Loss-Reduction Provisions of A Federal Earthquake Insurance Program

Summary

Issued in Furtherance of the Decade
for Natural Disaster Reduction

LOSS-REDUCTION PROVISIONS OF A FEDERAL EARTHQUAKE INSURANCE PROGRAM

FINAL REPORT SUMMARY

Prepared for

The Federal Emergency Management Agency (FEMA)

Under
Contract No. EMW-88-C-2872

by

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EXECUTIVE SUMMARY

In anticipation of current proposed legislation concerning federal earthquake insurance or reinsurance, this report on the loss-reduction component of federal earthquake insurance programs was prepared by Dames & Moore under contract to the Federal Emergency Management Agency (FEMA) (No. EMW-88-C-2872). Significant assistance on this project was provided by the University of Southern California, University of Pennsylvania, George Washington University, Milliman & Robertson, Inc., and Risk Engineering, Inc.

Procedures utilized to conduct the study include a thorough examination of existing information on available earthquake hazard reduction activities and techniques, three meetings of a nationally recognized advisory panel, and a project workshop. The project workshop involved experts and representatives of many diverse agencies, organizations, and interests from throughout the country in order to construct acceptable findings. A nationally recognized Advisory Panel provided critical review of project progress and findings.

Major project findings include the following:

(1) There are cost-effective, technically credible earthquake loss-reduction measures (LRMs), chiefly in landuse and building practice, that are acceptable for inclusion in a federal earthquake insurance or reinsurance program. Table 1 summarizes those acceptable LRMs identified in this project. Figure 1 provides a small-scale seismic zonation map that suggests where the LRMs in Table 1 can be applied to zones of seismic hazard (numbered 0 through 4) throughout the United States.

(2) Current earthquake risk analysis techniques -- in spite of their uncertainties -- are acceptable for the evaluation of LRMs and the determination of both primary earthquake insurance rates and secondary earthquake insurance prices.

(3) Two primary vehicles exist for the effective inclusion of the fifteen LRMs into a federal earthquake insurance or reinsurance program. These are
   - o earthquake ordinances for state and local government adoption and enforcement and
   - o a system of partially risk-based insurance rates that provide financial incentives for the adoption and enforcement of earthquake ordinances.

(4) An enhanced federal program of earthquake loss-reduction can be justified by the resulting reduction of existing contingent federal liabilities, especially with respect to public and private non-profit facilities in higher risk seismic zones (2 and especially 3 and 4).

Based on project findings, we make the following recommendations:

(1) The fifteen LRMs listed in Table 1 should be incorporated into a federal earthquake insurance or reinsurance program.

(2) Small-scale maps for implementation of these LRMs throughout the nation should be developed by the insurance administrator, primarily on a scientific basis. Figure 1 could be used in the interim.

(3) FEMA should initiate an enhanced federal program designed to provide cost-effective LRMs and technical assistance and training to state and local governments. FEMA should seek the necessary resources to undertake this enhanced program.

(4) Activities identified in this report should be initiated or continued to facilitate or support the fifteen recommended LRMs.

(5) Earthquake risk methods for evaluation of LRMs and for primary earthquake insurance rating and secondary earthquake insurance pricing should be probabilistic -- i.e., evaluate all potentially damaging earthquakes. For developing equitable financial incentives for the recommended LRMs and for avoiding other administrative pitfalls, earthquake insurance rating maps should be similar to maps for LRM application, and both should be risk-based.

(6) In a primary federal earthquake insurance program, the earthquake insurance administrator should employ a combination of risk-based rates and earthquake ordinances in order to implement the recommended LRMs.

(7) In a secondary federal earthquake insurance program, possible ways of inducing LRMs include use of secondary pricing that reflects risks, agreements with state insurance regulators that risks be reflected in rates, and/or leverage from a combined primary and secondary program that requires earthquake ordinances.

(8) Continuous program monitoring, review, and improvement are essential features of any federal program initiated.

(9) Evaluation of the many issues -- in addition to loss-reduction -- related to the feasibility of a federal earthquake insurance program should be undertaken.

Table 1
Loss-Reduction Measures Recommended for
a National Earthquake Insurance Program

Landuse LRMs (Applicable only in seismic zones 3 and 4)

New Development

LRM 1 Require in high liquefaction susceptible zones that geotechnical techniques be used to minimize potential ground failures for

- o new commercial, public, and residential subdivision development and
- o major modifications of commercial, public and residential subdivision development. (Exceptions of scattered construction of single-family dwellings may be considered in legal and administrative versions of this loss-reduction measure.)

LRM 2 Use zoning ordinances, subdivision ordinances, and other techniques to control new development in active fault zones, high site-amplification, landslide and liquefaction susceptible zones.

Existing Development

LRM 3 Permit reconstruction or replacement of existing development in areas identified as active fault zones, high landslide, or liquefaction susceptible zones experiencing damage of more than 50% of replacement value only if the identified risk is reduced to an acceptable level. Consider purchase of existing damaged properties in high landslide susceptible zones unless suitable measures are used to protect existing development from damage.

LRM 4 Proscribe additions to buildings in areas identified as active fault zones, high landslide or liquefaction susceptible zones unless the risks are reduced to an acceptable level, except additions to single-family dwellings up to 50% of the replacement cost, which can be made without such risk reduction.

Building Practice LRMs

New Construction

LRM 5 Eastern model codes shall be encouraged to incorporate (adopt by transcription) the latest version of the NEHRP seismic provisions. All model codes should incorporate a geotechnical component that considers local site amplification effects on strong ground motion and minimization of potential ground failure effects.

LRM 6 Building regulatory authorities should adopt and enforce model codes that have adequate seismic provisions for buildings including one- and two-family dwellings and anchorage of mobile homes. The building code should apply also to repairs of earthquake-damaged buildings to assure that losses are not repeated in subsequent earthquakes.

Table 1 (Continuation)

New Construction (Continued)

LRM 7 In seismic zones 2, 3, and 4, new essential buildings and public schools, including colleges and universities, should be designed in conformance with current model code seismic provisions.

LRM 8 In seismic zones currently designated 2 with high seismic catastrophic loss potential (designated 2*) model codes should require the detailing requirements applied to zones of high seismicity.

LRM 9 For new construction in seismic zones 3 and 4, a building "hazard rating" must be disclosed to potential buyers well before the close of escrow.

Existing Construction

LRM 10 In seismic zone 4, local jurisdictions should institute ordinances with requirements for seismic retrofit of unreinforced masonry (URM) bearing wall buildings. These buildings should be required to be upgraded to a minimum level or else demolished within a 20-year period.

LRM 11 In seismic zone 4, local jurisdictions should institute ordinances for the securing/strengthening of building parapets and external ornamentation within a 20-year period.

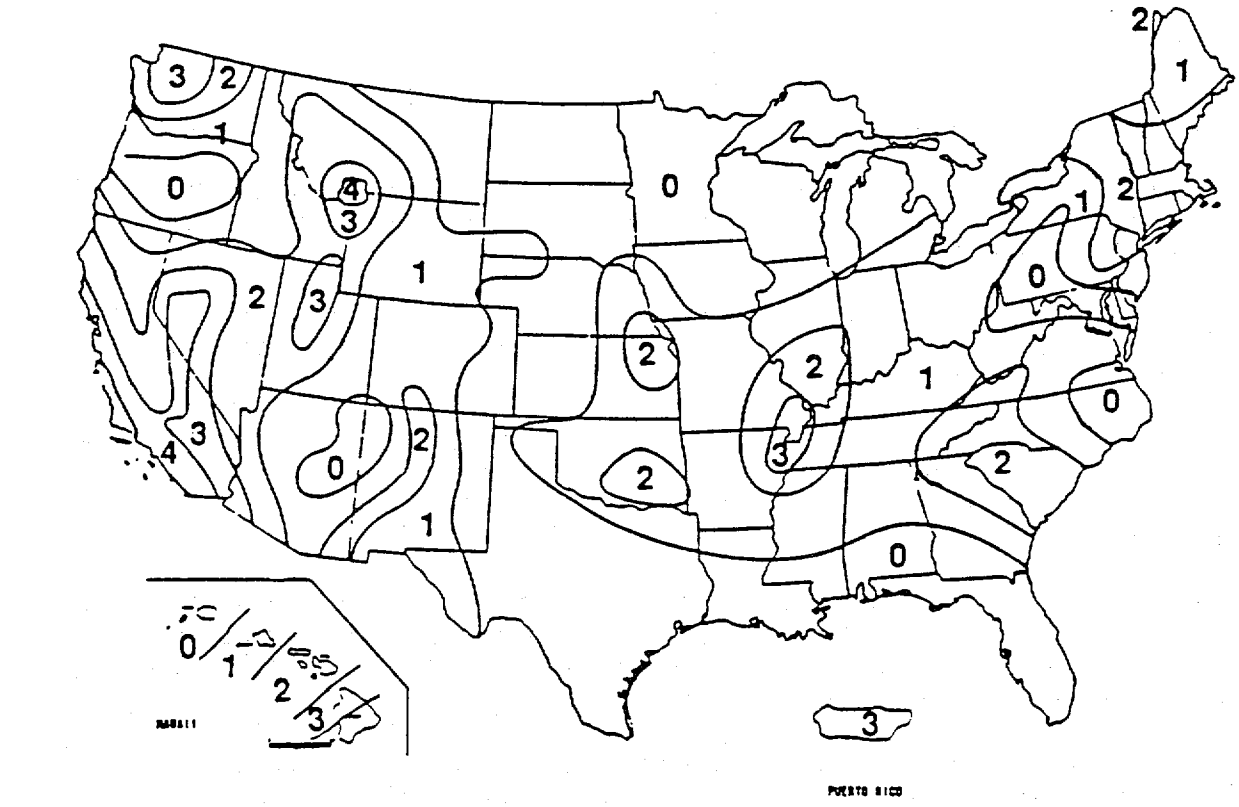
LRM 12 In seismic zone 4, potentially hazardous (other than URM) essential buildings and public schools, including colleges and universities, must be retrofitted or phased out within a 20-year period.

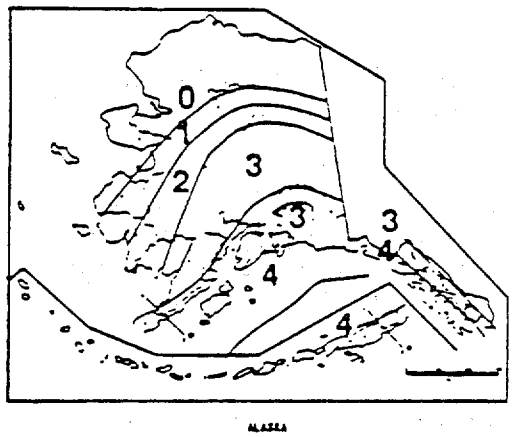
LRM 13 In seismic zones 3 and 4, inspections of buildings including one- and two-family dwellings and anchorage of mobile homes should be performed prior to significant financial commitment or property transfer and hence well before the close of escrow. A report to the potential buyer should indicate whether or not

a. the dwelling is anchored to the foundation,
b. unbraced cripple walls are present, and
c. gas water heaters (if present) are adequately braced or strapped to the framing.

LRM 14 In seismic zone 4, state law should require that gas water heaters in multi-family dwellings (new and existing) be braced or strapped to structural framing.

LRM 15 In seismic zone 4, concrete tilt-up construction which does not have adequate roof-to-wall anchors and continuity ties shall be required to be retrofitted within 10 years.





* EXPLANATION

For Adapting Figure C-1, We Have Used the Following Relationships Between Seismic Zones and Peak Horizontal Ground Accelerations:

Seismic Zone	Peak Ground Acceleration (Percentage of Gravity)	Shaking Hazard Level
0	< 0.05	Lowest
1	≥ 0.05 and < 0.1	
2	≥ 0.1 and < 0.2	
3	≥ 0.2 and <0.4	
4	≥ 0.4	Highest

Figure 1. Illustrative Seismic Zone Map for the United States
(Adapted * from "NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings," FEMA Publication 18 by the Building Seismic Safety Advisory Council, 1988)

PROJECT SUMMARY

The Congress of the United States is considering the establishment of a federal insurance program designed to reduce earthquake-caused mortality, morbidity, and economic losses and to protect homeowners, businesses, and financial and public institutions from sudden and disruptive catastrophic economic losses. In anticipation of this current consideration, the Federal Emergency Management Agency (FEMA) contracted for this study (Contract No. EMW-88-C-2872) in order to have addressed some of the key issues concerning federal earthquake insurance or reinsurance. Specifically, this study has been contracted to "identify feasible alternative earthquake loss-reduction provisions and develop a strategy to FEMA for incorporation of recommended loss-reduction provisions into a national earthquake insurance program" -- if one should be created by the Congress.

Major project goals were to

- o identify, evaluate, and recommend loss-reduction measures (LRMs) that are promising for incorporation into an earthquake insurance program involving the federal government,
- o indicate appropriate earthquake risk analysis methods for assessing and applying LRMs and for setting earthquake insurance rates, and
- o describe how recommended LRMs may be incorporated into a federal earthquake insurance or reinsurance program.

Loss-reduction is considered by many to be one of the major objectives of any earthquake insurance or reinsurance program involving the federal government. Many of the other objectives of such a program, such as reducing the Federal deficit, providing stability to homeowners and financial institutions after catastrophic earthquakes, and providing affordable insurance, involve considerations beyond the scope of this report.

Diverse views are held regarding loss-reduction in a federal earthquake insurance program. Specifically, views differ on

- o the cost-effectiveness of specific earthquake loss-reduction measures and of earthquake loss-reduction measures generally,
- o the feasibility of geological mapping of local seismic hazards, seismic building reviews, and other activities to support LRMs and to provide bases for earthquake insurance rate-setting (rating),

- o the proper role of the federal government, if any, in state and local landuse and building practices generally and those related to earthquake loss-reduction specifically, and
- o the feasibility of incorporating cost-effective LRMs into either a primary or a secondary earthquake insurance program. (In a primary earthquake property insurance program, the insurance is provided directly to the property owner; in a secondary earthquake insurance program, insurance is provided to the insurer.)

In order to understand these positions better, we have

- o held three meetings of a nationally-recognized advisory panel to identify and discuss diverse viewpoints regarding this study.
- o reviewed existing information on earthquake loss-reduction activities and measures,
- o identified from this information search loss-reduction measures that are technically sound,
- o subjected these technically-sound loss-reduction measures to economic analysis in order to determine which activities are cost-effective and who pays for and who benefits from these activities,
- o evaluated and revised selected measures at a workshop of experts and individuals from many diverse organizations throughout the United States,

As a critical part of these efforts, we have

- o identified fifteen LRMs that are technically sound, cost-effective, and politically and administratively feasible for inclusion in a federal earthquake insurance program,
- o identified activities needed to initiate, support or sustain these fifteen LRMs,
- o determined that earthquake risk analysis methods are currently adequate for LRM assessment for community use and for earthquake insurance rating,
- o clarified current contingent federal liabilities resulting from current federal disaster assistance and other federal policies and indicated how some of the activities required to initiate or to sustain recommended LRMs may justify an enhanced federal program of state and local programs and assistance to reduce these liabilities, and
- o demonstrated how the fifteen LRMs can be incorporated into earthquake ordinances which, along with the encouragement of risk-based rates, can serve to make the implementation of these LRMs consistent with a federal primary or secondary earthquake insurance program, and
- o provided forums permitting and encouraging the expression of a wide variety of viewpoints.

Forums for Clarifying Project Issues

Given the wide range of views on earthquake risk analysis methods, the acceptability of LRMs, the desirability of supporting activities for LRMs and for rating, and the feasibility of incorporating LRMs into a federal earthquake insurance program, no unanimity of results was possible. Instead, the project approach was to permit this wide variety of positions to be expressed, along with their rationales, so that these views could be used to modify project results or to clarify issues addressed.

For instance, a view that earthquake property loss-reduction may not be cost-effective has derived from the observation that seismic codes are life-safety based; therefore, performance of some buildings suffering total constructive loss from earthquakes is considered a success because no casualties were sustained. To address this viewpoint, we have emphasized economic criteria along with technical, administrative, and other criteria in determining the acceptability of LRMs. Past earthquake investigations have shown that buildings designed with little or no seismic resistance are much more likely to suffer higher degrees of damage -- as well as be life-threatening -- than are buildings designed to adequate current model seismic code provisions. Hence, this study concludes that a strong relationship exists between property-loss reduction and seismic safety even though model seismic codes could give more emphasis to damage control.

Risk Analysis Methods

This report contains a condensed section on earthquake risk analysis methods appropriate for a federal earthquake insurance program. Our examination of earthquake risk analysis methods has found that

- earthquake risk analysis has advanced sufficiently over the past twenty years to provide an adequate basis for assessing LRMs and for determining earthquake insurance rates in spite of large uncertainties;

- current techniques are adequate for the development of small-scale seismic zone maps for use by a federal earthquake insurance administrator in spite of some differences in approach;

- seismic risk methods for inclusion in a federal earthquake insurance program should be probabilistic and should evaluate all potentially damaging earthquakes and likelihood of occurrence; otherwise, both benefits of LRMs and expected earthquake insurance losses could be either grossly underestimated or arbitrarily assigned; and

- detailed engineering reviews of all buildings covered in a federal earthquake insurance program would be cost-prohibitive; moderate underwriting expenditures can provide a federal earthquake insurance program administrator with sufficient information for encouraging LRMs and for setting rates; and

- o program monitoring of exposures and losses is essential for improving loss-reduction efforts and establishing rates along with continual review and application of pertinent research findings.

Recommended Loss-Reduction Measures

We have identified fifteen LRMs, involving both improved landuse and building practices, that are suitable for inclusion in a federal earthquake insurance program. These are summarized in Table 1.

Some of the LRMs in Table 1, namely building code requirements, apply throughout the country; however, the cost-effectiveness of implementing special building code requirements in low seismic zones has been questioned. Figure 1 is used here to illustrate different seismic zones that can be used for the application of LRM requirements in a federal earthquake insurance program. Seismic zones 0 and 1 have the least earthquake strong motion hazards. The low level of hazards in these zones implies very limited long term benefits of LRMs. Consequently, requiring LRMs in these areas in exchange for the earthquake insurance benefit may as a rule be uneconomic. Nonetheless, there are benefits to inclusion of such regions in the building code process. These benefits are derived from uncertainties inherent in the seismic zonation process which are highlighted when extremely low probability damaging earthquakes occur in regions thought to be aseismic. When this occurs seismic zone designations can be changed appropriately to reflect improved information. Purchase of earthquake insurance at very low rates in low seismic hazard zones provides economic protection against extremely low-probability events.

Figure 1 is adapted from FEMA publications (95 and 96), "NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings." It is intended to illustrate how the recommended LRMs become more stringent in the higher seismic zones especially zones 3 and 4. Other seismic maps, such as those found in the 1988 Uniform Building Code or the 1982 American National Standards Institute Code are more or less consistent with Figure 1.

In all such maps, portions of California, Alaska, and possibly Montana have the highest (zone 4) seismic zone designations. Portions of Arizona, Arkansas, Guam, Hawaii, Idaho, Illinois, Kentucky, Nevada, Puerto Rico, Tennessee, Utah, the Virgin Islands, Washington and Wyoming may be high (zone 3) or higher seismic zone designations. Regions east of the Rockies with seismic zone 2 designations with high catastrophic loss potential may include portions of states possibly affected by earthquakes in New Madrid, Missouri, or Charleston,

Table 1
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a National Earthquake Insurance Program

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LRM 1 Require in high liquefaction susceptible zones that geotechnical techniques be used to minimize potential ground failures for

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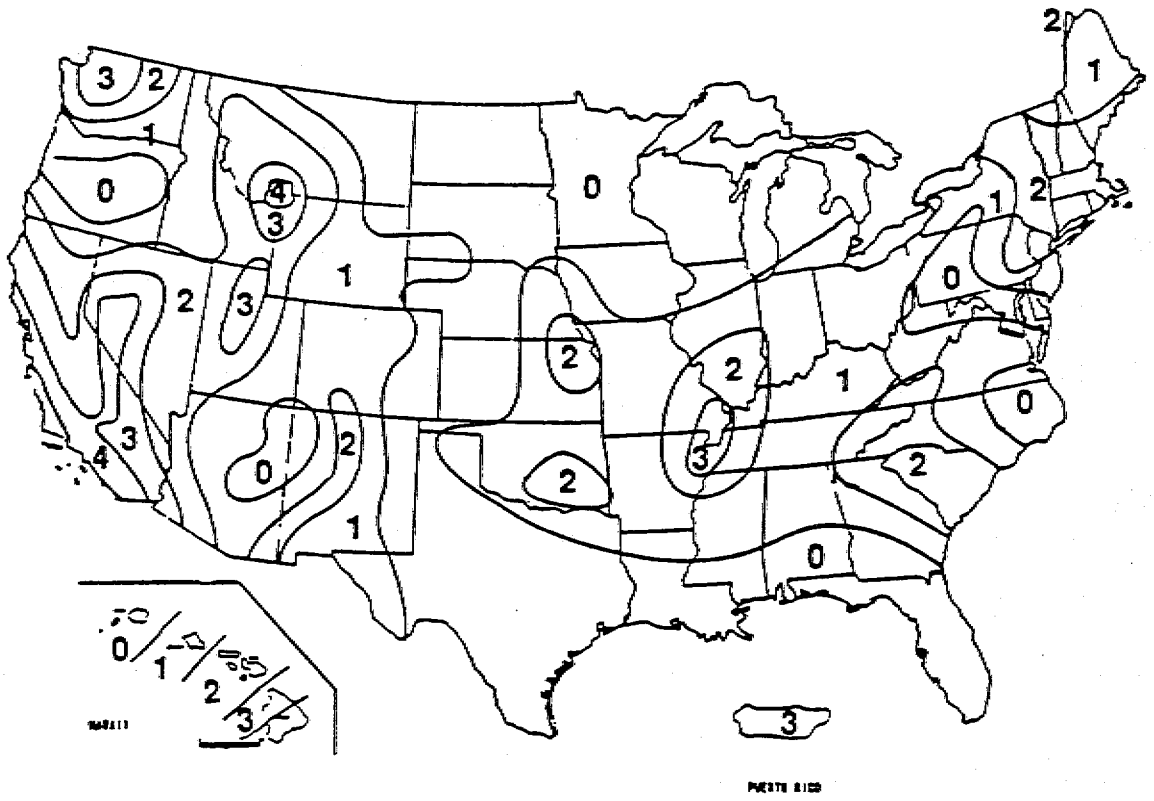

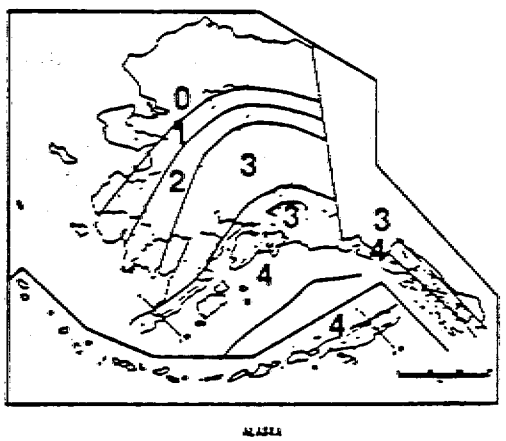

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Figure 1. Illustrative Seismic Zone Map for the United States

(Adapted * from "NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings," FEMA Publication 18 by the Building Seismic Safety Advisory Council, 1988)

South Carolina, or possibly the northeastern United States. Regions west of the Rockies having seismic zone 2 designations but with high catastrophic loss potential may include portions of Alaska, Oregon, Utah and Washington.

Figure 1 could be used on an interim basis for the implementation of LRMs in a federal earthquake insurance program. One of the first steps in such a program should be the establishment of national seismic zone maps. Methods for developing these maps are currently available and being updated. These maps are technically acceptable for the LRMs recommended in this project.

Economic analysis has determined the following loss-reduction measures as being most cost-effective:

- o adoption of, compliance with, and enforcement of adequate seismic design provisions in new construction (LRMs 5, 6, 7, 8, and 9),
- o seismic retrofit of unbolted and/or poorly anchored wood-frame residences in seismic zone 4 (LRM 13), and
- o use of geotechnical techniques (supported by landuse planning) to minimize severe landslide, liquefaction, and/or subsidence hazards in seismic zone 4 (LRMs 1 and 2).

The remainder of the LRMs presented in Table 1 were determined to be adequately cost-effective and acceptable to representatives of a broad range of geographic regions and interests.

The LRMs recommended provide guidance to FEMA on which LRMs to include in a federal earthquake insurance program. Administrative discretion should be used with respect to such expressions as "50% of replacement value." Substitution of "50% of market value," for instance, may prove to be administratively easier. The LRMs recommended are expressed generally enough to represent a consensus among the professional engineers, landuse planners, economists, and state and local administrators who participated on the project. Additional specificity in terms used would require additional legal, public policy, scientific, and engineering discussion and analysis.

The emphasis in LRMs recommended lies in practices for new construction, especially with respect both to adoption, compliance, and enforcement of adequate seismic code provisions and to minimization of potential ground failure hazards during new development and major modifications of existing construction.

We have developed a list of major types of potentially hazardous construction for purposes of characterizing "potentially hazardous" construction as referenced in Table 1. This list is provided in Table 2. Other potential "hazard rating" categories include "Conforming"

Table 2

Potentially Hazardous Building Construction Classes Identified for Public Policy Purposes

(1) Buildings with unreinforced masonry bearing walls which do not have complete or adequate load paths for seismic forces.

(2) Concrete tilt-up or reinforced masonry structures with flexible roofs. Flexible roofs include those of wood or steel deck without concrete fill. Structures having one or more of the following inadequate features:

  (a) wood ledgers used in cross-grained bending or tension,

  (b) no bolts or anchor straps for anchorage of walls to roof diaphragm,

  (c) excessive spacing or inadequate capacity of roof to wall anchors,

  (d) chord elements that are discontinuous (not supplied with continuity plates, etc.), and/or

  (e) inadequate connection of tilt-up wall panels to foundation.

(3) Non-ductile concrete frames -- concrete moment-resisting frames not conforming to the detailing provisions of the 1976 or later editions of the Uniform Building Code (UBC) and American Concrete Institute (ACI) Standard 318-77, including appendix A, (1977 edition or later) including "pre-cast" frames.

(4) Buildings with "soft" or "weak" first stories -- particularly those having story strengths less than 65 percent of the strength of the story above, as per 1988 UBC.

(5) Buildings having unreinforced or inadequately braced parapet walls or inadequately attached exterior ornamentation.

(6) Buildings with inadequately attached or rigidly attached (inadequate allowance for story drift) exterior glazing or pre-cast concrete, masonry, or stone curtain wall panels.

(7) Unreinforced masonry "infill" exterior walls.

(8) Unreinforced masonry interior partitions or "infill" walls in stairwells and elevator shafts.

(9) Buildings where no lateral force resisting system is present or can be identified either in the whole building or in a story of the building. Buildings in which the seismic lateral force resisting system is incomplete or has significant gaps that could allow portions of the structure to collapse.

(to current model seismic code provisions), "Nonconforming" (to these provisions), and "Retrofit" (to 65 percent of current model seismic design force requirements). For jurisdictions in seismic zones 3 and 4 who comply with LRMs or other model seismic codes, the distinction between "Conforming" and other hazard rating categories will be between new and existing buildings. Disclosure requirements of LRM 9 may further assist in providing disincentives for the prolonged use of potentially hazardous buildings in seismic zones 3 and 4. A major objective of a federal earthquake program is to reduce over time the seismic vulnerability of the extremely large stock of existing potentially hazardous construction, especially in higher seismic zones.

Activities Supporting Recommended LRMs

Loss-reduction measures cannot be implemented without adequate information, resources, and organizational capability. A set of activities needed to initiate, sustain, and/or support the fifteen recommended LRMs are listed in Table 3.

As with the recommended LRMs, the supporting activities are defined generally enough to achieve consensus among representatives of a broad range of interests and diverse geographic regions. Further administrative and professional effort is required to define such expressions as "minimum population" and "high liquefaction susceptibility".

The supporting elements described in Table 3, for the most part, involve a continuation of programs already underway in conjunction with both NEHRP programs and state and local practices. For instance, mapping scales required by the supporting elements are no larger than 1:24,000, and then only in higher seismic risk zones (zones 3 and 4) with significant urban development. Considerable data and maps already exist to help fulfill these requirements. As defined, the lack of full supporting elements should not delay implementation of the most significant and cost-effective LRMs in Table 1. In view of the considerable progress in NEHRP programs and the potential for future progress, the activities in Table 1 should be regarded primarily as LRMs that are cost-effective to implement -- even considering costs of supporting activities. Research that suggests additional cost-effective ways to reduce losses from earthquakes should be used to periodically evaluate and improve the LRMs included.

The Community Basis of LRM Enforcement

We recommend for adoption by appropriate state and local bodies earthquake ordinances analogous to those adopted under the national flood plain management program within the National Flood Insurance Program (NFIP).

Table 3

Activities Needed to Support Recommended LRMs

Activities Supporting Landuse LRMs
(except for L1, applicable only in seismic zones 3 and 4)

L1 For the entire United States, development of small scale maps (1:5,000,000) of ground motion, evaluated by an expert panel.

L2 For urban areas with a minimum population (e.g., 50,000) development of intermediate scale maps (1:100,000) of ground motion that include examination of local geological effects on strong ground motion (e.g., maps of relative site velocities for different spectra).

L3 Compilation and as necessary development of large scale maps (1:24,000) of Quaternary surface faulting within a 50-mile band outside the perimeter of urban areas having a minimum population. Compilation and development of intermediate scale maps (1:100,000) elsewhere in seismic zones 3 and 4.

L4 Compilation and development of large scale liquefaction and landslide high seismic susceptibility maps (1:24,000) for urban areas having a certain minimum population. Greater attention should be placed on quantitative interpretation of such expressions as "high susceptibility." Areas mapped should be large enough to accommodate short-term growth in undeveloped areas around the city.

L5 Construction of information databases and transfer mechanisms so that the foregoing maps may be readily available and understandable to local officials, realtors, developers, insurance companies, and the general public.

L6 Requirement that general plans include a seismic safety element that sets development policy for local geological hazards including high relative site response factors, fault zones, and regions of high liquefaction and/or landslide susceptibility.

L7 Development of requirements for areas identified as active fault zones, and high landslide or liquefaction susceptible zones that a geologic/geotechnical report be prepared for critical facilities, high-occupancy buildings, new subdivisions, and major modifications of high-occupancy (and/or critical) buildings, and that these be reviewed by a suitable licensed professional.

L8 Development of guidelines for preparation and review of geologic/geotechnical reports.

L9 Provision of resources for state and local programs, procedures, and staffing to effect LRMs.

Table 3 (Continuation)

Activities Supporting Building Practice LRMs

B1 Definition of "potentially hazardous buildings" as in Table 2.

B2 Definition of seismic zone 2* as those seismic zone 2 areas with high seismic potential at extended recurrence intervals and/or with high seismic loss potential.

B3 Definition of criteria and a program for seismic evaluation and retrofit of existing buildings.

B4 Provision for limitations on liability of local jurisdictions and their building official(s) when they provide and permit criteria (as in B3) for evaluation and retrofit design which is less stringent than building code requirements for new construction.

B5 Permission for voluntary seismic upgrades without mandated upgrades for non-safety related functions.

B6 Support for the development of programs and procedures and of professional state and local building staffing to effect LRMs.

B7 Support for dislocated or disadvantaged tenants during seismic retrofit programs.

B8 Continued research directed at reducing costs for seismic construction, both new and existing.

B9 Continued work to incorporate a geotechnical component into model seismic code provisions.

B10 Continued research into the development of codes that emphasize property damage control and maintenance of function over and above critical life-safety protection.

The concept of earthquake ordinances recognizes that these LRMs are implemented at state and local levels and that public agencies, as opposed to financial institutions, are the appropriate enforcers of these LRMs. The concept also recognizes that earthquake loss-reduction implementation programs require coordination among various agencies within municipalities, even though most of the currently active earthquake loss-reduction programs are handled exclusively by building safety departments. The LRMs in Table 1 are accordingly designed for adoption by state or local community-based programs. Especially in higher seismic zones, individuals, firms, municipalities, or states may, based on life-safety, economic, political, or legal reasons, decide to use higher seismic standards than those implied in Table 1. Moreover, selected insurers may provide detailed rate credits for seismic safety practices. Table 1 LRMs generally require some degree of regulation and cover a wide range of possible cases -- not merely unique motivations or circumstances.

Loss-Reduction through Enhanced Current Public Policy

We review existing earthquake loss-reduction programs at federal, state, and local levels in order to examine the framework within which project objectives can be achieved. We maintain that, in spite of the progress that has been made in these programs, further efforts at a federal level could be made to strengthen these programs and reduce existing contingent federal liabilities. A strengthened federal program could in turn provide support for the higher cost activities listed in Table 3 through reduction of these liabilities. Provision of resources for state and local programs, procedures, in particular, and staffing to effect LRMs (L9 and B6 for landuse and building practices, respectively) could be initiated based on such an enhanced federal program.

Current public policy involves no direct federal involvement in earthquake insurance and has many constraints on local adoption and enforcement of earthquake ordinances and promotion of loss-reduction activities. These include lack of adequate staffing, competition within the building construction industry to keep front-end construction costs as low as possible, and resistance to landuse planning that adjusts real estate values. One of the more significant constraints is the Federal financial contribution toward repair, restoration, and replacement of damaged facilities. Once the President has declared a disaster, Section 406 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (P.L. 100-707) commits the federal government to financing not less that 75 percent of the net eligible costs of repair, restoration, reconstruction, or replacement of public facilities and private nonprofit facilities. Expectation of the 75 percent federal cost share serves as a disincentive to the local

and state application of adequate seismic standards to construction and/or retrofit of public and selected private nonprofit buildings.

The Stafford Act does require that loss-reduction measures in the form of local codes, specifications, and standards be applied to recovery efforts financed through any disaster loan or grant under the provisions of the Act. The Act provides 50 percent financial support for hazard mitigation activities and requires natural hazard evaluation in those areas receiving assistance under the Stafford Act.

The January 5, 1990, Executive Order 12699 on Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction requires that each Federal agency responsible for the design and construction of a new Federal building shall ensure design and construction with appropriate seismic standards. Further, new buildings constructed and leased for Federal use or constructed with Federal financial assistance or regulated by a Federal agency shall appropriately use seismic safety standards. Nationally-recognized private sector standards and practices shall be used when possible or adequate local building codes. Implementation of this order should reduce earthquake losses to Federal, Federally subsidized, or Federally regulated new buildings.

While the Stafford Act and Executive Order 12699 reflect considerable progress with respect to loss-reduction efforts, the very significant contingent federal liabilities resulting from current federal policies indicate the need for increased federal controls to reduce these liabilities. Additional resources are needed to achieve the specific goal of reducing existing federal liabilities associated with potential earthquakes, even without a federal earthquake insurance program.

Federal disaster relief policy, along with other federal policies such as taxation, Small Business Administration (SBA), and Federal Deposit Insurance Corporation (FDIC) policies, supports a significant federal government interest in state and local landuse and building practices. Additional federal action to strengthen landuse and building practices for earthquake loss-reduction is warranted. Financial support for training programs and for local staffing, as was provided during the early implementation of the Clean Air Act, is an example of such needed Federal program strengthening. Part of the support for LRMs identified in Table 1 can be provided through a wide variety of federal programs specifically designed to reduce existing contingent federal liabilities.

Federal Involvement in Earthquake Insurance

One possible change in programs would involve the federal government in earthquake insurance. This would initially increase direct federal liabilities in the short term but with premium inome and loss-reduction could decrease them over the long term. In order to discuss how this may affect the implementation of loss-reduction measures, we consider

- o earthquake risk analysis methods and their application in the selection and monitoring of LRMs and in insurance rate-setting, and
- o how insurance rating influences the implementation of loss-reduction measures.

We use expected reductions in annual losses to ensure that recommended LRMs are cost-effective. However, traditional seismic loss estimation methods (expected annual loss and probable maximum loss methods, respectively) are not suitable for earthquake insurance rating purposes. Instead, new multisite methods exist which are better able to incorporate both expected annual losses and extreme fluctuation in those losses into a coherent framework for earthquake insurance rating. These methods can better deal with risk diversification and rate reduction issues. These methods also can be used to determine suitable prices in a secondary earthquake insurance context. However new these methods are with respect to earthquake, they are similar to methods used since the onset of the National Flood Insurance Program.

Protection of the public, insurance rate-reductions, and economic stability of public and private entities, with resulting benefits to individuals, would be major goals of a federal earthquake insurance involvement. Another goal -- the principal focus of this project -- would be to reduce future losses through the incorporation of loss-reduction measures into federal earthquake insurance program involvement. Without these measures, expected primary earthquake losses would increase, thus affecting adversely the safety, health, and welfare of the nation's citizens and the economic stability of the nation's public and private entities.

Two primary vehicles exist whereby implementation of LRMs such as those listed in Table 1 can be made compatible with and incorporated into a federal earthquake insurance program: (1) adoption of and enforcement of state and local earthquake ordinances and (2) a system of partially risk-based insurance rates -- rates that discourage poor seismic construction quality and encourage adoption and enforcement of adequate seismic standards. Without a system of partially risk-based rates, federal earthquake insurance involvement

would be seriously incompatible with the loss-reduction measures proposed. With partially risk-based rates, communities could be further encouraged to adopt, comply with, and enforce loss-reduction ordinances. With primary federal earthquake insurance programs, a combination of partially risk-based rates and ordinances can be strongly encouraged, as in the NFIP. With secondary federal earthquake involvement, e.g., federal reinsurance provided to primary earthquake insurers, earthquake ordinances can only indirectly be encouraged such as through secondary pricing that reflects risks of exposures to primary insurers.

Various goals can be reached with the combined encouragement of earthquake ordinances and a system of partially risk-based rates. These include short-term goals of improving the protection of the people and ensuring the nation's economic stability in the face of potential catastrophic earthquakes and the long-term goals of reducing the losses resulting from earthquakes.

Recommendations

Based on project findings, we make the following recommendations:

(1) **The fifteen LRMs listed in Table 1 should be incorporated into any Federal earthquake insurance involvement.** These LRMs are scientifically and technically valid, practical and cost-effective and have been critically reviewed by experts and representatives from a wide variety of geographic regions and interest groups. The primary loci of direct enforcement for these LRMs are state and local government authorities, not financial institutions.

(2) For implementation of these LRMs, **small-scale seismic zone maps for the nation should be developed** primarily on scientific and statistical bases. Figure 1 should be used in the interim and would be adequate for starting a federal earthquake insurance involvement incorporating LRMs. State and local jurisdictions can require additional seismic protection.

(3) **FEMA should initiate an enhanced federal program specifically designed to provide cost-effective LRMs to reduce existing contingent federal earthquake-related liabilities.** FEMA should seek the necessary legislative mandates and resources to undertake this enhanced program. This report identifies many of those liabilities and

demonstrates how they can be cost-effectively reduced to the benefit of the federal taxpayer. This recommendation supports Administrative and Congressional deficit-reducing themes discussed in Darman (1990) and GAO (1989a and b) and further supports the loss-reduction goals described in the January 5, 1990 Executive Order on "Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction." An enhanced program of this sort would provide many of the supporting elements needed for incorporation of LRMs into any federal earthquake insurance program and would further ensure that public buildings, as well as private nonprofit buildings, serve as examples of good seismic practice.

(4) Should a federal earthquake insurance program be initiated, other **supporting activities** as indicated in Table 3 **should be initiated or augmented.** In almost all instances these supporting elements are not marginally expensive. Cost considerations should not delay implementation of the fifteen LRMs. In other instances, especially B6 -- support for the development of programs and procedures and professional state and local building staffing to effect LRMs, these should be considered as part of the deficit-reducing program suggested in recommendation (3).

(5) We recommend that **probabilistic multisite risk analysis methods be used for insurance rate-setting.** Although actuarial and public policy analyses are needed to determine how rates are to be structured in a federal earthquake insurance involvement, preliminary conclusions pertinent to LRMs and rating methods were drawn. In order to account for both expected earthquake losses and potentially extreme fluctuations in those losses. Inventory of exposures should occur during application to the program. Second, we recommend **partially risk-based rates** that support and sustain the fifteen LRMs proposed. To the extent that rates reflect risks, seismic zone maps in recommendations (2) and (4) will be similar to or mirror rating maps. In contrast, to the extent that territorial or jurisdictional or other considerations enter into this public policy analysis, seismic zone maps suggested for LRMs may diverge somewhat from those for rating. To the maximum degree possible, a single mapping program should be used for both LRM application and insurance rate-setting. This offers decided administrative advantages over using widely divergent maps for LRMs and for rates.

(6) The fifteen LRMs proposed in this project can be incorporated into state and local government earthquake ordinances. **In a primary federal earthquake insurance**

program, we recommend that the administrator employ a combination of partially risk-based rates and insurance availability conditional on cost-effective LRMs being adopted and enforced and by **earthquake ordinances.** These methods are analogous to methods effectively being implemented under the NFIP. A mandatory primary program and, hence, a monopolistic program, has the potential disadvantage that an administrator may wish to cut program costs that would otherwise be incurred in a competitive market situation. These include modest costs of underwriting partially risk-based rates. As a result, rating incentives for cost-effective loss-reduction measures must be built into the objectives of such a mandated program.

(7) **In a secondary federal earthquake insurance program,** a federal insurance administrator will be faced with a difficult challenge in incorporating LRMs. **The administrator may use secondary pricing that reflects risks, agreements with state insurance regulators to ensure that risks are reflected in rates, or leverage from a combined primary and secondary federal earthquake insurance program in order to require earthquake ordinances.** We regard the incorporation of LRMs into a secondary federal earthquake insurance program as being feasible but challenging.

(8) **Program monitoring, review, and improvement are essential** features of the program envisaged here. Developments are ongoing in mapping earthquake hazards, assessing earthquake risks, and improving cost-effective risk-reduction technologies. A federal earthquake insurance program containing a loss-reduction element should systematize pertinent program information and should periodically review and evaluate this information against developments to assure continuing and improving program efficacy in loss-reduction.

(9) **Examination should be undertaken of the many issues** -- over and above loss-reduction -- **related to the feasibility of a federal earthquake insurance program.** Actuarial, economic, and public policy analyses, for instance, are needed to examine various detailed issues concerning the protection of the Federal Treasury, the provision of affordable earthquake insurance, and the reduction of post-earthquake instabilities in the financial sector of the economy. Issues of mandating insurance purchase requirements should also be examined. Further consideration should be given to how a government insurance program may and should differ from a private sector or competitive program.