PART IV: CASE STUDIES

CHARLESTON, SOUTH CAROLINA

INTRODUCTION

In spite of the fact that historic buildings are important to Charleston's economy, they are at great risk. Earthquake retrofit is not mandatory while history shows that damaging earthquakes have occurred and will continue to occur in this region. Worton has stated that "there is sufficient likelihood that a major earthquake will occur in the Eastern United States and very possibly in the Southeastern United States during our lifetime".[1] The occurrence of an earthquake of similar intensity to the 1886 Charleston earthquake could cause extensive damage to these older buildings. Large numbers of these old buildings had limited seismic strength when constructed and were considerably weakened still further by the impact of the 1886 Charleston earthquake. (Lindbergh, 1986). The need to protect the building stock of Charleston is twofold. It is an irreparable historical asset for all America and it plays an important role in the local economy.

Charleston has been very successful in implementing rehabilitation programs, although none of these have incorporated seismic safety. Part of this success derives from the fact that rehabilitation has been traditionally a concern fully integrated within the city planning process. However the adoption and enforcement of comprehensive seismic retrofit programs designed to preserve the large number of historical buildings located throughout Charleston is still in its early form. It is expected that the range of urban seismic programs undertaken by many cities in California and Utah and included in this report, can benefit Charleston in expanding the seismic components of their urban programs.

This case study highlights the success of Charleston in implementing redevelopment programs for the rehabilitation of older structures, discusses major aspects of the 1886 Charleston earthquake, and reviews several initiatives undertaken primarily by the private sector to upgrade the seismic safety of Charleston.

DEVELOPMENT OF CHARLESTON

The City of Charleston is located on the shore of the Atlantic Ocean at the juncture of the Ashley and Cooper Rivers forming the Charleston Peninsula. The Peninsula comprises the central business district, municipal offices, shipping activities, and the area's major cultural facilities. Metropolitan Charleston, also known as the "low-country", is a tri-county region which encompasses Berkeley, Charleston, and Dorchester Counties. Charleston was one of the first major cities established in the United States, founded by a group of English colonists in 1670.

Due to the historical characteristics of Charleston, redevelopment activities are a special force in this city. They are strongly tied to the rehabilitation of older buildings which constitute Charleston's important architectural heritage. Indeed, one of the most unique aspects of Charleston is that its historic district has remained basically unchanged. Charlestonians have persistently renovated and rehabilitated their buildings in spite of the fact that the city has been damaged severely by war occupation, fires, earthquakes, and hurricanes.

The urban fabric of Charleston did not remain stable throughout its history; it fluctuated according to different economic trends. For instance, these devastating events plus a lagging economy (a fixation on cotton and rice in the antebellum period was followed by economic collapse after the Civil War) turned a once flourishing metropolis into a poverty-stricken and languishing town. (Silver, 1991) However, it was this very urban decay that became a significant component of the revitalization movement that took place in the 1920s. The main motivation of the preservation movement was to save the vanishing architectural legacy of the city as

[1]Worton et al Seismic Potential in the Southeastern U.S in Earthquake Hazards, Risk and Mitigation, 1986

well as providing a less costly solution than the process of rebuilding. The creation of the Society for the Preservation of Old Dwelling in 1920 (today the Preservation Society of Charleston) marked the beginning of an strong urban preservation movement. (Silver, 1991)

Today, Charleston is a dense network of tight urban streets comprising a large number of churches; small shops of brick, stone, and cast iron fronts; and houses of narrow and tiered porches (piazzas); all in an array of Georgian, Federal Greek Revival, Second Empire, and Queen Anne styles. In terms of population, metropolitan Charleston is the fastest-growing major metropolitan area in South Carolina with a 18 percent growth rate over the past decade. Its estimated population in 1992 is 82,207 people.

REDEVELOPMENT IN CHARLESTON

The City of Charleston has undertaken several major redevelopment programs over the years. However, the most common activity is the renovation of single-and multi-family structures by private individuals. The vulnerability of these building is one of the major problems faced by Charleston due to the large number of building that require retrofit and lack of seismic strengthening guidelines for existing buildings.

Major redevelopment and preservation programs started early in Charleston. From the 1920s to 1950 the preservation and planning movements overlapped significantly. They followed independent strategies as historic preservation gained an institutional base in the 1950s and 1960s. Later on, these strategies merged into a more broadly based movement aimed at conserving the residential base of the center city in the 1970s and 1980s. (Silver, 1991) This integration between preservation concerns and city planning has been one of the factors that has turned preservation into an extremely successful movement in Charleston. Today, preservation has been recognized as a complementary component of city planning and redevelopment programs.

In the City of Charleston, rehabilitation and/or revitalization depends of an array of public and private institutions, volunteer associations, and citizen's initiatives. These institutions, with different objectives and/or overlapping roles, are the leading agencies in terms of urban programs.

One of the early accomplishments of the preservation movement was efforts in pushing the City of Charleston to undertake its first official planning act. Charleston became the first city in the United States to have historic zoning. The Charleston Zoning Ordinance adopted in 1931 controls the development and redevelopment of the older section of the city. Unlike any other in the county, it contains explicit protection for a designated historic district. The ordinance calls for the "protection of the old historic or architecturally worthy structures and quaint neighborhoods and for a general harmony as to style, form, color, proportion, texture and materials between buildings of historic design and those of more modern design." (Silver, 1991)

The zoning ordinance designates two distinct types of districts within the city. The first is the highly regulated old and historic district. The second is the old city district which includes the entire peninsular portion of the City of Charleston. Currently, the Zoning Ordinance includes a historic architecture inventory which serves for ranks historic structures as exceptional, excellent, significant, or contributory. Buildings that fall in the categories of exceptional or excellent are preserved in situ at all costs.

The City of Charleston only adopted an official land-use planning process in 1976 in spite of the fact that the city has the oldest historic preservation ordinance in the nation. (Gori and Green, 1982) When Charleston adopted its first zoning ordinance in 1931, there were disagreements on how land should be regulated. These disagreements hindered the adoption of land-use planning during this earlier period.

Currently the City is in the process of revising its land-use planning process. The Charleston 2000 Plan completed in 1993 monitors the land-use and the economic development of Charleston. However, geological and earthquake information is usually not utilized in Charleston's land-use decisions. Gori and Greene reported in

1982[2] that only occasionally is geologic information utilized in the land-use planning process. The situation remains almost identical today.

In Charleston, rehabilitation programs are usually processed through the Board of Architectural Review of the Department of Planning and Urban Development. The Board regulates permits for demolition, removal or alteration of any structure within the Old and Historic District. The primarily concerns of this board are the preservation of the historic value of the buildings, their architectural and aesthetic features, and their use and importance to the city. At present this board can prohibit indefinitely or permanently the demolition of any building within the Old and Historic District.

Earthquake retrofit of older buildings is not mandatory. Seismic safety measures might or might not be incorporated when rehabilitation takes place in Metropolitan Charleston. Thus, owners are not required to provide assessments of the structural system when processing their building permits for rehabilitation. Retrofit in compliance with current building codes are left to a discretionary process. For example, during building inspection a structural deficiency might be identified. In this case building inspectors can require that a particular structural element or the entire building to be rehabilitated in compliance with prevailing codes and standards. However, since thorough assessments (i.e., field and load testing and structural analysis) are not required a single structural element might be modified according to the present code while the entire building remained unstrengthened.

The Board of Architectural Review almost exclusively limits itself with the aesthetic value of the exterior of the historic buildings and has limited interest in earthquake retrofit. Only in cases where the renovation cost exceeds 50 percent of the appraised value of the structure or the building is undergoing a change in use (i.e., residential to commercial) do local building officials require adherence to seismic provisions stipulated by the building code. Unfortunately, such provisions are easily sidestepped: the owner when faced with retrofitting requirements can plan the renovation of a building in various stages, each at a lower cost than 50 percent of the value of the building.

There are an array of voluntary institutions that are involved in the preservation of Charleston. The Preservation Society of Charleston, the Historic Charleston Foundation, Save Charleston Foundation, Carolina Arts Association, the Historic Society, the Council for Urban Quality, the Society for the Preservation of the Charleston Waterfront are the most relevant institutions working on the preservation of historic buildings.

The Preservation Society of Charleston was the first preservation organization created in Charleston (1920). This Society has been traditionally concerned with the survey and research of historical buildings. As an example of the important contribution that this society has made toward preservation, a survey of historic buildings prepared by this Society in 1931 served as a guide to the City in delineating the original boundaries of the Old and Historic District. Another full-scale survey was conducted later, in 1940, and served as an information system for the classification of buildings of historical importance. It is the research arm of the Board of Architectural Review.

The Historic Charleston Foundation was organized in 1948 and has made important contributions to the preservation efforts in Charleston. One of the major programs implemented by the Foundation includes the restoration of various historical single structures and the renovation of complete neighborhoods.

Recently, the Foundation has completed a survey and map-guide for historic buildings. This survey was done with funds established for Hurricane Hugo and it documents the condition of more than 600 structures in Hurricane Hugo's affected area. A companion study is currently being completed showing damage to

[2]Earthquake Hazards Information Dissemination: A Study of Charleston, South Carolina (USGS, 1982)

properties of historic significance. The survey can be an important starting point in determining the structural conditions of most old and historic buildings and their vulnerability or level of exposure to different natural hazards, including earthquakes.

The Save Charleston Foundation was initiated as a result of severe discrepancies between the public and developers in terms of the height of certain new development projects. In the early 1970s the proposed construction of a high-rise condominium within Charleston's Old and Historic District, received no opposition either from city government or the Board of Architectural Review. Height requirements in the zoning ordinance for commercial and industrial zones were liberal and would have permitted the construction of this high rise structure. A group of local residents who felt the proposed structure would disturb the city's low skyline and historic vistas formed the Save Charleston Foundation and conducted an extensive campaign of public eduction and fund raising. The Foundation was able to raise funds to purchase the site. Since then the Foundation has participated in a large number of projects that have converted obsolete structures into appropriate commercial sites. Its major contribution has been to merge historic preservation with downtown commercial redevelopment.

EARTHQUAKES AND CHARLESTON

On August 31, 1886, the most damaging earthquake in the Eastern United States affected the City of Charleston and the surrounding areas. Interpretation of the intensity data for the 1886 Charleston earthquake established that the maximum epicentral intensity was MMI X in the epicentral area, and IX in the City of Charleston. (Harlan and Lindbergh, 1988) The effects of the 1886 Charleston earthquake included the formation of ground fissures, craterlets, mud fountains, earth and water waves, and the release of sulfur gas.

Most of the damage occurred in the peninsular part of Charleston where the majority of the population lived (50,000 people). More than 60 persons were killed and total damage was estimated at $5 million (1886 equivalent). Within the city, hardly any building escaped damage, although only a few completely collapsed. Masonry buildings were especially hard hit. Several hundred buildings lost a large portion of their walls and ninety percent of the 14,000 chimneys were broken off at roof level. It was recorded that 102 buildings were determined to be unsafe and ordered to be demolished. (Nuttli, 1983)[3] The effects of building after the earthquake can be seen today in "earthquake bolts" used to tie together damaged walls, in metal cornices and storefronts, and in newer wooden buildings which those who feared another earthquake considered safer than masonry.

The earliest reported earthquake in South Carolina impacted the area of Charleston in February 1698. Eighteen other earthquakes are known to have occurred between 1698 and 1886. (Harlan and Lindbergh, 1988). However, since the 1886 Charleston earthquake, no other large earthquake has occurred in South Carolina, although other minor earthquakes have affected the area repeatedly.

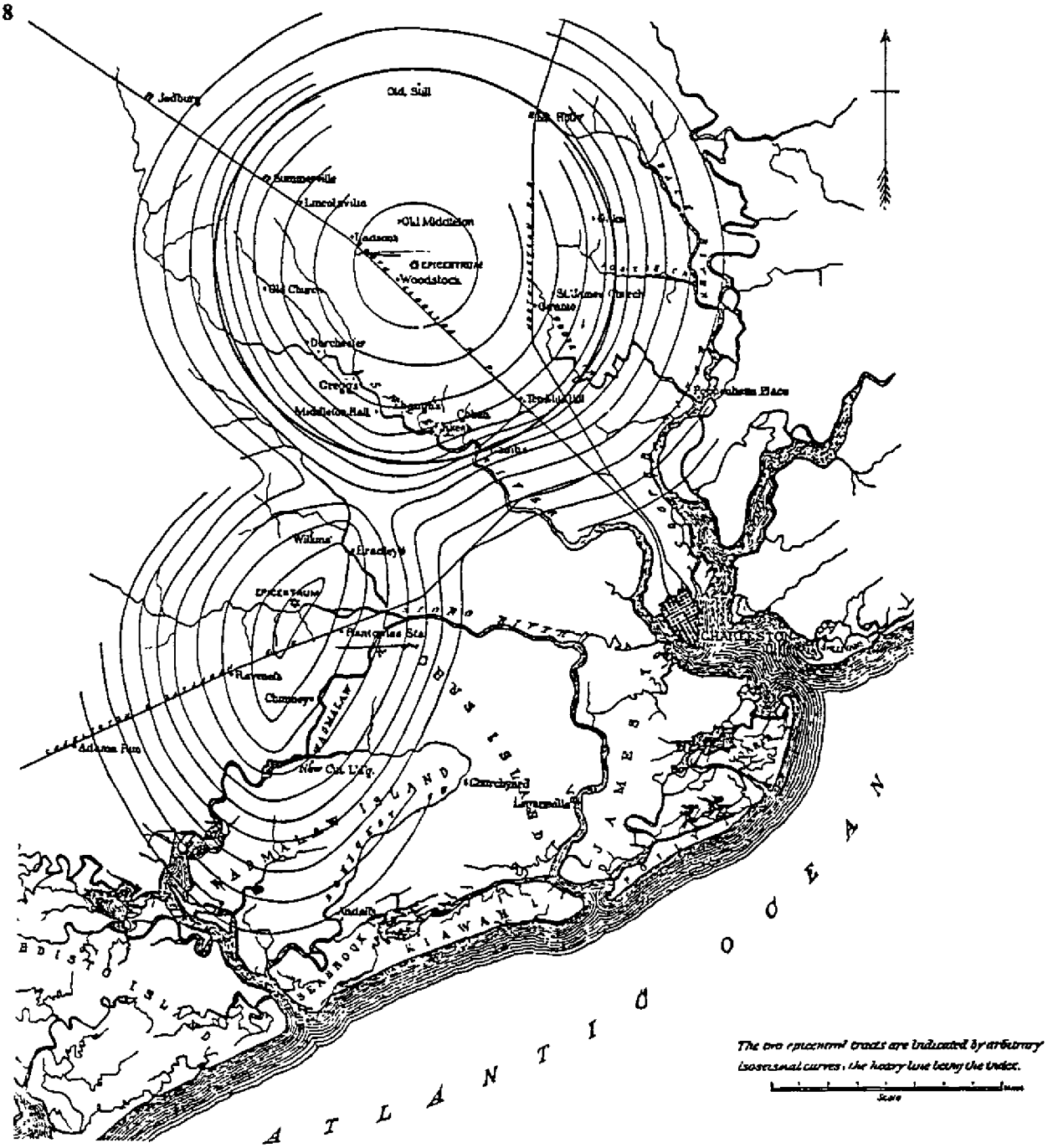
The 1886 Charleston earthquake was preceded by light tremors and two earthquakes on August 27 and 28 of 1886 affecting the area of Summerville. From 1886 to 1914, an unusual high level of seismic activity affected the region; this period of high seismicity is considered part of the 1886 Charleston earthquake aftershocks. (Bagwell 1992, Harlan and Lindbergh, 1988)

A period of relatively low seismic activity followed this period until 1951. After 1951, increasing activity affected the area of Charleston-Summerville, as well as the upper parts of South Carolina. In particular, the 1974 earthquake, which affected Charleston-Summerville, caused great fright, and significant damage to chimneys, building plaster, and building steps. (Bagwell, 1982)

[3] 1886 Charleston, South Carolina, Earthquake Revisited in USGS, 1983

CHARLESTON 1886 EARTHQUAKE EPICENTERS

Exhibit 8



Source: From Dutton, 19889 in *An Earthquake Vulnerability Analysis of the Charleston, South Carolina, Area* (Harlan and Lindbergh, 1986).

In the last 100 years, approximately 37 seismic events with MMI VI or greater, and five with MMI VIII or greater have occurred. Since 1973 there have been over 200 earthquakes in South Carolina with more than half of these being felt in the low-country. Since January 1990 through August 1992, 42 events have occurred in lower South Carolina (Bagwell, 1992)

For the region as a whole, it is estimated that minor earthquakes occur more frequently in the Southeastern United States region than in the rest of the US. However, the occurrence of major events in the area is infrequent, thus, the recurrence of large earthquakes is uncertain. A time frame for earthquake recurrence has been developed estimating a MMI VI might occur every ten years while larger earthquakes, MMI VIII or greater are expected every 100 years (Bollinger, 1972 in the Vulnerability Analysis).

Earthquakes affecting the Southeastern region of the U.S. do not cause surface rupture, unlike earthquake activity experienced in the West. This occurs in spite of the fact that focal depths of Eastern and Western earthquakes are similar. Studies on the causative tectonics of earthquakes in the Southeastern region indicate that rupture dies out before it reaches the surface. This particular characteristic results in a difficult understanding of the fault system affecting the region and the fact that most seismo-tectonic work must center on understanding the causes of the 1886 Charleston earthquake.[4]

Harlan and Lindbergh prepared a *Vulnerability Analysis* for the Charleston tri-county region for an earthquake of epicentral intensity MMI VII. The main objectives of the *Vulnerability Analysis* were to identify the earthquake potential for the region and its effects on people, structures, and lifelines functions. It also quantified the extent of potential damage in order to provide guidance for preparedness and mitigation planning to federal, state, and local agencies.

The damage forecast methodology utilized in the vulnerability study included a) maps for the postulated earthquakes expressed in Modified Mercalli Intensities; b) a classification of buildings utilizing a modified ISO (Insurance Service Office) classification system with adjustments made in terms of local features, conditions, buildings codes and construction practices; c) a building inventory based on a survey of critical facilities, census records, tax records, sandborne maps, land-use codes, and site inspections; and d) a maximum loss value due to vibratory motion of the studied earthquake.

In the historic district of peninsular Charleston, there is a high percentage of old unreinforced brick homes, many of which pre-date the 1886 Charleston earthquake. Residential housing in Charleston involves a relatively high use of masonry. The predominant characteristics of the housing stock are wood frame and wood frame with brick veneer.

The probable maximum loss as a result of an earthquake of MMI VII for wood frame housing is 5 percent and 14 percent for a MMI IX earthquake; wood frame housing with brick veneer is 20 percent in case of a MMI VII earthquake and 56 percent for MMI IX; and for unreinforced masonry housing losses are estimated at 37 percent for a MMI VII earthquake and 91 percent for a MMI IX earthquake.

In general, the physical characteristics of commercial/industrial facilities are defined as all metal structures and mixed construction of unreinforced hollow concrete masonry, both equally balanced in terms of numbers. Maximum total losses are estimated at 56 percent in an earthquake of MMI IX scale, and 23 percent for an earthquake of MMI VII.

[4]Turner, Stuart et al in Differences Between Eastern United States and Western United States Earthquakes, with Application to the Southeastern States in Earthquake Hazards, Risk, and Mitigation, 1986

Public administration buildings in the Charleston area are a mix of older and newer construction. Several of the older buildings are historic brick structures, most of which are reinforced concrete frame or steel frame buildings less than four stories. Post offices are one-story structures, usually built with a steel frame and concrete materials. For an earthquake of MMI VII a probable maximum loss of 19 percent of public buildings is to be expected.

The Department of Education is responsible for the construction of schools in the state of South Carolina. Currently, the Department has advised local school districts of the seismic threat to the state. However, the Department of Education only recommends the use of seismic strengthening provisions; final decisions for adopting such provisions are left with the local school district authorities. Only since 1988 has the S.C. Department of Education encouraged new school construction in some state regions to be seismic-resistant.

Historically schools have been vulnerable buildings throughout the U.S . (i.e., 1933 Long Beach, 1983 Coalinga earthquake, 1949 Olympia earthquake, and 1965 Seattle-Tacoma earthquake). In South Carolina, many old and newer school buildings are built of unreinforced or under-reinforced concrete block masonry buildings. (Lindbergh, 1989). Indeed, a vulnerability survey of public school buildings in the Charleston tri-country area revealed that area schools are in essentially the same state as California Schools before the enactment of the Field Act after the 1933 Long Beach earthquake. It is estimated that damage to schools will be 97 percent in unreinforced masonry buildings (Harlan and Lindbergh, 1988).

According to the Vulnerability Study, damage to schools may be of catastrophic proportions during a major earthquake. It is expected than less than 30 percent would be available immediately after a MMI VII earthquake. Beside the critical exposure of children in buildings that can be damaged during an earthquake, there is a second post-disaster scenario that can take place. The number of homeless people expected during the first five days after an earthquake MMI VII far exceeds the ability to provide shelter. For the MMI IX earthquake, the estimated number of homeless may exceed shelter availability for as long as 90 days after such an earthquake.

At present, a new Program to Improve the Safety of Existing and New Elementary and Secondary School Buildings for the Natural Hazards Environment in South Carolina has been promoted (Lindbergh, 1989). This program encourages legislative action to improve all existing schools to incorporate minimum resistance to natural hazards and the construction of new schools to use criteria consistent with their essential functions. It calls for the creation by legislation, of a panel to develop an action plan to guide the formulation of the school seismic safety program.

Older critical structures are particularly expected to be affected by severe damage or extensive destruction as a result of an earthquake MMI VII or stronger. Because this group of structures includes hospitals, fire stations, and emergency vehicle stations, vital services that would not be fully available after the event. As indicated in the Vulnerability Study, the effects on critical lifelines would be severe. Most bridges and overpasses in the area would suffer extensive damage. Many highways would be blocked by debris, thus affecting the operation of emergency vehicles that survived the damage and destruction at their stations.

The maximum loss of buildings due to an earthquake MMI VII is shown in the following table.

SUMMARY OF TRI COUNTY AREA
PROBABLE MAXIMUM LOSS OF FACILITIES DUE TO
MODERATE EARTHQUAKE - MMI VII

Exhibit 9

County	Critical Facilities	Residential Dwellings	Commercial Facilities
Charleston	269	724	321
Berkeley	33	192	102
Dorchester	14	160	76
Total	316	1,076	499

From: An Earthquake Vulnerability Analysis of Charleston, (Harlan and Lindbergh, 1988)

EARTHQUAKE SAFETY

The introduction of earthquake safety measures within the rehabilitation and/or revitalization process in Charleston is complex. The absence of large-magnitude earthquakes since the 1886 Charleston event, the low probability of occurrence of a structurally damaging earthquake during the lifetime of an individual building, and the low threat that earthquakes represent when compared to other natural hazards -- i.e., hurricanes, tornadoes, and flooding -- have been a barrier to the adoption and enforcement of earthquake safety as an integral component of the planning process.

Wyner and Mann conducted a study of 13 jurisdictions throughout California in 1986 depicting the failure of many local governments in undertaking seismic safety policies. Some of their findings seem to be relevant to present Charleston's situation. Wyner and Mann's study indicates that albeit most communities have a high level of consciousness in term of earthquake risk, they were either fatalistic about it or believed that the likelihood of their being directly affected by this type of event was relatively low. They felt that they had not been seriously affected by earthquakes over the many years of living in earthquake-prone areas, and thus, there were no reasons to be concerned. In fact, they admitted that there was very little that could be done to alter the consequences of a major earthquake.

The study also indicates that many building officials typically are not fully aware of the problems of poor performance of old building during earthquakes and believe that the possible benefits of introducing earthquake safety might be outweighed by the social and economic costs and the disruption that strict enforcement might cause within the community.

In addition to the findings of the Wyner and Mann study, field work indicates that the lack of mandatory earthquake retrofit during the rehabilitation process in Charleston seems to be related to the community's belief that the burden of community welfare should not be the economic responsibility of the individual building owner.

Throughout South Carolina the adoption and implementation of effective building code provisions for earthquake resistance has been a slow process. Some counties and jurisdictions have still not adopted a specific building code even today. The Standard Building Code (SBC), published by the Southern Building Code Congress International (SBCCI), is the code most extensively used throughout the State.

In 1981 the City of Charleston adopted the SBC for commercial buildings. However, until 1988 the enforcement of seismic safety provisions was cumbersome since the wording of the Section 1207 on Seismic Design was vague.[5] This caused jurisdictions that had adopted the SBC to overlook or not enforce the section relevant to seismic safety. However, in 1988 this problem was rectified. Section 1206 on Earthquake Loads clearly states the enforcement of earthquake provisions.[6] Furthermore, the 1985 version of SBC more clearly defines the seismicity of the State of South Carolina. In early versions only the area of Charleston was considered "Zone 1" (moderate damage) following the recommendation of ANSI A58.1[7] while the rest of the state was considered "Zone 2" (minor damage).

The city of Charleston currently uses the 1991 edition of SBC. This version contains earthquake design provisions which have been superseded by extensive 1992 revisions. These revisions embody many of the recommendations of the National Earthquake Hazards Reduction Program (NEHRP). Other changes related to earthquake safety are expected by the time the 1994 SBC is published.

The automatic adoption of these revisions and future revisions by various jurisdictions will have a significant impact upon earthquake design procedures for new construction and rehabilitation. However, it is important to note that Charleston unlike some other jurisdictions, does not adopt revisions which occur during the three year period between published code editions. Thus Charleston will not benefit from such changes until early 1995.

However, in spite of these advancements there are still areas of great conflict in terms of the adoption and enforcement of earthquake provisions. For instance, independent of the new design requirements that will be introduced by the SBC in 1994, it is still likely that the model code procedures will underestimate the hazard potential in the immediate Charleston area. According to Johnson and Bozan-Zurita (1986) the geology of the area is somewhat unique. Many experts (Bagwell 1992, Lindbergh, 1992) feel that there is potential for more earthquakes of greater magnitudes in the Charleston area than in the surrounding areas which share the same zone.

The enforcement of seismic procedures related to renovation is limited. As mentioned before, the renovation of existing buildings is not enforced by code. Section 101.5 (SBC, 1991) supports rehabilitation without requiring the structure to comply with the codes for new construction. "Alterations, repairs or rehabilitation work may be made to any existing structure, building electrical,gas, mechanical or plumbing system without requiring the building, structure, plumbing, electrical, mechanical or gas system to comply with all the requirements of the technical codes provided that the alteration, repair or rehabilitation work conforms to the requirements of the technical codes for new construction. The Building Official shall determine the extent to which the existing system shall be made to conform to the requirements of the technical codes for new

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[5] Section 1207 was worded: "Where seismic design is required by local authorities, all building and structures shall be design to withstand seismic forces in accordance with the requirements of ANSI A58.1"

[6] Section 1206 is presently worded: "Every building and structure and portion thereof shall be designed and constructed to resist the earthquake effects determined in accordance with the requirements of this section. Seismic zones shall be determined by location in Figure 1206.1"

[7] Building Code Requirements for Minimum Design Loads in Buildings and other Structures, prepared by the American Society of Civil Engineers (ASCE)

construction." The only measure that partially counteracts the negative impact of this lack of enforcement is that owners or developers are not allowed to perform renovation work that will diminish the capacity of the structure to withstand earthquakes. (Rennhaeck, 1992)

At present, various sectors are exerting pressure for the adoption of a unified building code throughout South Carolina. There is a consensus among key professional and decision-makers in the area that views the lack of a unified statewide code as a decisive element in the production of substandard building practices throughout the state. Without success, repeatedly, remedial legislation has been filed in the Senate and House of Representatives that would mandate the use of building codes statewide and require the appropriate certification of building inspectors who administer the provisions.

A 1981 Conference held in Knoxville, Tennessee, was the beginning of many important initiatives in South Carolina in terms of earthquake safety and mitigation. As a result of this conference several organizations and initiatives emerged, which include the following.

The South Carolina Seismic Safety Consortium (SCSSC) was established in 1981 to develop and influence the implementation of a comprehensive action plan for earthquake preparedness and mitigation in South Carolina. The Consortium includes representatives from government, private industry, professional associations, and universities.

The SCSSC was formed to address seismic safety policy issues and to alert the public and various public agencies to the threat of earthquakes. It encompasses three major objectives: a) to develop and influence the implementation of a comprehensive state seismic safety policy ensuring adequate earthquake preparedness and mitigation, with emphasis on the low-country region; b) to promote interdisciplinary cooperation and technical competence among professionals, governmental leaders, and the public to effect adequate sustained implementation of seismic safety policy; and c) to ensure that federal and state seismic research and development programs adequately address the technical needs of the Southeastern United States.

One of the major contributions of the SCSSC includes the preparation of a document entitled "Earthquake Hazards and Risks in South Carolina and the Southeastern United States" (1982) which has served as a guide for the assessment of seismic potential in South Carolina.

The Technology Transfer and Development Council (TTDC) was formed to promote effective earthquake engineering technology throughout the region. The TTDC consists of leading regional engineers and scientists engaged in earthquake engineering application and research. Its membership collectively represents earthquake engineering research activities in Alabama, Florida, Georgia, North Carolina, South Carolina, Tennessee, and Virginia.

In 1986, TTDC requested that the South Carolina Building Codes Council implement an Action Plan to include the use of a mandatory legislation for the adoption of building code provisions and the design and adoption of construction standards for wind and seismic hazards throughout the State. This initiative is to a) promote as mandatory the current optional legislation on seismic design; b) promote training on wind/seismic design, and construction procedures for building officials; c) enhance qualifications of professional engineers in the nature and practice of wind/seismic design; e) resolve and sponsor prudent code revision for the wind/seismic strengthening of existing buildings; and d) effectively participate in the development of emerging multiple hazard building code technology, especially that of the NEHRP (National Earthquake Hazards Reduction Program)[8]

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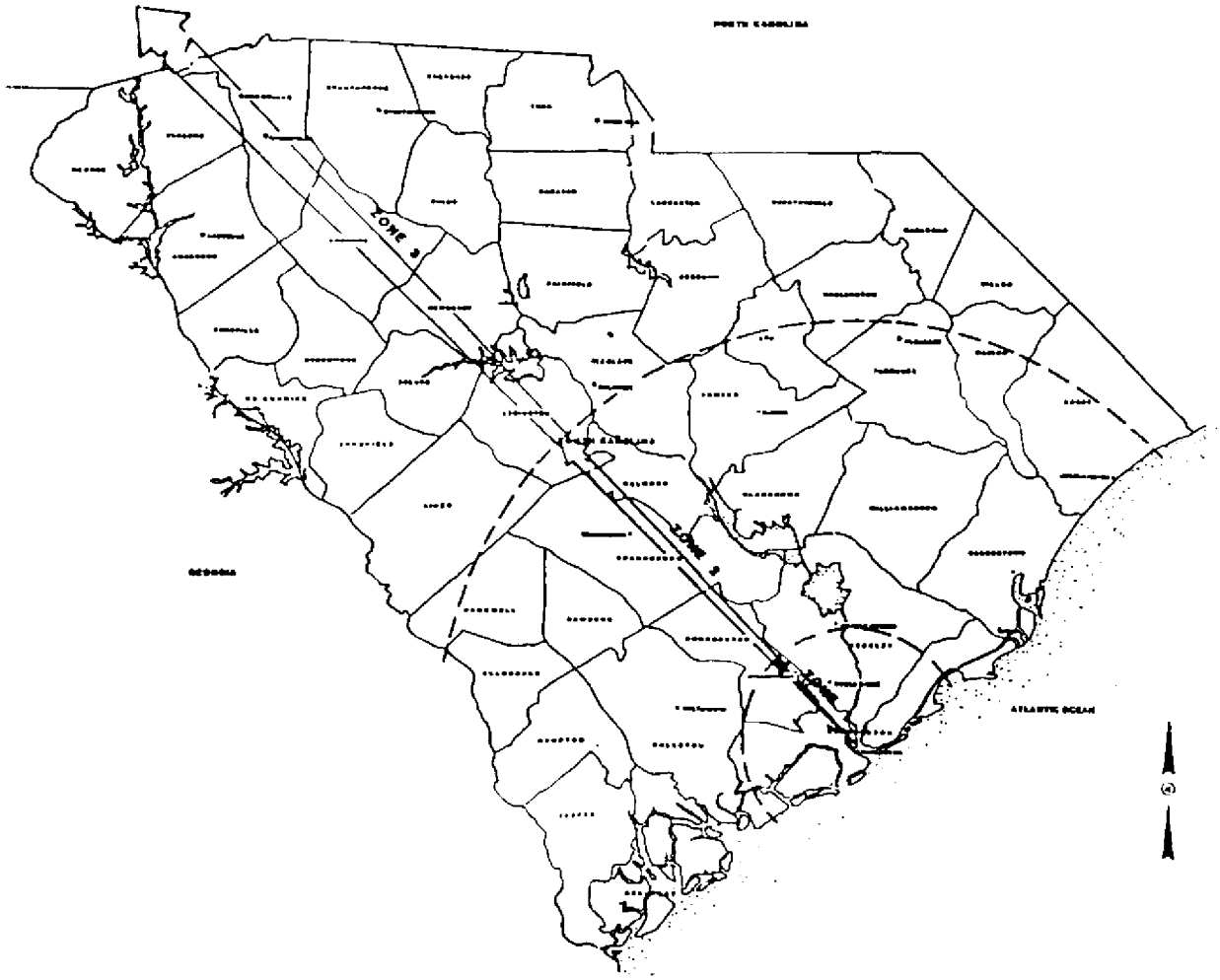
[8] Lindbergh, Charles, "Post-Workshop Section" in Earthquake Hazards, Risk and Mitigation, 1986 (Lindbergh, Charles, , ed).

POTENTIAL DAMAGE REGIONS, CHARLESTON EPICENTER EARTHQUAKE

Exhibit 10



Potential damage from an earthquake similar to the one that occurred in 19886 reveals that considerable destruction and damage will probably occur within an area of a 100-mile radius. The damage areas are divided into three zones: the region within a 25-mile radius of the epicenter (zone 1), the region between the 25- to 100-mile radius (zone 2), and the region beyond a 100-mile radius (zone 3) from the epicenter

Source: *An Earthquake Vulnerability Analysis of the Charleston, South Carolina, Area* (Harlan and Lindbergh, 1986).