

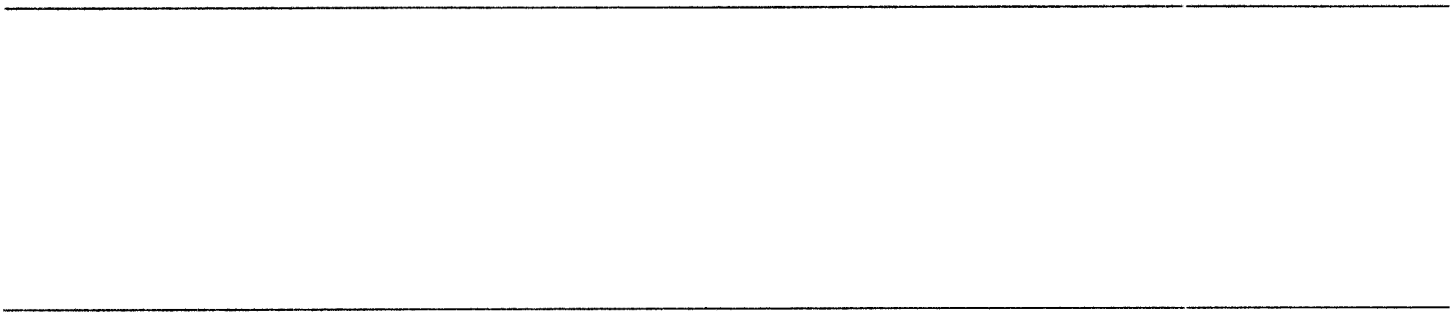
May 1992

FEDERAL BUILDINGS

Many Are Threatened by Earthquakes, but Limited Action Has Been Taken



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**United States
General Accounting Office
Washington, D.C. 20548**

General Government Division

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Chairman
The Honorable John C. Danforth
Ranking Minority Member
Committee on Commerce, Science,
and Transportation
United States Senate

The Honorable George Miller
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Ranking Minority Member
Committee on Interior and
Insular Affairs
House of Representatives

The Honorable George E. Brown, Jr.
Chairman
The Honorable Robert S. Walker
Ranking Minority Member
Committee on Science, Space,
and Technology
House of Representatives

This report, mandated by the National Earthquake Hazards Reduction Program Reauthorization Act of 1990 (P.L. 101-614), provides information on (1) the number of federally owned and leased buildings in areas of seismic risk and the value of owned buildings and (2) federal agencies' efforts to reduce the vulnerability of these buildings.

We are sending copies of this report to the Secretaries of Defense and Veterans Affairs; the Administrator, General Services Administration; the Postmaster General; the Director, Office of Management and Budget; and other interested congressional Committees and Subcommittees. Copies of this report will be made available to others upon request.

If you or your staff have any questions concerning this report, please contact me at (202) 275-8676. The major contributors to this report are listed in appendix VIII.

L. Nye Stevens
Director, Government Business
Operations Issues

Executive Summary

Purpose

Earthquakes strike without warning and can wreak widespread havoc within seconds. A violent reminder of this potential, the 1989 Loma Prieta earthquake caused 63 deaths, 3,757 injuries, and about \$6 billion of damage to buildings, highways, and bridges. Yet experts point out that the damage from Loma Prieta was minimized by sustained efforts in California to make buildings earthquake-resistant. They warn that earthquakes of similar force would cause greater damage in other earthquake-prone states (moderate seismic risk or greater), such as Washington, South Carolina, and Tennessee, that have not undertaken long-term hazard reduction.

In the wake of recent devastating earthquakes, Congress asked federal agencies how many of their buildings were vulnerable to earthquake damage, but found that the information was not readily available. As a result, the 1990 National Earthquake Hazards Reduction Program Reauthorization Act required, in part, that GAO develop information on (1) the number of federally owned and leased buildings in areas of seismic risk and the value of owned buildings and (2) federal agencies' efforts to reduce the vulnerability of these buildings, including the funds they have spent and will need to spend on their buildings.

Background

Nationwide, the federal government employs about 3 million people who work in federally owned buildings and leased space. In 1989 the government owned about 417,000 buildings and had 68,000 different lease locations, representing 3 billion square feet of space. This space was used primarily for offices, housing, storage, and agency support activities. Of the 26 federal agencies that own buildings and the 21 that lease space, 6 manage over 85 percent of federal space: the Departments of the Army, Navy, Air Force, and Veterans Affairs; the General Services Administration; and the Postal Service. Of these six, only Veterans Affairs is legislatively mandated (by the Veterans Health Care Expansion Act of 1973) to reduce the vulnerability of its buildings to earthquake damage.

In 1990, Executive Order 12699 directed federal agencies to implement seismic safety standards for both new federal buildings and new space constructed for federal lease. Similarly, the National Earthquake Hazards Reduction Program Reauthorization Act of 1990 required that the Interagency Committee on Seismic Safety in Construction develop seismic safety standards for existing federal buildings or leased space and that federal agencies adopt these standards before December 1994.

To meet its requirements under the act, GAO (1) determined the number of federal buildings and employees located within earthquake-prone areas and the value of owned buildings by matching various databases and (2) contacted the six major agencies managing federal buildings to obtain information on their policies and programs for increasing earthquake safety as well as data on how much they have spent and estimate they will need to spend to make buildings safer.

Results in Brief

Approximately 40 percent of federal buildings, lease locations, and employees are located in seismically active areas, where the risk of earthquake damage varies from moderate to very high. About 15 percent of federal buildings and employees are in zones of high to very high seismic risk. Even though buildings are located within the same seismic risk zone, damage to buildings would vary because of factors such as construction type and soil properties. Most agencies lack comprehensive data on these factors, so it is not now possible to determine which buildings are more vulnerable than others.

Although many federal buildings and employees are at risk from earthquakes, agencies' efforts to reduce building vulnerability have been limited. Of the six agencies GAO reviewed, the Army and Air Force have not begun identifying vulnerable buildings. The remaining four agencies have programs to identify the vulnerability of their owned buildings, but only Veterans Affairs has progressed in making its buildings earthquake-resistant. Three of these agencies consider seismic safety issues when making leasing decisions.

Agency officials did not have complete data on funds spent or needed to strengthen buildings. However, four of the six agencies estimated that they collectively will need about \$2 billion to make their buildings more earthquake-resistant. Officials cited the lack of funding as a major impediment to improving seismic safety.

GAO's Analysis

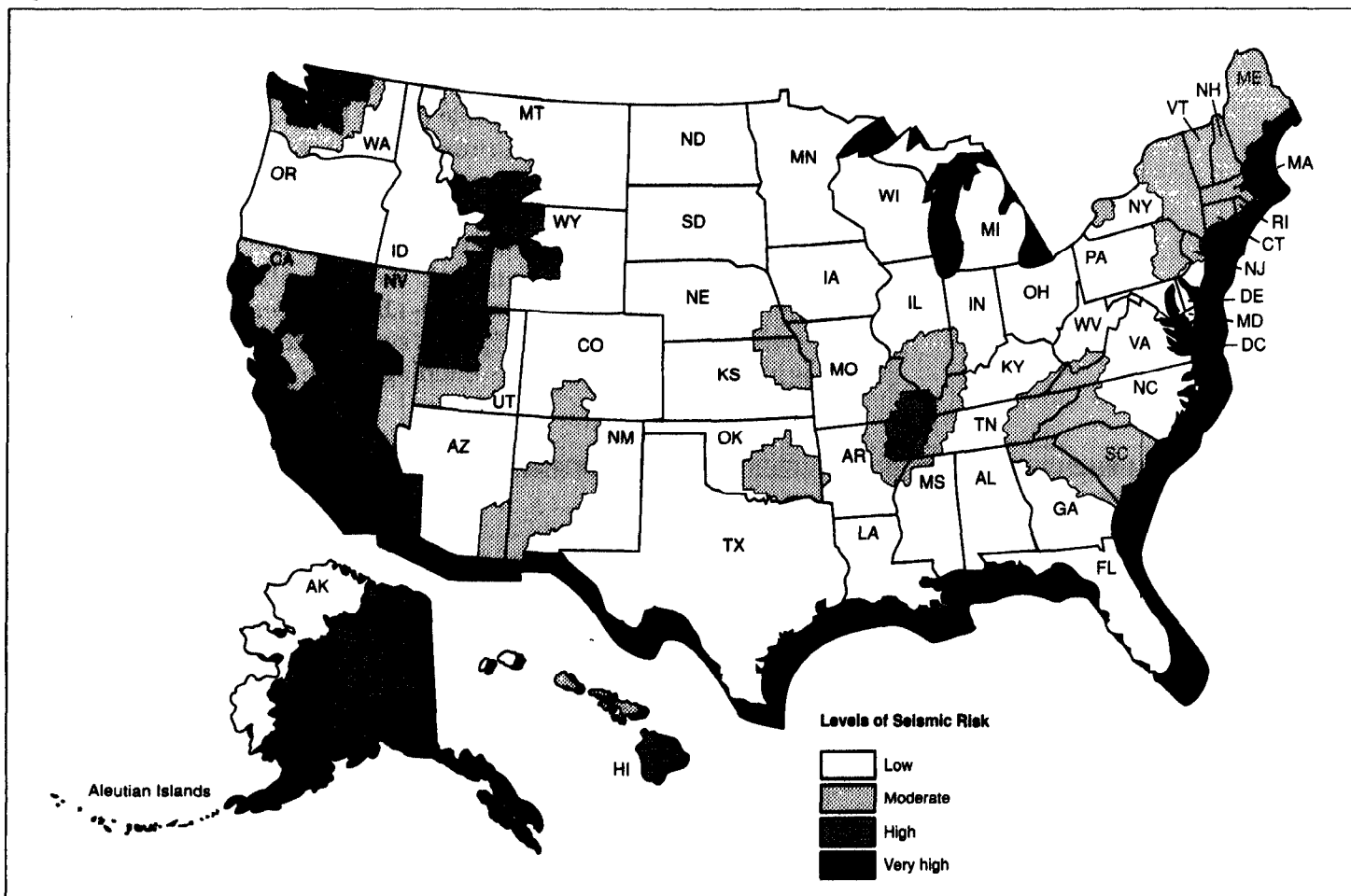
Many Federal Buildings Are in Seismically Active Areas

Nationwide, many federal buildings are located in areas of moderate to very high seismic risk. In 1989, the government owned about 183,000 buildings, containing 1.2 billion square feet of space; these had been acquired at a cost of \$34 billion. Also in 1989, the government had about 27,000 leased locations, totaling about 83 million square feet of space.¹ According to the U.S. Geological Survey (USGS), the potential earthquake damage to buildings in these areas would vary from some buildings damaged in moderate-risk areas to most buildings damaged in very high-risk areas. Over 1 million federal employees work in these moderate- to very high-risk areas. Figure 1 shows the location of seismic risk zones nationwide, and table 1 details the levels of seismic risk to federal buildings and employees.

According to USGS, location is a primary factor in determining risk. However, buildings in the same seismic risk zone will sustain varying earthquake damage, depending on factors such as construction type and the properties of underlying soils. Some construction types, such as brick buildings, are likely to sustain several times as much damage as steel frame buildings. Soft soils can intensify or amplify ground shaking leading to more severe damage. Therefore, the severity of potential damage to buildings cannot be determined without knowing more about the construction type and soil properties. GAO found that comprehensive data on these factors do not exist for federal buildings. (See pp. 44-51.)

¹Data are not available on the number of buildings leased by the federal government. Information is maintained by number of leased locations only; each location can represent space ranging from a small office within a building to several floors in a building or an entire building. There may also be more than one lease for a given building.

Figure 1: Seismic Risk Zones Nationwide



Source: National Earthquake Hazards Reduction Program Seismic Map.

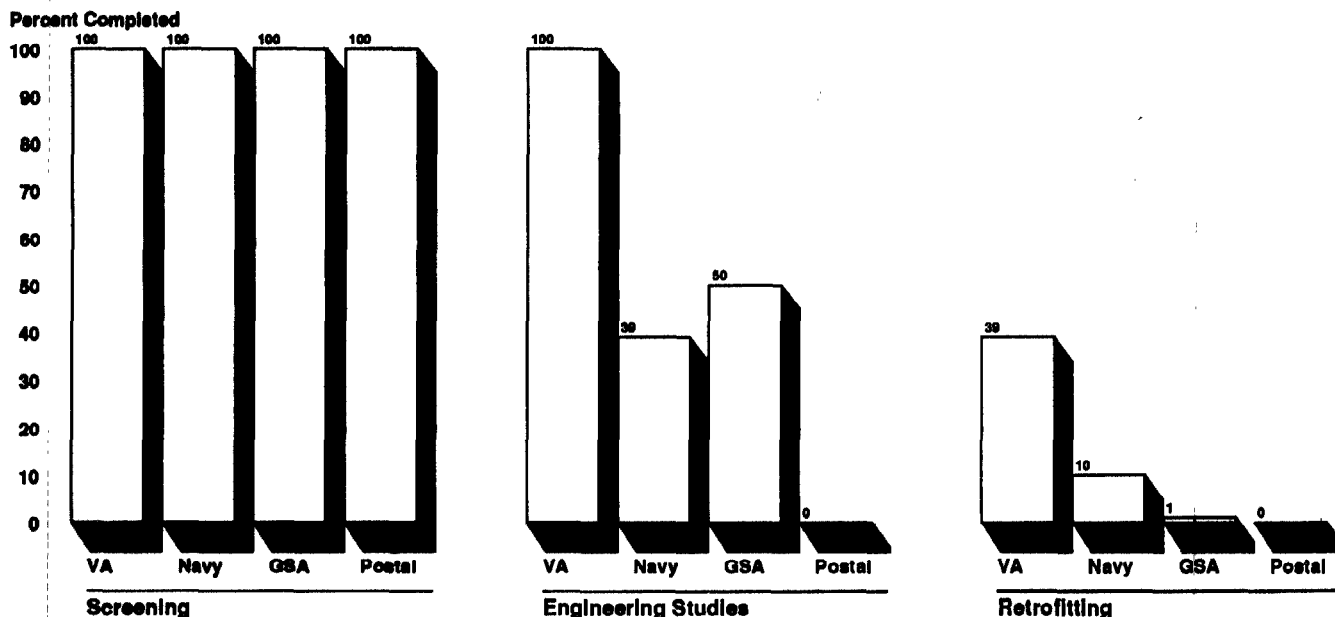
Table 1: Federal Buildings, Leased Space, and Employees in Seismic Risk Zones Nationwide

Level of seismic risk	Level of expected damage	Number of owned buildings	Number of leased space locations	Number of employees
Very high	Most buildings	32,000	2,000	218,000
High	Many buildings	52,000	3,000	224,000
Moderate	Some buildings	99,000	22,000	668,000
Low	No buildings	234,000	41,000	1,759,000

Agencies' Efforts to Reduce Vulnerability Have Been Limited

Although four agencies have established seismic safety programs, only one has made substantial progress in reducing the risk to its buildings. Veterans Affairs, the Navy, General Services Administration, and the Postal Service have screened the buildings they own in seismically active areas to identify those that are most vulnerable on the basis of factors such as location, age, height, and construction type. Three of these agencies—Veterans Affairs, the Navy, and General Services Administration—have completed a significant number of engineering studies of their most vulnerable buildings to gauge potential damage, along with options and costs for reducing risk. Veterans Affairs has made the most progress in reducing vulnerability—about 39 percent of its buildings at risk have been strengthened. Figure 2 summarizes each agency's progress in reducing the risk to its buildings. (See pp. 53-55.)

Figure 2: Federal Agencies' Seismic Safety Progress



Most agencies cited limited funding as a major reason why studies and/or strengthening projects have not been done. Currently, the agencies do not receive specific funding for seismic safety. Agencies could not estimate precisely what they had spent or would need to spend, but the Army and Air Force estimated that they would need over \$60 million just to complete screening and engineering studies. Once studies are complete, long-term

seismic strengthening projects must compete with other construction projects for limited funds. (See pp. 55-56.)

Moreover, strengthening a structure by installing earthquake safeguards that were not built in, known as seismic retrofitting, is very expensive. For example, General Services Administration estimated that retrofitting a small brick building housing the U.S. Post Office and Courthouse in Eureka, California, would cost \$1.1 million—about twice the building's estimated market value. (See pp. 56-57.)

Most agencies had not done the studies needed to accurately estimate retrofit cost. However, the Navy, Veterans Affairs, General Services Administration, and the Postal Service estimated that the total cost of retrofitting their buildings will collectively approach \$2 billion. Given this estimate, and the number of potentially vulnerable buildings at other agencies, it seems likely that limited funding will continue to impede completion of seismic retrofit projects. (See p. 57.)

Efforts to assess leased space for seismic safety were also limited. Veterans Affairs, General Services Administration, and the Postal Service considered seismic safety when entering into or renewing leases; the Postal Service had also systematically screened all of its existing leased space to identify buildings at risk. The Army, Navy, and Air Force required leased space to meet local building codes, but experts agreed that not all local codes contained adequate seismic safety provisions. Agencies noted difficulties in reducing the risk to employees and the public in leased space. Although agencies believed that vacating unsafe leased space was the most feasible option, sometimes no safer space was available locally. Retrofitting leased space is seldom an option, because lessors are reluctant to retrofit their buildings, given the cost; federal agencies are reluctant to retrofit an entire building when they lease only part of it; and retrofitting only part of a building is not considered feasible. (See pp. 57-59.)

Matter for Congressional Consideration

A large number of federal buildings are potentially vulnerable to earthquake damage, and retrofitting these buildings to improve seismic safety can be very expensive. If agencies are to adopt seismic safety standards before December 1994 and start retrofitting their most vulnerable buildings, additional funding will be needed. Given the lack of comprehensive information on the vulnerability of federal buildings and the high cost of retrofitting buildings, Congress may wish to consider targeting initial funds for the rigorous studies needed to identify (1) agencies' most

vulnerable buildings and (2) the costs associated with reducing their seismic risk. Congress could then identify priorities and judiciously allocate scarce resources for costly retrofits of the most important vulnerable federal buildings.

Agency Comments

In commenting on a draft of this report, the General Services Administration, the Departments of Defense and Veterans Affairs, and the Postal Service generally agreed with the information presented and the matter for congressional consideration. General Services Administration and the Departments of Defense and Veterans Affairs provided additional information describing their seismic safety efforts; Veterans Affairs provided some technical comments that GAO considered in preparing this report. Chapter 3 discusses the comments made by the four agencies; their actual comments appear in appendixes IV, V, VI, and VII.

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Abbreviations

DOD	Department of Defense
GSA	General Services Administration
ICSSC	Interagency Committee on Seismic Safety in Construction
NEHRP	National Earthquake Hazards Reduction Program
OPM	Office of Personnel Management
USGS	United States Geological Survey
VA	Department of Veterans Affairs

Introduction

Protecting lives and property from earthquakes presents special challenges. Major earthquakes can cause damage over thousands of square miles. Also, because earthquakes strike without warning, victims cannot evacuate or take last-minute steps to reduce damage, as they usually can when threatened by hurricanes or floods. Although the potential for widespread and sudden destruction argues for long-term programs to reduce the risk, the infrequent occurrence of major earthquakes can undermine the commitment to such programs.

Earthquakes Can Cause Significant Damage

As a recent reminder of the potential effects of earthquakes, the Loma Prieta earthquake caused 63 deaths, 3,757 injuries, and about \$6 billion in damage to the San Francisco Bay Area in October 1989. The earthquake destroyed homes and apartment buildings, shut down major transportation arteries, put companies out of business, and disrupted public agencies for periods ranging from several days to several months. The federal agencies affected included the following:

- The Environmental Protection Agency had to permanently evacuate the space leased for its San Francisco regional office. As a result, over 700 federal employees worked at home for several months until new space was located.
- The U.S. Court of Appeals had to disperse employees among seven leased offices when a building in San Francisco used as a post office and courthouse suffered structural damage and was condemned. The cost to repair and strengthen it was estimated at \$28 million.
- The Department of Veterans Affairs (VA) lost 270 hospital beds and 300,000 square feet of hospital, clinical, and laboratory space when structural and nonstructural damage caused the main building of a VA Medical Center in Palo Alto to be condemned. According to VA, the cost to rebuild the facility is estimated at \$180 million.

Although the damage from Loma Prieta was severe, experts believe it was reduced by long-term efforts to design and construct earthquake-resistant buildings in California, which has some of the most stringent seismic design codes in the world. They compare the damage from Loma Prieta to the aftermath of a similar-sized earthquake in Soviet Armenia in 1988, where 87 percent of the buildings in the city of Spitak collapsed or were severely damaged and at least 25,000 people were killed. They warn that earthquakes of similar force would cause greater damage in other earthquake-prone states (moderate seismic risk or greater), such as

Washington, South Carolina, and Tennessee, that have not undertaken long-term hazard reduction.

Seismic Activity Across the United States

Earthquakes can be caused by a variety of geological conditions ranging from movements along rock faults or zones to the movement of molten rock beneath the ground surface. Earthquakes are known to have occurred in all 50 states, but geologic mapping and historical records have identified a number of areas within the United States that may be more susceptible to earthquakes. These areas are affected by seismic faults or fault zones such as the San Andreas fault along the California coast, the Cascadia fault in Washington, the Wasatch fault in Utah, and the New Madrid seismic zone in the Mississippi Valley.

Seismologists use the Richter scale to measure the amount of ground motion caused by an earthquake. Seismologists assign each earthquake a number, which is based on seismograph readings of ground motion in an earthquake, to indicate its magnitude. The Richter scale is logarithmic, so an increase in magnitude of one whole number represents a factor of about 10 when measuring the increase of ground motion using a seismograph. Therefore, a magnitude 8.0 earthquake ground motion is 10 times greater than a magnitude 7.0 earthquake and 100 times greater than a magnitude 6.0 earthquake. The United States Geological Survey (USGS) characterizes earthquakes according to magnitude as follows:

- Moderate: 5.0 - 5.9,
- Strong: 6.0 - 6.9,
- Major: 7.0 - 7.9, and
- Great: 8.0 and above.

Nationwide, at least 39 states are considered at risk from moderate to great earthquakes, and, in fact, such earthquakes have struck various areas of the country including Alaska and the Central and East Coast States. Note the following examples:

- During the winter of 1811-12, the Central States were shaken by 2,000 earthquakes centered near New Madrid, Missouri (100 miles north of Memphis); these included three of the largest earthquakes in U.S. history, with magnitudes 8.7, 8.6, and 8.4.
- The Seattle area sustained a magnitude 7.1 earthquake in 1949 and a 6.5 earthquake in 1965.

- Alaska experiences more earthquakes than any other part of the country, including a magnitude 9.2 earthquake that happened on Good Friday in 1964, the second largest earthquake in the world during this century.
- Along the East Coast, damage has resulted from a magnitude 6.5 earthquake off Cape Ann, Massachusetts, in 1755; a magnitude 7.7 earthquake near Charleston, South Carolina, in 1886; and a magnitude 7.0 earthquake in the St. Lawrence Valley in 1925.

Moderate to major earthquakes are much more frequent than great earthquakes. According to USGS data, more than 50 moderate to major earthquakes caused damage, injury, and loss of life in the United States between 1985 and 1990. The most recent great earthquake occurred in the Aleutian Islands, Alaska, in 1965.

Federal Buildings

The federal government is the largest property manager in the United States. In 1989 the government owned about 417,000 buildings, representing 2.8 billion square feet of space. These buildings cost about \$83 billion to construct or purchase; their replacement value would likely be much higher. In commenting on a draft of this report, General Services Administration (GSA) estimated that a functional replacement of these buildings would conservatively cost \$276 billion. Agencies primarily use this space for housing, service activities, storage, and office space. In addition, the government had 68,000 leased locations, representing about 218 million square feet.¹ Agencies mostly use leased space for office space and postal offices. About 3 million federal employees work in owned buildings and leased space.

Although 26 federal agencies own buildings and 21 lease space, 6 agencies manage over 85 percent of federally owned and leased property: the Departments of the Army, Navy, and Air Force; VA; GSA; and the U.S. Postal Service. In addition to providing space for their own employees, these agencies manage space visited by the general public, such as Defense recruiting stations, hospitals, Social Security offices, and post offices.

¹Data are not available on the number of buildings leased by the federal government. Information is maintained by number of leased locations only; each location can represent space ranging from a small office within a building to several floors in a building or an entire building. There may also be more than one lease for a given building.

Federal Agencies' Role in Hazard Mitigation

Congress enacted the Earthquake Hazards Reduction Act of 1977 (P.L. 95-124) to reduce risks to life and property by establishing an effective earthquake hazards reduction program. President Carter established the National Earthquake Hazards Reduction Program (NEHRP) to carry out the mandates of the act. Four agencies have primary responsibility for NEHRP activities:

- The Federal Emergency Management Agency, as the lead agency, plans and coordinates NEHRP activities and works with state and local officials to translate research into hazard mitigation programs.
- USGS, within the Department of the Interior, does earthquake prediction research, prepares hazard and risk assessments, and collects seismic data.
- The National Science Foundation supports fundamental research in earthquake engineering and earth sciences.
- The National Institute of Standards and Technology, within the Department of Commerce, provides technical support and does research in seismic design and construction methods.

Since the primary NEHRP agencies have no authority over those agencies that manage federal space, the Interagency Committee on Seismic Safety in Construction (ICSSC) was established in 1978. ICSSC serves as a forum for seeking a consensus among federal agencies on earthquake hazard reduction measures and for assisting agencies in developing and adopting such measures. ICSSC also issues seismic guidelines and standards; these are advisory only, unless made mandatory by executive order. ICSSC membership is open to all federal agencies that construct, manage, or lease space, as well as agencies that conduct research on earthquake hazard reduction. Currently, 27 agencies are ICSSC members.

Objectives, Scope, and Methodology

On November 16, 1990, President Bush signed the National Earthquake Hazards Reduction Program Reauthorization Act of 1990. This act, among other things, required us to provide the Senate Committee on Commerce, Science, and Transportation and the House Committees on Interior and Insular Affairs and on Science, Space, and Technology information on (1) the number of federally owned and leased buildings in areas of seismic risk and the value of owned buildings and (2) federal agencies' efforts to reduce the vulnerability of these buildings, including the funds they have spent and will need to spend on their buildings.

To determine the number of federally owned and leased buildings in seismic risk areas, we first obtained a database from the Applied

Technology Council, which assigned a seismic risk level to each county in the United States.² The Council based its assessment of seismic risk on a USGS statistical analysis that predicts, at a 90-percent probability level, the maximum earthquake ground shaking hazard that could be expected during the next 50 years in a given county. In other words, within a 50-year span, the chance of a more severe level of ground shaking than that predicted by USGS is only 10 percent. On the advice of USGS, we modified the database to include a very high risk zone in 21 additional counties in California and 12 counties in Alaska, to recognize the severity and frequency of the earthquakes expected in those areas.

We then obtained tapes of (1) GSA's governmentwide real property database, as of September 30, 1989, cataloging federally owned buildings and leased space and (2) the Office of Personnel Management's (OPM) civilian personnel database as of December 31, 1990. We matched the GSA and OPM databases against the seismic risk zone database to identify federal buildings and employees located within seismic risk zones. By analyzing the results of the computer match, we developed data on the number of buildings owned and leased locations, square footage of owned and leased locations, acquisition cost of federally owned buildings, and the number of employees by seismic risk zone. GSA's data do not describe the number of buildings leased, but rather the number of leased locations. Each location can represent space ranging from a small office in a building to several floors in a building or an entire building.

Using the OPM tape, we created a file that contained 79,886 summary records of civilian employees located within the United States. We then were able to match all of these records against the seismic risk database. Using the GSA tape, we created a file that contained 82,570 records of federally owned buildings and leased locations within the United States. We were able to match 80,421 of the 82,570 records against the seismic risk database. We were unable to match the remaining 2,149 of the building and lease records because they lacked sufficient address and lease information. These unmatched records contained over 45 million square feet of space in about 33,000 federally owned buildings, acquired at a cost of \$933 million. The unmatched records also contained over 156,000 square feet of space in about 90 leased locations.

²The Applied Technology Council is a nonprofit structural engineering firm that has worked extensively with the public sector in the areas of seismic design and hazard mitigation.

To check the reliability of the Applied Technology Council database, we verified it against the NEHRP Seismic Map, which identifies the seismic risk for every county within the United States. Our results indicated that, except for some minor errors, the database was accurate. Although we verified our matched results against annual reports generated from the GSA and OPM databases, we did not verify the accuracy of the information contained in the databases.

From USGS, we obtained technical information on (1) seismicity within the United States and (2) two important factors that increase the vulnerability of some buildings to earthquake damage—construction type and soil properties. We met with USGS experts to discuss the information they provided. We also toured four federal facilities in the San Francisco Bay Area that had been damaged by the Loma Prieta earthquake or were considered seismically vulnerable to observe the damage and factors that made the buildings vulnerable. We then discussed the conditions of the buildings with knowledgeable agency officials.

To gain information on federal agencies' efforts to reduce the vulnerability of the buildings they own or lease, we did detailed work at the headquarters of the six agencies that own or lease 85 percent of federal space. We reviewed their seismic safety policies, procedures, and records. We discussed with the agencies' seismic safety officials whether and how much progress their agencies made in reducing the seismic risk to their buildings. We also discussed progress made and unique problems associated with ensuring the seismic safety of leased space.

To determine how much the agencies have spent and will need to spend to reduce the vulnerability of their buildings, we reviewed available seismic safety cost studies prepared by technical experts of VA, Navy, and the Postal Service. We also interviewed seismic safety and budget officials at the agencies to obtain (1) their opinions on seismic safety costs and funding and (2) estimates of their agencies' expenditures and funds needed for seismic safety.

We worked with USGS seismologists and engineers as our consultants on techniques for assessing seismic risk and strengthening or retrofitting buildings. In addition, USGS did an independent technical review of this report. We also contacted experts at the National Institute of Standards and Technology and the Federal Emergency Management Agency to obtain a wide range of scientific and technical information on seismic issues.

**Chapter 1
Introduction**

We did our work between October 1990 and August 1991 in accordance with generally accepted government auditing standards. GSA, the Department of Defense, VA, and the Postal Service provided written comments on a draft of this report. Their comments are evaluated in chapter 3 and appear in appendixes IV through VII.

Close to 200,000 Federal Buildings Are Located in Seismically Active Areas

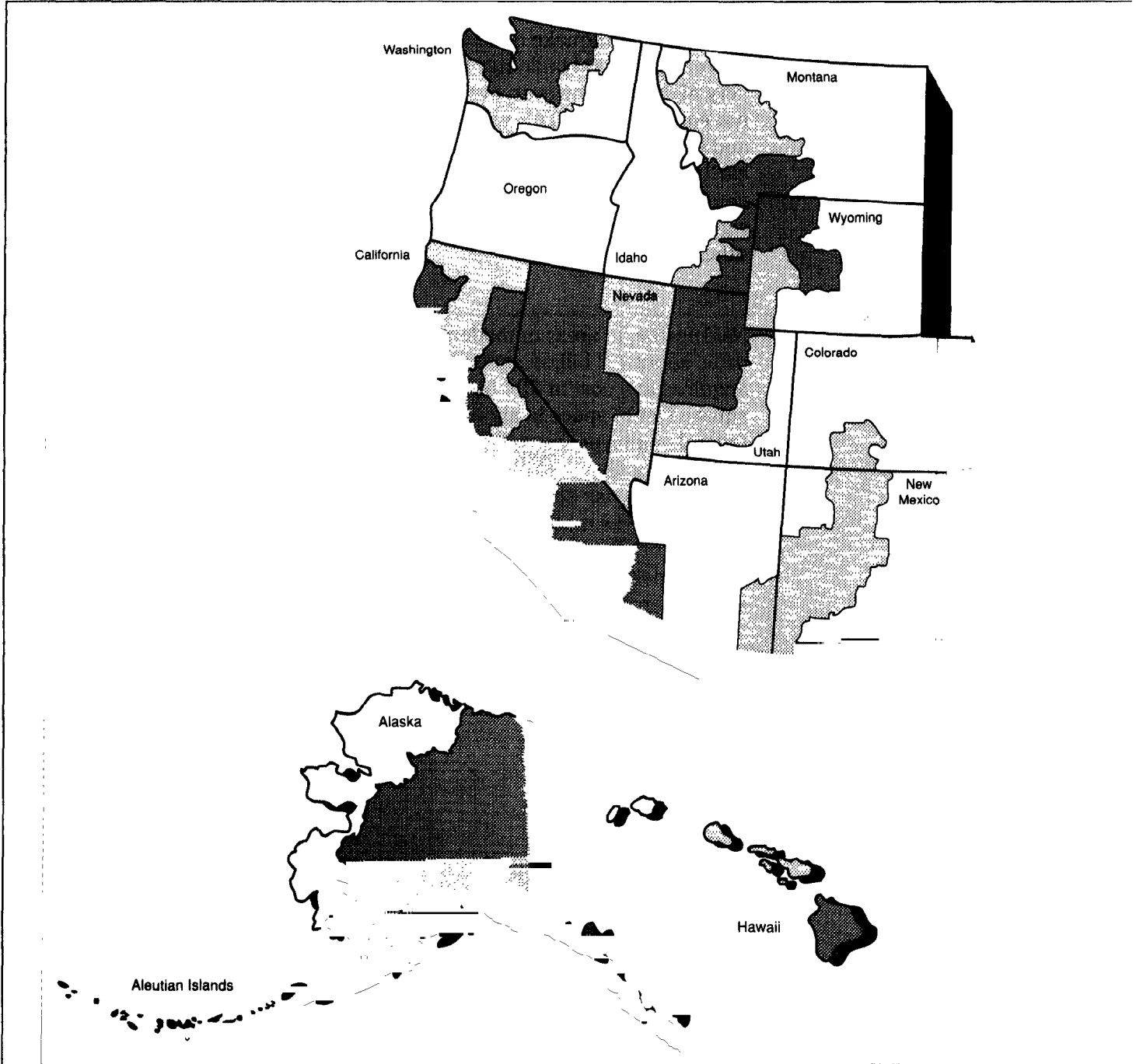
Approximately 40 percent of federal buildings, leased locations, and employees are located in seismically active areas across the country where the risk of earthquake damage varies from moderate to very high. About 15 percent of federal buildings and employees are located in zones of high to very high risk. However, even when located in the same zone, buildings are not equally at risk. This variance occurs because building construction type and soil properties—the most important factors in earthquake-resistance—vary within a zone. Most agencies lack comprehensive data on these factors, so it is not possible without a rigorous study to determine which buildings are more vulnerable than others.

Federal Buildings in Seismically Active Areas

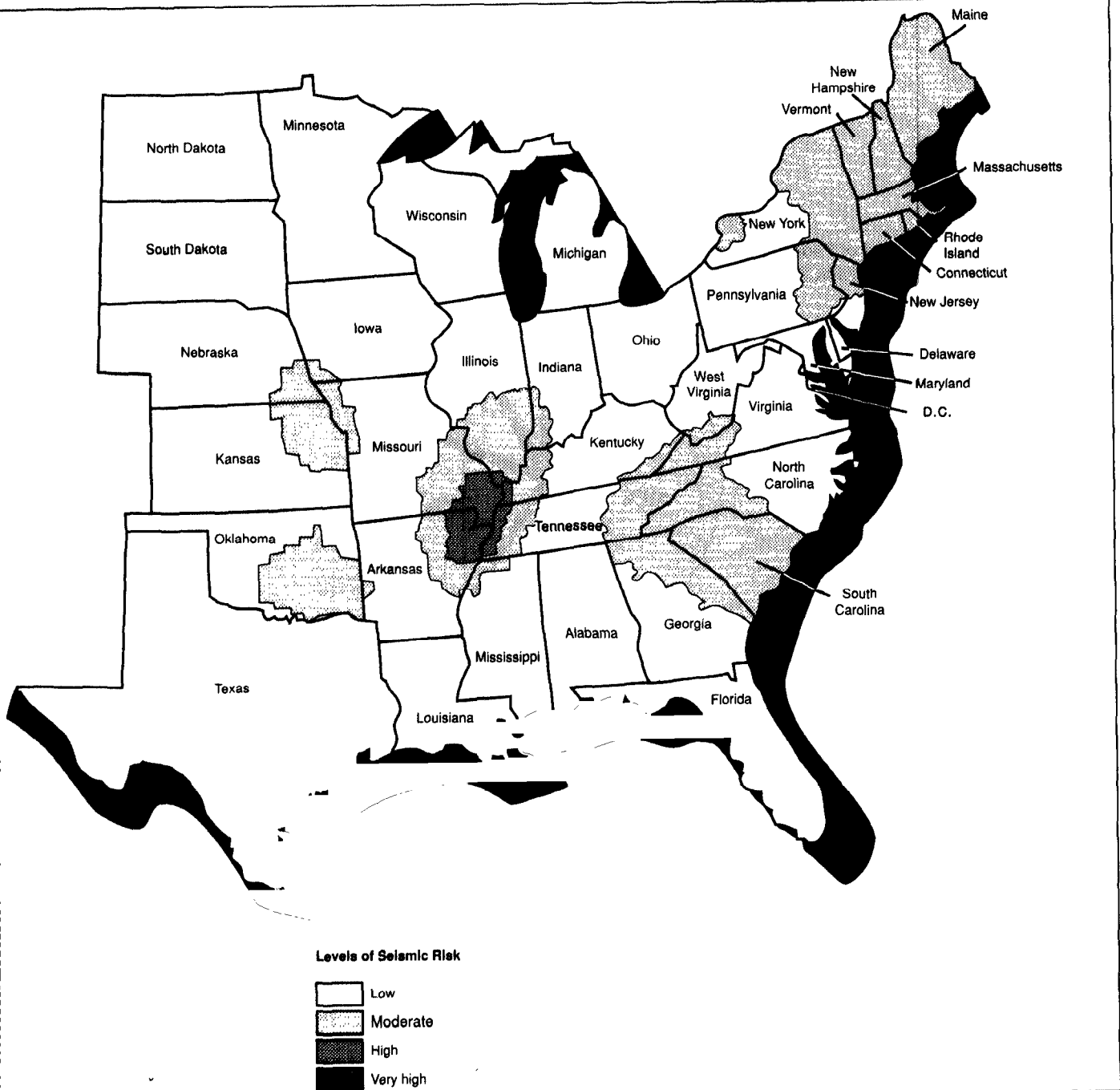
Nationwide, in areas of moderate to very high seismic risk, the government owns about 1.2 billion square feet of space in about 183,000 buildings, acquired at a cost of \$34 billion. In addition, it leases about 83 million square feet of space in about 27,000 leased locations. Over 1 million federal employees work in these hazardous areas. According to USGS, the potential earthquake damage to buildings would vary between risk areas. In moderate-risk areas some buildings would be damaged, and in very high-risk areas most buildings would be damaged. Figure 2.1 shows the location of seismic risk zones nationwide, table 2.1 details the levels of seismic risk to federal buildings and employees, and figure 2.2 displays the acquisition cost of federally owned buildings by level of seismic risk.

Chapter 2
Close to 200,000 Federal Buildings Are
Located in Seismically Active Areas

Figure 2.1: Seismic Risk Zones Nationwide



Chapter 2
Close to 200,000 Federal Buildings Are
Located in Seismically Active Areas



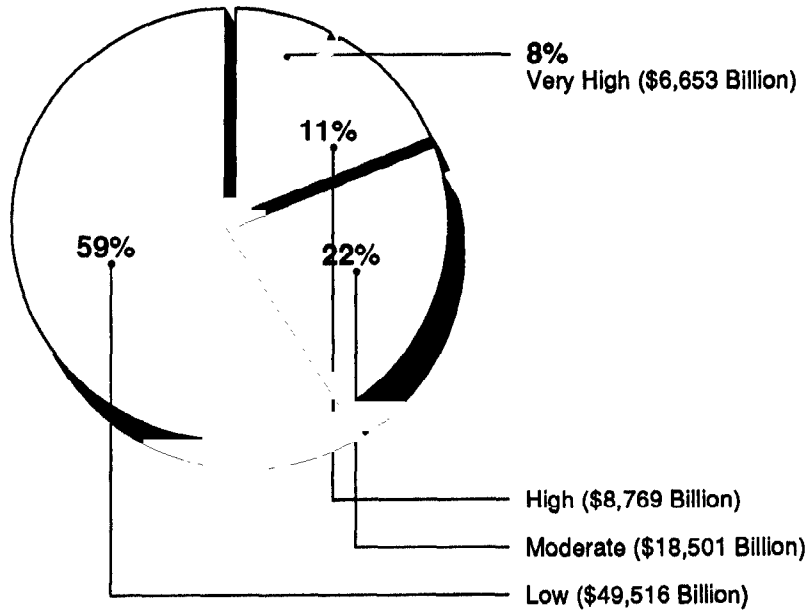
Source: NEHRP Seismic Map.

Chapter 2
Close to 200,000 Federal Buildings Are
Located in Seismically Active Areas

Table 2.1: Federal Buildings, Leased Space, and Employees in Seismic Risk Zones Nationwide

Level of seismic risk	Level of expected damage	Number of owned buildings	Number of leased space locations	Number of employees
Very high	Most buildings	32,000	2,000	218,000
High	Many buildings	52,000	3,000	224,000
Moderate	Some buildings	99,000	22,000	668,000
Low	No buildings	234,000	41,000	1,759,000

Figure 2.2: Acquisition Cost of Federally Owned Buildings in Seismic Risk Zones Nationwide



To illustrate how federal buildings are distributed in earthquake-prone areas throughout the country, we divided the country into five regions—Alaska and Hawaii, the West Coast, the Mountain States, the Central States, and the East Coast. Detailed information on the risk to federal buildings and employees in each region can be found in appendix III.

Alaska and Hawaii

Alaska has a very high level of seismic activity and annually experiences more earthquakes than any other state. Fortunately, most of the earthquakes occur in the sparsely populated Aleutian Islands, although the Great Prince William Sound earthquake in 1964 caused widespread damage to the Anchorage area.¹ Hawaii has a history of moderate earthquakes resulting from volcanic activity. Historical earthquakes for these two states are listed in table 2.2.

Table 2.2: Historical Earthquakes in Alaska and Hawaii

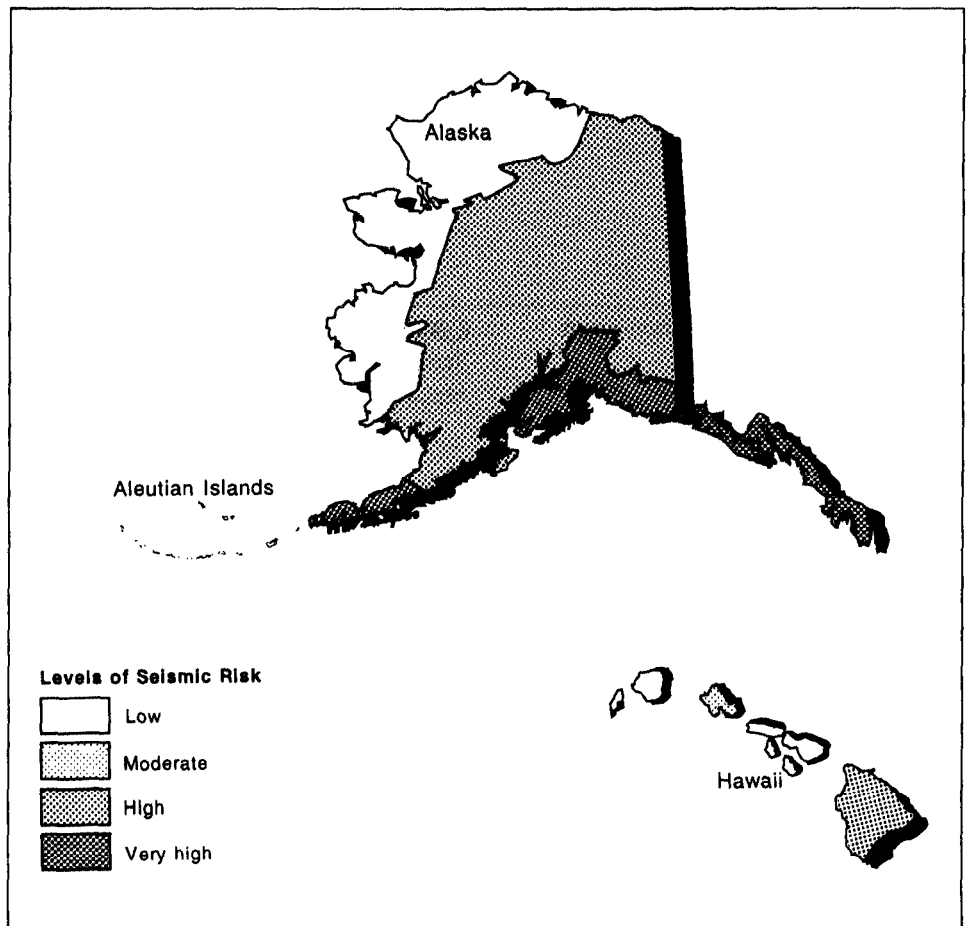
State	Year	Approximate location	Magnitude
Alaska			
	1986	Kodiak Island	7.7
	1979	Mount St. Elias	7.7
	1965	Rat Islands	8.7
	1964	Prince William Sound	9.2
	1957	Andreanof Islands	9.1
	1938	Shumagin Islands	8.7
	1929	Dutch Harbor	8.6
	1899	Yakutat Bay	8.6
Hawaii			
	1983	Mauna Loa	6.6
	1975	Northeast of Hawaii	7.2
	1973	Northeast of Hawaii	6.3
	1954	Kalapana	6.5
	1951	Kilauea	6.5
	1951	Kona	6.9
	1938	Maui	6.7

Source: USGS.

¹USGS notified the state of Alaska that one or more major earthquakes near magnitude 8 on the Richter scale, nearly equal in force to the great 1964 Alaskan earthquake, are due in the Valdez area and could take place at any time.

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Figure 2.3: Levels of Seismic Risk in Alaska and Hawaii

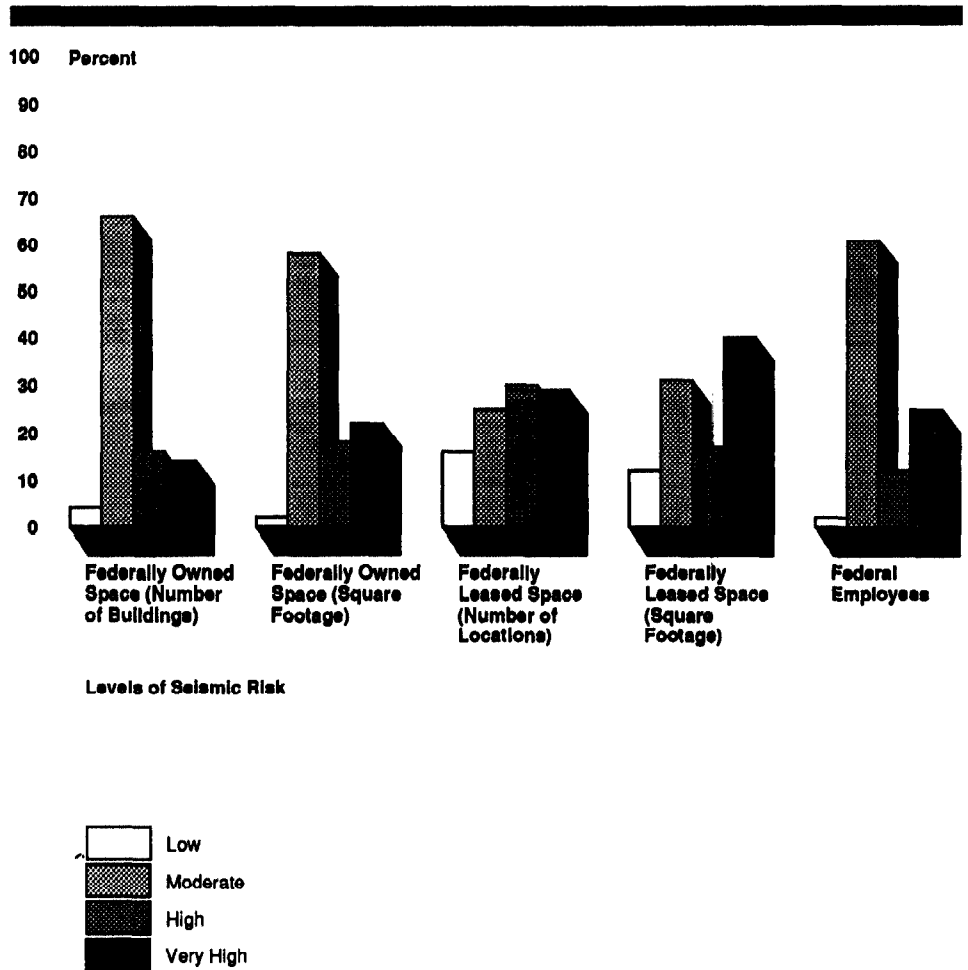


Source: NEHRP Seismic Map.

Figure 2.3 shows the location of seismic risk zones in Alaska and Hawaii. Roughly 40,000 federal employees work in Alaska and Hawaii. The federal government owns about 22,000 buildings, containing 123 million square feet of space, and leases an additional 2 million square feet in these two states.

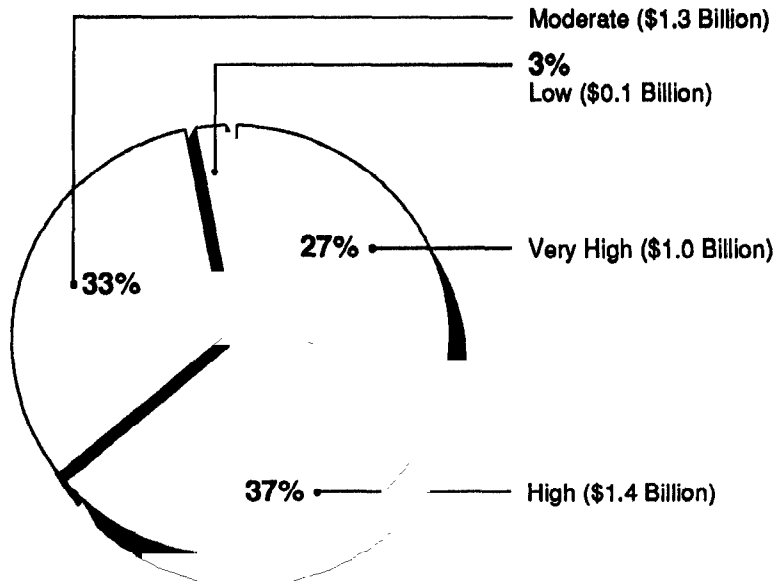
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Figure 2.4: Federal Buildings, Leased Space, and Employees in Seismic Risk Zones of Alaska and Hawaii



Over 85 percent of the federal employees and space in Alaska and Hawaii are in zones of moderate to very high risk (see fig. 2.4). More than 20 percent of employees and government-owned space and about 40 percent of leased space are located in the very high-risk zone along the Alaska coast.

Figure 2.5: Acquisition Cost of Federally Owned Buildings in Seismic Risk Zones of Alaska and Hawaii



The federal government has spent about \$4 billion to acquire the buildings it owns in Alaska and Hawaii. As shown in figure 2.5, the buildings in moderate- to very high-risk zones represent about 97 percent of total acquisition costs.

West Coast States

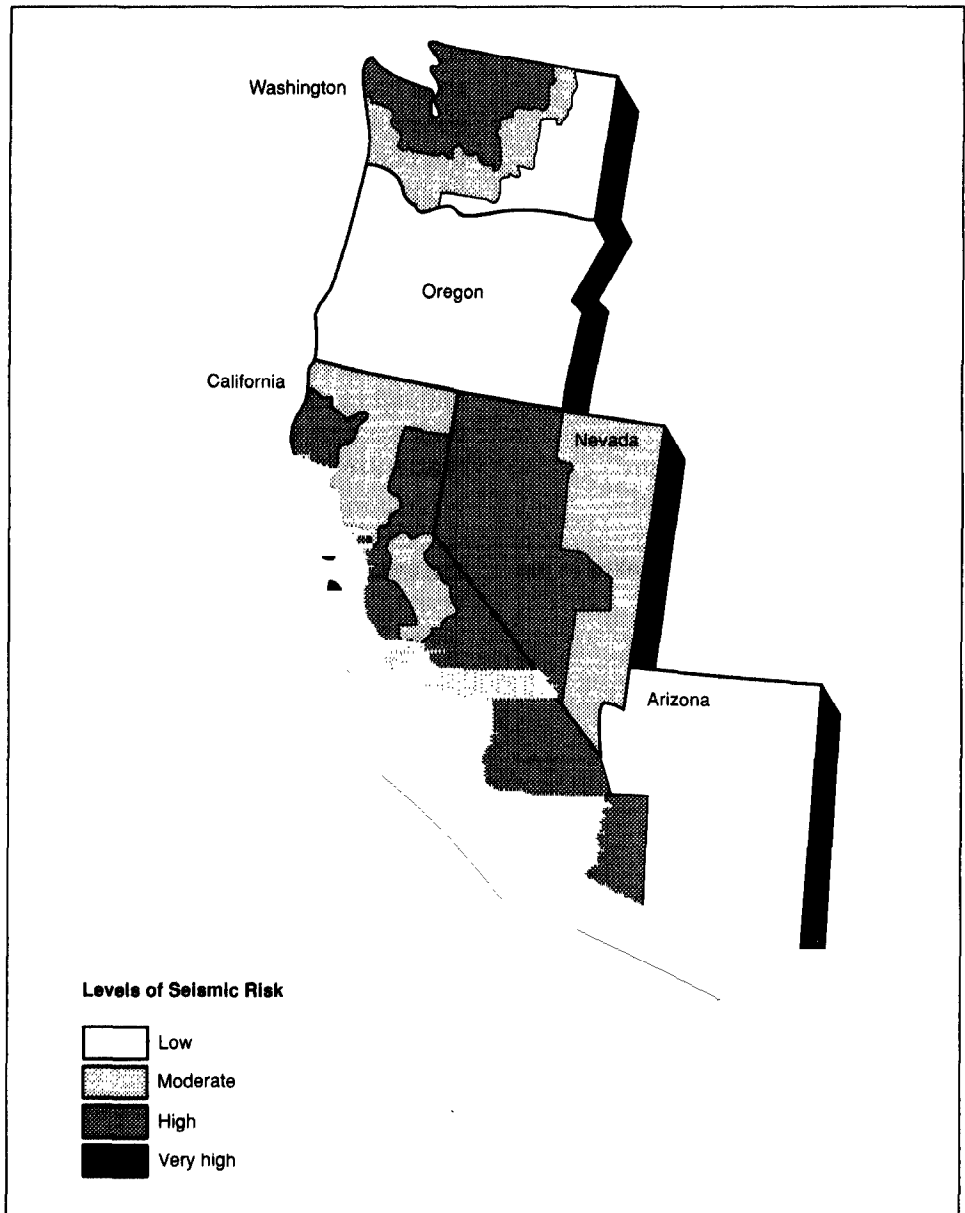
The Pacific Northwest has historically experienced strong and major earthquakes. USGS researchers recently concluded that the Cascadia fault zone could produce a great earthquake of magnitude 8.0 to 9.5 along the coast of Washington and Oregon, although an earthquake of this size has not occurred during recorded history. Along the California coast, many damaging earthquakes have occurred along the San Andreas and other fault zones and will undoubtedly occur in the future. For example, the California Working Group on Earthquake Probabilities estimated a 67-percent chance of a magnitude 7.0 or greater earthquake in the urbanized San Francisco Bay Area over the next 30 years. The Sierra Nevada in eastern California and western Nevada frequently experiences damaging earthquakes, in bursts of activity that move from fault system to fault system. Historical earthquakes that have occurred in the West Coast States are listed in table 2.3.

Table 2.3: Historical Earthquakes in the West Coast States

Year	Approximate location	Magnitude
1989	Loma Prieta Mt., Calif.	7.1
1987	Whittier Narrows, Calif.	6.1
1971	San Fernando, Calif.	6.4
1965	Seattle, Wash.	6.5
1954	Dixie Valley, Nev.	7.3
1954	Fallon, Nev.	6.3
1954	Fallon, Nev.	6.8
1949	Olympia, Wash.	7.1
1946	Tacoma, Wash.	6.3
1932	Cedar Mountain, Nev.	7.3
1906	San Francisco, Calif.	8.3

Source: USGS.

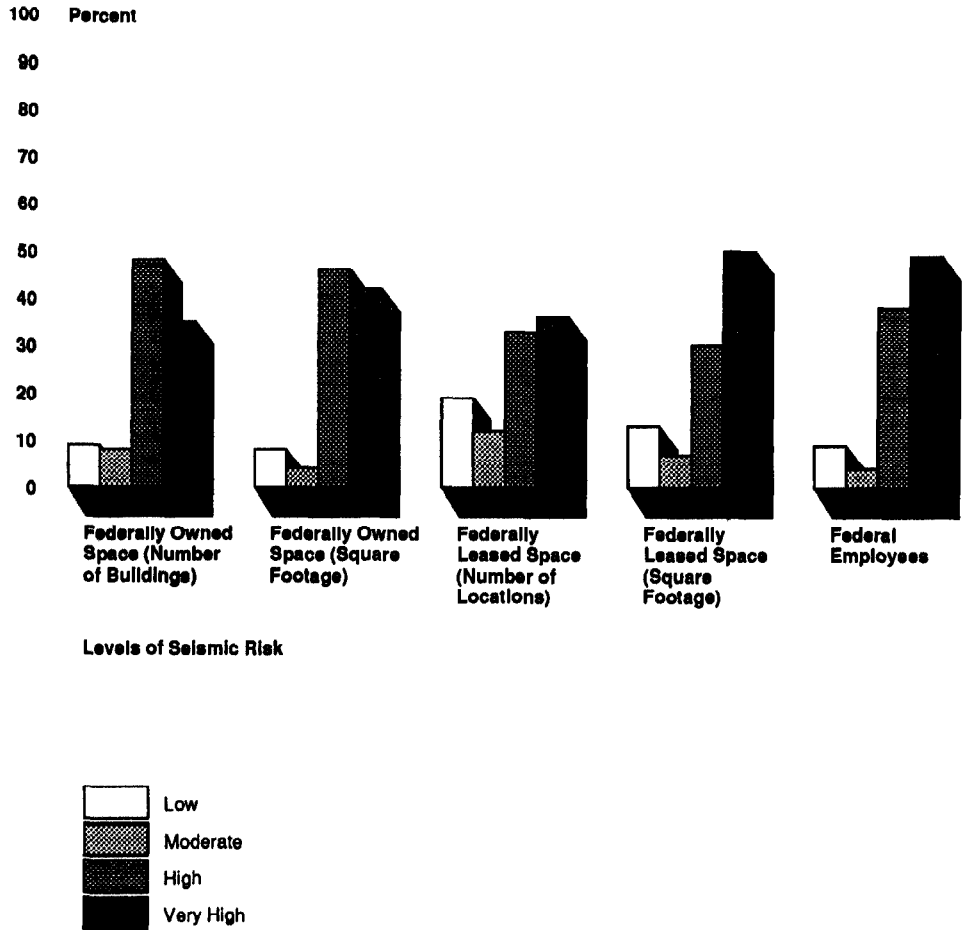
Figure 2.6: Levels of Seismic Risk in the West Coast States



Source: NEHRP Seismic Map.

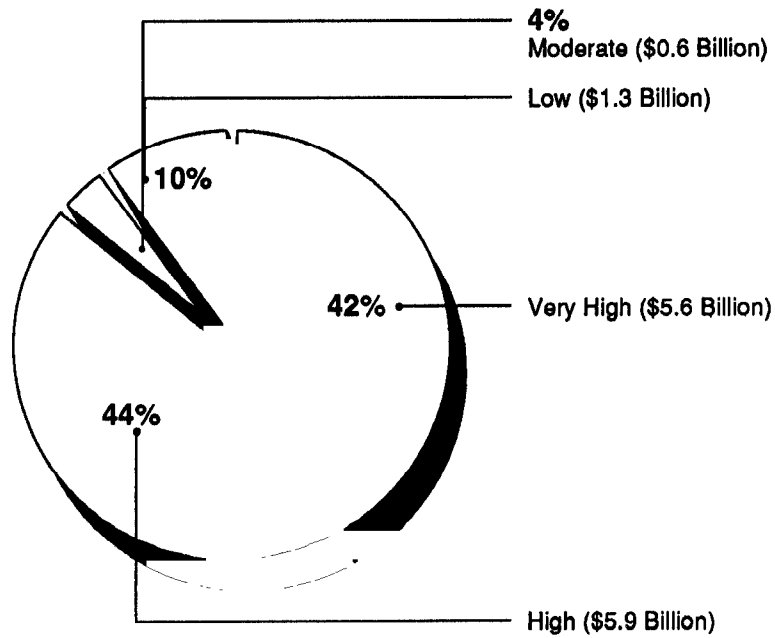
Figure 2.6 shows the location of seismic risk zones along the West Coast. About 422,000 federal employees work in the West Coast States. The federal government owns about 83,000 buildings, containing 471 million square feet, and leases an additional 28 million square feet in this region.

Figure 2.7: Federal Buildings, Leased Space, and Employees in Seismic Risk Zones of the West Coast States



As shown in figure 2.7, over 85 percent of the federal space and employees on the West Coast are in zones of moderate to very high risk. More than 40 percent of federal space and employees are in the very high-risk zone along the California coast.

Figure 2.8: Acquisition Cost of Federally Owned Buildings in Seismic Risk Zones of the West Coast States



The federal government has spent about \$13 billion to acquire the buildings it owns in the West Coast States. As shown in figure 2.8, the buildings in moderate- to very high-risk zones represent about 90 percent of total acquisition costs.

Mountain States

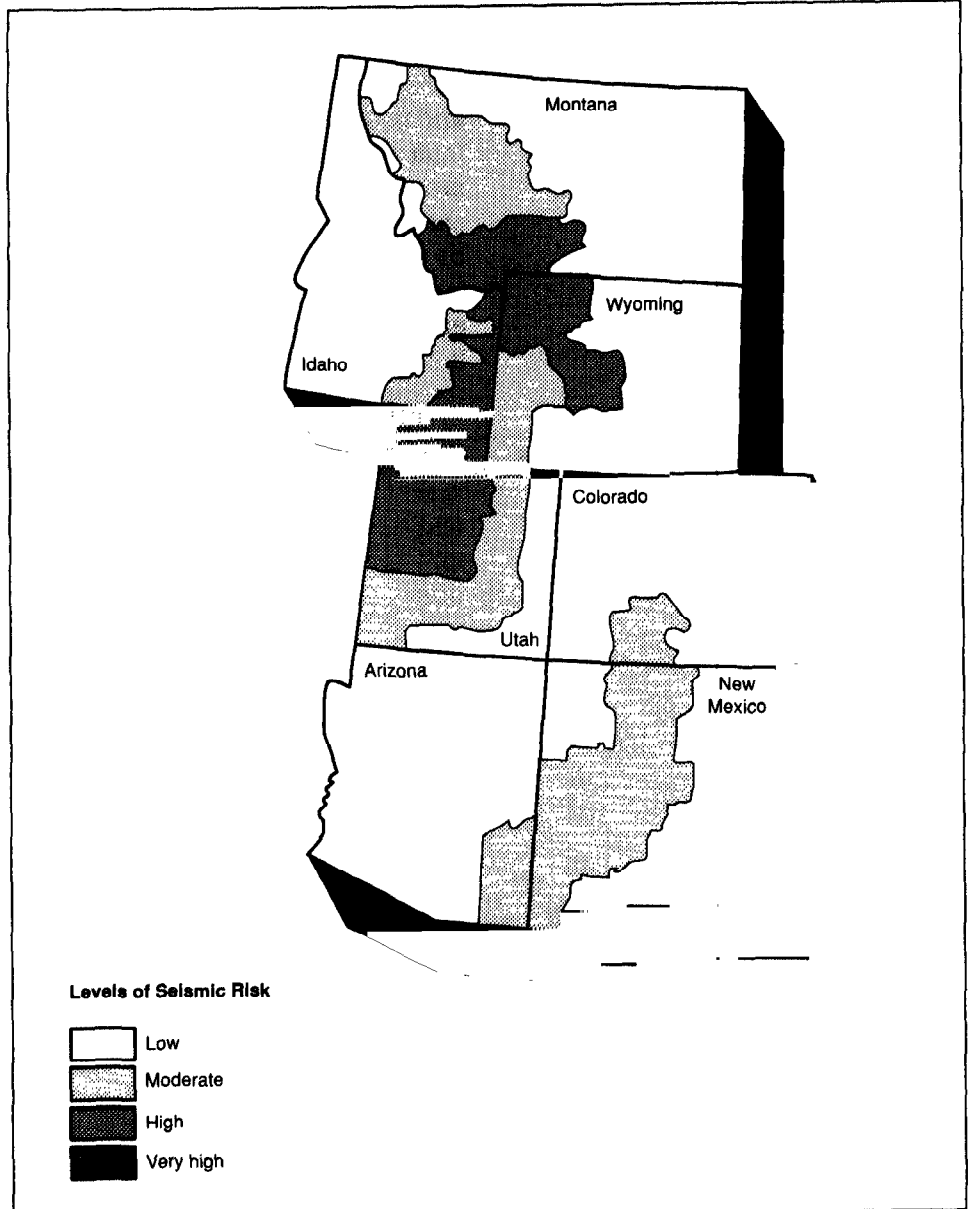
One of the greatest areas of concern in the Mountain States is the Wasatch fault zone, which lies under the Great Salt Lake Basin in Utah. About 75 percent of Utah's population lives within 10 miles of the Wasatch Fault, and USGS researchers believe the potential for a large earthquake along this fault is considerable. Strong and major earthquakes also occur in and around Yellowstone National Park, Wyoming, but the cause of these earthquakes is not well understood. Arizona and New Mexico are underlaid by the Rio Grande Rift and other faults, which have generated moderate to large earthquakes sporadically throughout the region. Historical earthquakes that have occurred in the Mountain States are listed in table 2.4.

Table 2.4: Historical Earthquakes in the Mountain States

Year	Approximate location	Magnitude
1983	Lost River Mts., Idaho	7.3
1975	Yellowstone National Park	6.4
1975	Pocatello Valley, Idaho	6.1
1962	Salt Lake City, Utah	5.2
1959	Yellowstone National Park	7.1
1935	Helena, Mont.	6.0
1935	Helena, Mont.	6.2
1934	Helena, Mont.	6.7
1934	Hansel Valley, Utah	6.0
1934	Hansel Valley, Utah	6.6

Source: USGS.

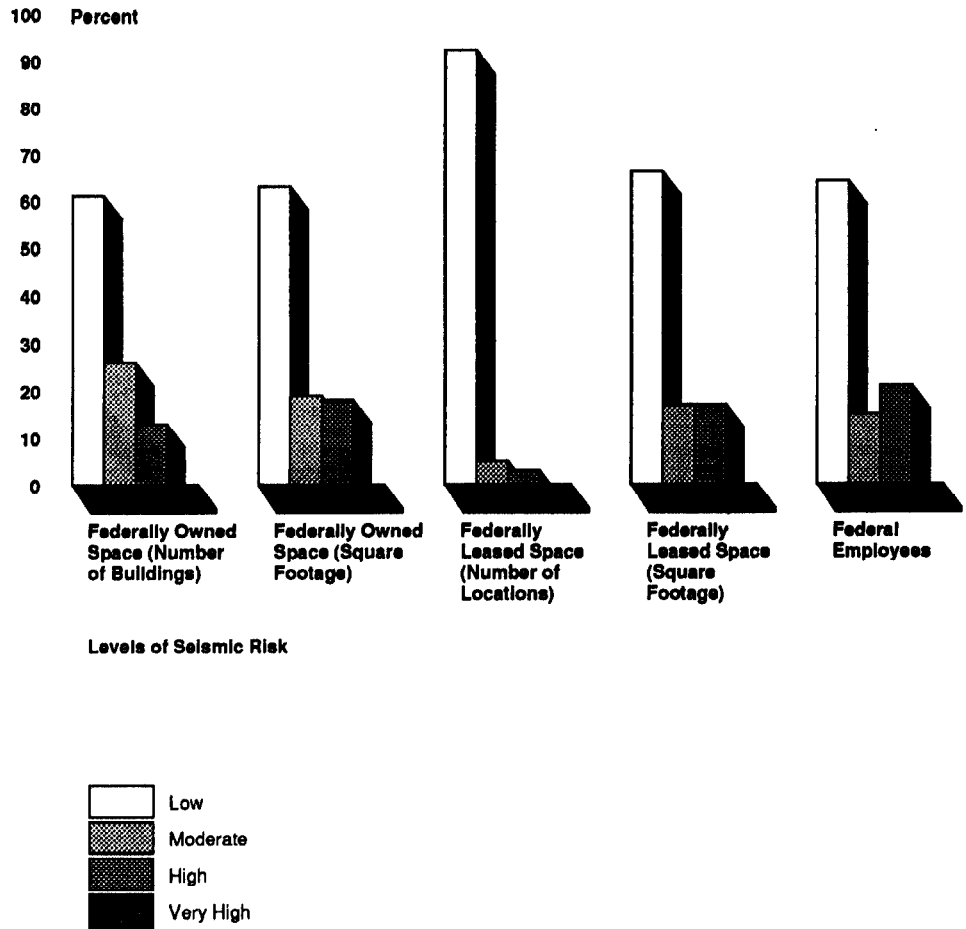
Figure 2.9: Levels of Seismic Risk in the Mountain States



Source: NEHRP Seismic Map.

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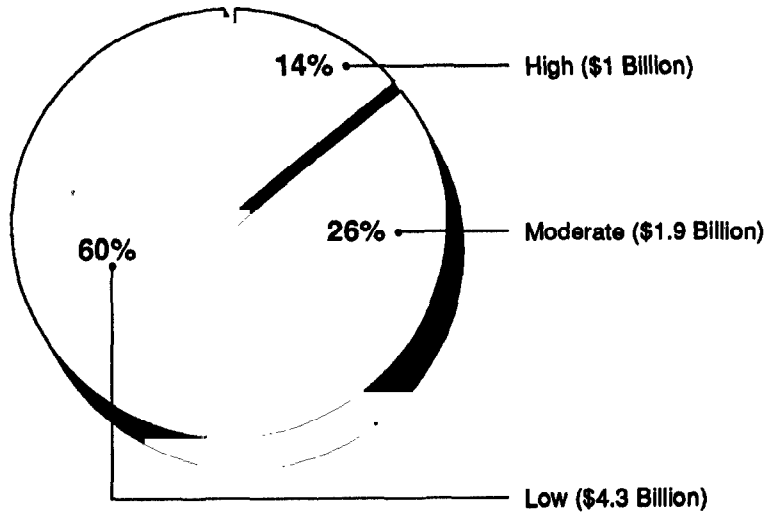
Figure 2.10: Federal Buildings, Leased Space, and Employees in Seismic Risk Zones of the Mountain States



Note: There are no very high seismic risk zones in the Mountain States.

Figure 2.9 shows the location of seismic risk zones in the Mountain States. Approximately 180,000 federal employees work in the Mountain States. The federal government owns about 54,000 buildings, containing 237 million square feet, and leases an additional 14 million square feet in this region. As shown in figure 2.10, over 33 percent of the federal space and employees located in the Mountain States are in moderate- and high-risk zones.

Figure 2.11: Acquisition Cost of
Federally Owned Buildings in Seismic
Risk Zones of the Mountain States



Note: There are no very high-risk zones in the Mountain States.

The federal government has spent about \$7 billion to acquire the buildings it owns in the Mountain States. As shown in figure 2.11, the buildings located in moderate- to high-risk zones represent about 40 percent of total acquisition costs.

Central States

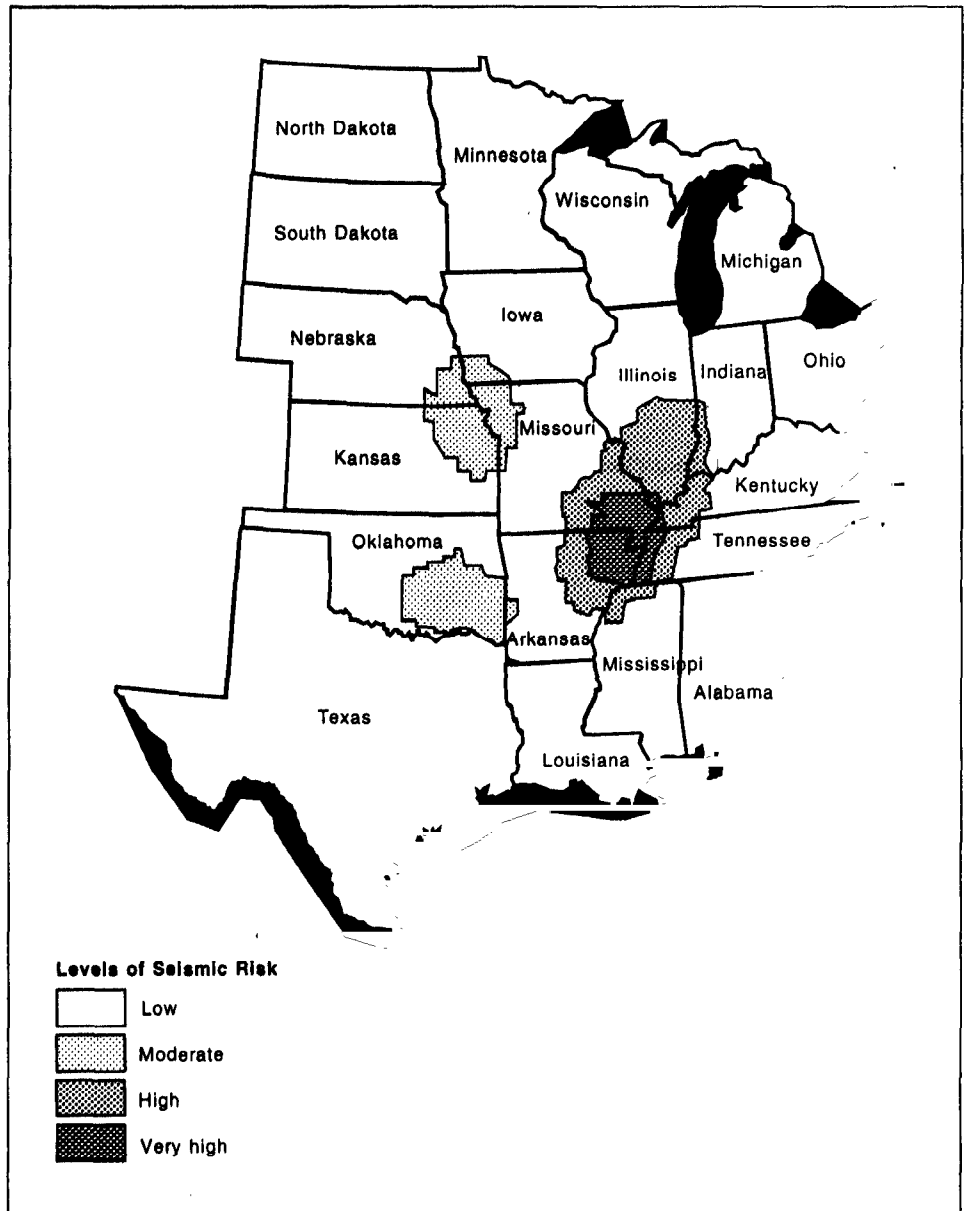
The area of greatest concern in the Central States is the New Madrid seismic zone. Located in the Mississippi River Valley, this buried fault zone produced three great earthquakes in the early 1800s and remains the most seismically active area east of the Rockies. Although researchers do not expect a great earthquake to occur along the fault in the near future, Memphis State University researchers estimate a 40- to 63-percent chance of a magnitude 6.0 earthquake along the New Madrid seismic zone by the year 2000. Seismic activity in the Nebraska-Kansas and Oklahoma-Arkansas regions is not well understood, but moderate earthquakes have occurred throughout the region. Historical earthquakes in the Central States are listed in table 2.5.

Table 2.5: Historical Earthquakes in the Central States

Year	Approximate location	Magnitude
1980	Sharpsburg, Ky.	5.1
1968	Southern Illinois	5.5
1906	Manhattan, Kan.	5.5
1867	Manhattan, Kan.	5.3
1812	New Madrid, Mo.	8.4
1812	New Madrid, Mo.	8.7
1811	New Madrid, Mo.	8.6

Source: USGS.

Figure 2.12: Levels of Seismic Risk in
the Central States



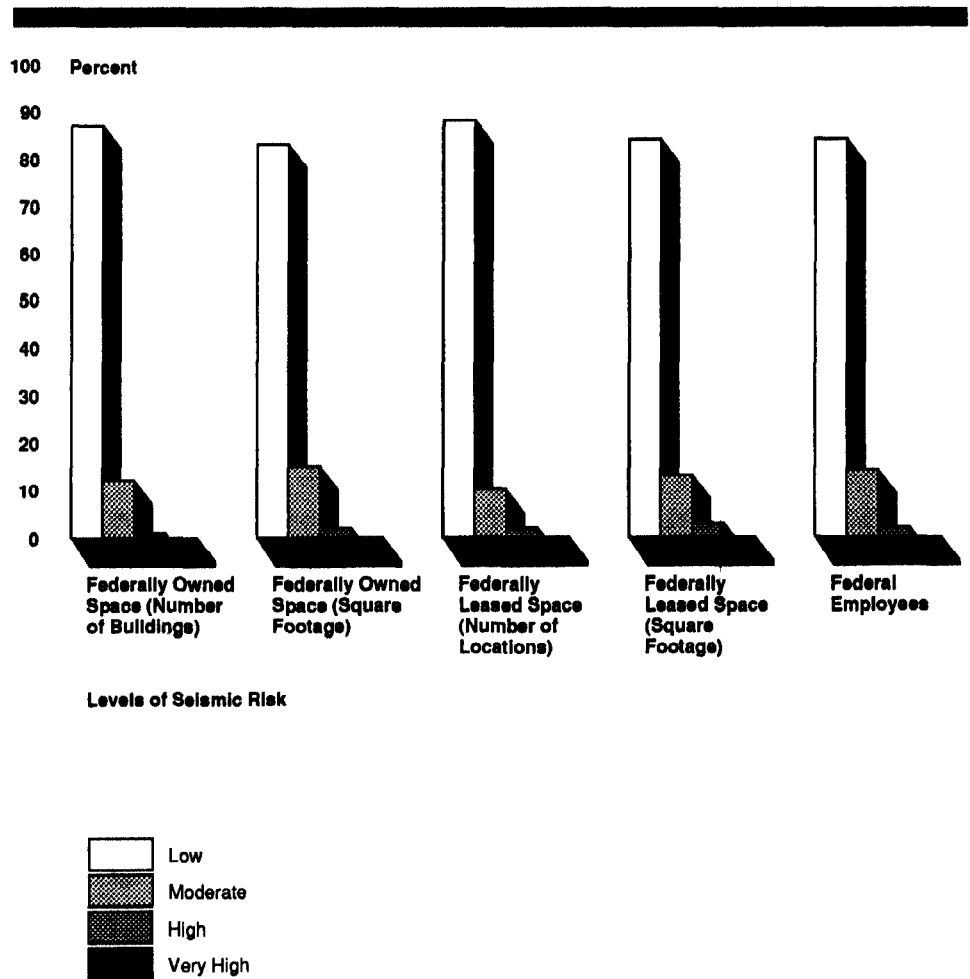
Source: NEHRP Seismic Map.

Figure 2.12 shows the location of seismic risk zones in the Central States. About 917,000 federal employees work in the Central States. The federal government owns about 131,000 buildings, containing 885 million square feet, and leases an additional 72 million square feet in this region. As

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shown in figure 2.13, about 16 percent of federal space and employees in the Central States are in moderate- to high-risk zones. Relatively few federal buildings and employees are in high-risk areas—about 2 percent of employees and space. Overall, this region has a low seismic risk because many of the Central States, such as Texas, North Dakota, and Wisconsin, experience little seismic activity. However, a significant number of federal buildings and employees are located along the New Madrid seismic zone. Roughly 72 million square feet of owned space, 6 million square feet of leased space, and more than 88,000 federal employees are in moderate- to high-risk areas along the New Madrid seismic zone.

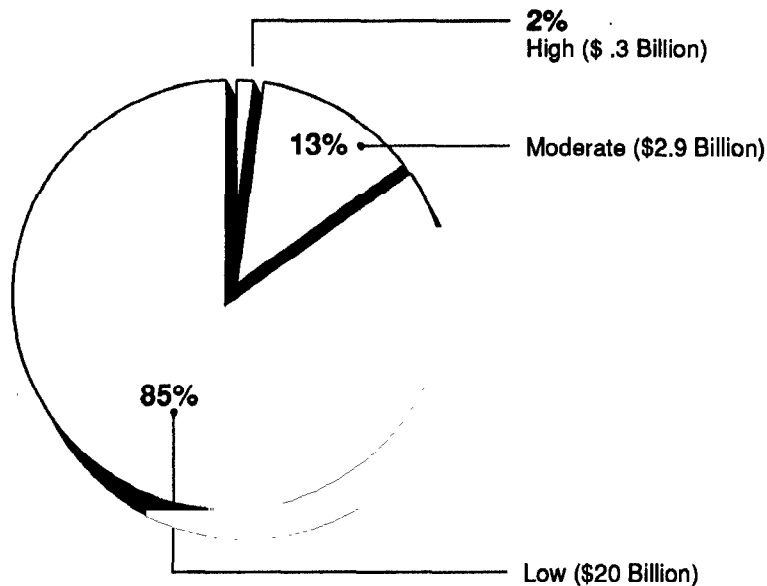
Figure 2.13: Federal Buildings, Leased Space, and Employees in Seismic Risk Zones of the Central States



Note: There are no very high seismic risk zones in the Central States.

The federal government has spent about \$23 billion to acquire the buildings it owns in the Central States. As shown in figure 2.14, the buildings in moderate- and high-risk areas represent about 15 percent of total acquisition costs.

Figure 2.14: Acquisition Cost of Federally Owned Buildings in Seismic Risk Zones of the Central States



Note: There are no very high seismic risk zones in the Central States.

East Coast

The causes of earthquakes along the East Coast are not as well understood as those in California. Although East Coast earthquakes are relatively infrequent, these earthquakes affect larger geographic regions than comparable earthquakes in California. An East Coast earthquake can create a ground shaking hazard to tall buildings located up to 500 miles away from the earthquake's epicenter. The South Carolina coast generally has a low level of seismic activity, but it experienced a major earthquake in 1886. Researchers believe that damaging earthquakes could recur in the area in the future. Major earthquakes have occurred near New York's St. Lawrence Valley, but the rest of the Northeast generally experiences scattered, minor earthquakes. Historical earthquakes in the region are listed in table 2.6.

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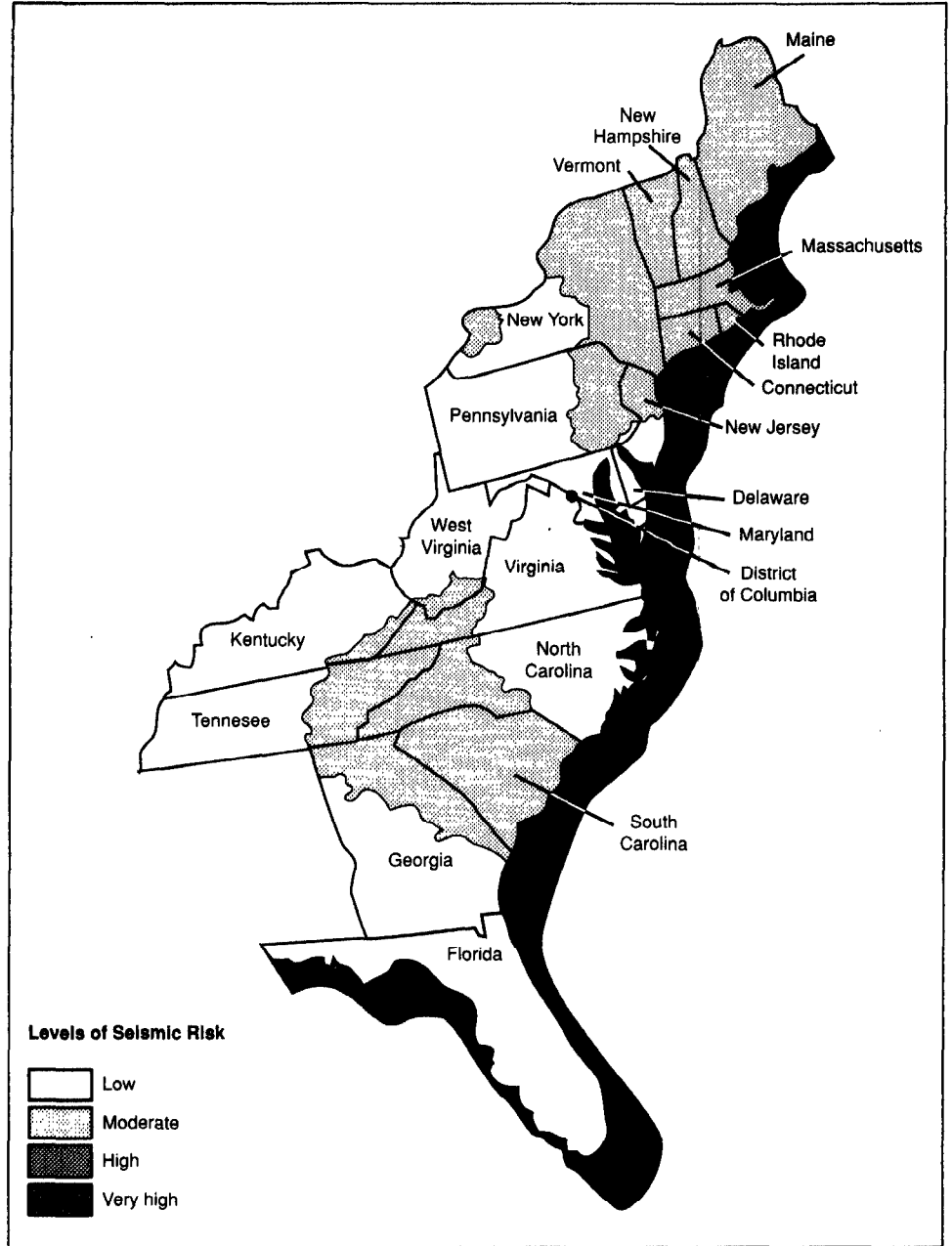
Table 2.6: Historical Earthquakes in the East Coast States

Year	Approximate location	Magnitude
1944	St. Lawrence Valley	6.0
1929	Attica, N.Y.	5.5
1925	St. Lawrence Valley	7.0
1913	Union County, S.C.	6.0
1897	Giles County, Ga.	6.3
1886	Charleston, S.C.	7.7
1755	Cape Ann, Mass.	6.5
1663	St. Lawrence Valley	7.0
1638	St. Lawrence Valley	7.0

Source: USGS.

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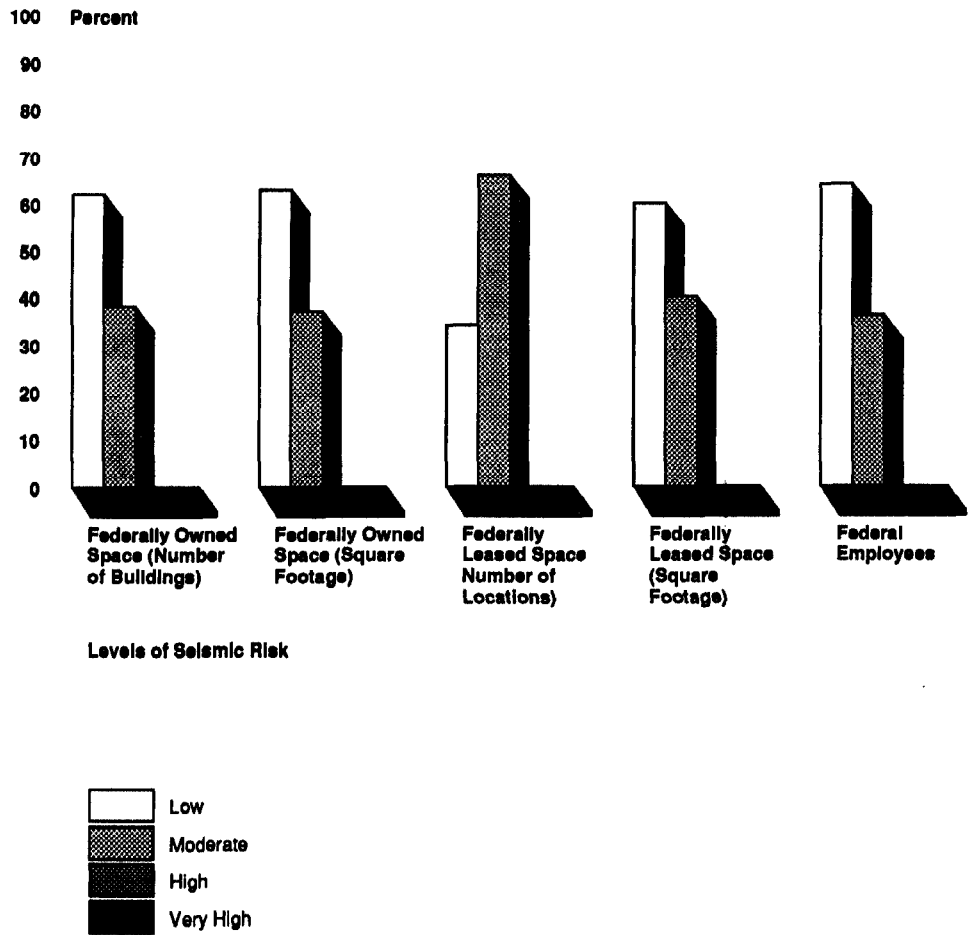
Figure 2.15: Levels of Seismic Risk in the East Coast States



Source: NEHRP Seismic Map.

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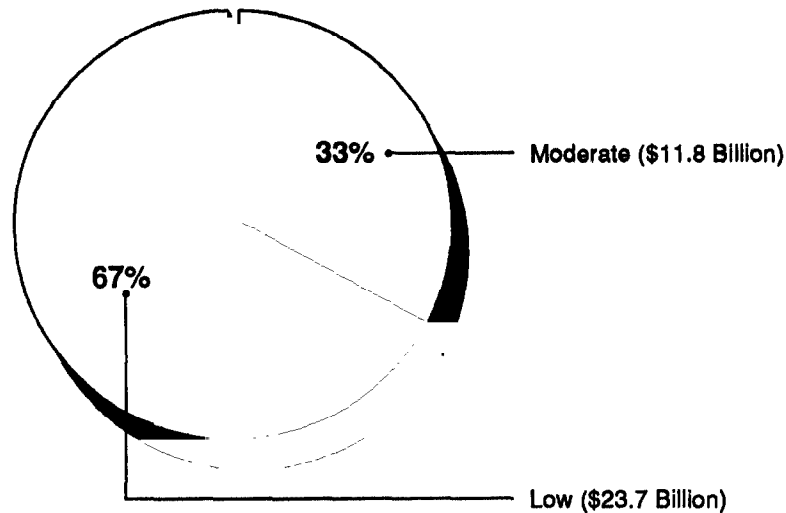
Figure 2.16: Federal Buildings, Leased Space, and Employees in Seismic Risk Zones of the East Coast States



Note: There are no very high or high seismic risk zones in the East Coast States.

Figure 2.15 shows the location of seismic risk zones along the East Coast. Roughly 1.3 million federal employees work along the East Coast. The federal government owns about 127,000 buildings, containing 1 billion square feet, and leases an additional 102 million square feet in this region. As shown in figure 2.16, over 36 percent of the federal employees and space on the East Coast are located in moderate-risk areas.

Figure 2.17: Acquisition Cost of Federally Owned Buildings in Seismic Risk Zones of the East Coast States



Note: There are no very high or high seismic risk zones in the East Coast States.

The federal government has spent about \$35 billion to acquire the buildings it owns on the East Coast. As shown in figure 2.17, the buildings located in moderate-risk areas represent about one-third of total acquisition costs.

Factors Contributing to Earthquake Vulnerability

Although location plays a major role in determining whether buildings are seismically vulnerable, an earthquake will cause different levels of damage to buildings—even when they are located in the same risk zone. One building may be destroyed, while a nearby building remains untouched. The difference in damage results from a number of factors, most importantly, construction type and the properties of the underlying soils.

There is reason to be concerned about the 183,000 buildings located in moderate to very high seismic risk zones. However, the number of buildings actually at risk cannot be determined without information on their construction type and soil properties. We found that most agencies lack comprehensive data on these factors for their buildings. According to USGS, such information should be gathered through a rigorous study of the seismic vulnerability of federal buildings. Nevertheless, we attempted to

provide some perspective on this issue by obtaining some anecdotal information on these factors for several buildings from three agencies.

Construction Type

A building's resistance to earthquake damage depends partly on its strength and flexibility. Buildings constructed of stiff, brittle materials, such as brick or concrete, do not sway with earthquake vibrations. They are more likely to suffer severe structural damage or collapse than buildings constructed with strong and/or flexible materials, such as wood or steel.

Structural engineers have developed classification systems ranking the relative vulnerability of construction types on the basis of their observations of building damage from major earthquakes over the years. Although there are a variety of classification schemes, the following descriptions, ranked from most to least vulnerable, are commonly used to distinguish among construction types:

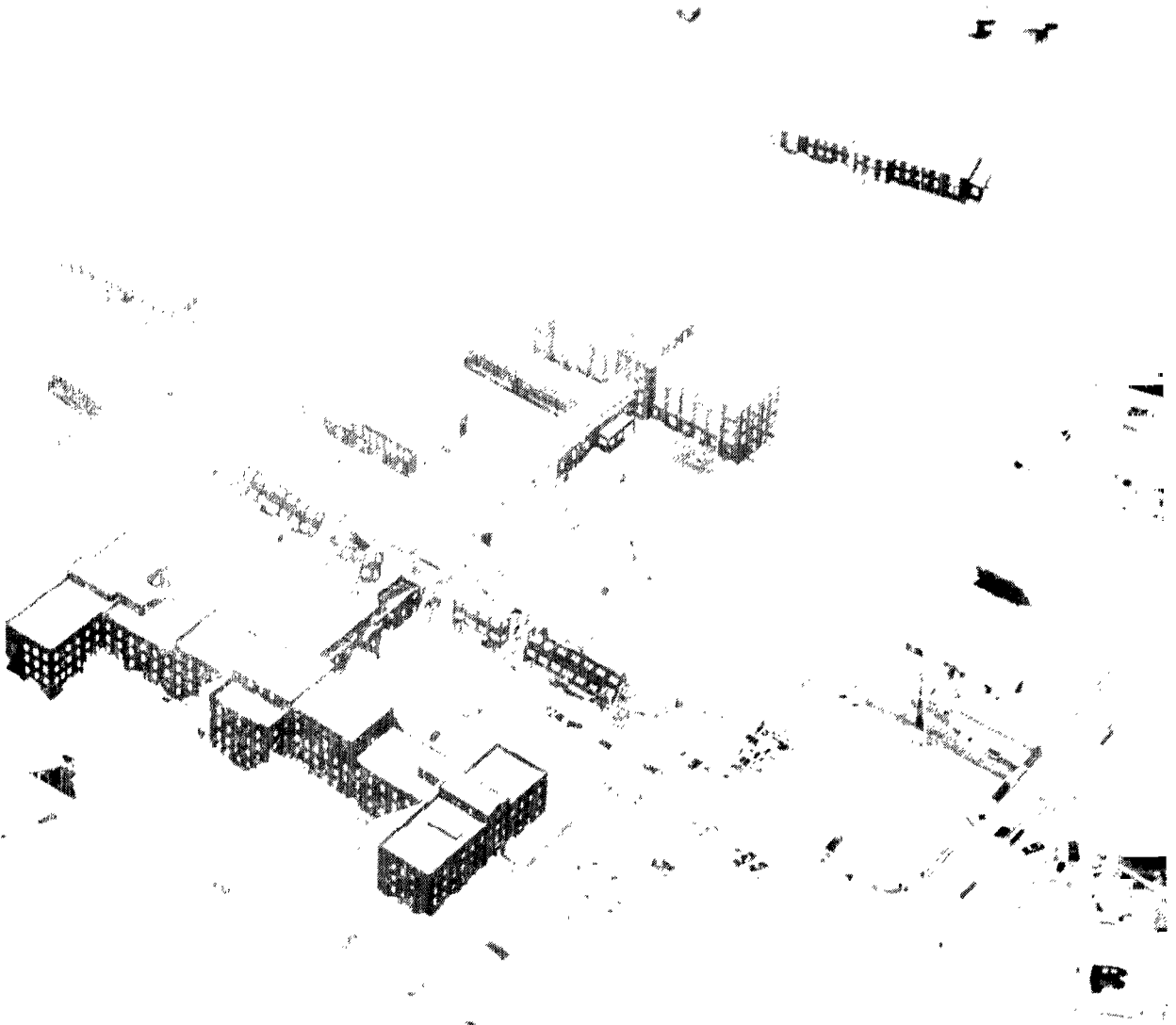
1. Unreinforced masonry (e.g., brick).
2. Tilt-up concrete (buildings constructed by casting large concrete slabs at the construction site and tilting them up into place).
3. Reinforced concrete (concrete buildings with steel-reinforced columns and beams).
4. Reinforced masonry (masonry buildings usually with steel-reinforced columns and beams or steel structural bracing).
5. Steel frame (buildings with a structural steel frame, combined with walls of a different material).
6. Wood frame.
7. Light metal (buildings with light metal stud walls with metal sheathing or a stucco finish).

Some construction types, such as brick buildings, are likely to sustain several times as much damage as steel frame buildings.

Although information on construction type is not readily available governmentwide, federal agencies provided some limited information on their overall building inventory, along with specific examples of vulnerable buildings. For example, the Navy estimated that 80 percent of its buildings in Memphis, Tennessee, which could be affected by an earthquake along the New Madrid seismic zone, were constructed with unreinforced masonry.

One long-standing concern has been the construction type of hospitals, which have an earthquake-response role and generally a high occupancy rate. After the Loma Prieta earthquake, the main building of a VA Medical Center in Palo Alto, which was constructed of reinforced concrete, was condemned because of structural and nonstructural damage. The building had previously been identified as hazardous, after a VA hospital of the same construction type collapsed during the 1971 San Fernando earthquake and killed 46 people. The earthquake damage to the VA Hospital in San Fernando, California, is shown in figure 2.18. VA's Palo Alto Center lost 270 hospital beds and 300,000 square feet of hospital, clinical, and laboratory space. According to VA, the cost to rebuild the facility was estimated at \$180 million.

Figure 2.18: VA Hospital in San Fernando, California, After the 1971 Earthquake



Source: VA.

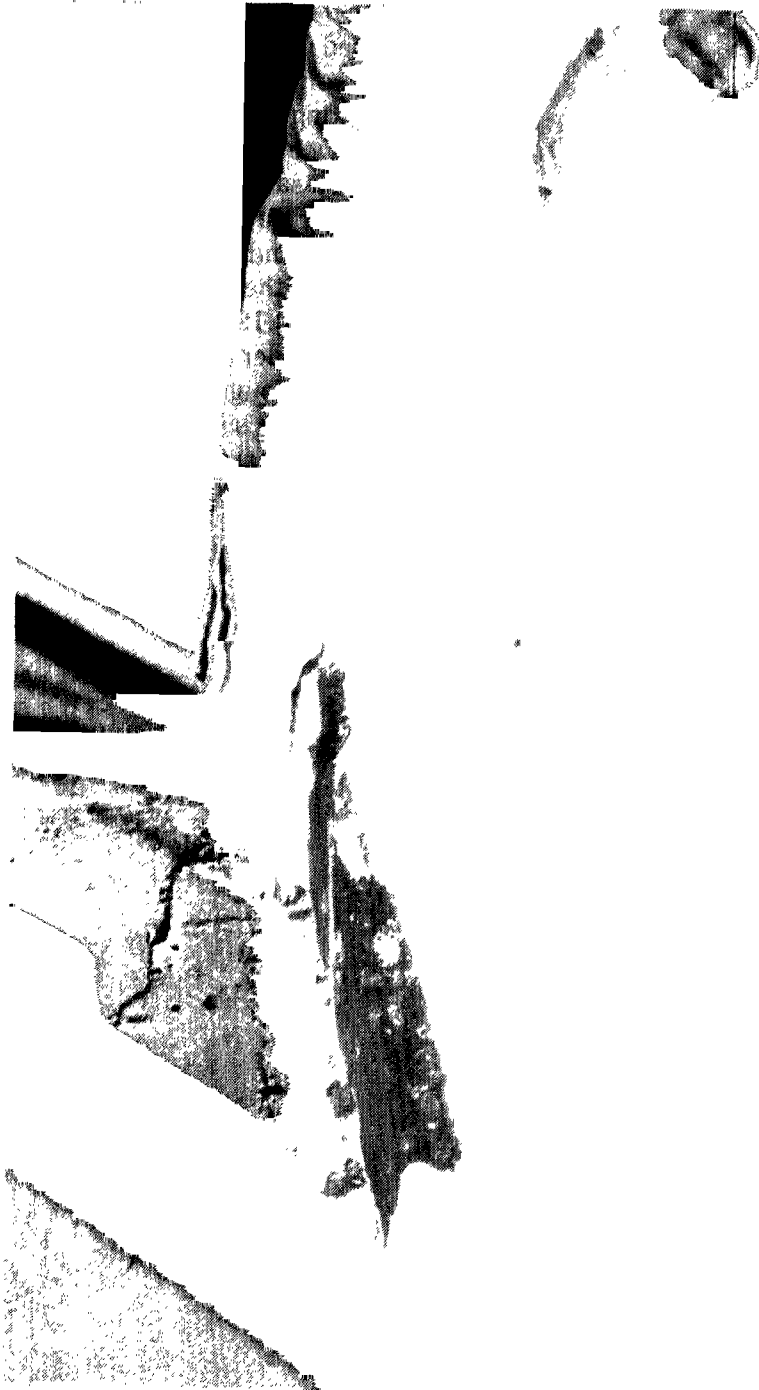
Engineering studies indicate that other hospitals may be at risk during future earthquakes. For example, VA's General Medical Hospital in Memphis has been known for 15 years to need major structural strengthening because of inadequate seismic design and construction. In 1976 VA engineering studies concluded that parts of the building, including the intensive care unit, were subject to serious failures or collapse. VA said that replacement facilities are being planned and designed for this building. Similarly, Oakland Naval Hospital is constructed of reinforced concrete and could collapse in an earthquake stronger or closer than Loma Prieta. In commenting on a draft of this report, the Department of Defense (DOD) said that its buildings are constructed to local building codes; it recognized that local codes frequently are inconsistent in the application of seismic safety provisions. Specifically, DOD said that the Oakland Hospital is at high risk because it was designed to comply with the 1965 building code, which had inadequate seismic design requirements for reinforced concrete. DOD also pointed out, and we agree, that a reinforced concrete facility designed and built to comply with appropriate seismic safety provisions will be less vulnerable to earthquakes.

Soil Properties

Soil properties greatly influence the level of earthquake vibrations that a building sustains. Solid, stable bedrock tends to dampen earthquake motion, while soft, loose soil can intensify or amplify ground shaking to match earthquake motion or undergo liquefaction. These two phenomena, amplified ground shaking and liquefaction, are of particular concern. Amplified ground shaking occurs when deep, soft soil deposits enhance the level and length of earthquake vibrations that occur within a second. Buildings typically sway back and forth and have a natural frequency of vibration (i.e., movement per second). Therefore, buildings whose natural frequency matches the frequency of soft soil shaking can suffer much greater shaking than buildings on bedrock, even if the latter are located closer to the earthquake's epicenter. Liquefaction occurs when earthquake ground shaking causes loose, water-saturated sandy or clay soils to temporarily act like a liquid instead of a solid. This liquefied soil loses its bearing strength and is unable to support the foundations of the buildings above. Buildings on liquefiable soils may sustain partial or total collapse of their foundations.

Most of the deaths and structural damage caused by Loma Prieta, including the collapsed Cypress Freeway in Oakland, occurred in areas with underlying soft soil. One federal facility severely affected by both amplified ground shaking and liquefaction during that earthquake was Treasure Island, a Navy installation. An artificial island created by placing sandy bay fill on top of a sandbar and bay mud, Treasure Island suffered ground shaking two or three times stronger than that experienced at a nearby natural rock island. The foundation of one large building settled nearly 6 inches, causing the east wall to pull loose from the ceiling and nearly cave inward. Figure 2.19 shows some of the damage to the foundation. The floor slabs in some older buildings separated, and sand flowed down the hallways and through the rooms. Repairing and replacing the damaged buildings will cost several million dollars, and Navy engineers believe that a larger magnitude or closer earthquake could cause much greater structural damage at Treasure Island.

Figure 2.19: Settled Foundation of a Building at Treasure Island, California, Caused by Loma Prieta



Similar soil conditions tend to occur along coastlines and waterways, and geotechnical engineers are concerned about such areas in Memphis, St. Louis, Anchorage, and Charleston. For example, Memphis lies within the Mississippi Embayment, a trough-like depression filled with thousands of feet of sediment. Because of the soft soil and high water tables, experts believe the Memphis area could experience both amplified ground shaking and liquefaction during an earthquake along the New Madrid seismic zone. One federal building in Memphis that could be threatened by poor soil is the Clifford Davis Federal Building, located two blocks from the Mississippi River. This building houses several courtrooms, 3 congressional offices, numerous federal agencies, and about 1,200 federal employees. A 1990 seismic study concluded that a severe earthquake could collapse the ceilings and interior walls, sever electrical power, and dislodge 6,000-pound exterior panels that would fall to the plaza below. In addition, the soil underneath the building could liquefy and cause a catastrophic structural failure. GSA plans to address these problems by 1994.

Conclusion

Approximately 40 percent of federal buildings and employees are located in seismic risk zones with a moderate or greater risk of earthquake damage. About 15 percent of federal buildings and employees are in zones of high to very high seismic risk. However, some federal buildings are at greater risk than others because of building and site characteristics, such as construction type and soil properties. Although there is reason to be concerned about the 183,000 buildings located in seismically active zones, the number of buildings actually at risk of damage cannot be determined without a rigorous study to gather additional information on these characteristics.

Federal Agencies' Efforts to Reduce Seismic Vulnerability of Buildings Have Been Limited

Although the federal government has a forum to address seismic safety issues for federal buildings, seismic safety efforts of the six agencies we reviewed have been limited. Four agencies—VA, the Navy, GSA, and the Postal Service—have established seismic safety programs to identify vulnerable buildings. Of the four, VA has made the most progress in improving the earthquake-resistance of its vulnerable buildings. Agencies said limited funding slowed their progress in completing seismic studies and retrofits, especially since these projects must compete with all other design and construction projects for scarce resources. On the basis of engineering studies completed so far, four of the agencies estimated that they would collectively need about \$2 billion to complete needed retrofit projects. And buildings with completed studies represent only a portion of those that are vulnerable and may need retrofiting.

The six agencies' efforts to assess and reduce the seismic risks of leased space have also been limited. Only three agencies—VA, GSA, and the Postal Service—have programs that give priority to leasing seismically safe space. The Postal Service has also recently started a program to assess its existing leased space. The other three agencies—the Departments of the Army, Navy, and Air Force—assume that leased buildings are safe if they were constructed to local building codes; however, as we noted in chapter 2, experts agree that codes do not always ensure that a building is seismically safe. Reducing the risk to occupants of leased space presents special problems, because leased buildings are managed and controlled by the private sector.

Governmentwide Efforts to Set Seismic Safety Standards

The Interagency Committee on Seismic Safety in Construction is the forum for governmentwide efforts to address the seismic safety of federal buildings. During its first 9 years, ICSSC concentrated on the development of seismic guidelines and standards for designing and constructing new federal buildings. In 1987 ICSSC issued seismic design guidelines for new buildings. In January 1990, Executive Order 12699 directed federal departments and agencies to implement, at a minimum, nationally recognized seismic safety standards for both new federal buildings and new space constructed for federal lease. The order does not require agencies to replace or revise existing seismic safety programs if they meet or exceed the order's minimum standard. Rather, the order requires agencies without programs to establish programs that comply with the order, and agencies with less stringent programs to take action to meet the minimum standard.

Since 1987, ICSSC has given priority to developing seismic safety standards for existing buildings. In 1989 it issued guidelines to help federal agencies evaluate their existing buildings for potential earthquake hazards. The 1990 National Earthquake Hazards Reduction Program Reauthorization Act required that ICSSC develop seismic safety standards for existing federal buildings or space leased by the federal government. The act also required that federal agencies and departments adopt these standards before December 1, 1994. Currently, ICSSC is developing these standards to assist the agencies in assessing and enhancing the seismic safety of their existing buildings or leased space. ICSSC expects to complete these standards by December 1993.

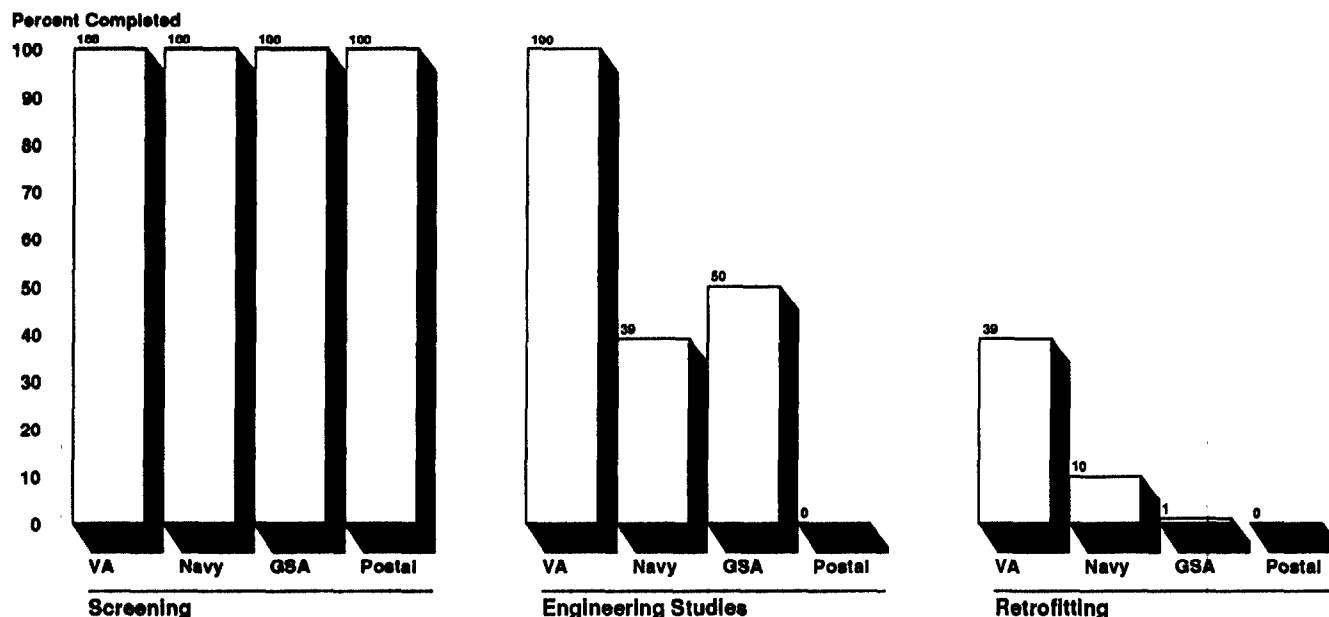
Progress Slow in Reducing Seismic Hazards to Federally Owned Buildings

Only one of the six agencies we reviewed is required to establish a seismic safety program for its owned buildings. After the 1971 San Fernando earthquake caused two VA hospital buildings to collapse, killing 46 people, Congress passed the Veterans Health Care Expansion Act of 1973, which required that all VA medical facilities be earthquake-resistant. During hearings, Congress also recommended that VA identify buildings vulnerable to earthquakes and retrofit them, replace them, or relocate patients. Similar legislative requirements and guidance have not been issued to the other agencies we reviewed.

Although most agencies are not required to assess and reduce seismic hazards to their owned buildings, four of the agencies we reviewed—VA, the Navy, GSA and the Postal Service—have established systematic programs to do so. Since studying all buildings is infeasible, each of these agencies identifies its most vulnerable buildings in order to plan and prioritize needed retrofit work. These agencies generally follow a three-step process to identify and reduce the seismic risk to buildings. First, they screen buildings, based on factors such as seismic risk zone, age, height, and construction type, to identify the buildings most vulnerable to earthquakes. Next, they do engineering studies to identify the potential damage to vulnerable buildings, the options for strengthening the buildings, and the costs of these options. Then, they are able to reduce the risk by either retrofitting the building or vacating it.

Figure 3.1 provides an overview of the progress the four agencies have made in completing each of these three steps. The other two agencies we reviewed, the Army and the Air Force, do not have a program to assess and reduce the seismic risk to their 248,000 buildings.

Figure 3.1: Federal Agencies' Seismic Safety Progress



As figure 3.1 shows, most progress has been made in completing the first two steps—screening buildings and completing engineering studies for buildings at risk. All four agencies have screened their buildings in seismically active areas. VA, the Navy, and GSA have also made significant progress in engineering studies. VA reported that it has completed all necessary studies for its buildings. The Navy has completed about 39 percent of the studies required nationwide. GSA officials told us that they have studied two-thirds of the buildings that require evaluation. As of August 1991, VA had spent about \$4 million for screening and engineering studies; the Navy, an estimated \$11 million; and GSA, \$6.7 million. The Postal Service had spent about \$344,000 on its screening program. Of the four agencies, VA reported the most progress in completing the third step—reducing the risk to buildings vulnerable to earthquakes. It reported having retrofitted 117 of 301 unsafe buildings, or about 40 percent. VA could not estimate its expenditures for these seismic retrofit projects. Although the Navy has identified 329 buildings at serious risk, it has retrofitted only 32, or about 10 percent. The Navy estimated that since 1972 it had spent about \$2.5 million on these seismic retrofit projects. The Navy also said that it had initiated retrofit projects for 80 additional buildings. GSA officials said that of 101 vulnerable buildings so far

identified, only 4 had been retrofitted. GSA estimated that from 1987 through 1991, it had spent about \$13.5 million on major seismic retrofit projects.¹

Although agencies have retrofitted few buildings identified through their systematic screening, they have strengthened some buildings while accomplishing other major repairs or alterations. However, because such seismic work is not tracked separately, agencies could not provide either the number of buildings that have been seismically upgraded in conjunction with other construction or the costs associated with this work.

Actions other than retrofitting, such as abandoning or demolishing a building, would eliminate the risk to federal employees. However, even the agencies that indicated they used these alternatives did so infrequently because of the high costs associated with relocating building occupants and the lack of other available space owned by the government. For instance, the Navy estimated that it had abandoned or demolished seven buildings; GSA estimated that it had abandoned two buildings.

Limited Funding Slows Progress on Seismic Work

Four of the six agencies cited limited funding as the major reason for slow progress in identifying and strengthening seismically unsafe buildings. Currently, the agencies do not receive specific funding for seismic safety. They told us they have insufficient funds for the engineering studies that must be done before retrofit projects can be initiated. Without these studies, it is difficult for agencies to identify their most vulnerable buildings, prioritize retrofit projects, select the best retrofit options, estimate the funds needed to complete retrofit projects, and justify to top agency management and others the funds needed. The Navy estimated that it would need \$7.5 million to complete its engineering studies, and the Army and Air Force estimated that they would need over \$30 million each. GSA estimated that it would need \$20 million over the next 5 years. Moreover, once engineering studies are done, expensive seismic retrofit work has difficulty competing with other construction projects for funding. Agency officials said seismic projects are almost always deferred when competing with more urgent projects, such as repairing leaking roofs.

¹The difference in the ratio of costs to buildings—i.e., the Navy spent about \$78,000 per building, while GSA spent about \$3.4 million per building—is caused in part by variations in the cost of retrofit projects.

Although incorporating seismic safety features into new construction does not significantly increase construction costs, retrofitting a building with seismic safety features is expensive. Further, retrofitting costs include not only the direct costs of materials and labor, but may also include the indirect costs of disrupting operations and temporarily relocating occupants. The direct costs of retrofitting can vary considerably on the basis of such factors as the level of safety chosen, the type of construction, and the desire to preserve historic architecture.

Costs are higher when a building is retrofitted to ensure that it will not sustain serious damage and that operations can continue uninterrupted (known as a functional retrofit) than when it is retrofitted to prevent collapse and ensure unobstructed entry and exit (known as a life-safety retrofit). For example, in 1977 the Navy estimated that retrofitting the Oakland Naval Hospital to a life-safety level would cost about \$9 million, while a functional retrofit would cost \$14 million, plus increased indirect costs for disruption of hospital functions during the retrofit. (According to the Navy, 1991 costs to retrofit this hospital for seismic life safety were estimated at about \$20 million.)

Another important factor in retrofit costs is the building's construction type. According to a 1988 Federal Emergency Management Agency report, the direct costs of retrofitting a building can range from about \$4 to \$13 per square foot.² The report stated that an unreinforced masonry brick building can cost \$6 per square foot, while a reinforced concrete building can cost about twice as much. However, agency officials told us that in their experience retrofitting costs are much higher. For example, VA officials said the cost to retrofit hospital space is about \$30 to \$50 per square foot.

Costs can also increase when construction must not alter the original architectural features of a historic building. For instance, construction costs are estimated at \$1.1 million, or about \$50 per square foot, for retrofitting a small brick historic building housing the U.S. Post Office and courthouse in Eureka, California. The total cost to retrofit this building would be about twice the property's estimated market value.

Since most agencies have not completed seismic engineering studies, they could not accurately estimate the total amount of funding needed in the

²Typical Costs for Seismic Rehabilitation of Existing Buildings, Federal Emergency Management Agency, FEMA 156 (July 1988).

future to complete seismic retrofit projects. However, VA, the Navy, GSA, and the Postal Service identified a combined need of about \$2 billion to reduce the risk to buildings that have been studied. Considering this figure, as well as the number of vulnerable buildings so far identified but not studied and the number as yet unscreened at other agencies, it is apparent that limited funding will continue to impede completion of seismic retrofit projects for federal buildings.

Agencies' Efforts to Reduce Seismic Risk to Leased Space Have Been Limited

None of the six federal agencies we reviewed are required by law to assess or reduce the seismic risk to leased space, but three have established a program to do so. GSA, VA, and the Postal Service review the safety of space at the time of leasing. In addition, the Postal Service has systematically screened all of its leased buildings to identify potentially hazardous space. Other agencies, such as the Navy, Army, and Air Force, told us that they rely on local codes to ensure the seismic safety of leased space.

The Postal Service and GSA, which together account for 77 percent of all space leased by the government, have taken somewhat different approaches to assessing the seismic safety of their leased space. GSA incorporates seismic safety into its leasing process, where appropriate. As GSA begins or renews leases of 10,000 square feet or more in high seismic risk areas, it gives priority to space that meets its seismic standards, even if that space is more expensive than competing offers. The Postal Service, which also assesses the seismic safety of space when it is leased, has taken an additional step and recently started doing engineering studies on the safety of all space it currently leases. Next it intends to develop plans for reducing the risk to all identified unsafe space. VA follows procedures similar to those used by GSA.

Building Codes Do Not Necessarily Ensure Seismic Safety

Although federal buildings are exempt from local building codes, according to GSA, commercial space leased by the federal government must meet these codes. The three military departments assume a building is safe if it is constructed to local building codes, but expert opinion calls this assumption into question, for three reasons.

First, two of the three model building codes used throughout the United States as the basis for local codes were not considered to contain adequate seismic safety provisions. Only the Uniform Building Code, used in the West, was considered sufficiently stringent. The National Building Code, used in the Northeast and most of the Midwest, had less stringent

provisions. The Standard Building Code, used primarily in the Southeast, had no seismic provisions at all until 1988, and was still considered inadequate. The developers of the National and Standard Building Codes recognized these inadequacies and updated their codes in 1991. The updated seismic provisions of the National Building Code were issued in 1991; those of the Standard Building Code are scheduled to be issued in 1992. According to VA and the Postal Service, these updated codes now provide a level of seismic safety substantially equivalent to the 1988 NEHRP Recommended Provisions and are considered sufficiently stringent.

Second, some codes have been continually modified to reflect the most current engineering standards. So even in the West, older buildings—built to comply with seismic design provisions of earlier codes—are not necessarily safe. For example, deficiencies in the Uniform Building Code standards for designing reinforced concrete buildings were not identified and corrected until 1976, following building failures during the 1971 San Fernando earthquake.

Third, in some cases the building codes used by local jurisdictions can vary from the model codes. Some states require all local jurisdictions to adhere to a particular code, while others place no requirements on local jurisdictions, resulting in codes that vary from city to city. In California, all jurisdictions must adopt, at a minimum, the state code, which is based on the Uniform Building Code. In contrast, while Tennessee adopted the seismic provisions of the Standard Building Code in August 1990, it granted exemptions to 25 cities that, in effect, allow them to adopt varying provisions from the code. In 1990, one of these exempt cities, Memphis, adopted seismic code provisions for the first time; however, these provisions were less stringent than those in the Standard Building Code adopted by the state.

**Numerous Constraints
Hamper Reduction of
Seismic Risk to Leased Space**

Agency officials said that there is little more they can do to ensure the seismic safety of the space they lease. Even if agencies establish programs to identify leased space in vulnerable buildings, they see few practical options for reducing the risk to federal employees and the public. Lessors are reluctant to reduce the vulnerability of buildings leased entirely by the government because retrofitting is expensive. Where the government occupies only a portion of a building, federal agencies are reluctant to spend the money to retrofit an entire building and often unable to influence lessors to do so. For example, 72 percent of GSA leases are less than

10,000 square feet. At the same time, retrofitting a portion of a building is not considered a feasible approach.

Although agencies believe that vacating unsafe leased space is probably the best option, it is not always an available option. In areas predominated by old buildings or buildings constructed to inadequate codes, there is often no safer alternative. For example, an official said GSA can vacate seismically unsafe leased space in San Francisco, because it can be assured of finding safer space to lease. In contrast, safe space is scarce in Memphis, which had no seismic codes until 1990.

Conclusions

The efforts of federal agencies to reduce the seismic risk to the buildings they own and lease have been limited. Although a few agencies have made progress in identifying and studying unsafe buildings, VA has made the most progress in making them safer. Federal agency officials believe that they will never be able to fully implement programs for reducing earthquake risk to the buildings they own, unless they receive increased funding for engineering studies and retrofit projects. Currently, agencies do not receive specific funding for such studies and projects. For leased buildings, although three agencies have set up programs to emphasize seismically safe space, three others rely on local building codes, which do not necessarily ensure seismic safety. Moreover, there are limits to what the government can do to reduce the risk to buildings it does not own.

Matter for Congressional Consideration

A large number of federal buildings are potentially vulnerable to earthquake damage, and retrofitting these buildings to improve seismic safety can be very expensive. If agencies are to adopt seismic safety standards before December 1994 and start retrofitting their most vulnerable buildings, additional funding will be needed. Given the lack of comprehensive information on the vulnerability of federal buildings and the high cost of retrofitting buildings, Congress may wish to consider targeting initial funds for the rigorous studies needed to identify (1) agencies' most vulnerable buildings and (2) the costs associated with reducing their seismic risk. Congress could then identify priorities and judiciously allocate scarce resources for costly retrofits of the most vulnerable federal buildings.

Agency Comments and Our Evaluation

In commenting on a draft of this report, GSA, DOD, VA, and the Postal Service generally agreed with the information presented and the Matter for Congressional Consideration; their comments appear in appendixes IV, V, VI, and VII, respectively. GSA, DOD, and VA provided some additional information, which follows, on their seismic safety efforts. VA also provided some technical comments that we considered in preparing this report. We did not include a copy of these technical comments as a part of VA's formal comments because they did not significantly change the report's message.

GSA

GSA said that policies and programs are in place and actions are being taken to improve the seismic safety of its facilities. According to GSA, its programs are designed to (1) acquire new space that meets current seismic standards and (2) improve federally owned buildings by installing seismic strengthening and protection features during planned upgrades and modernization of buildings. GSA emphasized that it does not put people in deficient buildings. GSA said that it has vacated buildings found to be hazardous that could not be strengthened to ensure the safety of occupants and the public.

GSA also said that it could not verify the accuracy of the data presented in appendixes I, II, and III, and saw no benefit to including these appendixes in the final report. We disagree with GSA's view. The data presented are the best available to give some perspective on where federal buildings and employees are located relative to seismic risk zones. As discussed in chapter 1 of this report, we obtained, verified, and updated a copy of the Applied Technology Council's database on the seismic risk of each county in the United States.

We also obtained copies of GSA's governmentwide real property database and OPM's civilian personnel database. Although we did not verify the accuracy of these databases, we did verify our matched results against the GSA and OPM annual reports generated from these databases. We found that there was no difference between our OPM civilian employment matched results and the results in OPM's annual report on civilian employment for 1990. We also found that our GSA matched results were very close to the results in GSA annual reports on owned and leased property for 1989. We determined that the small difference between the results is attributable to our not being able to use some of GSA's records because they contained incomplete data. As discussed in the Objectives, Scope, and Methodology section of this report, we were unable to match 2,149 building and lease records because they lacked location and leasing information. These 2,149

**Chapter 3
Federal Agencies' Efforts to Reduce Seismic
Vulnerability of Buildings Have Been Limited**

records accounted for the difference between our matched results and the results in GSA's annual reports on owned and leased real property for 1989.

It is also important to recognize that Congress may find this type of information useful. The Senate Report accompanying the NEHRP Reauthorization Act states that there is limited information available on federal buildings' vulnerability to earthquakes. The report also states that there are no credible estimates of the number of federal buildings and occupants at risk. These appendixes are an attempt to provide Congress with some information on the location of federal buildings and occupants relative to seismic risk zones.

DOD

DOD said that although much more needs to be done, it believes that it has made significant strides to protect against the threat of earthquakes. DOD pointed out that the Navy's development of an earthquake mitigation methodology is one example of the progress DOD has made. DOD also said that it recognizes the threat that earthquakes pose to life and facilities and will work quickly within existing resources to resolve this threat. However, DOD said that resolving the earthquake threat will take an extended period of time because it expects substantial resource reductions.

DOD partially agreed with our suggestion that Congress target initial funds to identify (1) agencies' most vulnerable buildings and (2) the cost associated with reducing their seismic risk. DOD said that it continues to depend upon the budget process to identify priorities and allocate resources. According to DOD, about \$110 million is needed to do engineering studies to identify its most vulnerable buildings and prioritize their retrofits. DOD also estimated that about \$3 billion is needed to retrofit its buildings, on the basis of studies completed to date.

VA

VA said that it was pleased with the information presented in this report but wanted to explain its decisions to (1) close the VA Medical Center in Martinez, California, and (2) retrofit the VA Medical Center in Memphis, Tennessee.³ VA emphasized that its closure of the Martinez Medical Center was based on the weight of seismic vulnerability evidence. VA said that the Martinez Center, constructed using 1958 design technology, has a major

³VA chose to explain its decisions to close one center and retrofit the other because the Martinez Center's closure has led to much public and congressional concern. GAO is currently reviewing VA's decision to close the Martinez Center.

shear wall that stops below the second floor and does not go down to the foundation. According to VA, independent seismic experts and VA technical staff concluded from analysis, as well as experience, that such a structural feature will lead to serious damage in an earthquake. Total collapse of the building is probable in the event of a severe earthquake.

On the other hand, VA said that its decision to retrofit the Memphis Medical Center was based on a different set of vulnerability evidence. VA said that, unlike the Martinez Center, it did not deem it necessary to vacate the Memphis Center immediately, because of the lower probability of significant seismic activity in the near future and the lower expected strength of such seismic activity. VA pointed out that funding for this project will be a priority in a future budget.

Federally Owned Buildings—Number, Gross Square Footage, Acquisition Cost, and Level of Seismic Risk, by Agency

Agency	Buildings			
	Level of seismic risk	Number	Gross square footage	Acquisition cost (thousands)
Government Printing Office				
	Very high	0	0	\$0
	High	0	0	0
	Moderate	0	0	0
	Low	5	1,852,724	17,585
	Subtotal	5	1,852,724	17,585
Department of Agriculture				
	Very high	520	1,351,368	31,262
	High	2,200	2,733,494	97,758
	Moderate	2,325	4,839,749	136,364
	Low	5,803	15,524,804	444,019
	Subtotal	10,848	24,449,415	709,403
Department of Commerce				
	Very high	92	196,541	3,497
	High	117	1,059,795	45,036
	Moderate	152	388,539	9,522
	Low	382	3,715,257	131,190
	Subtotal	743	5,360,132	189,245
Department of the Interior				
	Very high	635	1,801,190	60,531
	High	3,244	6,360,740	658,329
	Moderate	7,843	12,868,021	230,671
	Low	23,784	47,298,529	1,262,705
	Subtotal	35,506	68,328,480	2,212,236
Department of Justice				
	Very high	148	907,883	25,183
	High	68	834,794	37,824
	Moderate	268	3,356,534	86,864
	Low	1,220	11,835,573	276,562
	Subtotal	1,704	16,934,784	426,433

(continued)

**Appendix I
 Federally Owned Buildings—Number, Gross
 Square Footage, Acquisition Cost, and Level
 of Seismic Risk, by Agency**

Agency	Buildings			
	Level of seismic risk	Number	Gross square footage	Acquisition cost (thousands)
Department of Labor				
	Very high	14	108,230	0
	High	52	207,920	0
	Moderate	414	3,054,405	3,219
	Low	814	6,642,376	6,407,599
	Subtotal	1,294	10,012,931	6,410,818
Department of the Navy				
	Very high	12,615	85,953,269	1,702,905
	High	13,988	88,236,688	2,562,680
	Moderate	18,170	94,292,498	2,035,268
	Low	31,550	251,042,802	5,812,610
	Subtotal	76,323	519,525,257	12,113,463
U.S. Postal Service				
	Very high	280	11,832,527	772,335
	High	307	7,699,336	414,813
	Moderate	1,452	40,798,605	2,056,838
	Low	3,316	77,081,327	3,569,615
	Subtotal	5,355	137,411,795	6,813,601
Department of State				
	Very high	0	0	0
	High	1	70	2
	Moderate	0	0	0
	Low	8	14,624	127
	Subtotal	9	14,694	129
Department of the Treasury				
	Very high	6	284,132	7,360
	High	7	8,470	199
	Moderate	14	55,656	1,556
	Low	339	4,574,387	99,292
	Subtotal	366	4,922,645	108,407

(continued)

**Appendix I
 Federally Owned Buildings—Number, Gross
 Square Footage, Acquisition Cost, and Level
 of Seismic Risk, by Agency**

Agency	Buildings			
	Level of seismic risk	Number	Gross square footage	Acquisition cost (thousands)
Department of the Army				
	Very high	7,645	44,031,127	806,315
	High	16,023	90,560,829	1,296,630
	Moderate	35,714	197,358,354	3,876,204
	Low	88,510	474,744,775	8,659,569
	Subtotal	147,892	806,695,085	14,638,718
Federal Communications Commission				
	Very high	11	9,720	144
	High	10	21,936	232
	Moderate	15	18,295	311
	Low	29	53,268	2,370
	Subtotal	65	103,219	3,057
Department of Veterans Affairs				
	Very high	339	7,448,437	411,099
	High	152	5,910,781	424,279
	Moderate	1,334	36,395,197	1,720,083
	Low	3,062	73,058,845	3,517,611
	Subtotal	4,887	122,813,260	6,073,072
General Services Administration				
	Very high	124	13,366,603	463,409
	High	162	12,853,091	300,809
	Moderate	698	54,168,698	1,340,602
	Low	1,730	151,480,026	3,580,099
	Subtotal	2,714	231,868,418	5,684,919
National Science Foundation				
	Very high	0	0	0
	High	1	1,276	137
	Moderate	2	2,552	458
	Low	199	1,057,392	127,454
	Subtotal	202	1,061,220	128,049

(continued)

**Appendix I
 Federally Owned Buildings—Number, Gross
 Square Footage, Acquisition Cost, and Level
 of Seismic Risk, by Agency**

Agency	Buildings			
	Level of seismic risk	Number	Gross square footage	Acquisition cost (thousands)
Department of the Air Force				
	Very high	7,037	37,130,299	1,011,044
	High	11,848	71,753,286	2,345,291
	Moderate	21,385	125,118,452	3,175,317
	Low	57,450	350,627,548	9,940,251
	Subtotal	97,720	584,629,585	16,471,903
Federal Emergency Management Agency				
	Very high	0	0	0
	High	0	0	0
	Moderate	0	0	0
	Low	26	482,734	3,386
	Subtotal	26	482,734	3,386
Tennessee Valley Authority				
	Very high	0	0	0
	High	4	12,378	621
	Moderate	243	1,219,461	38,016
	Low	277	2,408,337	53,246
	Subtotal	524	3,640,176	91,883
U.S. Information Agency				
	Very high	17	72,475	3,095
	High	0	0	0
	Moderate	0	0	0
	Low	21	159,635	6,080
	Subtotal	38	232,110	9,175
Environmental Protection Agency				
	Very high	0	0	0
	High	4	39,435	3,079
	Moderate	50	1,665,039	15,510
	Low	62	706,197	41,217
	Subtotal	116	2,410,671	59,806

(continued)

**Appendix I
 Federally Owned Buildings—Number, Gross
 Square Footage, Acquisition Cost, and Level
 of Seismic Risk, by Agency**

Agency	Buildings			
	Level of seismic risk	Number	Gross square footage	Acquisition cost (thousands)
Department of Transportation				
	Very high	678	1,729,078	72,839
	High	1,616	4,728,030	133,092
	Moderate	2,986	10,363,606	219,337
	Low	6,165	16,188,786	560,795
	Subtotal	11,445	33,009,500	986,063
Department of Health and Human Services				
	Very high	130	1,027,284	38,740
	High	167	516,202	45,072
	Moderate	216	2,078,681	120,473
	Low	2,103	17,355,019	825,426
	Subtotal	2,616	20,977,186	1,029,711
National Aeronautics and Space Administration				
	Very high	559	7,101,065	606,140
	High	95	732,117	17,270
	Moderate	179	2,273,819	194,081
	Low	2,175	32,980,455	1,920,128
	Subtotal	3,008	43,087,456	2,737,619
Department of Energy				
	Very high	927	8,858,194	599,054
	High	1,615	4,459,180	362,964
	Moderate	4,902	60,017,711	3,199,913
	Low	2,725	33,359,754	2,049,206
	Subtotal	10,169	106,694,839	6,211,137
Department of Education				
	Very high	20	549,899	14,753
	High	25	663,728	17,569
	Moderate	28	953,229	23,120
	Low	79	3,665,387	60,268
	Subtotal	152	5,832,243	115,710

(continued)

**Appendix I
 Federally Owned Buildings—Number, Gross
 Square Footage, Acquisition Cost, and Level
 of Seismic Risk, by Agency**

Agency	Buildings			
	Level of seismic risk	Number	Gross square footage	Acquisition cost (thousands)
Commodity Futures Trading Commission	Very high	0	0	0
	High	0	0	0
	Moderate	0	0	0
	Low	1	799	432
Subtotal		1	799	432
U.S. Army Corps of Engineers	Very high	118	362,773	23,750
	High	173	393,494	5,452
	Moderate	692	787,422	17,839
	Low	2,581	6,824,099	148,129
Subtotal		3,564	8,367,788	195,170
Total		417,292	2,760,719,146	\$83,441,130

Federally Leased Space—Number of Locations, Gross Square Footage, and Level of Seismic Risk, by Agency

Agency	Level of seismic risk	Locations	
		Number	Gross square footage
Department of Agriculture			
	Very high	51	95,980
	High	197	638,564
	Moderate	671	1,421,690
	Low	2,130	3,995,364
	Subtotal	3,049	6,151,598
Department of Commerce			
	Very high	26	139,751
	High	43	331,913
	Moderate	109	748,038
	Low	276	2,028,624
	Subtotal	454	3,248,326
Department of the Interior			
	Very high	39	147,960
	High	49	210,732
	Moderate	10,073	355,987
	Low	10,132	836,147
	Subtotal	20,293	1,550,826
Department of Justice			
	Very high	25	53,711
	High	18	34,298
	Moderate	24	58,662
	Low	67	306,538
	Subtotal	134	453,209
Department of Labor			
	Very high	9	230,083
	High	48	909,744
	Moderate	206	1,619,402
	Low	242	2,250,870
	Subtotal	505	5,010,099
Department of the Navy			
	Very high	84	508,651
	High	23	614,034
	Moderate	64	816,879
	Low	201	2,546,915
	Subtotal	372	4,486,479

(continued)

**Appendix II
 Federally Leased Space—Number of
 Locations, Gross Square Footage, and Level of
 Seismic Risk, by Agency**

Agency	Level of seismic risk	Locations	
		Number	Gross square footage
U.S. Postal Service			
	Very high	769	7,266,480
	High	1,257	4,511,372
	Moderate	7,341	26,084,840
	Low	18,332	49,961,226
	Subtotal	27,699	87,823,918
Department of the Treasury			
	Very high	6	11,150
	High	7	18,640
	Moderate	25	116,439
	Low	94	496,789
	Subtotal	132	643,018
Department of the Army			
	Very high	192	690,503
	High	195	691,202
	Moderate	1,088	2,394,404
	Low	2,993	8,117,852
	Subtotal	4,468	11,893,961
Federal Communications Commission			
	Very high	0	0
	High	0	0
	Moderate	0	0
	Low	1	31,045
	Subtotal	1	31,045
Department of Veterans Affairs			
	Very high	22	190,865
	High	21	130,237
	Moderate	86	1,016,698
	Low	185	1,366,483
	Subtotal	314	2,704,283
General Services Administration			
	Very high	341	4,861,414
	High	347	4,250,226
	Moderate	971	14,925,890
	Low	2,753	54,853,198
	Subtotal	4,412	78,890,728

(continued)

**Appendix II
 Federally Leased Space--Number of
 Locations, Gross Square Footage, and Level of
 Seismic Risk, by Agency**

Agency	Level of seismic risk	Locations	
		Number	Gross square footage
National Science Foundation			
	Very high	0	0
	High	1	851
	Moderate	0	0
	Low	13	103,620
	Subtotal	14	104,471
Department of the Air Force			
	Very high	2	2,694
	High	4	2,312
	Moderate	44	317,349
	Low	32	273,917
	Subtotal	82	596,272
Tennessee Valley Authority			
	Very high	1	960
	High	3	6,861
	Moderate	57	3,095,189
	Low	26	243,143
	Subtotal	87	3,346,153
Environmental Protection Agency			
	Very high	0	0
	High	1	1,349
	Moderate	4	66,135
	Low	14	548,890
	Subtotal	19	616,374
Department of Transportation			
	Very high	347	445,495
	High	367	529,253
	Moderate	1,163	1,567,588
	Low	3,238	4,178,877
	Subtotal	5,115	6,721,213
Department of Health and Human Services			
	Very high	52	72,257
	High	77	100,130
	Moderate	25	86,213
	Low	124	627,751
	Subtotal	278	886,351

(continued)

**Appendix II
 Federally Leased Space—Number of
 Locations, Gross Square Footage, and Level of
 Seismic Risk, by Agency**

Agency	Level of seismic risk	Locations	
		Number	Gross square footage
National Aeronautics and Space Administration			
	Very high	0	0
	High	0	0
	Moderate	0	0
	Low	8	140,237
	Subtotal	8	140,237
Department of Energy			
	Very high	40	163,148
	High	0	0
	Moderate	70	263,574
	Low	60	968,674
	Subtotal	170	1,395,396
Commodity Futures Trading Commission			
	Very high	1	8,265
	High	0	0
	Moderate	2	27,492
	Low	7	145,794
	Subtotal	10	181,551
U.S. Army Corps of Engineers			
	Very high	2	2,062
	High	5	5,491
	Moderate	22	25,757
	Low	134	652,255
	Subtotal	163	685,565
Total		67,779	217,561,073

Supporting Statistics for Figures on Federal Buildings, Leased Space, and Employees, by Seismic Risk Zones

Table III.1: Federally Owned Buildings—Number, Gross Square Footage, and Acquisition Cost by Level of Seismic Risk Nationwide

Level of seismic risk	Buildings		
	Number	Gross square footage	Acquisition cost (thousands)
Very high	31,915	224,122,094	\$6,653,455
High	51,879	299,787,070	8,769,138
Moderate	99,082	652,074,523	18,501,566
Low	234,416	1,584,735,459	49,516,971
Total	417,292	2,760,719,146	\$83,441,130

**Appendix III
Supporting Statistics for Figures on Federal
Buildings, Leased Space, and Employees, by
Seismic Risk Zones**

**Table III.2: Federally Owned
Buildings—Number, Gross Square
Footage, and Acquisition Cost by
Region and Level of Seismic Risk**

Region	Level of seismic risk	Buildings		
		Number	Gross square footage	Acquisition cost (thousands)
Alaska and Hawaii				
	Very high	3,124	26,663,745	\$1,041,978
	High	3,586	22,199,487	1,444,046
	Moderate	14,708	71,267,517	1,310,311
	Low	980	2,461,420	126,398
	Subtotal	22,398	122,592,169	3,922,733
West Coast States				
	Very high	28,791	197,458,349	5,611,477
	High	39,445	218,211,285	5,936,171
	Moderate	7,139	19,394,496	573,188
	Low	7,373	35,582,971	1,309,487
	Subtotal	82,748	470,647,101	13,430,323
Mountain States				
	Very high	0	0	0
	High	7,047	42,442,768	1,021,607
	Moderate	13,943	44,685,833	1,886,681
	Low	33,079	150,264,299	4,357,782
	Subtotal	54,069	237,392,900	7,266,070
Central States				
	Very high	0	0	0
	High	1,801	16,933,530	367,314
	Moderate	17,471	161,150,513	4,111,570
	Low	113,789	736,831,345	20,059,853
	Subtotal	133,061	914,915,388	24,538,737
East Coast States				
	Very high	0	0	0
	High	0	0	0
	Moderate	47,975	385,758,548	11,781,114
	Low	79,212	659,665,907	23,665,593
	Subtotal	127,187	1,045,424,455	35,446,707
Total		417,292	2,760,719,146	\$83,441,130

**Appendix III
Supporting Statistics for Figures on Federal
Buildings, Leased Space, and Employees, by
Seismic Risk Zones**

**Table III.3: Federally Leased
Space—Number and Gross Square
Footage by Level of Seismic Risk
Nationwide**

Level of seismic risk	Locations	
	Number	Gross square footage
Very high	2,009	14,891,429
High	2,663	12,987,209
Moderate	22,045	55,008,226
Low	41,062	134,674,209
Total	67,779	217,561,073

**Appendix III
Supporting Statistics for Figures on Federal
Buildings, Leased Space, and Employees, by
Seismic Risk Zones**

**Table III.4: Federally Leased
Space—Number and Gross Square
Footage by Region and Level of Seismic
Risk**

Region	Level of seismic risk	Locations	
		Number	Gross square footage
Alaska and Hawaii			
	Very high	199	734,538
	High	205	317,713
	Moderate	173	559,750
	Low	109	211,452
Subtotal		686	1,823,453
West Coast States			
	Very high	1,810	14,156,891
	High	1,683	8,561,062
	Moderate	625	1,888,242
	Low	949	3,862,885
Subtotal		5,067	28,469,080
Mountain States			
	Very high	0	0
	High	374	2,337,087
	Moderate	706	2,389,071
	Low	12,094	9,143,987
Subtotal		13,174	13,870,145
Central States			
	Very high	0	0
	High	401	1,771,347
	Moderate	2,207	9,611,074
	Low	18,637	60,308,777
Subtotal		21,245	71,691,198
East Coast States			
	Very high	0	0
	High	0	0
	Moderate	18,334	40,560,089
	Low	9,273	61,147,108
Subtotal		27,607	101,707,197
Total		67,779	217,561,073

**Appendix III
Supporting Statistics for Figures on Federal
Buildings, Leased Space, and Employees, by
Seismic Risk Zones**

**Table III.5: Federal Employees—Number
of Employees in Seismic Risk Zones
Nationwide**

Level of seismic risk	Number
Very high	217,671
High	224,260
Moderate	667,500
Low	1,759,229
Total	2,868,660

**Appendix III
Supporting Statistics for Figures on Federal
Buildings, Leased Space, and Employees, by
Seismic Risk Zones**

**Table III.6: Federal Employees—Number
of Employees by Region and Level of
Seismic Risk**

Region	Level of seismic risk	Number
Alaska and Hawaii		
	Very high	10,007
	High	4,730
	Moderate	24,347
	Low	867
Subtotal		39,951
West Coast States		
	Very high	207,664
	High	160,885
	Moderate	17,397
	Low	35,816
Subtotal		421,762
Mountain States		
	Very high	0
	High	37,711
	Moderate	27,189
	Low	115,016
Subtotal		179,916
Central States		
	Very high	0
	High	20,934
	Moderate	125,449
	Low	770,878
Subtotal		917,261
East Coast States		
	Very high	0
	High	0
	Moderate	473,118
	Low	836,652
Subtotal		1,309,770
Total		2,868,660

Comments From the General Services Administration



Administrator
General Services Administration
Washington, DC 20405

January 28, 1992

The Honorable Charles A. Bowers
Comptroller General
of the United States
General Accounting Office
Washington, DC 20548

Dear Mr. Bowers:

Thank you for the opportunity to comment on the General Accounting Office (GAO) draft audit report entitled, "Federal Buildings: Many Are Threatened By Earthquakes But Limited Action Taken," GAO/GGD-92-XX.

The draft report presents a relatively accurate assessment of the General Services Administration's (GSA's) program and progress in the seismic safety of Government-owned and leased space. Policies and programs are in place for both types of space. Actions are being taken to improve the seismic safety of our facilities. Our programs are based on bringing new space into the inventory which meets current seismic standards, and to improve existing Government-owned space. Seismic upgrading has been and will continue to be accomplished by installing seismic strengthening and protection features with other planned improvements such as elevators, fire sprinklers, and lights or in conjunction with overall building modernization projects. GSA has vacated buildings found to be hazardous which could not be strengthened to a level meeting our performance objectives, ensuring the safety of the occupants and the public, in a cost-effective manner. We do not put people in deficient buildings, and we intend to continue our progress at evaluating and retrofitting building(s) for seismic safety.

We offer two recommendations for improvement of the final report. The initial acquisition cost of the total Government-owned space is estimated at \$83 billion. This really understates current market conditions if the space would have to be replaced either functionally or as a replication. A functional replacement of a square foot of space at an average cost of \$100 per square foot would indicate the inventory today is conservatively a \$276 billion capital asset. Replication of the inventory including historic and monumental buildings would raise this amount significantly. We cannot verify the accuracy of the data in Appendices I, II, and III, and do not see the overall benefit they provide to the written portions of the report. It is suggested they be left out of the final report.

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**Appendix IV
Comments From the General Services
Administration**

-2-

We will be pleased to work with your staff to ensure that the mandates of the National Earthquake Hazards Reduction Program Reauthorization Act of 1990 are achieved.

Sincerely,



Richard G. Austin
Administrator

Comments From the Department of Defense



PRODUCTION AND LOGISTICS

THE ASSISTANT SECRETARY OF DEFENSE

WASHINGTON, DC 20301-8000

20 MAR 1992

Mr. L. Nye Stevens
Director, Government Business
Operations Issues
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Stevens:

This is the Department of Defense response to the GAO draft report, "FEDERAL BUILDINGS: Many are Threatened By Earthquakes But Limited Action Taken," dated December 23, 1991 (GAO Code 240038/OSD Case 8921). The Department generally agrees with the report findings and partially agrees with the Matter for Congressional Consideration.

It should be noted that the Oakland Hospital is at high risk because of the inadequate design requirements of the 1965 building code--not because of the reinforced concrete construction. Reinforced concrete performs satisfactorily under seismic load, if designed in accordance with the appropriate seismic code. In addition, resolving the threat of earthquakes for leased space is further complicated by the constraints associated with leases.

Although there is much left to be done, the DoD has made significant strides to protect against the threat of earthquakes. For example, the Navy has developed an earthquake mitigation methodology. In addition, the Navy has screened 80 percent of its buildings and identified 329 buildings that are at serious risk. Based on that screening, the Navy has retrofitted 32 buildings and initiated retrofit projects for 80 additional buildings.

The Department recognizes the potential danger to life, mission disruption, and facilities and will work as quickly as possible within existing resources to resolve the earthquake threat. It would depend upon an additional investment of approximately \$110 million for earthquake engineering surveys and studies determining the vulnerability of all existing DoD construction. Estimates of the correction cost approaches \$3 billion. With existing DoD budget resources being reduced substantially, the Department projects total correction will take an extended period of time.

The Department appreciate the opportunity to comment of the draft report. The DoD comments on the Matter for Congressional consideration are provided in the enclosure.

Sincerely,

David J. Berteau
David J. Berteau
Principal Deputy

Enclosure

GAO DRAFT REPORT--DATED DECEMBER 23, 1991
(GAO CODE 240038) OSD CASE 8921

"FEDERAL BUILDINGS: MANY ARE THREATENED
BY EARTHQUAKES BUT LIMITED ACTION TAKEN'

DEPARTMENT OF DEFENSE COMMENT

MATTER FOR CONGRESSIONAL CONSIDERATION

SUGGESTION: The GAO suggested that the Congress consider targeting initial funds for the rigorous studies needed to identify (1) agencies' most vulnerable buildings and (2) the cost associated with reducing their seismic risk. The GAO pointed out that, with such information, the Congress could identify priorities and allocate scarce resources judiciously for costly retrofits of the most vulnerable Federal Buildings. (p, 12, p. 78/GAO Draft Report)

DOD RESPONSE: Partially concur. The Department continues to depend upon the budget process to identify priorities and allocate resources. The DoD estimates that it could take up to \$110 million to conduct engineering studies to identify and prioritize all DoD existing construction for maximum reduction in loss of life from earthquakes. In addition, the Department estimates building retrofits would be approximately \$3 billion based on current work requirements. It is also pointed out that utilities beyond the building five foot line are not included in the \$3 billion estimate and could well exceed the building retrofit cost.

Comments From the Department of Veterans Affairs



THE SECRETARY OF VETERANS AFFAIRS
WASHINGTON

FEB 3 1992

Mr. Richard L. Fogel
Assistant Comptroller General
General Government Division
U. S. General Accounting Office
441 G Street, Northwest
Washington, DC 20548

Dear Mr. Fogel:

We have reviewed your draft report, FEDERAL BUILDINGS: Many Are Threatened By Earthquakes But Limited Action Taken (GAO/GGD-92-XX). We are pleased that the GAO found that the Department of Veterans Affairs was the leader among the agencies reviewed in reducing the vulnerability of its facilities to seismic risk. Not only does VA consider seismic hazards when planning for new construction, we also assess our existing buildings and leased space for those risks. GAO correctly notes that the lack of funding is a major impediment to improving seismic safety in our facilities.

Most recently, an assessment of the VA Medical Center in Martinez, California, vulnerability to seismic hazards led to the difficult decision to close that facility. Continuing to maintain a medical center there ignores the weight of seismic vulnerability evidence and could be disastrous. The Martinez medical center, constructed using 1958 design technology, has a major shear wall that stops below the second floor and does not go down to the foundation. Independent seismic experts and VA technical staff concluded from analysis, as well as experience, that such a structural feature will lead to serious damage in an earthquake. Total collapse of the building is probable in the event of a severe earthquake.

While the GAO report refers to the seismic vulnerability of the VA Medical Center, Memphis, Tennessee, I believe it should note that the Department's decision to retrofit that facility was based on a different set of vulnerability evidence. Unlike the facility in Martinez, we did not deem it necessary to vacate the Memphis facility immediately, because of the lower probability of significant seismic activity in the near future and the lower expected strength of such seismic activity. Funding for this project will be a priority in a future budget.

**Appendix VI
Comments From the Department of Veterans
Affairs**

2.

The enclosure contains specific corrections that should be made to the report prior to its publishing. Thank you for the opportunity to comment on this report.

Sincerely yours,



Edward J. Derwinski

Enclosure
EJD/vz

Comments From the U.S. Postal Service



THE POSTMASTER GENERAL
Washington, D.C. 20260-0010

January 23, 1992

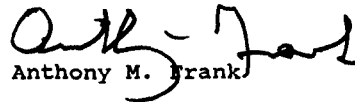
Dear Mr. Fogel:

This refers to your draft report entitled Federal Buildings: Many are Threatened by Earthquakes But Limited Action Taken.

We think the report provides an excellent discussion of the magnitude and complexity of the problem of reducing the vulnerability of existing Federal buildings to earthquake damage and accurately describes the Postal Service's own efforts in this regard.

Thank you for offering us an opportunity to comment.

Sincerely,



Anthony M. Frank

Mr. Richard L. Fogel
Assistant Comptroller General
United States General Accounting
Office
Washington, D.C. 20548-0001

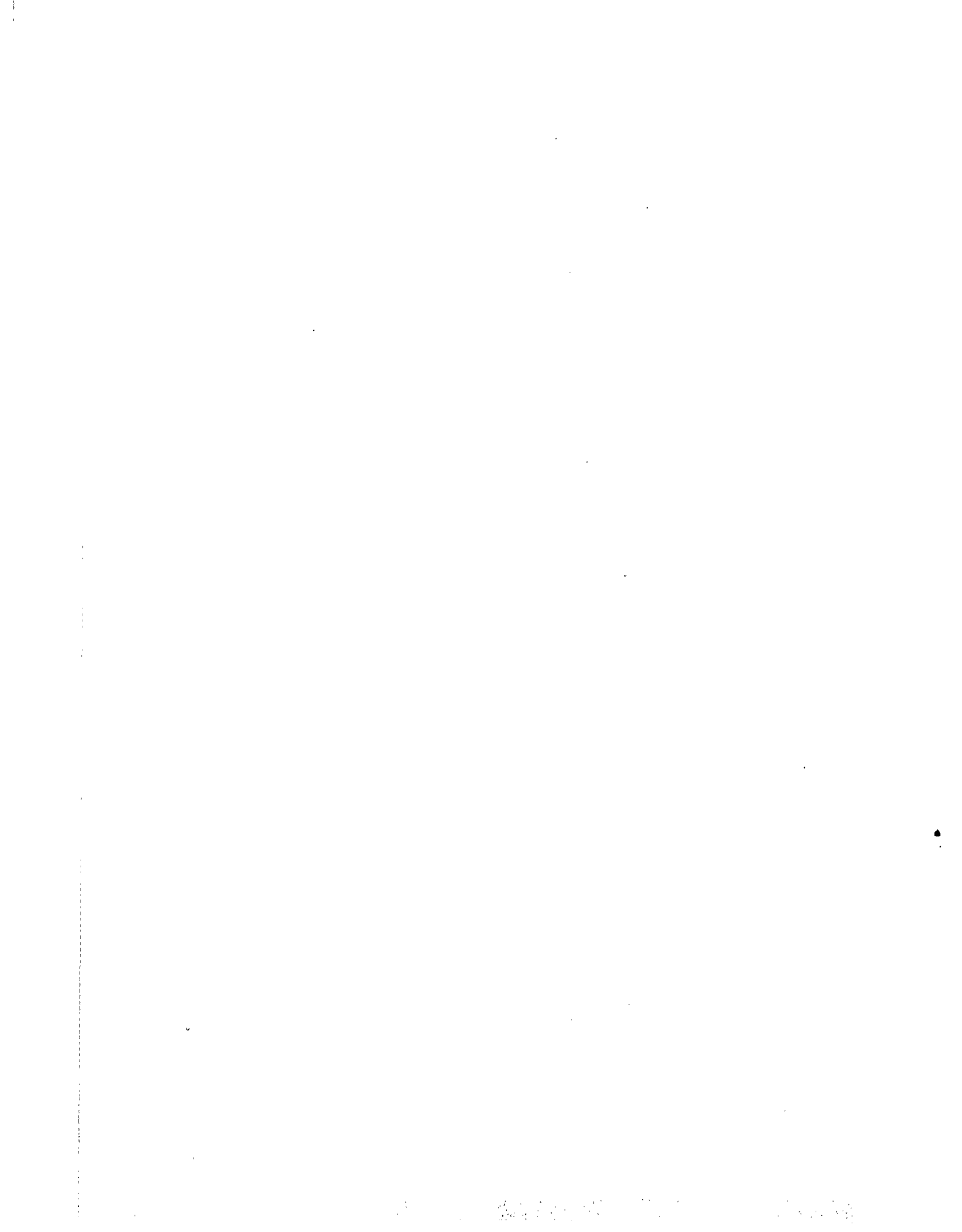
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