

ATC-20-2

Addendum to the ATC-20 Postearthquake Building Safety Evaluation Procedures

by

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

Prepared for:

NATIONAL SCIENCE FOUNDATION
S.C. Liu and Henry Lagorio, Project Officers
Grant No. BCS 9003890

Funded by:

U.S. GEOLOGICAL SURVEY

PRINCIPAL INVESTIGATOR
Robert Bruce

TECHNICAL CONSULTANTS
Patricia Bolton
James E. Russell
James L. Stratta (deceased)
Patricia Weis-Taylor

REPORT PREPARATION
SERVICES
Peter Mork
Nancy Sauer
Rodney Sauer

PROJECT ENGINEERING PANEL
David R. Bonneville
David J. Hammond
Fred Herman
William H. King
Larry L. Litchfield
David L. Messinger
Sherry D. Oaks
Richard A. Ranous
Arthur E. Ross *
Richard Eisner **
M. Neal Hardman **

* ATC Board Representative

** Ex-officio

Preface

Approximately one month prior to the damaging 1989 Loma Prieta, California, earthquake the Applied Technology Council (AT.C) published the ATC-20 report, *Procedures for Postearthquake Safety Evaluation of Buildings*, and the companion ATC-20-1 report, *Field Manual: Procedures for Postearthquake Safety Evaluation of Buildings*. The ATC-20 documents were widely used in the Loma Prieta earthquake recovery efforts, providing an opportunity to evaluate their effectiveness.

In response to this opportunity, the National Science Foundation (NSF) awarded a grant to ATC in 1990 to review the implementation of the ATC-20 procedures and to develop an addendum that would provide revisions to the original ATC-20 procedures, as well as any needed supplementary information. This ATC-20-2 document is the result of that effort. During the preparation of the document, further earthquakes occurred in California, including the damaging Northridge earthquake of January 1994. The recovery experience following these earthquakes further added to the present document's knowledge base.

ATC Technical Director Robert Bruce served as Principal Investigator and Project Director. He was assisted in the preparation of the document by several subcontractors who provided material for various chapters: James Russell (Chapter 3, Appendix A), Patricia Weis-Taylor (Chapter 5), James Stratta (Chapters 3, 4, and 6) and Patricia Bolton (Chapter 7). The Project Engineering Panel (PEP) provided overall project guidance. PEP members were David

Bonneville, Richard Eisner (ex-officio), David Hammond, Neil Hardman (ex-officio), Fred Herman, William King, Larry Litchfield, David Messinger, Sherry Oaks, Richard Ranous, and Arthur Ross (ATC Board Representative). Patty Christofferson, Peter Mork, Nancy Sauer, and Rodney Sauer provided publication and editorial assistance. The affiliations and addresses of these individuals are provided in the list of Project Participants.

ATC acknowledges the other individuals who provided valuable assistance during the preparation of this report: Susan Dowty of the International Conference of Building Officials coordinated related documents; William King of the City of Los Angeles and Barbara White of Sacramento County arranged interviews with Loma Prieta earthquake mutual aid safety evaluation inspectors from their jurisdictions; and Tom Wangerin of the University of California at Berkeley Program in Environmental Hazard Management and Paul Deis of the California Specialized Training Institute reviewed Chapter 5.

ATC also gratefully acknowledges the valuable support and patience of the NSF Project Officers S. C. Liu and Henry Lagorio. We wish to thank the many sponsors of seminars at which the ATC-20 methodology was presented. Participants at these seminars provided valuable feedback throughout the project.

Christopher Rojahn
ATC Executive Director

Table of Contents

Preface	iii
Illustration Credits	xi
1. Introduction	1
1.1 Project Technical Approach	1
1.2 Document Content Overview	2
1.2.1 ATC-20 Topics Modified or Expanded in ATC-20-2	2
1.2.2 Topics New to ATC-20-2	4
2. Posting Placards and Evaluation Forms	7
2.1 Background to Revisions to Posting Placards and Evaluation Forms	7
2.2 Placard Revisions	9
2.2.1 INSPECTED Placard	9
2.2.2 RESTRICTED USE Placard	9
2.2.3 UNSAFE Placard	13
2.3 Assessment Form Revisions	13
3. Safety Assessment Management	19
3.1 Records Management	19
3.1.1 Use of Computers for Data Collection and Reports	19
3.1.2 Data Records Maintenance, Retention and Access	20
3.1.3 Other Record Keeping and Information Demands	20
3.2 Reconnaissance Survey Procedures	21
3.2.1 Survey Planning	22
3.2.2 Survey Conduct	22
3.2.3 Survey Assessment Procedures	23
3.2.4 Survey Debriefing	25
3.3 Removal Of Goods From Buildings With Safety Risks	25
3.4 Demolition Considerations	27
4. Technological Considerations for Safety Evaluation	29
4.1 Wood Frame Construction	30
4.2 Unreinforced Masonry Construction	31
4.3 Reinforced Masonry Construction	33
4.4 Steel Construction	33
4.4.1 Relationship between Architectural Finish Damage and Structural Damage	34
4.4.2 Structural Damage Due to Story Drift Deformation	34
4.4.3 Steel Light Frame Buildings	35
4.4.4 Steel Frame Buildings with Concrete Structural Walls	35
4.5 Concrete Construction	35
4.5.1 Concrete Shear Wall Buildings	36
4.5.2 Ductile Concrete Frame Buildings	37
4.5.3 Nonductile Concrete Frame Buildings	37
5.1 Common Hazardous Materials	40
5.1.1 Hazardous Materials in Residential Buildings	40

5.1.2 Hazardous Materials in Commercial or Industrial Buildings	40
5.2 Reported Hazardous Materials Problems in the 1989 Loma Prieta Earthquake in California	41
5.3 Hazardous Materials Placarding and Labeling Systems	41
5.3.1 National Fire Protection Association System	41
5.3.2 Department of Transportation System	42
5.3.3 National Paint and Coatings Association System	42
5.3.4 Pesticide Labeling	42
5.3.5 Summary	44
5.4 Asbestos Hazards	44
5.4.1 Health Effects of Asbestos	44
5.4.2 Types of Asbestos Products	46
5.4.3 Inspecting Buildings That May Contain ACMs	46
5.4.4 Evaluation Procedures	50
6. Loss-Value Estimation	51
6.1 Loss Value Estimation Procedures	51
6.1.1 Replacement Cost Estimation	52
6.1.2 Repair Cost Estimation	52
6.2 General Considerations for Repair Cost Estimation	52
6.2.1 Story Drift Deformation Damage	52
6.2.2 Shaking Damage	53
6.2.3 Foundation or Soil Failure	53
6.3 Repair Cost Considerations for Predominant Structural Materials	53
6.3.1 Wood Frame Construction	53
6.3.2 Steel Construction	54
6.3.3 Concrete Buildings	55
6.3.4 Masonry Construction	57
7. Human Behavior Following Earthquakes	61
7.1 Human Behavior After Disaster	61
7.2 Dealing with Occupants and Owners of Damaged Property	62
7.3 Coping with Stress in the Field	63
7.4 Providing Support to Inspectors in the Field	64
Appendix A: Guidance for Owners and Occupants of Damaged Buildings	67
A.1 Understanding Safety Assessment Procedures and Postings	67
A.2 Steps to Take to Ensure Damage Is Properly Repaired	69
A.3 Guidelines for Securing Disaster Assistance	70
Appendix B: Placards and Forms for Safety Evaluations	73
References	81
Project Participants	83
Applied Technology Council Projects and Report Information	85