, Suite 550
Redwood City, CA 94065

Funded by:

NATIONAL SCIENCE FOUNDATION
NATIONAL BUREAU OF STANDARDS
Washington, DC

Amendments prepared by a joint committee of the:
Building Seismic Safety Council
National Bureau of Standards

Amendments funded by:
Federal Emergency Management Agency

1978, 1984 Second Printing

PREFACE TO REPRINT

The Applied Technology Council (ATC) started development of the ATC-3 “Tentative Provisions for the Development of Seismic Regulations for Buildings” in 1974 under a project funded by the National Science Foundation (NSF) and the National Bureau of Standards (NBS). The Tentative Provisions were published in June 1978. Six thousand copies were distributed by ATC to the earthquake engineering profession world wide. Another 2,000 copies were distributed by the Federal government.

The authors of ATC-3 realized the Tentative Provisions include many innovations and thus need careful assessment. The preface states:

“BECAUSE OF THE MANY NEW CONCEPTS AND PROCEDURES INCLUDED IN THESE TENTATIVE PROVISIONS, THEY SHOULD NOT BE CONSIDERED FOR CODE ADOPTION UNTIL THEIR WORKABILITY, PRACTICABILITY, ENFORCEABILITY, AND IMPACT ON COST ARE EVALUATED BY PRODUCING AND COMPARING BUILDING DESIGNS FOR THE VARIOUS DESIGN CATEGORIES INCLUDED IN THIS DOCUMENT.”

During 1979-80 NBS, in conjunction with the Building Seismic Safety Council (BSSC) and with funding by the Federal Emergency Management Agency (FEMA) reviewed and assessed the Tentative Provisions. A total of nearly 100 individuals divided into ten committees participated, representing industry, trade and professional organizations, and code promulgating groups. ATC, under a grant from NBS, furnished ten consultants who previously had been involved with the ATC-3 development. The Structural Engineers Association of California (SEAOC) selected several of its members to participate in the review.

Numerous meetings and discussions were held and correspondence exchanged, which resulted in over 300 proposed modifications or clarifications. Each of the proposed modifications were voted upon by all the participants; the members of BSSC then were balloted. The result was that about 250 of the proposed changes were adopted. The adopted modifications were published by NBS and BSSC in December 1982 as “Amendments to ATC-3-06 Tentative Provisions for the Development of Seismic Regulations for Buildings.” These amendments are considered to be tentative, not final, and are being subjected to a formal program of evaluation and testing.

This publication is a reprint of the original ATC-3-06 report, with the proposed amendments to ATC-3-06 included as Appendix B. These two documents are printed together to keep the earthquake engineering profession up to date with respect to the status of ATC-3—06.

TABLE OF CONTENTS

<u>CHAPTER/ SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
	PREFACE TO REPRINT	ii
	FOREWORD	iii
	PREFACE	iv
	TABLE OF CONTENTS	v
	LIST OF TABLES AND EXHIBITS	xx
	LIST OF FIGURES AND PLATES	xxii
	ABSTRACT	xxiv
	INTRODUCTION	1
	Background	1
	Philosophy	2
	Objectives	2
	New Concepts	3
	Areas Requiring Additional Research Information	4
	Project Organization	5
	GUIDE TO USE OF ATC-3 TENTATIVE PROVISIONS	13
	SI CONVERSION UNITS	18
1	<u>ADMINISTRATION</u>	27
1.1	PURPOSE	27
1.2	SCOPE	27
1.3	APPLICATION OF PROVISIONS	27
1.3.1	New Buildings	27
1.3.2	Existing Building Alterations and Repairs	28
1.3.3	Change of Use	28
1.3.4	Systematic Abatement of Seismic Hazards in Existing Buildings	28
1.4	SEISMIC PERFORMANCE	28
1.4.1	Seismicity Index and Design Ground Motions	28
1.4.2	Seismic Hazard Exposure Groups	29
1.4.3	Seismic Performance Categories	30
1.4.4	Site Limitation for Seismic Design Performance Category D	30
1.5	ALTERNATE MATERIALS AND METHODS OF CONSTRUCTION	30
1.6	QUALITY ASSURANCE	30
1.6.1	Quality Assurance Plan	30
1.6.2	Special Inspection	31
1.6.3	Special Testing	32
1.6.4	Reporting and Compliance Procedures	33
1.6.5	Approved Manufacturers Certification	34
2	<u>DEFINITIONS AND SYMBOLS</u>	37
2.1	DEFINITIONS	37
2.2	SYMBOLS	40

3	<u>STRUCTURAL DESIGN REQUIREMENTS</u>	45
3.1	DESIGN BASIS	45
3.2	SITE EFFECTS	45
3.2.1	Soil Profile Types	45
3.2.2	Site Coefficient	45
3.2.3	Soil-Structure Interaction	46
3.3	FRAMING SYSTEMS	46
3.3.1	Classification of Framing Systems	46
3.3.2	Combinations of Framing Systems	46
3.3.3	Seismic Performance Categories A and B	46
3.3.4	Seismic Performance Category C	46
3.3.5	Seismic Performance Category D	47
3.4	BUILDING CONFIGURATION	47
3.4.1	Plan Configuration	47
3.4.2	Vertical Configuration	48
3.5	ANALYSIS PROCEDURES	48
3.5.1	Seismic Performance Category A	48
3.5.2	Seismic Performance Category B	48
3.5.3	Seismic Performance Categories C and D	48
3.6	DESIGN AND DETAILING REQUIREMENTS.	48
3.6.1	Seismic Performance Category A	48
3.6.2	Seismic Performance Category B	48
3.6.3	Seismic Performance Category C	49
3.6.4	Seismic Performance Category D	49
3.7	STRUCTURAL COMPONENT LOAD EFFECTS	49
3.7.1	Combination of Load Effects.	49
3.7.2	Orthogonal Effects	49
3.7.3	Discontinuities in Strength of Vertical Resisting System	50
3.7.4	Nonredundant Systems	50
3.7.5	Ties and Continuity	50
3.7.6	Concrete or Masonry Wall Anchorage	50
3.7.7	Anchorage of Nonstructural Systems	50
3.7.8	Collector Elements	50
3.7.9	Diaphragms	50
3.7.10	Bearing Walls.	51
3.7.11	Inverted Pendulum-Type Structures	51
3.7.12	Vertical Seismic Motions for Buildings Assigned to Categories C and D	51
3.8	DEFLECTION AND DRIFT LIMITS	51
4	<u>EQUIVALENT LATERAL FORCE PROCEDURE</u>	55
4.1	GENERAL	55
4.2	SEISMIC BASE SHEAR	55
4.2.1	Calculation of Seismic Coefficient	55
4.2.2	Period Determination	56
4.3	VERTICAL DISTRIBUTION OF SEISMIC FORCES	57
4.4	HORIZONTAL SHEAR DISTRIBUTION AND TORSION	57
4.5	OVERTURNING	57

4.6	DRIFT DETERMINATION AND P-DELTA EFFECTS	58
4.6.1	Story Drift Determination	58
4.6.2	P-Delta Effects	58
5	<u>MODAL ANALYSIS PROCEDURE</u>	61
5.1	GENERAL	61
5.2	MODELING	61
5.3	MODES	61
5.4	PERIODS	61
5.5	MODAL BASE SHEAR	61
5.6	MODAL FORCES, DEFLECTIONS AND DRIFTS	62
5.7	MODAL STORY SHEARS AND MOMENTS	62
5.8	DESIGN VALUES	63
5.9	HORIZONTAL SHEAR DISTRIBUTION AND TORSION	63
5.10	FOUNDATION OVERTURNING	63
5.11	P-DELTA EFFECTS	63
6	<u>SOIL-STRUCTURE INTERACTION</u>	65
6.1	GENERAL	65
6.2	EQUIVALENT LATERAL FORCE PROCEDURE	65
6.2.1	Base Shear	65
6.2.2	Vertical Distribution of Seismic Forces	68
6.2.3	Other Effects	68
6.3	MODAL ANALYSIS PROCEDURE	69
6.3.1	Modal Base Shears	69
6.3.2	Other Modal Effects	69
6.3.3	Design Values	70
7	<u>FOUNDATION DESIGN REQUIREMENTS</u>	73
7.1	GENERAL	73
7.2	STRENGTH OF COMPONENTS AND FOUNDATIONS	73
7.2.1	Structural Materials	73
7.2.2	Soil Capacities	73
7.3	SEISMIC PERFORMANCE CATEGORY A	73
7.4	SEISMIC PERFORMANCE CATEGORY B	73
7.4.1	Investigation	73
7.4.2	Pole-Type Structures	73
7.4.3	Foundation Ties	74
7.4.4	Special Pile Requirements	74
7.5	SEISMIC PERFORMANCE CATEGORY C	74
7.5.1	Investigation	74
7.5.2	Foundation Ties	74
7.5.3	Special Pile Requirements	75
7.6	SEISMIC PERFORMANCE CATEGORY D	75
7.6.1	Special Pile Limitations	75

8	<u>ARCHITECTURAL, MECHANICAL AND ELECTRICAL COMPONENTS AND SYSTEMS</u> . . .	77
8.1	GENERAL REQUIREMENTS	77
8.1.1	Interrelationship of Components	77
8.1.2	Connections and Attachments	77
8.1.3	Performance Criteria	77
8.2	ARCHITECTURAL DESIGN REQUIREMENTS	78
8.2.1	General	78
8.2.2	Forces	78
8.2.3	Exterior Wall Panel Attachment	78
8.2.4	Component Deformation	78
8.2.5	Out-of-Plane Bending	79
8.3	MECHANICAL AND ELECTRICAL DESIGN REQUIREMENTS	79
8.3.1	General	79
8.3.2	Forces	79
8.3.3	Attachment Design	80
8.3.4	Component Design	80
8.3.5	Utility and Service Interfaces	81
9	<u>WOOD</u>	85
9.1	REFERENCE DOCUMENTS	85
9.2	STRENGTH OF MEMBERS AND CONNECTIONS	85
9.3	SEISMIC PERFORMANCE CATEGORY A	86
9.3.1	Bracing Requirements	86
9.4	SEISMIC PERFORMANCE CATEGORY B	86
9.4.1	Detailing Requirements	86
9.5	SEISMIC PERFORMANCE CATEGORY C	86
9.5.1	Material Limitations	86
9.5.2	Framing Systems	87
9.5.3	Detailing Requirements	87
9.6	SEISMIC PERFORMANCE CATEGORY D	87
9.6.1	Material Limitations	87
9.6.2	Framing Systems	87
9.6.3	Diaphragm Limitations	87
9.7	CONVENTIONAL LIGHT TIMBER CONSTRUCTION	88
9.7.1	Wall Framing and Connections	88
9.7.2	Wall Sheathing Requirements	88
9.7.3	Acceptable Types of Wall Sheathing	88
9.8	ENGINEERED TIMBER CONSTRUCTION	89
9.8.1	Framing Requirements	89
9.8.2	Requirements for All Shear Panels	89
9.8.3	Diagonally Sheathed Shear Panels	89
9.8.4	Plywood Shear Panels	90
9.8.5	Shear Panels Sheathed With Other Materials	91
9.8.6	Detailing Requirements	91

10	<u>STEEL</u>	95
10.1	REFERENCE DOCUMENTS	95
10.2	STRENGTH OF MEMBERS AND CONNECTIONS	95
10.2.1	Structural Steel	95
10.2.2	Cold Formed Steel	96
10.2.3	Steel Cables	96
10.3	SEISMIC PERFORMANCE CATEGORY A	97
10.4	SEISMIC PERFORMANCE CATEGORY B	97
10.4.1	Ordinary Moment Frames	97
10.4.2	Space Frames	97
10.5	SEISMIC PERFORMANCE CATEGORIES C AND D	97
10.5.1	Special Moment Frames	97
10.5.2	Braced Frames	97
10.6	SPECIAL MOMENT FRAME REQUIREMENTS	97
11	<u>REINFORCED CONCRETE</u>	101
11.1	REFERENCE DOCUMENTS	101
11.2	STRENGTH OF MEMBERS AND CONNECTIONS	101
11.3	SEISMIC PERFORMANCE CATEGORY A	101
11.4	SEISMIC PERFORMANCE CATEGORY B	102
11.4.1	Ordinary Moment Frames	102
11.5	SEISMIC PERFORMANCE CATEGORIES C AND D	102
11.5.1	Material Requirements	102
11.5.2	Framing Limitations	102
11.5.3	Frame Components Not Part of the Seismic Resisting System	102
11.5.4	Support for Discontinuous Components	102
11.6	REQUIREMENTS FOR ORDINARY MOMENT FRAMES ASSIGNED TO CATEGORY B	103
11.6.1	Flexural Members	103
11.6.2	Members Subjected to Bending and Axial Load	103
11.7	SPECIAL MOMENT FRAME REQUIREMENTS	104
11.7.1	Flexural Members	104
11.7.2	Members Subjected to Bending and Axial Load	105
11.7.3	Joints	107
11.8	SHEAR WALLS, BRACED FRAMES, AND DIAPHRAGMS	107
11.8.1	Shear Wall Details and Limitations	107
11.8.2	Diaphragm Details and Limitations	108
11.8.3	Openings in Shear Walls and Diaphragms	108
11.8.4	Boundary Members	108
11.8.5	Braced Frames	109
11.8.6	Splices and Anchorage	109
11.8.7	Construction Joints	109

12	<u>MASONRY</u>	111
	BACKGROUND	111
12.1	REFERENCE DOCUMENTS	111
12.2	STRENGTH OF MEMBERS AND CONNECTIONS	111
12.2.1	Special Design Procedures for Unreinforced Masonry Subjected to Seismic Forces	111
12.3	SEISMIC PERFORMANCE CATEGORY A	112
12.4	SEISMIC PERFORMANCE CATEGORY B	112
12.4.1	Construction Limitations	112
12.4.2	Material Limitations	113
12.5	SEISMIC PERFORMANCE CATEGORY C	113
12.5.1	Construction Limitations	113
12.5.2	Material Limitations	114
12.6	SEISMIC PERFORMANCE CATEGORY D	114
12.6.1	Construction Limitations	114
12.6.2	Material Limitations	115
12.6.3	Special Inspection	115
12.7	SHEAR WALL REQUIREMENTS	115
12.7.1	Reinforcement	115
12.7.2	Boundary Members	116
12.7.3	Compressive Stresses	116
12.7.4	Horizontal Components	116
12A	<u>MASONRY CONSTRUCTION</u>	117
12A.1	GENERAL	117
12A.1.1	Definitions	117
12A.1.2	Reference Documents	118
12A.1.3	Symbols	120
12A.1.4	Criteria for Masonry Units	121
12A.1.5	Initial Rate of Absorption	122
12A.1.6	Brick Masonry Unit Surfaces for Grouted Masonry	122
12A.1.7	Re-Use of Masonry Units	122
12A.1.8	Cast Stone	122
12A.1.9	Natural Stone	122
12A.1.10	Glass Building Units	122
12A.1.11	Glazed and Prefaced Units	122
12A.1.12	Water	122
12A.1.13	Shrinkage of Concrete Units	122
12A.1.14	Cement	123
12A.1.15	Lime	123
12A.1.16	Mortar	123
12A.1.17	Grout	124
12A.1.18	Reinforcement	125

12A.2	CONSTRUCTION	125
12A.2.1	Joints	125
12A.2.2	Bond Pattern	125
12A.2.3	Corbeling	126
12A.2.4	Reinforcement	127
12A.2.5	Temperature Limitations	127
12A.2.6	Anchorage	128
12A.2.7	Bolt Placement	128
12A.2.8	Penetrations and Embedments	128
12A.2.9	Support by Wood	128
12A.3	TYPES OF CONSTRUCTION	128
12A.3.1	Unburned Clay Masonry	128
12A.3.2	Stone Masonry	129
12A.3.3	Solid Masonry	129
12A.3.4	Cavity Wall Masonry	129
12A.3.5	Grouted Masonry	130
12A.3.6	Hollow Unit Masonry	132
12A.3.7	Partially Reinforced Masonry	133
12A.3.8	Glass Masonry	134
12A.4	DETAILED REQUIREMENTS	134
12A.4.1	Combination of Dissimilar Units or Construction	135
12A.4.2	Thickness of Walls	135
12A.4.3	Piers	135
12A.4.4	Chases and Recesses	136
12A.4.5	Holes, Pipes, and Conduits	136
12A.4.6	Arches and Lintels	136
12A.4.7	Anchorage	136
12A.4.8	End Support	136
12A.4.9	Distribution of Concentrated Loads	136
12A.5	STRENGTHS AND ALLOWABLE STRESSES	137
12A.5.1	Masonry	137
12A.5.2	Steel	137
12A.5.3	Bolts	138
12A.6	DESIGN REQUIREMENTS	138
12A.6.1	Design Procedure for Unreinforced Masonry	138
12A.6.2	Alternate Design Procedure for Unreinforced Brick Masonry	140
12A.6.3	Design Procedure for Reinforced Masonry	142
12A.6.4	Masonry Shear Walls	151
12A.6.5	Screen Walls	152
12A.7	SPECIFIC INSPECTIONS, SPECIAL INSPECTIONS, AND TESTS	153
12A.7.1	Specific Inspections and Tests	153
12A.7.2	Special Inspection and Tests	153
12A.7.3	Load Tests	155
12A.7.4	Reporting	155
12A.8	TEST CRITERIA	155
12A.8.1	Masonry Prisms	155
12A.8.2	Tests for Grout and Mortar	157
12A.8.3	Core Tests for Shear Bond	157

13	<u>SYSTEMATIC ABATEMENT OF SEISMIC HAZARDS IN EXISTING BUILDINGS</u>	167
	AMENDMENTS TO CHAPTER 1	167
	AMENDMENTS TO CHAPTER 2	167
13.1	GENERAL	168
13.1.1	Identification of Buildings Requiring Evaluation	168
13.2	EVALUATION OF SEISMIC HAZARDS IN EXISTING BUILDINGS	169
13.2.1	Qualitative Evaluation	169
13.2.2	Analytical Evaluation	169
13.3	HAZARD ABATEMENT MEASURES	170
13.3.1	General	170
13.3.2	Permissible Times to Complete Seismic Hazard Abatement Measures	171
14	<u>GUIDELINES FOR REPAIR AND STRENGTHENING OF EXISTING BUILDINGS</u>	173
14.1	GENERAL	173
14.1.1	Scope	173
14.1.2	Building Codes	173
14.1.3	Economic Considerations	173
14.1.4	Modes of Failure	174
14.1.5	Design of Modifications	174
14.1.6	Quality Assurance Requirements	175
14.1.7	Preservation of Design and Construction Documents	175
14.2	COLLECTION OF BASIC DESIGN INFORMATION	176
14.3	STRUCTURAL STEEL COMPONENTS	176
14.3.1	Pre-Modification Verification of Materials	176
14.3.2	Repair and Strengthening	180
14.4	REINFORCED CONCRETE	182
14.4.1	Pre-Modification Verification of Materials	182
14.4.2	Repair and Strengthening	182
14.4.3	Verification of Modification	187
14.5	PRECAST CONCRETE AND/OR PRESTRESSED CONCRETE STRUCTURES	188
14.5.1	Pre-Modification Verification of Materials	188
14.5.2	Repair and Strengthening	188
14.5.3	Verification of Modification	189
14.6	WOOD	189
14.6.1	Pre-Modification Verification of Materials	190
14.6.2	Repair and Strengthening	193
14.7	MASONRY	196
14.7.1	Nonbearing Masonry Walls	196
14.7.2	Pre-Modification Verification of Materials	198
14.7.3	Repair and Strengthening	200
14.7.4	Verification of Modification	201
14.8	FOUNDATIONS	201
14.8.1	Pre-Modification Verification	201
14.8.2	Repair and Strengthening	202

14.9	NONSTRUCTURAL COMPONENTS	203
14.9.1	Pre-Modification Verification	204
14.9.2	Repair and Strengthening of Nonstructural Components	204
	BIBLIOGRAPHY	214
15	<u>GUIDELINES FOR EMERGENCY POST-EARTHQUAKE INSPECTION AND EVALUATION</u> <u>OF EARTHQUAKE DAMAGE IN BUILDINGS</u>	223
15.1	INTRODUCTION	223
15.2	OBJECTIVE AND SCOPE	224
15.3	SELECTION OF INSPECTION PERSONNEL	227
15.3.1	Qualifications	227
15.3.2	Recruitment Sources	227
15.3.3	Enrollment of Personnel	228
15.3.4	Training	228
15.3.5	Equipment	230
15.3.6	Mobilization	232
15.4	PROCEDURES FOR INSPECTION	233
15.4.1	Establish Areas of Damage	233
15.4.2	Central Control Groups	233
15.4.3	Closing Off of Damaged Areas	234
15.4.4	Selection of Teams	234
15.4.5	Transportation of Crews	234
15.4.6	Communications With Inspection Teams	235
15.5	EVALUATION OF STRUCTURAL DAMAGE	235
15.5.1	Emergency Earthquake Damage Inspection Team	235
15.5.2	Photographs	236
15.5.3	Possibility of Adjacent Buildings Collapsing on Building Being Inspected	236
15.5.4	Rating of Buildings for Hazard and Continued Occupancy	236
15.5.5	Posting of Buildings	236
15.5.6	Ordinance	236
15.6	EVALUATION OF NONSTRUCTURAL DAMAGE	237
15.6.1	Emergency Earthquake Damage Inspection Form	237
15.6.2	Photographs	237
15.7	EVALUATION OF AUXILIARY SYSTEMS	237
15.7.1	Hospitals	237
15.7.2	Power Stations, Transformer Stations, Pumping Stations for Water and Sewage, Communication Facilities, etc.	238
15.7.3	Standby Facilities, Such as Schools with Auditoriums, Gymnasiums, or Cafeterias	238
15.7.4	Food Warehouses	238
15.7.5	Office Buildings	238
15.7.6	Manufacturing Plants	239
15.7.7	Apartment Buildings, Individual Residences	239
15.7.8	Elevators	239

15.8	ON-SITE SOIL AND FOUNDATION CONDITIONS	240
15.8.1	Sliding	240
15.8.2	Faulting	240
15.8.3	Soil Liquefaction	240
15.8.4	Compaction or Consolidation Due to Shaking Effects	240
15.8.5	Lateral Compression or Sliding	240
15.8.6	Lateral and Flexural Failures of Piling	241
15.9	TSUNAMI AND SEICHE EFFECTS	241
15.10	CONTROLS AS A RESULT OF INSPECTION	241
15.10.1	Reinspection	241
15.10.2	Records	242
15.10.3	Repairs	242
	REFERENCES	280
	SELECTED BIBLIOGRAPHY	281
C1	<u>ADMINISTRATION - COMMENTARY</u>	287
C1.1	PURPOSE	288
C1.2	SCOPE	288
C1.3	APPLICATION OF PROVISIONS	288
C1.3.1	New Buildings	288
C1.3.2	Existing Building Alterations and Repairs	288
C1.3.3	Change of Use	289
C1.3.4	Systematic Abatement of Seismic Hazards in Existing Buildings	289
C1.4	SEISMIC PERFORMANCE	289
C1.4.1	Seismicity Index and Design Ground Motions	289
C1.4.2	Seismic Hazard Exposure Groups	289
C1.4.3	Seismic Performance Categories	292
C1.4.4	Site Limitation for Seismic Design Performance Category D	292
C1.5	ALTERNATE MATERIALS AND METHODS OF CONSTRUCTION	292
C1.6	QUALITY ASSURANCE	292
C1.6.1	Quality Assurance Plan	293
C1.6.2	Special Inspection	294
C1.6.3	Special Testing	295
C1.6.4	Reporting and Compliance Procedures	295
C1.6.5	Approved Manufacturers Certification	295
C1.4.1	Seismicity Index and Design Ground Motions. Determination of A _a and A _v Coefficients and Definitions of Seismicity Index	296
	A. Introduction	296
	B. Policy Decision	296
	C. Design Earthquake Ground Motion	297
	D. Ground Motion Parameters	298
	E. Map for Effective Peak Acceleration	299
	F. Map of Effective Peak Velocity	300
	G. Risk Associated with EPA and EPV	302
	H. Design Elastic Response Spectra	303
	I. Lateral Design Force Coefficients	305
	J. County-by-County Maps	306
	K. Cost Implications	307
	L. Implied Risks	308
	M. Acceptable Risks	312
	REFERENCES	332

C3	<u>STRUCTURAL DESIGN REQUIREMENTS - COMMENTARY</u>	335
C3.1	DESIGN BASIS	335
C3.2	SITE EFFECTS	336
C3.3	FRAMING SYSTEMS	336
C3.3.1	Classification of Framing Systems	336
C3.3.2	Combinations of Framing Systems	338
C3.3.3- C3.3.5	Seismic Performance Categories A, B, C, and D	338
C3.4	BUILDING CONFIGURATION	339
C3.5	ANALYSIS PROCEDURES	340
C3.6	DESIGN AND DETAILING REQUIREMENTS	344
C3.6.1	Seismic Performance Category A	345
C3.6.2	Seismic Performance Category B	345
C3.6.3	Seismic Performance Category C	345
C3.6.4	Seismic Performance Category D	347
C3.7	STRUCTURAL COMPONENT LOAD EFFECTS	347
C3.7.1	Combination of Load Effects	347
C3.7.2	Orthogonal Effects	348
C3.7.3	Discontinuities in Strength of Vertical Resisting System	349
C3.7.4	Nonredundant Systems	349
C3.7.5	Ties and Continuity	350
C3.7.6	Concrete or Masonry Wall Anchorage	350
C3.7.7	Anchorage of Nonstructural Systems	350
C3.7.8	Collector Elements	350
C3.7.9	Diaphragms	351
C3.7.10	Bearing Walls	351
C3.7.11	Inverted Pendulum-Type Structures	351
C3.7.12	Vertical Seismic Motions for Buildings Assigned to Categories C and D	351
C3.8	DEFLECTION AND DRIFT LIMITS	352
C4	<u>EQUIVALENT LATERAL FORCE PROCEDURE - COMMENTARY</u>	361
C4.1	GENERAL	361
C4.2	SEISMIC BASE SHEAR	361
C4.3	VERTICAL DISTRIBUTION OF SEISMIC FORCES	363
C4.4	HORIZONTAL SHEAR DISTRIBUTION AND TORSION	364
C4.5	OVERTURNING	366
C4.6	DRIFT DETERMINATION AND P-DELTA EFFECTS	367
C5	<u>MODAL ANALYSIS PROCEDURE - COMMENTARY</u>	375
C5.1	GENERAL	375
C5.2	MODELING	375
C5.3	MODES	375
C5.4	PERIODS	376
C5.5	MODAL BASE SHEAR	376

C5.6	MODAL FORCES, DEFLECTIONS, AND DRIFTS	377
C5.7	MODAL STORY SHEARS AND MOMENTS	377
C5.8	DESIGN VALUES	378
C5.9	HORIZONTAL SHEAR DISTRIBUTION AND TORSION	378
C5.10	FOUNDATION OVERTURNING	378
C5.11	P-DELTA EFFECTS	378
	REFERENCES	379
C6	<u>SOIL-STRUCTURE INTERACTION - COMMENTARY</u>	381
C6.1	BACKGROUND AND SCOPE	381
C6.2	EQUIVALENT LATERAL FORCE PROCEDURE	384
C6.2.1	Base Shear	384
C6.2.2	Vertical Distribution of Seismic Forces	394
C6.2.3	Other Effects	394
C6.3	MODAL ANALYSIS PROCEDURE	395
	OTHER METHODS OF CONSIDERING THE EFFECTS OF SOIL-STRUCTURE INTERACTION	395
	CONCLUSION	396
	ACKNOWLEDGEMENTS	396
	REFERENCES	400
C7	<u>FOUNDATION DESIGN REQUIREMENTS - COMMENTARY</u>	403
C7.1	GENERAL	403
C7.2	STRENGTH OF COMPONENTS AND FOUNDATIONS	403
C7.2.1	Structural Materials	403
C7.2.2	Soil Capacities	403
C7.3	SEISMIC PERFORMANCE CATEGORY A	403
C7.4	SEISMIC PERFORMANCE CATEGORY B	403
C7.4.1	Investigation	403
C7.4.2	Pole-Type Structures	404
C7.4.3	Foundation Ties	404
C7.4.4	Special Pile Requirements	404
C7.5	SEISMIC PERFORMANCE CATEGORY C	405
C7.5.1	Investigation	405
C7.5.2	Foundation Ties	405
C7.5.3	Special Pile Requirements	405
C7.6	SEISMIC PERFORMANCE CATEGORY D	405
C8	<u>ARCHITECTURAL, MECHANICAL AND ELECTRICAL COMPONENTS - COMMENTARY</u>	409
C8.A	BACKGROUND TO ARCHITECTURAL CONSIDERATIONS	409
C8.B	BACKGROUND TO MECHANICAL AND ELECTRICAL CONSIDERATIONS	410
C8.C	DESIGN CONSIDERATIONS	411
C8.D	SCOPE	412

C8.1	GENERAL REQUIREMENTS	413
C8.1.1	Interrelationships of Components	413
C8.1.2	Connections and Attachments	414
C8.1.3	Performance Criteria	414
C8.2	ARCHITECTURAL DESIGN REQUIREMENTS	415
C8.2.1	General	415
C8.2.2	Forces	416
C8.2.3	Exterior Wall Panel Attachment	418
C8.2.4	Component Deformation	418
C8.2.5	Out-of-Plane Bending	419
C8.3	MECHANICAL AND ELECTRICAL DESIGN REQUIREMENTS	419
C8.3.1	General	419
C8.3.2	Forces	419
C8.3.5	Utility and Service Interfaces	423
	TABLES 8-B AND 8-C OCCUPANCY-COMPONENTS-PERFORMANCE RELATIONSHIPS . .	424
	CONCLUDING COMMENTS	425
	REFERENCES	436
C9	<u>WOOD - COMMENTARY</u>	437
C9.1	REFERENCE DOCUMENTS	437
C9.2	STRENGTH OF MEMBERS AND CONNECTIONS	437
C9.3	SEISMIC PERFORMANCE CATEGORY A	437
C9.4	SEISMIC PERFORMANCE CATEGORY B	438
C9.5	SEISMIC PERFORMANCE CATEGORY C	438
C9.6	SEISMIC PERFORMANCE CATEGORY D	438
C9.7	CONVENTIONAL LIGHT TIMBER CONSTRUCTION	438
C9.8	ENGINEERED TIMBER CONSTRUCTION	438
C10	<u>STEEL - COMMENTARY</u>	439
C10.1	REFERENCE DOCUMENTS	439
C10.2	STRENGTH OF MEMBERS AND CONNECTIONS	439
C10.2.1	Structural Steel	439
C10.2.2	Cold Formed Steel	441
C10.2.3	Steel Cables	441
C10.3	SEISMIC PERFORMANCE CATEGORY A	441
C10.4	SEISMIC PERFORMANCE CATEGORY B	441
C10.4.1	Ordinary Moment Frames	441
C10.4.2	Space Frames	441
C10.5	SEISMIC PERFORMANCE CATEGORIES C AND D	441
C10.5.1	Special Moment Frames	441
C10.5.2	Braced Frames	442
C10.6	SPECIAL MOMENT FRAME REQUIREMENTS	442
	REFERENCES	446

C11	<u>REINFORCED CONCRETE - COMMENTARY</u>	449
C11.2	STRENGTH OF MEMBERS AND CONNECTIONS	449
C11.3	SEISMIC PERFORMANCE CATEGORY A	450
C11.4	SEISMIC PERFORMANCE CATEGORY B	450
C11.5	SEISMIC PERFORMANCE CATEGORIES C AND D	450
C11.5.1	Material Requirements	450
C11.5.4	Support for Discontinuous Components	451
C11.6	REQUIREMENTS FOR ORDINARY MOMENT FRAMES ASSIGNED TO CATEGORY B	451
C11.6.1	Flexural Members	451
C11.6.2	Members Subjected to Bending and Axial Load	452
C11.7	SPECIAL MOMENT FRAME REQUIREMENTS	452
C11.7.1	Flexural Members	452
C11.7.2	Members Subjected to Bending and Axial Load	454
C11.7.3	Joints	455
C11.8	SHEAR WALLS, BRACED FRAMES, AND DIAPHRAGMS	455
C11.8.4	Boundary Members	455
C11.8.5	Braced Frames	456
C11.8.7	Construction Joints	456
	BIBLIOGRAPHY	458
C12	<u>MASONRY - COMMENTARY</u>	461
C12.1	GENERAL	461
C12.2	STRENGTH OF MEMBERS AND CONNECTIONS	461
C12.2.1	Special Design Procedures for Unreinforced Masonry Subjected to Seismic Forces	462
C12.3	SEISMIC PERFORMANCE CATEGORY A	462
C12.4	SEISMIC PERFORMANCE CATEGORY B	462
C12.5	SEISMIC PERFORMANCE CATEGORY C	463
C12.6	SEISMIC PERFORMANCE CATEGORY D	463
C12.7	SHEAR WALL REQUIREMENTS	463
C12A	<u>MASONRY CONSTRUCTION - COMMENTARY</u>	465
C12A.1	GENERAL	465
C12A.1.1	Definitions	466
C12A.1.4	Criteria for Masonry Units	466
C12A.1.11	Glazed and Prefaced Units	466
C12A.1.14	Cement	466
C12A.1.16	Mortar	466
C12A.1.17	Grout	467
C12A.2	CONSTRUCTION	467
C12A.2.1	Joints	467
C12A.2.2	Bond Pattern	467
C12A.2.3	Corbeling	468
C12A.2.4	Reinforcement	468
C12A.2.6	Anchorage	468
C12A.2.7	Bolt Placement	468
C12A.2.8	Penetrations and Embedments	469

C12A.3	TYPES OF CONSTRUCTION	469
C12A.3.4	Cavity Wall Masonry	469
C12A.3.5	Grouted Masonry	469
C12A.3.6	Hollow Unit Masonry	470
C12A.3.7	Partially Reinforced Masonry	471
C12A.4	DETAILED REQUIREMENTS	471
C12A.4.2	Thickness of Walls	471
C12A.4.9	Distribution of Concentrated Loads	472
C12A.5	STRENGTHS AND ALLOWABLE STRESSES	472
C12A.5.1	Masonry	472
C12A.5.2	Steel	472
C12A.5.3	Anchor Bolt	473
C12A.6	DESIGN REQUIREMENTS	473
C12A.6.1	Design Procedure for Unreinforced Masonry	473
C12A.6.2	Alternate Design Procedure for Unreinforced Masonry	473
C12A.6.3	Design Procedure for Reinforced Masonry	474
C12A.6.5	Masonry Shear Walls	475
C12A.6.7	Screen Walls	475
C12A.7	SPECIFIC AND SPECIAL INSPECTIONS AND TESTS	476
C12A.8	TEST CRITERIA	476
C12A.8.1	Masonry Prisms	476
C12A.8.2	Tests for Grout and Mortar	477
C12A.8.3	Core Tests for Shear Bond	477
C13	<u>SYSTEMATIC ABATEMENT OF SEISMIC HAZARDS IN BUILDINGS - COMMENTARY</u>	479
C13.1	GENERAL	479
C13.1.1	Identification of Buildings Requiring Evaluation	479
C13.2.1	Qualitative Evaluation	482
C13.2.2	Analytical Evaluation	483
C13.3	HAZARD ABATEMENT MEASURES	487
C13.3.2	Permissible Time to Complete Hazard Abatement Measures	488
	REFERENCES	498
	BIBLIOGRAPHY	498
	APPENDIX A	501
	APPENDIX B	507