

# Index

## A

Accelerographs, 64  
Active control systems, 83-84  
Active mass damping, 83  
Active tendons, 83  
Advocates, role of, 116  
Air Force Office of Scientific Research, 133  
Alaska, 42-43  
Alquist-Priolo Act, 104  
Amplification effects, 63-65  
Applied research, 19  
Architectural research, 136  
Armenia, 6-7, 72  
Australia, earthquake program, 144-146  
Australian Geological Survey Organization, 145  
Avalanches, 40

## B

Base isolation, 80, 82-83  
Basic research, 19  
Basin effects, 64, 66  
Blind thrust faults, 44  
Borehole volumetric strainmeters, 55  
Bridges, 86-88  
Building Act of 1991, 152, 153  
Building codes  
  China, 148-149  
  Japan, 150-151  
  United States, 78-79, 103-109  
Building damage  
  accomplishments of federally sponsored research, 90  
  existing buildings, 84-86  
  future research needs, 90-93  
  new construction, 22, 75-84  
  types of damage, 8, 74-75  
Building Officials and Code Administrators code, 78, 108  
Building rehabilitation, 112  
Building Research Association, 153  
Building Seismic Safety Council, 78

## C

California. *See also specific locations by name*  
  earthquake hazards, 43-46  
  earthquake prediction, 62  
  land-use planning, 104  
  San Andreas fault, 2, 39-40, 43-45  
  seismic retrofit in Los Angeles, 112-114  
  voluntary retrofit in Palo Alto, 115  
California Division of Mines and Geology, 81-82, 130  
California Institute of Technology, 81  
Caltech. *See* California Institute of Technology  
Caltech-USGS Broadcast of Earthquakes system, 81  
Canada, earthquake program, 146-147  
Casualties, 72-74  
CDMG. *See* California Division of Mines and Geology  
Center for Earthquake Research in Australia, 145  
Central United States, earthquakes, 48-49  
Central United States Earthquake Consortium, 140  
CERA. *See* Center for Earthquake Research in Australia  
China  
  earthquake prediction, 62  
  earthquake program, 147-149  
Chinese Ten-Year Committee, 147  
Cocos Plate, 151  
Code adoption process, 108  
Code enforcement, 108-109  
Collapse, 74  
CONCERT. *See* Coordinating Organization for Northern California Earthquake Research and Technology  
Concrete frame buildings, 76  
Construction costs, 79  
Contents damage, 74-75  
Cookbook codes, 107  
Coordinating Organization for Northern California Earthquake Research and Technology, 130  
County Geologist Program, 105  
Creepmeters, 55

Cripple walls, 76  
 Cross-agency coordination, 26-27  
 CUBE. *See* Caltech-USGS Broadcast of Earthquakes system  
 CUSEC. *See* Central United States Earthquake Consortium

## D

Data Management System, 133  
 Database, 27  
 Deaths, 6-7, 72-73  
 Demolition, 109-110  
 Disaster Prevention Radio Communications Network, 151  
 Distributional impacts, 9

## E

Early warning systems, 81-82  
 Earth Science Division, 132  
 Earth science research  
     changes needed, 20-21  
     forecasting, 58-59  
     foretelling earthquake effects, 61, 63-67  
     fundamental seismological research, 56  
     key findings, 67-69  
     objectives, 51, 53  
     paleoseismology, 56, 58  
     prediction, 58-63  
     programs, 132-133  
     reducing economic losses, 120-121  
     reducing loss of life, 119-120  
     regional tectonic studies, 53-56  
 Earthquake Assessment Committee, 149  
 Earthquake Commission, 152-153  
 Earthquake engineering, 135-136  
 Earthquake Hazard Mitigation Program, 132  
 Earthquake Hazards Reduction Act, 125-126  
 Earthquake Lifelines Project, 139  
 Earthquake notification systems, 81-82  
 Earthquake prediction, 58-63, 125-126, 147-150  
 Earthquake risk, 41-42  
 Earthquake systems integration, 136  
 Earthquakes. *See also specific locations by name*  
     California, 43-46  
     casualties, 72-74  
     Central United States, 48-49  
     congressional interest in, 9-10  
     Eastern United States, 49-51  
     effects at the earth's surface, 36-41  
     effects of, 2, 4-9  
     factors limiting assessment, 51  
     forecasting, 58-59  
     geologic setting for, 36

Intermountain Seismic Belt, 46-48  
     key findings, 67-69  
     loss estimation, 4-5  
     major U.S. earthquakes, 3, 73  
     major worldwide earthquakes, 72, 144  
     methods of evaluating severity, 34  
     mitigation, 10-12  
     non-NEHRP agencies activities, 141-142  
     occurrence of, 1-2  
     Pacific Northwest, 42-43  
     seismicity of the U.S., 35  
     summary of U.S. hazards, 52  
 Eastern United States, earthquakes, 49-51  
 Economic losses, 8-9, 120-121  
 Education, 122  
 Elastomeric bearings, 80  
 Electricity systems, 89  
 Emergency Management Australia, 145  
 Engineering research  
     changes needed, 21-23  
     implementation, 121  
     Japan, 150-151  
 EQC. *See* Earthquake Commission  
 EWSs. *See* Early warning systems  
 Executive Order 12148, 126  
 Executive Order 12699, 12  
 Executive Order 12941, 12-13

## F

Faulting, 34  
 Federal Agency Earthquake Activities homepage on the Internet, 27  
 Federal buildings, 12-13  
 Federal disaster assistance, 27-29  
 Federal Emergency Management Agency  
     activities, 138-140  
     budget components, 15, 138  
     history, 137  
     lead agency designation, 126  
     policy focus, 12  
     program coordination, 25-27  
 Federal government. *See also specific agencies by name*  
     accomplishments of sponsored research, 90  
     agencies, 141-142  
     role of, 20  
 Federal response planning, 140. *See also* Federal Emergency Management Agency  
 FEMA. *See* Federal Emergency Management Agency  
 Financial incentives, 31  
 Forecasting, 58-59  
 Foreshocks, 62  
 Fracturing, 34

**G**

GAO. *See* General Accounting Office  
 General Accounting Office, 137  
 Geodetic studies, 54-56  
 Geodimeters, 55  
 Geographical Information System, 65  
 Geological Survey of Canada, 146  
 Geotechnical engineering research, 136  
 GIS. *See* Geographical Information System  
 Global Geodetic Network, 155  
 Global Positioning System, 54, 134  
 Global Seismographic Network, 133, 155  
 GPS. *See* Global Positioning System  
 Ground failure, 40, 41, 65  
 Ground rupture, 40  
 Ground shaking, 2, 6, 37-38, 60  
 Groundwater table, 62  
 GSC. *See* Geological Survey of Canada  
 GSN. *See* Global Seismographic Network

**H**

Hazard insurance, 27-29  
 Hazard zones, 105  
 Hot spots, 63

**I**

IDNDR. *See* International Decade for Natural Disaster Reduction  
 IGNS. *See* Institute of Geological and Nuclear Sciences  
 Implementation of seismic mitigation efforts  
   approaches to, 97-98, 104-105, 111-115  
   assessing risk, 99-100  
   assessing vulnerability, 100-102  
   direct measures for improvement, 122-124  
   earth science research measures, 119-121  
   engineering research measures, 121  
   factors affecting, 111, 114-119  
   modifying the built environment, 102-111  
   overview, 95-96  
   seismic hazard maps, 98-99  
   steps for application of seismic codes, 117  
   voluntary nature of, 96-97  
 In-fault measurements, 55  
 Incentives, 31, 124  
 Incorporated Research Institutions for Seismology, 133  
 Indirect losses, 8-9  
 Information-only approach, 19-20  
 Injuries, 7-8, 73-74  
 Institute of Geological and Nuclear Sciences, 152  
 Insurance, 27-29  
 Intensity, 34, 36  
 Intermountain Seismic Belt, earthquakes, 46-48

International Committee Conference of Building Officials, 108  
 International Decade for Natural Disaster Reduction, 147, 154  
 International earthquake programs, 143-155  
 Internet, 27, 131  
 Intraplate earthquakes, 2, 40  
 IRIS. *See* Incorporated Research Institutions for Seismology

**J**

Japan  
   earthquake prediction, 62  
   earthquake program, 149-151  
   geodetic techniques, 54  
   U.S.-Japan Panel on Wind and Seismic Effects, 154-155  
 Japan International Cooperation Agency, 151  
 Japan Meteorological Agency, 149  
 JMA. *See* Japan Meteorological Agency

**L**

Land-use planning, 102-105  
 Landslides, 40  
 Large-Scale Earthquake Countermeasures Act, 149  
 Laser interferometry, 55  
 Lead agency, 26, 126  
 Life safety, 119-120, 121  
 Lifelines damage, 8, 23, 86-90, 92-93  
 Liquefaction, 40, 65  
 Loma Prieta earthquake, 7, 9, 74, 86-87  
 Los Angeles Seismic Ordinance, 112-114  
 Loss estimation, 4-5

**M**

Magnitude, 34  
 Mass damping, 83  
 Mechanical systems research, 136  
 Mercalli Intensity scale, 34, 37  
 Mexico, earthquake program, 151-152  
 Mexico city earthquake, 41  
 Microzonation, 68-69  
 Minimum Design Loads for Buildings and Other Structures, ASCE-7-93, 108  
 Mississippi River, 48  
 Mitigation, 10-12, 23-24  
 Mitigation advocates, 116  
 MMI. *See* Modified Mercalli Intensity scale  
 Model codes, 108  
 Modified Mercalli Intensity scale, 34, 37  
 Moment magnitude scale, 34, 36  
 Moral hazards issue, 29

Multi-hazard assessment, 140  
 Multiagency coordination, 26-27

**N**

National Building Code of Canada, 146  
 National Center for Earthquake Engineering Research, 14, 135-136  
 National Earthquake Hazards Reduction Program.  
*See also* NEHRP Provisions  
     allocating funding, 24-25, 130  
     budget, 128  
     challenges, 18-20  
     contributions of program, 16-17  
     contributions to earthquake engineering, 90  
     description, 13-16  
     federal disaster assistance, 27-29  
     financial incentives, 31  
     implementation gap, 17-18  
     insurance, 27-29  
     policy focus, 12-13  
     policy options, 20  
     portfolio changes, 20-25  
     reauthorization history, 126-128  
     regulation, 30-31  
     role of, 118-119  
     structural and operational changes, 25-27  
 National Earthquake Information Center, 131, 132  
 National Institute of Standards and Technology  
     accomplishments, 90  
     activities, 141  
     authorization of, 126  
     description, 15-16  
     funding history, 140  
     international cooperation and coordination, 155  
     policy focus, 12  
 National Mitigation Strategy, 26  
 National Oceanic and Atmospheric Administration, 66  
 National Research Council, 81  
 National Research Institute for the Earth Sciences and Disaster Prevention, 150  
 National Science Foundation  
     description, 14  
     earth science research, 132-135  
     earthquake engineering, 135-136  
     funding appropriations, 126  
     international cooperation and coordination, 154  
     policy focus, 12  
 National Seismograph Network, 58  
 National Society for Earthquake Engineering, 153  
 Natural Disaster Fund, 152  
 Natural gas systems, 89-90  
 Natural Hazards Research and Applications Information Center, 140

NCEER. *See* National Center for Earthquake Engineering Research  
 NEHRP. *See* National Earthquake Hazards Reduction Program  
 NEHRP Provisions, 78, 108, 138-140  
 NEIC. *See* National Earthquake Information Center  
 New Madrid earthquakes, 48-49  
 New Madrid seismic zone, 49  
 New Zealand, earthquake program, 152-153  
 Newmark-Stever report, 125  
 NIST. *See* National Institute of Standards and Technology  
 Nonstructural building components, 106-107  
 Nonstructural damage, 74  
 North American Plate, 39  
 Northeastern States Earthquake Consortium, 140  
 Northridge earthquake, 9  
 NSF. *See* National Science Foundation  
 NSN. *See* National Seismograph Network  
 Nuclear Regulatory Commission, 58  
 Nucleation phase, 61

**O**

Open Partial Agreement on Major Hazards of the Council of Europe, 155  
 Oregon, 42-43  
 Outages, 86

**P**

Pacific Northwest, earthquakes, 42-43  
 Pacific Plate, 39  
 Paleoseismology, 56, 58  
 Parkfield (CA) prediction experiment, 62  
 PASSCAL. *See* Program for Array Seismic Studies of the Continental Lithosphere  
 Plate tectonic theory, 118  
 Post Earthquake Evaluation Program, 155  
 Post-earthquake investigation program, 132  
 Precast concrete, 76  
 Precursors, identifying, 62  
 Prediction, 58-63, 125-126, 147-150  
 Private preparations, 110-111  
 Probabilistic forecasting, 59  
 Program coordination, 25-26  
 Program for Array Seismic Studies of the Continental Lithosphere, 133  
 Prudent Business Practices program, 139  
 Public outreach, 122, 124

**R**

Rapid Array Mobilization Program, 133  
 Rapid Earthquake Data Integration system, 81  
 R&D. *See* Research and development  
 Reauthorizations, 126-128

Recommended Lateral Force Requirements and Tentative Commentary, Blue Book, 108  
 Recurrence interval, 58  
 REDI. *See* Rapid Earthquake Data Integration system  
 Reelfoot Rift, 48-49  
 Regional tectonic studies, 53-56  
 Regulation, 30-31  
 Reinforced masonry, 76  
 Remote sensing, 55  
 Research and development, 19, 33  
 Research grants, 132-133  
 Resource Management Act of 1991, 152, 153  
 Retrofitted bridges, 87-88  
 Retrofitting, 22, 84-86, 109-110, 112-115  
 Richter magnitude scale, 34, 36  
 Ridge effects, 64  
 Robert T. Stafford Disaster Relief and Emergency Assistance Act, 12  
 Russia, earthquake program, 153-154

## S

Salt Lake County Natural Hazards Ordinance, 105  
 San Andreas fault, 2, 39-40, 43-45  
 SCEC. *See* Southern California Earthquake Center  
 Sedimentary basins, 64, 66  
 Seiches, 65-67  
 Seismic Belt, earthquakes, 46-48  
 Seismic codes. *See* Building codes  
 Seismic Hazard Committee, 115  
 Seismic hazard maps, 68, 98-99  
 Seismic hazards, 41-51  
 Seismic monitoring, 57-58  
 Seismic-resistant features, 79  
 Seismic retrofit action, 112-114  
 Seismic waves, 34, 37  
 Seismic zones, 59, 148-149  
 Seismological research, 56  
 Seismology, 118  
 Seismometers, 56, 57  
 Setbacks of buildings from faults, 104  
 Sewer systems, 88-89  
 Shear walls, 76  
 Sister cities, exchange of ideas and expertise between, 130-131  
 Small-scale preparations, 110-111  
 Social science research, 122, 124  
 Societal losses, 9, 71  
 Soft stories, 75-76  
 Southern Building Code Congress International, 78, 108  
 Southern California Earthquake Center, 130, 134-135  
 Special Study Zones, 104

State and Local Hazards Reduction Program, 139-140  
 State Engineering Codes, 153  
 Steel-frame buildings, 77  
 Steel-weld problem, 77  
 Strainmeters, 55  
 Strike-slip plate boundaries, 39-40  
 Strong motion recording, 64  
 Structural components, 106  
 Structural damage, 74  
 Structural failure, 74  
 Structural research, 136  
 Study Zones, 104  
 Subduction zones, 39  
 Supplemental appropriations bills, 9, 28  
 Surface faulting, 40  
 Synthetic aperture radar imagery, 55  
 Systems preparations, 110-111

## T

Technical assistance, 122  
 Tectonic plates, 2, 36, 38  
 Tectonic studies, 53-56  
 Tendon systems, 83  
 Thrust faults, 39  
 Tsunamis, 6, 65-67  
 Two-stage design process, 150

## U

UBC. *See* Uniform Building Code  
 UNAVCO. *See* University Navstar Consortium  
 Unengineered structures, 107  
 Uniform Building Code, 78, 108  
 United Nations Educational, Scientific and Cultural Organization, 155  
 United Nations International Decade for Natural Disaster Reduction, 147, 154  
 United States. *See* Eastern United States; Western United States; *specific states and cities by name*  
 United States-Japan Panel on Wind and Seismic Effects, 154-155  
 University Navstar Consortium, 135  
 Unreinforced masonry, 76, 85  
 URM. *See* Unreinforced masonry  
 U.S. Geological Survey  
   description, 13-14  
   earthquake notification systems, 81  
   earthquake-related R&D, 33  
   funding appropriations, 126  
   future direction of, 131  
   geographic focus, 130  
   goals, 129-130

## 162 | Reducing Earthquake Losses

- international cooperation and coordination, 154
- policy focus, 12
- post-earthquake investigation program, 132
- seismic hazard maps, 98-99
- spending under NEHRP, 131
- technology transfer, 130-131
- USGS. *See* U.S. Geological Survey
- Utah, land-use planning, 105

### V

- Very Long Baseline Interferometry, 54
- Visiting scholars, 27
- VLBI. *See* Very Long Baseline Interferometry

### W

- Wasatch fault zone, 47
- Washington, 42-43
- Water and sewer systems, 88-89
- Water waves, 40. *See also* Tsunamis
- Western States Seismic Policy Council, 140
- Western United States, 50
- Whining, 18-19
- Wood frame buildings, 76

### Z

- Zoning, 102-105